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The 'need for speed': Towards circular disruption—What it is, how to make it happen and how to know it's happening

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Abstract

The environmental, social and economic limits and shortcomings of the current linear model of production and consumption highlight the necessity of a rapid transition towards a sustainable paradigm. The concept of a circular economy has recently gained traction among scholars, policy-makers and businesses as a promising alternative. Yet our understanding of how to speed up the systemic transition from a linear economy paradigm towards a circular economy paradigm is lacking. In this paper, we address this research gap by introducing the concept of 'circular disruption' and by describing how such a disruption may unfold. To do so, we build on S-curve thinking and the concept of panarchy. Based on the resulting synthesis, we propose three phases that constitute the core of the disruption process: (1) the release phase, (2) the reorganisation phase and (3) the eruption phase. We then operationalise these three phases for different enabling innovation system functions and illustrate our observations with examples for the textile and fashion sector. We discuss how each of the three disruption phases can be accelerated to quickly create an opening for the new circular paradigm. The proposed circular disruption framework offers novel insights on socio-technical transitions and changes and contributes to strengthening a systemic and theoretically grounded approach to circular economy research. Scholars and practitioners alike may take advantage of this work to focus circular economy efforts on speed and scale—an urgently needed focus to start tackling the sustainability challenges humankind is currently facing.

KEYWORDS
circular economy, disruption, system innovation, sustainability transition, Technological Innovation Systems, urgency

1 | INTRODUCTION

The dominant linear economic model is reaching its environmental, social and economic limits. From an environmental perspective, accelerating material use in the last decades has put unprecedented strains on the Earth's natural resources. During the last century, global use of fossil fuels, ores, minerals and biomass increased eightfold (Krausmann et al., 2009). Global materials consumption reached 100 billion tons a year in 2017 for the first time ever (Circle Economy, 2021), whilst nature declines at unprecedented rates in human history (IPBES, 2019), resulting in the man-made mass estimated to exceed all global living biomass in 2020 (Elhacham

Bauwens and Blomsma should be considered joint first author.

et al., 2020). This went hand in hand with increasing amounts of waste and air, water and soil pollution. Material handling and use also account for the vast majority (70%) of greenhouse gases emitted, contributing to the on-going climate crisis (Circle Economy, 2021). From a social perspective, the current linear economy is not meeting the requirements for a foundation that provides basic needs and well-being (Raworth, 2017; Velenturf & Purnell, 2021). From an economic perspective, the linear economy leads to significant financial value loss in the form of material and energy waste (EMF, 2013). The pressure on natural resources also drives volatility in resource prices (Ecorys, 2012) and generates supply risks (Seuring & Müller, 2008).

These pressing problems require a rapid resolution. As such, a new consumption and production paradigm that operates within the limits of the planet and that safeguards social and economic prosperity is urgently needed. One avenue to accomplish this that has recently gained traction is the concept of a circular economy (CE)[1] (EMF, 2013). From an environmental perspective, implementing CE in food, construction and mobility sectors has the potential to cut 39% of total global emissions (Circle Economy, 2021). From a social perspective, the potential of the CE for job creation has been highlighted, especially in reuse and repair activities, which are more labour-intensive (Llorente-González & Vence, 2020), although effects on different parts of the world may differ (Repp et al., 2021).

As such, a rapid transition towards a circular way of dealing with waste and resources could contribute to bringing about a new consumption and production paradigm. Crucially, the 'need for speed' in systemic transitions has been under-researched, and this may hold true in particular for the CE transition. While circular strategies have been applied within industry for a long time (Blomsma & Brennan, 2017), no major shift towards a CE has occurred, and the economy has become less circular in recent years (Circle Economy, 2021; Haas et al., 2015). Meanwhile, research remains focused on discussing definitional nuances of the CE concept (Kirchherr et al., 2017). Furthermore, literature describing barriers preventing the CE transition has emerged in recent years (e.g., de Jesus & Mendonça, 2018; Kirchherr et al., 2018), also failing to outline practical pathways for accelerating CE implementation. We, thus, propose the concept of a 'circular disruption' to help shift the scholarly focus in CE research towards a conversation on how to achieve a circular economy with speed and scale. This concept builds on previous work that explores different developmental trajectories towards circularity as well as circular futures (Bauwens et al., 2020; Blomsma & Brennan, 2017; Reike et al., 2018) and responds to calls for more theoretical grounding of the CE literature (Korhonen et al., 2018).

The questions explored in this paper are (a) how to define 'circular disruption', (b) how it can be brought about and (c) how progress towards it can be monitored and course adjustments be made. In the subsequent sections, we address these questions in turn. The transition towards a CE requires interdisciplinary and transdisciplinary solutions (Wasieleski et al., 2021), and we follow in the tradition within organisation science that links management theory with the natural and system sciences (e.g., Senge, 2006; Wheatley, 2006). First, we offer a definition of the concept of 'circular disruption'. We then present a synthesis of S-curve thinking and the concept of panarchy to create a processual approach to the needed transition. The subsequent section applies this synthesis to circularity and operationalises it for the seven circular system innovation functions, hence offering an approach for assessing and directing the systemic transition. We close with a summary of our contribution and highlight how both practice and academia benefit from this work.

2 | BACKGROUND: DEFINING A 'CIRCULAR DISRUPTION'

We propose that the rapid transition that is needed can be conceptualised as a *circular disruption*: the period where a break away from a linear paradigm is accomplished, and an opening for a circular paradigm is created. Accordingly, a circular disruption is as follows:

> A transformation in a socio-technical system which causes the *systemic*, *widespread*, and *fast* change from the harmful 'take-make-use-dispose' model to a socially and environmentally *desirable* and *sustainable* model that reduces resource consumption and address structural waste through the deployment of circular strategies.

As indicated by the underscoring, there are five key components of circular disruption. First, it is *systemic*, meaning that it encompasses all technical and operational aspects of the industrial life-cycle, from production to consumption to end-of-use/life, and the relevant circular strategies. This also includes the accompanying changes in social institutions, as the way in which resources' flow is shaped by the social context in which they occur (Boons & Howard-Grenville, 2009; Meadows, 1999). After all, it is people that 'make flows flow' (Baumann, 2004).

Second, the change from a linear paradigm to a circular paradigm needs to be *widespread*, that is, across sectors, as well as across geographic regions. A relevant scale is one that covers a grouping of regions and/or countries, allowing for local experimentation and adaptation, whilst facilitating the exchange of best practices so they can have a wide impact (Circular Economy Initiative Deutschland, 2021; Haas et al., 2015).

Third, circular disruption has to be *desirable* (Hoffman & Ehrenfeld, 2013). That is, it is not only about being able to preserve, continue or sustain something (e.g., to be non-destructive) but also to be a process in service of creating a new and better version of 'the good life' (Perez, 2002), of human 'flourishing' (Jackson, 2009) and of growth that has a 'certain direction' (Mazzucato, 2021). This can also include moving 'post-growth' towards more meaningful indicators of human progress (Bauwens, 2021). Fuller (1969) already put it thus for change to come about one has to build 'a new model that makes the

[1]Note that we group the 'recycling economy' (Type II ecology) with the linear economy (Type I ecology), as it primarily adds a delay to linear processes. A 'circular economy' approaches what Graedel (1994) refers to as a Type III ecology.

existing model obsolete'. Such a reorientation enables changes in the preferences of 'consumers, citizens and workers' (Ashford & Hall, 2011, p. 679) and, thus, aligns consumer aspirations with sustainable behaviours, attunes citizen demands to sustainable policies and harmonises worker actions with embedding sustainable practices at the core of business activities.

Fourth, only a circular disruption with *sustainability* at its core will enable the creation of an economic approach fit to ensure environmental, social and economic prosperity (Circle Economy, 2021; Geissdoerfer et al., 2017; Kirchherr et al., 2017). Circular disruption needs to create environmentally beneficial outcomes, meaning to negate environmental destruction and, wherever possible, take restorative action; be socially just and inclusive (Kirchherr, 2021) and take care of the needs of all whilst excluding none; and allow for economic value creation, delivery and capture of value whilst creating healthy circular markets. This includes that a circular disruption is set up in a way that prevents circular rebound (Zink & Geyer, 2017) and other negative (side) effects that reduce or negate its benefits.

Finally, and crucially, circular disruption must be *fast*. The transformation needs to be well on the way or completed by the year 2030 to address the range of pressing problems, first and foremost among them to meet the global heating threshold of 1.5°C called for by the Intergovernmental Panel on Climate Change (IPCC, 2018). The IPCC asserts that the year 2030 is a benchmark of the 'point of no return' to avoid irreversible and run-away climate change with devastating impacts for human, animal and plant life (IPCC, 2018). The current linear paradigm, however, will result in a three to six degree Celsius temperature increase by the 2040s (Circle Economy, 2021; Meinshausen et al., 2011). Global carbon emissions needed to peak in the year 2020 and drastically reduce afterwards, to keep global heating below 1.5°C (IPCC, 2018).

Others have previously shed light on the aspects of systemic innovation (e.g., Colvin et al., 2014; Hellström, 2003; Wieczorek & Hekkert, 2012), the need for a widespread transition (Haas et al., 2015), desirability (e.g., Nikas et al., 2020) and sustainability (e.g., Jacobsson & Bergek, 2011; Schroeder et al., 2019). Although further development in each of these areas is still needed, the aspect of speed, in particular, has so far received little attention, whilst it poses a major unresolved challenge. Looking at historical transitions of the type and magnitude required, we see that a longer time-frame is indicated for this, with estimates ranging from 20–30 years for product-systems (Brezet et al., 2001) and over 20 years for sustainable technology innovations (Gross et al., 2018), and from 'one generation or more' (Grin et al., 2010) to 60–70 years (Kondratieff & Stolper, 1935) for a socio-technical paradigm shift. As such, there is an apparent contradiction between the 'need for speed' and the possibility of accelerating socio-technical transitions based on historical observations.

This paper attempts to resolve this contradiction and conceptualises the acceleration of the transition from a linear paradigm to a circular paradigm, which due to the speed can be thought of as 'disruption'. We note that the change occurs via the deployment of circular strategies by businesses, policy-makers and other societal stakeholders, operationalised by such circular strategies as, but not limited to sufficiency, reduction, reuse, intensified product use, increased robustness, longevity, upgrading, remanufacturing, recycling, composting, cascading and industrial symbiosis—as is in line with the umbrella concept of CE (Blomsma & Brennan, 2017). The definition of circular disruption offered in the above is our vision for 'the change we want and need, all around us, as quickly as possible', and it is our starting point for the remainder of this paper. Circular disruption, however, may be a stretch goal in the sense that although difficult to achieve, it is nevertheless worthwhile pursuing.

3 | THEORETICAL DEVELOPMENT: THE PHASES OF A DISRUPTION

3.1 | Starting point

Following Sterman (2002, p. 521), we ground our approach in process models and argue that 'focusing on the process of modelling rather than on the results of any particular model speeds learning and leads to better models, policies, and a greater chance of implementation and system improvement'. Since the outcomes of circular disruption are impossible to predict with any precision, we focus on the 'how' of disruption as opposed to defining the 'what' of the outcomes.[2] This aligns with the science of decision-making, where it has long been asserted that in complex situations, a focus on the process rather than the outcomes is the basis for making decisions (van de Ven, 1986). This is furthermore in line with thinking on sensemaking and innovating for complexity (Snowden & Boone, 2007).

In the following, we draw on and synthesise two prominent models for conceptualising socio-technical change: (1) the S-curve model, which is well known in management studies, and (2) the concept of panarchy, which we use to extend the S-curve model. Both the S-curve model and the panarchy concept describe socio-technical change, consider the element of time and are, therefore, well suited to meet the key objective of this paper: conceptualising the acceleration of the transition from a linear to a circular paradigm. Furthermore, the S-Curve model indicates systemic change driven from the inside of the system with technology as enabler, whereas the panarchy concept shows how systemic change happens based on both internal and external forces applied onto a system. These complementary inside-out and outside-in perspectives, the time element and the systemic approach make S-curve and panarchy highly suitable to address the 'systemic', 'widespread' and 'fast' components of the proposed circular disruption definition.

Next, we briefly introduce the two models, highlight their common ground, as well as their complementarity, and show how they can be synthesised to understand the process of disruption. Note that we take a broad interpretation of 'technology' and include in this not only high-tech innovation, but any innovation that serves as an enabler or as an aid in overcoming constraints. Technology, after all, is the application of ingenuity to overcome barriers in achieving a task

[2] cf. Bauwens et al. (2020), for an in-depth discussion of outcomes.

or a purpose (Kelly, 2010) and can be seen as 'configurations that work' (Rip & Kemp, 1998). We understand technology, therefore, more broadly as 'enablers'. Moreover, we acknowledge, in line with the frameworks drawn on, that the details may differ locally but that a heuristic device in the form of the proposed model is of value to orient analysis and decision making.

3.2 | S-curves: Strengths and limitations

Foster (1986), the creator of the S-curve innovation model, has suggested that customer benefits shape the rate of new technology adoption along successive curves that resemble a forward leaning 'S' (Chandy & Tellis, 2000). In this model, the increase of customer benefits (Chandy & Tellis, 2000) and, hence, performance in the marketplace (Foster, 1986) is plotted against time (Chandy & Tellis, 2000) and the associated resources spent (Foster, 1986) by the firm during the development and adoption of the technological invention. The curves can be made steeper through faster processes and through launching new products and services faster into the marketplace (Foster, 1986). The S-shape, therefore, indicates the maturity of a market operating under a given technological paradigm and is indicative of the maturity of a particular solution space (see Figure 1a).

Within S-curve thinking, the transition from one paradigm to the next is illustrated by sequential but separate S-Curves (Chandy & Tellis, 2000). It is this break that indicates the technological discontinuity, impacting both the micro level of firms and the macrolevel of the marketplace, resulting in the transition from one technological paradigm to another (Kuhn, 1962). Only discontinuities between curves may lead to novelty (Foster, 1986), disruption (Christensen, 1997) and, hence, 'chaos' for people within organisations (Foster, 1986, p.103).

In a period of fast change, the unsettling period of 'breaking with the old' creates room for experimentation, the creation of new practices and innovations (Drucker, 1985). Only radical technological inventions can change the competitive landscape in the marketplace because these inventions make established technologies obsolete (Dahlin & Behrens, 2005, p. 725): They must be novel ('dissimilar from prior inventions'), unique ('dissimilar from current inventions') and, perhaps most importantly, they have to be adopted ('influence the content of future inventions').

The S-curve model has been extended beyond technology inventions to include architectural innovation (Christensen, 1992), service innovation (Bettencourt, 2010) and systems thinking approaches (Forrester, 1964). Others such as economist Perez (2002) and transition management scholars (e.g., Geels & Schot, 2007) operationalise S-curves for systemic change in the areas of socio-technical change and sustainability transitions. That is, not just technological paradigms are characterised by profound paradigm shifts but similar S-curve shifts can be observed in socio-technical systems. It is this systemic tradition that we draw on.

The S-curve model, however, leaves unexplored the emergence of new needs and new problems that arise. Although it provides insight into how paradigms for solutions change, it does not pay attention to fundamental new challenges that require an examination of the constraints and a redefinition of what constitutes a solution. Given that sustainability is a challenge of how to deal with new constraints, this needs to be included as part of our approach to circular disruption. In addition, the S-curve model does not allow for understanding the relationships of the new paradigm with the old, as a new paradigm is conceptualised as gestating separated from and 'in the background' of the dominant paradigm until it is ready to burst onto the scene. Therefore, we turn to a model that remedies these shortcomings: panarchy.

3.3 | Panarchy: Strengths and limitations

Insightful for systems change is the *panarchy* model. This model, developed by Gunderson and Holling (2002), describes how connections between the parts of self-organising systems periodically reorganise as a result of different pressures. The model considers two main dimensions representing two forces that interact and create different system behaviours, depending on the relative strength of each force. The first dimension is the degree to which potential is achieved: It describes the number of options available for the future, and, as such, it describes the availability of 'enablers'. The second dimension of the model is the degree to which a system can control its own developmental trajectory and, as such, describes 'constraints'.

Panarchy proposes two main phases of change. The first phase is the 'forward loop'—the blue part of the curve in Figure 1b. This phase is characterised by (relative) stability, certainty, predictability, construction and accumulation, and it establishes and builds systems (Walker & Salt, 2006). The second phase is the 'back loop'; see the green part of the curve in Figure 1b. This phase is characterised by uncertainty, experimentation, emergence and novelty. It revitalises a system that has become stagnant, brittle and where resources have become 'locked up' or unavailable. This phase entails either destructive or creative change.

Together, the forward and the back loop form a lemniscate describing what is titled the *adaptive cycle*. This cycle is an ever-repeating rhythm where first connections form and tighten such that favourable conditions can be exploited and solutions can freely develop. Inevitably, as conditions slowly change and new constraints assert themselves, this is followed by the loosening, breaking and reorganising of those connections, and a system is forced to reorient itself to a different set of solutions that are demanded by the new constraints. This framework, thus, describes the transition from one paradigm to another, whilst acknowledging both the importance of the restructuring of existing elements as well as new elements being added to the system.

The panarchy model, however, merely implicitly references the dimension of time—posing that the back loop can take place much faster than the forward loop. Without acknowledging this explicitly, it is difficult to track and understand a systems' evolution over time, and the appearance is created that no thresholds are crossed. Gunderson and Holling (2002) acknowledge these limitations in their application

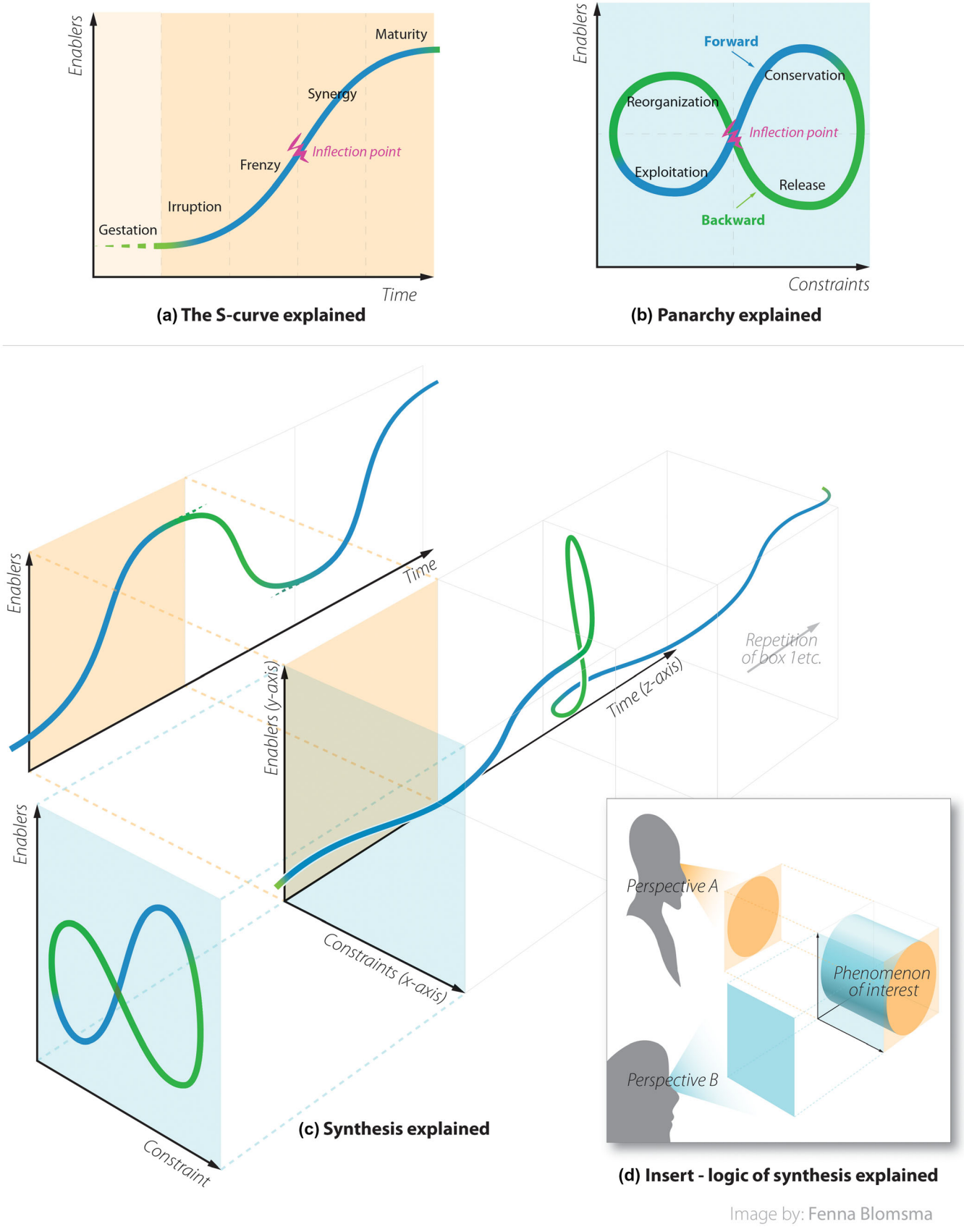

FIGURE 1 Visual synthesis of the S-curve and Panarchy models (logic on insert inspired by an image found at https://starecat.com/this-is-true-this-is-truth-square-circle-please-consider-before-talking-typing/)

of the framework, by allowing for a sequential connection of different lemniscate-curves.

3.4 | Synthesis: The waveS model

For our synthesis, we depart from previously attempted efforts in 2D (e.g., Curry & Tibbs, 2010; Doyon, 2018). Instead, we take a 3D approach and offer the 'waveS' model to describe, analyse and steer what happens during a period of circular disruption (see Figure 1c). The name of the 'waveS' model is derived from merging the panarchy curves with the S-curve shape through visual and content synthesis in a form that resembles a wave. Our synthesis is based on the observation that the S-curve and panarchy model share an overlapping dimension ('enablers') and that two complimentary dimensions can be seen ('time' and 'constraints'). The overlapping dimension of 'enablers' is used as the *y* axis, the *x* axis represents 'constraints' and the *z* axis depicts 'time'. The inset in Figure 1d shows the perspectives of this synthesis logic. Our synthesis corrects the wrongly assumed one-to-one mapping of the four S-curve phases directly onto the four panarchy phases in previous synthesis attempts (Curry & Tibbs, 2010). In our view, treating the phases of both models as equivalent to each other loses their unique contribution.

Instead, the proposed 3D synthesis highlights the importance of acknowledging, in the 'back loop', that the demands placed on new solutions have changed. For example, the innovation processes for addressing linear concerns become ineffective when applied in the search for circular solutions. What is required as an outcome is not just a bigger and/or better version of the same solution, but what constitutes a solution has to be fundamentally changed.

S-curves and panarchy have other conceptual similarities that aid synthesis. For one, both models operate at levels from the microscale to the macroscale, frequently depicted as nested versions of these models. The two models both acknowledge their intellectual roots Schumpeterian 'creative destruction'. Equally, both models are furthermore subdivided into sub-phases (e.g., for S-curves, we draw from Perez, 2002, and for panarchy, we use Gunderson & Holling, 2002, with particular importance given to the inflection points as they point to key thresholds within a systemic transition). In addition to these similarities, extensions of both models have been previously proposed that are in line with our synthesis. For example, the panarchy model has been extended to include additional dimensions apart from the two main dimensions (e.g., 'time' and 'resilience'; Gunderson & Holling, 2002). Similarly, work on S-curves has indicated a need to acknowledge repurposing elements from the old paradigm for the new one (Perez, 2002) and to extend the model to include a reverse curve (Luo et al., 2018).

3.5 | The phases of disruption

Here, we focus on the process of disruption in general, which is then applied to the transition from a linear to a circular paradigm in Section 4. To better understand the general process of disruption, we highlight the 'back loop' of panarchy (Gunderson & Holling, 2002), as well as its connections with the 'maturity' phase of the old paradigm and the 'eruption'[3] phase of the new paradigm. For clarity, we simplify Figure 1c into the Figure 2 waveS model: preserving the main dynamics from the synthesis, whilst acknowledging—as indicated by panarchy—that the transition from one paradigm to the next happens in a different 'state space' represented by a shifted plane at the top in Figure 2. The middle and bottom of Figure 2 show how a new paradigm emerges and how it uses elements from the preceding paradigm, as well as adding new elements.

In the three phases of disruption of the waveS model, a recalibration is accomplished: The new constraints are acknowledged and internalised, and as a result, the meaning of 'solution' is redefined. The 'release', 'reorganisation' and 'eruption' phases are powered by fast, action-based learning cycles. The beneficiaries of these learnings are the makers, interpreters and implementers of social rules: key actors in society, business and policy. At the level of the individual business and business unit, the action-based learning cycles are looking to create a fit between new solutions and customers (Blank, 2005). Table 1 describes the waveS phases.

Along the waveS model, various inflection points are indicated; see Figure 2 (middle, pink flashes). Such an inflection point usually indicates unrest and uncertainty—even crisis. Inflection points No. 1 can be characterised by bubble-and-crash dynamics where markets get over-excited by the promise and the quick growth of the new paradigm. Bankruptcies, unemployment, inflation, despair, inadequate policies, etc. may be seen when these bubbles burst. Similarly, inflection point No. 2 indicates a climax in discursive struggles: various alternative narratives are proposed, each of which is also heavily critiqued (Bauwens et al., 2020; Blomsma & Brennan, 2017; Calisto Friant et al., 2020). In short, at several points in a transition, difficulties can be expected. At these times, it is important to both address the fall-out of the disturbance and put together innovation teams that utilise the opening they represent for creative change (Snowden & Boone, 2007).

4 | CIRCULAR DISRUPTION: MAKING IT HAPPEN AND HOW TO KNOW IT'S HAPPENING

Now that the process of disruption with focus on 'systemic', 'widespread' and 'fast' is better understood in general, we investigate the process more closely for the transition from a linear to a circular paradigm. Specifically, we examine the phases of circular disruption in more detail, how circular disruption can be accelerated and what the tell-tale signs are of this acceleration to bring clarity to the 'desirable' and 'sustainable' components of the circular disruption definition

[3]We use 'eruption' instead of Perez's 'irruption' here as we think the term is clearer and easier to relate to.

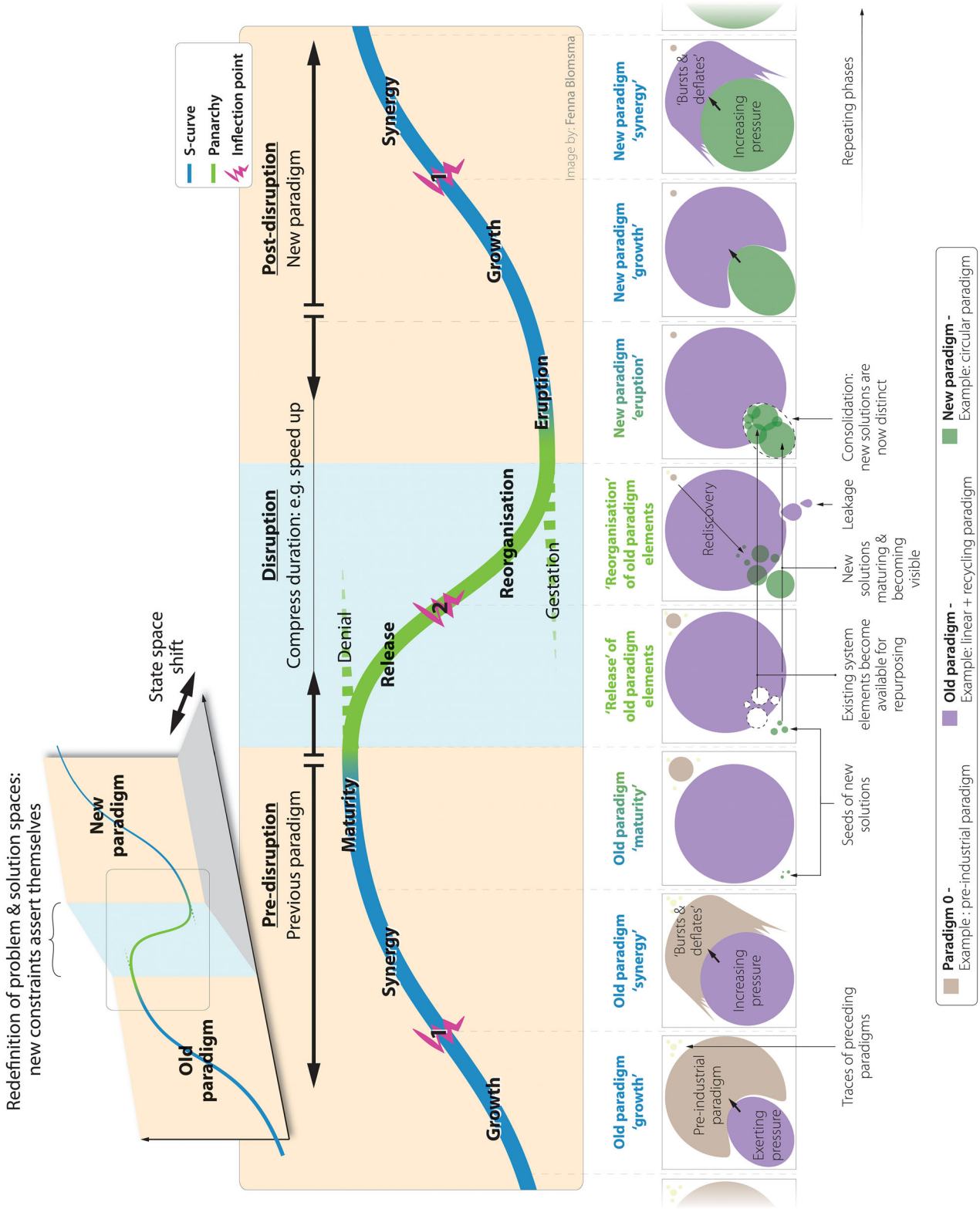

FIGURE 2 The waveS model shows the disruption phases Release, Reorganisation and Eruption during the shift/transition from the old to the new paradigm

TABLE 1 Phases of the waveS model: A synthesis of Perez (2002) and Gunderson and Holling (2002), unless indicated through additional references

Phase	The phases of circular disruption according to the waveS model
Pre-disruption Growth in the old paradigm starts to slow down and stagnate.	*Maturity of the old paradigm* The current paradigm starts to exhibit strong signs of stagnation. 'Doing more of the same' no longer gets the same results: the previously experienced 'golden age' is ending. Formerly booked successes start to slow down: new solutions experience very short life cycles, and profits are only marginally increased by mergers and exporting to markets abroad. The reason for this is that the system's rigidity asserts itself. This means that the limitations of the current paradigm become visible and the effect of the new constraints start to be felt. However, the evidence of (previously accumulated) success is still visible, leading to disbelief and blindness to the new conditions. A division starts to emerge between those who still advocate the 'old', and those who acknowledge the 'old' is no longer fit for purpose and who are asking deep and uncomfortable questions about the now dysfunctional paradigm.
Disruption Break away from the old and opening up to the new.	*Release phase - old elements becoming available for the new paradigm* This phase may come about through crisis or through deliberate action. A crisis can be triggered as a result of events that would previously be unremarkable, causing strong destabilizing feedback loops because the system has become rigid and brittle: the possibility to absorb shocks has been eroded in the previous phases in the name of efficiency. In- or external agents or events trigger cascade failures that will 'run their course' until the resources fuelling it are exhausted. This is amplified by dissatisfaction of people who operate within the old paradigm, causing an 'unfreezing' of organisational processes (Schein, 1996) and any human system (Cummings et al., 2016). This unfreezing causes the connections in a system to break and a sudden release of resources (physical, organisational, financial, knowledge, human, etc). Losses occur, but resources may be reserved to be 'carried over' in the new paradigm, too. Carry over and redeployment potential, however, may not be immediately obvious. It appears as if potential plummets, but in fact the stage is set for reorganisation. Alternatively, deliberate action can achieve a similar effect and destabilise with the intent to create space for the new in a more controlled manner - analogous to controlled forest fires that are meant to prevent fire disasters (Gunderson & Holling, 2002). Solutions from paradigms past may be re-examined. At the same time, isolated initiatives are ongoing that explore (partial) solutions to the current predicament.
	Reorganisation phase - new solutions gestating This phase is characterised by high resilience and high potential, as well as low connectedness and low internal regulation. Potential for subsequent growth is created in a variety of ways. For one, the 'released' resources from the previous paradigm are starting to be redeployed and reconfigured, sometimes leading to radical repurposing the form of exaptation (Snowden et al., 2021). Moreover, solutions from paradigms past find new roles in the new paradigm. True novelty and invention also become visible, which has been gestating in niches and other protected spaces (Kemp et al., 1998) - although these inventions may need to be protected for a while longer before they are sufficiently developed to withstand the selection pressures within the new paradigm. Exaptation, rediscovery and invention give rise to unexpected forms of renewal that are difficult to imagine or predict in advance. Whilst during this period losses exit the system and unexpected crises may arise, new opportunities start to be captured as new connections in the system start to be formed. Random and chance events may have a disproportionate influence on setting the course of the new paradigm - the creation of undesirable path dependencies is a risk. Adaptive management is necessary to minimise this risk, meaning that active learning and adjusting course accordingly are key.
	Eruption phase - a new paradigm starts to take shape The new paradigm experiences a frenzy of activity. Those businesses and institutions that are the fastest out the starting blocks, are the most aggressive, and are the most resilient and adaptable are likely to persist. Many fail, but learning accumulates in the system. In this phase, it is important to steer for desirable outcomes, and to make sure that the desired outcomes are amplified and undesirable ones are minimised. New investment is flowing toward the 'new', but from those that still hold a foot in the old paradigm. Success stories of the 'new' start to attract attention, which in some cases is seen as a threat. Positive feedback loops (synergies that amplify each other) are triggered that allow for the pace of change to pick up (Snowden et al., 2021). Pockets of the old paradigm may see short revivals and intensification, but a divergence between the old and the new can be seen more clearly as the new paradigm starts to consolidate.
Post-disruption Towards growth and exploitation of the new paradigm.	*Circular synergy and circular growth - a new paradigm takes hold* At this point, although the old paradigm is starting to decline, its legacy is still strong. The new paradigm is poised to become the new dominant paradigm soon, though, as it experiences continued growth. Gradually at first but then accelerating, as the positive feedback loops gain momentum. The uptake of new innovations and policies can be seen and other elements of the system start to increasingly orient themselves towards the new paradigm.

Note: Colour coding in line with Figure 2.

TABLE 2 The relationship between the seven Innovation System Functions and the three phases of Circular Disruption

	Release phase		Reorganisation phase		Eruption phase	
Innovation System Function	**Generic patterns**	**Example in the textile industry**	**Generic patterns**	**Example in the textile industry**	**Generic patterns**	**Example in the textile industry**
[1] Business experimentation *Experimentation, including business model experimentation, undertaken by intra- and entrepreneurs to generate and explore new knowledge and markets to turn them into action and new business opportunities*	Sustainability costs of linear business models become increasingly apparent and can no longer be ignored, although some growth spurts in the linear paradigm are still visible; various alternatives including circular business models are increasingly discussed.	Business experimentations (e.g., with the use of recycled content or recyclable materials in specific products or product groups) in circular fashion take place, but are still fragmented and isolated.	Linear business models are increasingly under pressure; emerging shared vision around circular business models as a viable alternative. Business experimentation takes place to broaden the application domains of viable solutions.	New connections are formed to adapt and diffuse innovations (e.g., collaboration of MUD Jeans and IKEA for circular cover, joint venture of H&M and Adidas to create new fibres from cellulose waste).	Proliferation of circular business models emerge, probing, experimenting and testing radically novel circular innovations.	Online retail platforms are being used by a growing number of circular companies and individual designers to reach potential consumers directly and without needing retail space. Second-hand online shops and fashion-as-a-service offerings proliferate.
[2] Guidance of the search by circular disruption principles *Activities within the innovation system that can positively affect the visibility and clarity of specific wants among technology users*	No clarity on the guidance of the search yet. Public funding for linear technologies R&D is increasingly questioned.	A variety of policies aimed at solving specific, isolated issues related to linear fashion is proposed, but does not yet reflect a coherent vision aiming at tackling systemic challenges.	Linear practices are increasingly dis-incentivised through, e.g., fiscal policies. Some supportive measures (e.g., public procurement rules, tax incentives, and subsidies) are taken for the emergence of circular innovations.	Circular procurements and extended producer responsibility policies are introduced for end-of-use clothing, linen and shoes.	The early measures implemented to 'destabilise the old' and 'create the new' in the previous phase are further reinforced, becoming less isolated and increasingly interconnected to create systemic change (policy mix for circularity).	Extended producer responsibility policies are combined with the large-scale introduction of a ledger system of materials and materials passports to enhance the traceability of material flows.
[3] Knowledge development *Learning mechanisms necessary to develop the innovation, embodied into R&D projects, patents, and investments in R&D*	Linear systems and their underlying knowledge are still dominant; first seeds of circularity developed 'under the radar'. There is a rediscovery and adaptation of 'old' circular knowledge to modern challenges	Previously available technologies (e.g., biobased fibres) take on new significance in the light of circular fashion.	Knowledge development efforts become more aligned and integrated, directed towards tackling systemic issues.	Knitting technologies are combined with the use of ocean plastic fibres in mono-material design, enabling zero-waste manufacturing, the use of waste as an input and cleaning up the ocean, as well as creating high recycling potential.	Integrated circular solutions are becoming more and more mature.	Circular fashion solutions are becoming more and more integrated and mature.

TABLE 2 (Continued)

Innovation System Function	Release phase		Reorganisation phase		Eruption phase	
	Generic patterns	**Example in the textile industry**	**Generic patterns**	**Example in the textile industry**	**Generic patterns**	**Example in the textile industry**
[4] Knowledge diffusion Networks interacting to diffuse knowledge about the innovation	Knowledge on linear systems is widely available and diffused; first seeds of circular knowledge have emerged, but with very limited diffusion so far.	Little knowledge on circular fashion, while linear fashion systems and their underlying knowledge are still dominant.	Knowledge on linearity continues to be widely available and diffused; increasing alignment of different actors, with the development of collective learning platforms and learning coalitions regarding circularity	Consortia and initiatives such as the Sustainable Apparel Coalition and Circle Economy's Firbresort initiative contribute to creating collective learning and learning coalitions for circular fashion.	Circular knowledge experiences wide diffusion in selected protected niches. The extent and the depth of the collaborations initiated in the previous phase to diffuse knowledge expand rapidly.	'Frontrunner in residence' experiences in mainstream companies are taking place, showing them the needs and opportunities of change.
[5] Market (de)formation Activities aimed at the of shrinking of markets for established technologies and products that have become economically, socially and environmentally unsustainable and/or at the formation of markets for superior alternatives (e.g., favourable tax regimes)	Conflicting signals: some decline of linear markets, but also still some growth in selected pockets.	Well-known customer-oriented companies (e.g., H&M, C&A and Tchibo) start communicating positively about CE in to (potential) users in ways visible to others in the sector.	Markets for linear products start shrinking because of changes in incentives. Market formation mechanisms for circular innovations start emerging in protected spaces.	Companies collaborate to create platforms (e.g., Circos.co), improving the offer for potential users and lowering entry barriers.	Successful circular market formation takes place in selected protected niches.	Circular fashion offerings are becoming more and more attractive as compared to their linear counterparts, increasing customer support for sustainability.
[6] Resource (de) mobilisation Activities aimed at the demobilisation of financial and human resources for established technologies and products that have become economically, socially and environmentally unsustainable and/or the mobilisation of financial and human resources for superior alternatives	Increasing considerations if financial and human resources are deployed in the right way.	Competitions are organised (e.g., the H&M Foundation's Globe Change Award and the Redress Design Award) to tentatively mobilise resources by making funds available to and training workers in new solutions.	Funders increase inquire and seek novel outlets for resource deployment; experimentation with new funding vehicles, decommissioning of old paradigm funding mechanisms.	Creation of innovative financing vehicles for circular fashion, such as blended finance and financing vehicles for fashion-as-a-service models.	Increasing amount of seed/series A capital available for circular innovation and first talents launch respectively join circular startups. Individual or small teams pursue niche circular innovation projects in established businesses.	Laid-off workers in the linear fashion industry are retrained and reoriented towards more labour-intensive and circular fashion activities, which also increasingly attract funding.

(Continues)

TABLE 2 (Continued)

Innovation System Function	Release phase		Reorganisation phase		Eruption phase	
	Generic patterns	Example in the textile industry	Generic patterns	Example in the textile industry	Generic patterns	Example in the textile industry
[7] Social and political mobilisation Activities aimed at deinstitutionalizing established rules, practices and technologies and/or institutionalizing new ones	Growing discontent among policy and business actors with the linear system. Increasing societal mobilisation against harmful environmental and social consequences of linear systems. Different alternatives for 'societal organisation' are popping up.	Accumulating scandals around social and environmental issues linked to linear fashion fuel an growing societal mobilisation against it. Visible thought leaders in the fashion sector (e.g., Patagonia, Nudie Jeans) advocate and actively explore a range of circular practices.	Decreasing legitimacy of the linear system. Emerging shared vision around a circular paradigm. Followers are being mobilised and alliances are being built.	New industry standards regarding, for instance, standards for organic and non-toxic materials and new coalitions emerge.	Societal actors share vision around the circular paradigm and strong coalitions of powerful actors to support it. Key actors of the linear paradigm are starting to be replaced or proclaim necessary change to the paradigm.	New industry standards have become widely adopted and coalitions of firms to lobby for a joint agenda for taxes on resource use and mandatory living wages are starting to bear fruit.

proposed in this paper. In our analysis, we draw on Technological Innovation Systems (TIS; Bergek et al., 2008; Hekkert et al., 2007), a framework that allows for examining innovation from a systemic perspective. This framework is uniquely suited for this because it highlights seven key activities (or 'functions') required for actors to build a supportive innovation system for new solutions to develop and diffuse. TIS poses that, when all seven functions are well developed, innovation processes can be used to influence the direction of the change (in our case towards sustainable circular systems) as well as the speed of the change (in our case reduce the time spent going from maturity of the old paradigm to the eruption and growth of the new paradigm).

To allow for TIS's use in the context of circular disruption, we provide our interpretations and adaptation of the original TIS functions (Hekkert et al., 2007) in Appendix A (Table A1). Here, we proceed with unpacking the proposed functions for the different phases of circular disruption, with emphasis on the disruption itself, whilst briefly highlighting the pre- and post-disruption phases. We illustrate our observations with examples from the fashion and textile industry, as circularity is expected to make a significant contribution to reducing the negative impact this sector has at present (EMF, 2017, 2021; Hartley et al., 2022). As the negative impacts of this sector are predominantly driven by consumption behaviour, the examples are well suited to shed light on the 'desirable' component of circular disruption. The examples are meant to illustrate what kind of developments could characterise a phase, rather than be taken as evidence that the fashion and textile industry finds itself in one of these phases. With this, we provide examples of developments that could be dampened down, or amplified, or multiplied to accelerate a circular disruption. To reiterate, the phases are heuristic devices and can overlap in reality. Table 2 provides an overview of the seven system innovation functions and a short description of what happens during each of the three circular disruption phases 'release', 'reorganisation' and 'eruption'.

4.1 | Pre-disruption overview: Maturity of the linear paradigm

We find ourselves in a time with stagnating growth and well-being (Jackson, 2009; Porritt, 2007), illustrating how the current production and consumption paradigm is no longer fit for purpose. The constraint that is becoming visible is the unsustainability of the linear paradigm in the long term: Fundamentally, it does not operate within planetary boundaries, nor does it provide the social foundation that is needed for humanity to thrive (Raworth, 2017). However, the success of linear consumption and production is visible, making the impending change difficult to acknowledge—even leading to denial (Feygina et al., 2010). The circular solutions existing as small initiatives outside of the linear paradigm illustrate, however, that alternatives are possible. Thought leaders—representing a range of societal actors—are seen to publicly ask deep and uncomfortable questions about the current linear paradigm.

Developments within the fashion and textile industry are illustrative of these broad developments. In this sector, accumulating scandals around social and environmental issues, such as the Rana Plaza collapse in Bangladesh in 2013 (Labowitz & Baumann-Pauly, 2014), low wages, child labour, hazardous chemical use or discharge and waste production, have led to increased stakeholder awareness and concern regarding the unsustainable practices of the fashion and textile industry (Aßländer et al., 2016; Kozlowski et al., 2012; Repp et al., 2021). The harmful environmental and social consequences of a linear production and consumption paradigm motivate an increasing societal mobilisation against it. Visible thought leaders, in the fashion sector, are companies like Patagonia and Nudie Jeans, who advocate and actively explore a range of circular practices.

4.2 | Circular disruption: Release phase

4.2.1 | What's happening in this phase

During this phase, pressure due to rising social and environmental costs further increases. As a result, there is growing discontent with the linear system among actors. *Business experimentation* takes place with the aim to generate and explore solutions to these concerns to facilitate in-depth learning about their possibilities (Ansell & Bartenberger, 2016; van den Bosch, 2010). This includes circular *business model experimentation*, relying on 'rapid learning based on empirical data to provide evidence on the viability of circular value propositions', with a focus on 'initiating wider transitions, such as transforming consumer behaviours for the circular economy' (Bocken et al., 2021).

These efforts can be regarded as a first attempt at capacity building. However, they take place in isolation and are primarily focused on localised problems and partial solutions. For example, businesses may experiment with using recycled content, or recyclable materials in specific products or product groups—without return systems being necessarily in place or being widely available. Illustrative examples in this case are the biodegradable Basket lifestyle sneaker (Puma, 2012) and the early phases of Adidas' Futurecraft initiative resulting in the 100% recyclable running shoe (Fastco, 2015). This is supported by *knowledge development* efforts aimed at progressing mixed fibre recycling, the use of non-toxic materials, mono-fibre technologies and biobased fibres (hemp, flax)—all technologies that were previously available but that take on new significance in the light of circular fashion and efforts in these areas are therefore renewed. At the same time, smaller companies and startups also put forward new solutions, such as lease models (e.g., MUD jeans) and resale models (e.g., The United Wardrobe), for the moment restricted to market niches (Henry et al., 2020).

However, the solutions put forward at this stage, instead of representing a unified vision, cover a range of competing visions: There is no clarity on the *guidance of the search* yet. CE is particularly vulnerable to this, due to the many circular strategies that fall under its umbrella. Within fashion and textile, for example, movements such as lowsumerism and slow fashion oppose the linear fast fashion paradigm that relies on fast material throughput (Fletcher, 2010). In contrast, images such as those put forward by the high-tech in-store recycling campaign 'Looop' by H&M (2020) emphasise recycling and, thereby, omit addressing the pace of material throughput. Such conflicting visions are also evident in the variety of policies that are proposed, which are aimed at solving specific, isolated issues and do not yet reflect a coherent vision aiming at tackling systemic challenges (Milios, 2018).

Nevertheless, visible and well-known consumer-oriented companies such as H&M, C&A and Tchibo, communicating positively about CE to (potential) users in ways visible to others in the sector, start providing directionality for the *guidance of the search* as well as address *market formation* and *social and political mobilisation*. Competitions that are organised, such as the H&M Foundation's Globe Change Award and the Redress Design Award, start to—tentatively—*mobilise resources* by making funds available to and training employees in new solutions. However, since connections in the system are still absent or weak in this phase, little *knowledge diffusion* is taking place, while linear systems and their underlying knowledge are still dominant. In sum, the first seeds of a CE are being developed under the radar, albeit with limited diffusion.

4.2.2 | How to accelerate and tell-tale signs of acceleration

To accelerate this phase, a number of *business experimentation* practices are crucial. The aim should be targeted testing of ideas (Bland & Osterwalder, 2019). Avoided must be a string of experiments that do not build on each other and the experiment aim should be to translate and integrate learnings into the main-stream products and service capabilities of a company (Weissbrod & Bocken, 2017). Organisations, both businesses and funding organisations, need to value and structure learning and acknowledge that such learning, captured through innovation accounting (Ries, 2011), can be more valuable than using customer conversion or avoided CO_2 emissions as measures of success at this stage. Experiments previously regarded as 'failed' may have to be re-examined and (in adapted form) re-run, as the new constraints may have created conditions that are now favourable where they previously were not (Kauffman, 1993).

In terms of *guidance of the search by circularity principles*, instead of adopting an attitude that dismisses the entirety of the 'old' system, investigations both into what parts of the linear paradigm need to be deinstitutionalised as well as which need to be preserved and repurposed is required. This applies to business models, technology, infrastructure, policy and user practices. In this regard, research on institutional disruption (Ahmadjian & Robinson, 2001; Maguire & Hardy, 2009; Oliver, 1992) could be translated and adapted for circular disruption. In particular, existing structures can be dissociated from their moral foundation or their core underlying assumptions and beliefs can be undermined by decreasing the perceived costs of innovation and differentiation (Lawrence & Suddaby, 2006). An example

of this is provided by Henry et al. (2020), who observe circular entrepreneurs initiating circular supply chain networks themselves due to lack of legislative clarity about by-products and waste streams, thus circumventing the inertia and transaction costs associated with changing established structures. In addition to actively destabilising the 'old' system, however, old elements can also be repurposed. Identifying these elements, and further developing and adapting them could potentially allow for capturing circular opportunities faster compared to creating entirely new systems from scratch.

Regarding *social and political mobilisation*, amplify the voices of those among policy-makers, researchers, businesses and civil society actors who have a positive and comprehensive vision of CE or that lead by example, that is, those that focus on systemic as opposed to partial solutions. In these cases, it is important to pay attention to framing the progress made as part of a larger journey, so that the connection to the comprehensive vision is evident. This also supports the formation of a shared vision around how to operate in the emerging circular paradigm.

Such a process consists of three main steps according to Armenakis and Bedeian (1999), Battilana et al. (2009) and Kanter (2003). First is the articulation of a vision that makes the case for a circular paradigm and framing it 'in terms that appeal to the actors needed to implement it' (Battilana et al., 2009, p. 79). Visions need to be broad enough for many actors to connect and yet provide sufficient clarity on the new direction (Grin et al., 2010). A crucial aspect is to garner different views and represent different stakeholder groups, not just the 'elite' experts. Citizen engagement and involvement via, for instance, (online) citizen consultations and assemblies can be vital to align the vision with the needs, values and expectations of ordinary citizens. This first step is followed by *mobilizing actors* for this vision through activities undertaken to gain others' support for and acceptance of new routines and, lastly, motivating them to sustain the vision through activities undertaken to institutionalise change. The formulation of industry and company roadmaps can further support this (McDowall, 2012) and contribute to resolving any discursive struggles that the release phase usually culminates in. Crucially, to speed up progressing to the reorganisation phase, start building the connections that support this second phase; otherwise, the release phase will 'fizzle out' and a well-functioning innovation system will not emerge. For a summary of actions to accelerate this phase, see Table 3.

TABLE 3 How to accelerate the disruption in the release phase

How to accelerate the release phase
• Investigate what parts of the linear paradigm should be deinstitutionalised and what should be preserved and repurposed.
• Amplify the voices of those among policy-makers, researchers, businesses and civil society actors that have a positive and comprehensive vision of CE or that lead by example.
• Form a shared vision around how to operate in the circular paradigm by articulating a vision that embraces the views of different stakeholder groups in society, including ordinary citizens, mobilising followers for this vision and cultivate collaboration and allies and motivating followers to sustain the vision.

Source: Authors.

4.3 | Circular disruption: Reorganisation phase

4.3.1 | What's happening in this phase

In this phase, having moved past the height of discursive struggles, a shared vision around circular solutions as a viable alternative is emerging. Again, *business experimentation* takes place with the aim to broaden the application domains of viable solutions (van den Bosch, 2010; Ansell & Bartenberger, 2016). A recent example of this is the collaboration of MUD Jeans and IKEA, where the processes, knowledge and capabilities of the smaller MUD Jeans' are leveraged to manufacture a circular cover (made out of old jeans) for one of the iconic couches of the much larger IKEA (IKEA, 2021). Similarly, H&M and Adidas have joined together to create new fibres from cellulose waste (Materialtrader, 2020). These examples also illustrate how new connections within the system are formed to adapt and diffuse innovations. In this sense, established businesses (whether previously in transition towards CE or not) and circular start-ups are becoming more intertwined and start to create synergies (Henry et al., 2020).

Knowledge development efforts—whether pertaining to old or new solutions—are no longer isolated: They start to become aligned and integrated, and directed towards tackling systemic issues—oftentimes also via the collaboration of academia and industry (Hartley et al., 2022). For example, knitting technologies are combined with the use of ocean plastic fibres in mono-material designs: at a stroke enabling zero-waste manufacturing, the use of waste as an input and cleaning up the ocean and creating high recycling potential. The later stage of Adidas' Futurecraft initiative is an example of this (Adidas, 2019). One can also think of FREITAG's extension beyond bags made from truck tarps, into a line of fully biodegradable workwear as part of a B2C product portfolio (Szmydke-Cacciapalle, 2018). Such developments provide the foundation for building circular configurations: situations where two or more circular strategies are deployed as part of a single solution to address multiple types of waste in a system (Blomsma & Tennant, 2020), which can involve different types of integration along the value chain (Blomsma et al., 2021; Hansen & Revellio, 2020). Less and less R&D efforts are going to linear developments.

Because of this increasing integration and connecting of solutions, *knowledge diffusion* becomes crucial to align different actors and to optimise the proposed solution for all involved. This necessitates collective learning platforms and learning coalitions (e.g., Henry, 2009). Examples of this are consortia such as the Sustainable Apparel Coalition, which have a broad remit, but also initiatives such as Circle Economy's Fibersort initiative that are aimed at tackling particularly challenging issues such as the recycling of mixed fibres through value chain collaboration. Illustrative also is the 'Make fashion circular' initiative of the Ellen MacArthur Foundation that used a collective learning approach to create a circular vision for the fashion industry.

In terms of *guidance of the search*, the directionality towards which changes need to be made is becoming clearer. To support consolidation of the emerging shared vision on the circular paradigm, however—where not yet initiated previously—collaborations and consortia should be formed. Furthermore, to boost the emergence of circular innovations such instruments as public procurement rules, tax incentives and subsidies are starting to be used (Pinkse et al., 2014; Hartley et al., 2020). Especially, where new solutions are too costly when first introduced, the government can play a crucial role as a first customer (Rainville, 2021). Other instruments such as extended or full producer responsibility, which obliges companies to set up recycling and waste management systems, are set up to further support the deinstitutionalisation of the linear paradigm. An example in the textile industry is the extended producer responsibility policy implemented in France for end-of-use clothing, linen and shoes, contributing to a threefold increase in the collection and recycling rates of post-consumer textiles since 2006 (Bukhari et al., 2018). In sum, the conception and early implementation of policy mixes that 'destabilise the old' and 'create the new' become visible (Kivimaa & Kern, 2016). Such measures also support creating legitimacy for the circular paradigm, contributing further to *social and political mobilisation*.

Market formation mechanisms are created. For example, reverse supply chain collaboration is intensified and companies collaborate to create platforms: This improves the offer for potential users, lowering entry barriers. Think of Circos.co, where various brands collaborate to offer baby and maternity clothing ranging from daily wear (Vigga, Arket), to outer wear (Patagonia) and shoes (Adidas). At the same time, there are now six circular fashion 'unicorns' based on renting or reusing clothing: companies valued over a billion (Ellen MacArthur Foundation Publishing, 2021), which indicates a growing interest in this way of accessing fashion.

Regarding *resource mobilisation*, new funding vehicles are experimented with—often alongside established funding mechanisms. Examples of this are blended finance instruments that combine public, private and philanthropic capital (Metabolic Institute, 2021) and financial solutions for product-as-a-service models (Working Group finanCE, 2016). An example of a blended financing vehicle in the fashion industry is the Good Fashion Fund, which invests in the implementation of innovative technologies in India, Bangladesh and Vietnam (Fashion for Good and Boston Consulting Group, 2020). The earlier mentioned public procurement rules, tax incentives and subsidies further contribute to this function.

4.3.2 | How to accelerate and tell-tale signs of acceleration

In this phase, an emphasis is placed on creating new and the right kind of connections. It is where existing parts of the system find new applications, whilst novel elements are starting to be integrated, too. *Knowledge development* led by researchers and scholars should be targeted at broadening the application domains of existing and emerging technologies. This requires a departure from classic innovation experiments and the adoption of transition experiment approaches, such as the broadening approach described by van den Bosch (2010). In terms of *social and political mobilisation*, this includes keeping societal challenges in sight, whilst seeking to create coalitions that collaboratively aim to address systemic issues. The creation of learning collaborations and networks through, for instance, formal and informal networking and matchmaking events are therefore crucial in this stage to foster rapid *knowledge diffusion* (Singh, 2005).

In terms of *guidance of the search by circularity principles*, instead of favouring particular firms, solutions or technologies, policy-makers and decision made in business should rather specify outcomes to allow for sufficient flexibility, in line with recent insights on mission-oriented innovation policies (Mazzucato, 2021; Wanzenböck et al., 2020). Moreover, new solutions developed in this phase may not yet be sufficiently mature to successfully withstand selection pressures—as the linear paradigm is still influential. Policy-makers will, therefore, have to create protective niches where solutions can develop and mature through appropriate funding and policies (Kemp et al., 1998; Smith & Raven, 2012). Note that chance events may have a disproportionate influence on the developmental trajectory of the emerging paradigm at this stage. Therefore, managers at all levels should adapt management practices to amplify desirable outcomes and dampen down undesirable ones—in line with adaptive management. The (re)building of knowledge and capabilities, in particular in public institutions, hence reversing the trend to outsource this, is essential (Mazzucato, 2021). The development of accurate assessment and evaluation measures that are quick to apply and easy to understand and use is essential for decision makers to assess potential negative effects, such as the potential for circular rebound (Zink & Geyer, 2017). For a summary of actions to accelerate this phase, see Table 4.

4.3.3 | What's happening in this phase

This phase is a time of intense exploration of all the possibilities opened up by the new circular paradigm. *Business experimentation*

TABLE 4 How to accelerate the circular disruption in the reorganisation phase

How to accelerate the reorganisation phase
• For researchers and scholars: broaden the application domains of existing and emerging technologies by adopting a transition experiment approach.
• For policy-makers and decision makers in business: design policy instruments that focus on circular solutions rather than specific products, specific technologies or specific sectors.
• For managers at all levels: nurture management practices aiming at amplifying desirable outcomes and dampening down undesirable ones.
• For decision makers of all types: create protective niches to develop and mature circular solutions.

Note: Circular disruption: eruption phase.

takes place with the aim to scale-up solutions and to learn about how to overcome the selection pressures operating in the mainstream market (Ansell & Bartenberger, 2016; van den Bosch, 2010). Circular firms newly created by entrepreneurs proliferate, as do circular initiatives by individuals or small teams in established businesses. The circular value propositions at the heart of the circular business models are being tested 'in a real-life context with customers and stakeholders, starting with a shared goal' (Bocken et al., 2021). In the fashion and textile industry, online retail platforms are being used by a growing number of new circular companies and individual designers to reach potential consumers directly and without needing retail space, resulting in the stagnation and eventual decline in the market shares of large existing brands and retailers that could not adapt to the emerging paradigm. This is paralleled by a proliferation of second-hand online shops and fashion-as-a-service offerings (Strähle & Klatt, 2017).

In terms of *knowledge development*, integrated circular solutions are becoming more and more mature, while in terms of *knowledge diffusion*, circular knowledge experiences a wide diffusion and activities that were previously in niche activities now find themselves on the threshold of the regime. The extent and the depth of the collaborations initiated in the previous phase to diffuse knowledge expand rapidly. In the fashion industry, this knowledge diffusion can, for instance, take place through 'frontrunner in residence' strategists in mainstream companies. Frontrunner innovators temporarily work in-house for mainstream companies to show them the needs and opportunities of change (Buchel et al., 2018). This also contributes to successful early *market formation*. In the eruption phase, targeted learning identifies what works under which social conditions, with the goal to create transferable circular options. As for *resource mobilisation*, laid-off workers in material-intensive sectors are retrained and reoriented towards more labour-intensive and circular activities, which also increasingly attract funding.

Regarding *guidance of the search by circularity principles*, the early measures implemented to 'destabilise the old' and 'create the new' in the previous phase are further reinforced, becoming less siloed and increasingly interconnected to create systemic change. For example, the aforementioned extended producer responsibility policies can be combined with the large-scale introduction of a ledger system of materials and materials passports using blockchain or other decentralised, open information technologies, allowing for an enhanced traceability of material flows (Wieczorek & Hekkert, 2012). As for *social and political mobilisation*, there is now a firm shared vision around the circular paradigm and strong coalitions of powerful actors to support it. Key actors of the linear paradigm are starting to be replaced or proclaim necessary changes to the linear paradigm. In the fashion industry, this shared vision translates into new industry standards regarding, for instance, standards for organic and non-toxic materials (e.g., the Global Organic Textile Standard). Coalitions of fashion companies lobbying for a joint agenda for taxes on resource use and mandatory living wages are starting to bear fruit.

4.3.4 | How to accelerate and tell-tale signs of acceleration

The key to the acceleration of this phase is to catalyse business experimentation, aiming at exploring how to best deliver the circular solutions developed in previous phases and how to best 'survive' the selection pressures in the mainstream market. A success factor for business experimentation in the eruption phase is to let cooperation structures and temporal structures (i.e., amount of time allocated to specific tasks) emerge within a set total time limit. So no detailed timeline planning should take place within the total experimentation time. This has proven to create useful product and service solutions during a study that observed hackathon teams (Lifshitz-Assaf et al., 2020).

In terms of *knowledge development* and *diffusion*, ways to accelerate this phase from actors operating in or otherwise influencing firms is to foster the interactions between and combinations of multiple innovations beyond the development of single innovations to trigger larger changes (Geels, 2018). This facilitates cross-sector innovations, and spill-overs between technologies enable firms to compensate for the scale and learning gap of the innovations. To illustrate, the textile industry can benefit from the advances of chemical recycling, used in the plastics industry to turn plastic polymers back into individual monomers, to depolymerise textile fibres of fabrics into monomers and produce virgin textile fibres of much superior quality than that from mechanical recycling methods (Asaadi et al., 2016). These spill-overs considerably shorten the timescale from invention to widespread commercialisation of new technologies.

In the circular growth phase, some circular business models and technologies are increasingly exposed to selection pressures of the regime. Those which are successfully selected start scaling and, ultimately, reach a tipping point where they become better in quality and in price than their linear counterparts, in addition to being environmentally more sustainable. They are then able to 'cross the chasm', that is, to appeal to the mainstream market due to this superior customer experience (Moore, 2002). Policy-makers accelerate this selection process by picking the 'winners' that are increasingly succeeding in the market, while increasingly ruling linear companies out of the market (e.g., via the introduction of mandatory circular design standards, preferential tax regimes for circular products, etc.; Hartley et al., 2020). Circular knowledge diffusion takes off beyond protected niches and becomes widely available within mainstream markets. There is a large-scale mobilisation supported by a majority of the population and social tipping points. The majority of key actors work to replace the linear paradigm or actively pursue the circular paradigm.

This process eventually leads to the circular synergy phase, in which circular business models have been proven and scaled. In the fashion and textile industry, this phase is characterised by a dramatic extension of the lifetime of clothes, as fashion-as-a-service schemes such as MUD Jeans and online second-hand clothing shops become mainstream. Policy-makers strongly back a resilient circular system and there are significant policy barriers for linear companies to operate—including limited consumer awareness and interest, currently

TABLE 5 How to accelerate the circular disruption in the eruption phase for actors operating in or otherwise influencing firms (e.g., policy-makers and funders)

How to accelerate the eruption phase
• Catalyse circular business model experimentation to explore how to best survive the selective pressures of the mainstream market.
• Foster the interactions between and combinations of multiple technologies.
• Facilitate cross-sector resource optimizing innovations and spill-overs between (technological) innovations.

Note: Post-disruption overview: circular growth and circular synergy.

the main barrier for circular textiles companies (Hartley et al., 2022). At this point, a return to a linear paradigm becomes increasingly unattractive and unfeasible. For a summary of actions to accelerate this phase, see Table 5.

5 | DISCUSSION AND CONCLUSION

In this paper, to help shift the scholarly focus in CE research towards a conversation on how to achieve a circular economy, we offered the concept of *circular disruption* as 'A transformation in a socio-technical system which causes the *systemic*, *widespread*, and *fast* change from the harmful "take-make-use-dispose" model to a socially and environmentally *desirable* and *sustainable* model that reduces resource consumption and addresses structural waste through the deployment of circular strategies'. This includes that a circular disruption prevents circular rebound (Zink & Geyer, 2017) and other negative effects that reduce or negate its benefits.

In addition, we described the process through which such a circular disruption can unfold, drawing on a synthesis of S-curve thinking (Foster, 1986) and the concept of panarchy (Gunderson & Holling, 2002). Based on this synthesis resulting in the waveS model, we identified the three phases of the disruption itself (release, reorganisation and circular eruption), whilst highlighting the pre-disruption phase 'linear maturity' and the post-disruption phases 'circular growth' and 'circular synergy'. We explained these phases using the seven Technological Innovation System (TIS) functions by Hekkert et al. (2007) to unpack the implications of waveS for systemic innovation. For each phase, we pointed to ways for accelerating the process of circular disruption and illustrate these by drawing on examples from the textiles industry.

With this, we address the apparent contradiction between the 'need for speed'—the necessity to quickly address the many pressing issues facing societies today—and the seeming impossibility of accelerating socio-technical transitions based on historical observations, traditionally put anywhere between 20+ to 70 years (Brezet et al., 2001; Grin et al., 2010; Gross et al., 2018; Kondratieff & Stolper, 1935). With this, we support unlocking agency in the face of complex systems change and provide pathways for businesses and other change agents to accelerate the needed change. The waveS model can contribute to greater awareness with regards to what phase (part of) a system is in, and what actions could be leveraged to reduce the time spent from our current linear model to a circular future. Scholars and practitioners alike may benefit from using the waveS model to assess the current status of a system as well as build and prioritise a set of actions accordingly.

For academia, our proposed waveS model contributes to the literature on transitions and socio-technical changes, exemplifying how interdisciplinary work can draw from the tools and approaches of multiple disciplines to provide new insights. Our synthesis enabled us to illuminate different aspects of the process of disruption. We argue that S-curves and panarchy represent different perspectives on transitions, each highlighting different dimensions of this phenomenon. Combining the waveS model with TIS connects transition dynamics and mechanisms from systemic (sub)domains to allow understanding how these dynamics and mechanisms align, so that virtuous feedback loops, or positive leverage points (Lenton et al., 2022), can be created. While our synthesis is applied to circular disruption, it may have broader significance for other transitions, such as those in the energy, food and transport sectors (Köhler et al., 2019). Indeed, the 'need for speed' is a need that has generally been stated in the transitions research community, most recently by Markard et al. (2020). So far, this scholarly community has largely focused on describing change that occured over many decades and more work is needed to outline the conditions necessary for accelerating change.

Our model and the suggested set of actions for a circular disruption are not meant to be deterministic or exhaustive. Indeed, the whole curve of the waveS model need not be utilised: a disruption can get stuck in one phase, phases may overlap or be skipped, or even revert back to a previous phase if the conditions prove unstable, as also indicated by Perez (2002) and Gunderson and Holling (2002). Moreover, within each disruption phase, further detail can be added. It is important that the newly adopted circular practices and technologies, while being subject to continuous adaptation and change toward further sustainability and desirability, are soundly entrenched into individuals' habits and companies' routines, previously identified as among the core barriers to a CE transition (de Jesus & Mendonça, 2018; Kirchherr et al., 2018) to ensure the adoption and resilience of the circular paradigm. There are multiple options, as our model outlines, on how this embedding may occur—provided that they result in the seven innovation functions aligning to push the system in the same direction. Importantly, our work highlights the centrality of emerging new constraints as part of the change dynamics.

By shedding light on the systemic processes for circular disruption and grounding this in three theoretical frameworks, the paper furthermore contributes to the literature on CE, a literature which has been frequently criticised for lacking theoretical underpinning (Korhonen et al., 2018). We aim to move the discourse away from a passive, descriptive account of the definition of CE and its barriers towards actively shaping the needed change. Indeed, our model highlights the importance of the evolution of solutions that fit the new constraints—whether embodied through new business models, repurposed and adapted solutions, or new inventions and technologies—

and emphasises the need for alignment of the different functions of innovation systems to trigger systemic change. We hope scholars will increasingly adopt such a systemic perspective when studying the CE in their respective contexts.

Several other avenues for further research are worth highlighting that address limitations and gaps not covered by this work. First, our paper implicitly focuses on how the process of circular disruption may unfold in high-middle and high-income countries, the countries of origin of the authors. The implications for the Global South, however, are numerous, given the integrated nature of global supply chains. Thus, the implications of circular disruption for Global South countries require further investigation. Second, the waveS model assumes, as does the TIS framework, that the systems of production and consumption replacing the existing paradigm are largely the same from an institutional perspective, with organisations embedded in market and corporate logics (Thornton et al., 2012). A fruitful avenue for further research would be to explore the roles of organisational forms embedded in different institutional logics, beyond the institutional logics dominant in the contemporary market economy (Feola, 2020). Third, providing further empirical insight is crucial: for example, the waveS model can be used as a basis for working with practitioners with regards to their views on what is needed for a circular disruption to happen in their respective industry or region, further refining the set of actions that can be taken to accelerate developments. An alliance of scholars and practitioners is needed to bring this about and we hope that the concept of 'circular disruption' proposed here will help to catalyse both theory and practice efforts to make this rapid change happen, since 'Theory without practice is empty; practice without theory is blind' (paraphrased from Kant). Open questions also remain with regards to how to identify which parts of linear systems should be repurposed as well as how to deal fairly with both 'winner' and 'losers' of a circular disruption. Lastly, we encourage sustainability transitions scholars to also engage with the proposed concept of circular disruption to possibly help illuminate pathways for acceleration in the respective sustainability fields they are studying. Further work such as this would allow society to not only, as Tom Cruise in his role as Maverick said, '*feel* the need for speed', but all can become change agents and act to bring about a more sustainable and circular world.

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APPENDIX A: THE INNOVATION FUNCTIONS OF CIRCULAR DISRUPTION

A Technological Innovation System is defined by Carlsson and Stankiewicz (1991, p. 94) as 'a network or networks of agents interacting in a specific technology area under a particular institutional infrastructure to generate, diffuse, and utilize technology'. Hekkert et al. (2007) distinguish seven functions required for actors to build a supportive innovation system for new technologies to develop and diffuse. Hence, this framework enables us to unpack innovation from a systemic perspective. We amended the TIS in four ways.

First, we replaced the function 'entrepreneurial activities' by 'circular business model evolution'. By doing so, we aim to highlight the centrality of business model innovations and experimentation for disruption, especially in relation to the circular economy (Bocken et al., 2016; Geissdoerfer et al., 2020; Lüdeke-Freund et al., 2019), whereas the TIS lacks an explicit business model analysis, leaving little room for firm-level perspectives, particularly on business models (Bidmon & Knab, 2018; Sarasini & Linder, 2018). We use the term 'evolution' to highlight that this function is concerned with both the destabilisation of established business models that have become economically, socially or environmentally unsustainable and the creation of superior ones.

Second, we specified the guidance of the search, which has to be conducted according to the five key principles of circular disruption as presented in Section 2, namely, the adoption of a systemic perspective, widespreadness, celerity, desirability and sustainability.

Third, we replaced the functions of 'market formation' and 'resource mobilisation' by 'market (de)formation' and 'resource (de)mobilisation', respectively, to emphasise that these functions are concerned with both the decline of the old paradigm and the emergence of the new one, while the TIS framework mainly focus on the emergence of innovation and overlooks the decline of established socio-technical systems.

Fourth, we replaced the function 'creation of legitimacy/counteract resistance to change' by 'social and political mobilisation'. By doing so, we seek to emphasise not only the outcome of this function (i.e., the creation of a powerful coalition advocating the new paradigm), but also the mechanisms through which advocacy coalitions are formed (consensus formation, followers mobilisation and motivation). Indeed, the TIS framework provides little insight into these mechanisms.

TABLE A1 The innovation functions of circular disruption

Number	Functions in the TIS framework	Description in the TIS framework	Corresponding system function of circular disruption	Justification for change
1	Entrepreneurial activities	Activities undertaken by entrepreneurs to turn the potential of new knowledge, networks, and markets into concrete actions to generate—and take advantage of—new business opportunities	Business experimentation	Highlights the centrality of business model innovations and experimentation for disruption, especially in relation to the circular economy (Geissdoerfer et al., 2017; Lüdeke-Freund et al., 2019; Weissbrod & Bocken, 2017), whereas the TIS lacks an explicit business model analysis (Bidmon & Knab, 2018; Sarasini & Linder, 2018).
2	Knowledge development	Learning mechanisms necessary to develop the innovation, embodied into R&D projects, patents, and investments in R&D	Knowledge development	No change made.
3	Knowledge diffusion through networks	Network interacting in order to diffuse knowledge about the innovation	Knowledge diffusion through networks	No change made.

TABLE A1 (Continued)

Number	Functions in the TIS framework	Description in the TIS framework	Corresponding system function of circular disruption	Justification for change
4	Guidance of the search	Activities within the innovation system that can positively affect the visibility and clarity of specific wants among technology users	Guidance of the search by circular disruption principles	Guidance of the search activities are equally important in the circular disruption framework, but are primarily guided by circular disruption principles, namely the adoption of a systemic perspective, widespreadness, celerity, desirability and sustainability.
5	Market formation	Protected spaces created for the development of new technologies, for example through the formation of temporary niche markets and favourable tax regimes	Market (de)formation	Highlights that this function is concerned with both the shrinking of markets for established technologies and products that have become unsustainable and the formation of markets for superior alternatives, while the TIS framework mainly focus on the latter process while overlooking the former.
6	Resources mobilisation	Acquisition of the financial and human capital necessary to all activities within the innovation system	Resources (de) mobilisation	Highlights that this function is concerned with both the demobilisation of resources for established technologies and products that have become unsustainable and the mobilisation of resources for superior alternatives, while the TIS framework mainly focus on the latter process while overlooking the former.
7	Creation of legitimacy/ counteract resistance to change	Creation of a powerful advocacy coalition which will push for a new technology trajectory	Social and political mobilisation	This function is also crucial in the circular disruption framework and emphasises the creation of a social movement as the main mechanism through which the building of this coalition takes place.