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Reconsidering the Circular Economy Rebound effect: Propositions from a case study of the Dutch Circular Textile Valley

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ABSTRACT

This article investigates the phenomenon of rebound effects in relation to a transition to a Circular Economy (CE) through qualitative inquiry. The aim is to gain insights in manifestations of rebound effects by studying the Dutch textile industry as it transitions to a circular system, and to develop appropriate mitigation strategies that can be applied to ensure an effective transition. The rebound effect, known originally from the energy efficiency literature, occurs when improvements in efficiency or other technological innovations fail to deliver on their environmental promise due to (behavioral) economic mechanisms. The presence of rebound in CE contexts can therefore lead to the structural overstatement of environmental benefits of certain innovations, which can influence reaching emission targets and the preference order of recycling. In this research, the CE rebound effect is investigated in the Dutch textile industry, which is identified as being vulnerable to rebound, yet with a positive potential to avoid it. The main findings include the very low awareness of this effect amongst key stakeholders, and the identification of specific and general instances of rebound effects in the investigated industry. In addition, the relation of these effects to Circular Business Models and CE strategies are investigated, and placed in a larger context in order to gain a more comprehensive understanding about the place and role of this effect in the transition. This concerns the necessity for a new approach to how design has been practiced traditionally, and the need to place transitional developments in a systems perspective. Propositions that serve as theory-building blocks are put forward and include suggestions for further research and recommendations about dealing with rebound effects and shaping an eco-effective transition.

1. Introduction

Our planet's ecology and its economy are on a collision course. This collision path manifests largely due to a contradiction in the assumptions of unlimited material- and economic growth fueling the linear economic paradigm. Our closed planetary ecosystem imposes limited amounts of space and a finite amount of resources upon its inhabitants. However, practically all the currently and historically applied methods of economics have been defiantly neglecting these realities, as resources are extracted, used and disposed of reluctantly. Several critical material stockpiles are being depleted, whilst over two billion tons of waste is created every year, putting heavy pressures on local and global ecosystems, biodiversity and material reserves (Amos, 2005; Silpa et al., 2018). The current, scarcity-driven economic system operates blindly and indifferently in the face of pollution, ecological degradation and social destabilization, as it places the burdens created by the system disproportionately on the shoulders of the poor.

A popular concept that constitutes an attempt to reorganize the economy to solve the problems mentioned above is the *Circular Economy (CE)*. The CE as promoted by many organizations and governments globally, is based on three major principles: "(1) Designing out waste, (2) keeping products and materials in use, and (3) regenerating natural systems" (Ellen MacArthur Foundation, n.d.; Rijksoverheid, 2016). The CE attempts to reconcile the extraction, production and usage of goods and resources with the limited availability of those resources and nature's regenerative capabilities. This perspective entails a shift throughout the supply chain, from material science (e.g. non-toxic, regenerative

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biomaterials) to novel logistical systems (e.g. low-carbon reverse logistics). Because of this, CE is often celebrated for its potential environmental benefits and its usefulness as a blueprint for sustainable development (e.g. Ghisellini et al., 2016; Ellen MacArthur Foundation, 2017). However, while the CE sounds intuitively beneficial for the environment, care should be taken when assessing the true environmental benefits of circular business: companies that operate within the CE paradigm and are based on Circular Business Models (CBMs).

One of the recently emerging reasons for the potential failure of CE practices to deliver on their environmental promises is called *Circular Economy Rebound* (CER) (Zink and Geyer, 2017). The original, more thoroughly researched 'classic' rebound effect typically occurs when increases in production/consumption efficiency are canceled out due to absolute increases in production/consumption, also known as Jevons' Paradox (Brookes, 1990; Barker et al., 2009; Jevons, 1865). A common example concerning this type of rebound can be found relating to energy: when energy efficiency improves, prices lower, and usage/demand rises in response, leading to a higher net use of energy (and a worse environmental outcome) (Berkhout et al., 2000; Greening et al., 2000; Borenstein, 2015). According to Zink and Geyer, rebound may occur in the context of CE and significantly diminish hypothesized environmental benefits, as the theory on CE places too much focus on material resource flows and lacks the inclusion of (behavioral) economic and market forces (Zink and Geyer, 2017). If CER is occurring, it could have implications for reaching greenhouse gas (GHG) emission reduction targets, and even change the preference order of End of Life (EoL) practices. CER can allegedly manifest itself in two main ways: through imperfect or insufficient substitution (microeconomic) and through price or re-spending effects (micro- and macroeconomic) (Makov and Font Vivanco, 2018; Zink and Geyer, 2017). However, as disclosed in this study, narrowing down on and quantifying particular manifestations of rebound effects in the CE can be problematic and lead to undesirable mitigation strategies.

Therefore, to add significant empirical insight to the existing body of literature, CER was investigated in the context of the Dutch circular textile and fashion industry. This industry is chosen due to a combination of factors. Firstly, the fashion industry is known to be the second largest polluting industry in the world, outranked only by the oil industry (Ellen MacArthur Foundation, 2017). As a result, experiments with CE strategies and CBMs have been popular as an attempt to decrease the many environmental problems associated with the industry, including companies such as Inditex, C&A, H&M, Nike, and GAP (Ellen MacArthur Foundation, 2017). Secondly, contemporary demand for fashion products is known to be insatiable, making the industry as a whole prone to the rebound effect as large volumes of products are being sold continuously (Zink and Geyer, 2017; Ellen MacArthur Foundation, 2017). Thirdly, theoretically, circular fashion products could reach high levels of substitution in relation to fashion products from primary production. High volumes of clothing and garments are in circulation and technologies for secondary production are increasingly promising concerning quality and price possibilities (Ellen MacArthur Foundation, 2017). Therefore, this industry represents not only a high vulnerability to CER, but also great potential to avoid it. Finally, the Netherlands is an appropriate setting for this research as Dutch circular initiatives in the textile and fashion industry (Fischer and Pascucci, 2017; Rijksoverheid Nederland, 2016) are internationally seen as frontrunners.

The aim of this research is to investigate the occurrence and the role of CER in the textile industry and its transition towards circularity. The aim is *not* to narrow down on or quantify the rebound effect in the specific cases discussed. A broader conceptual perspective is taken to get to the essence of *why*, *how* and *if* the rebound effect is an important or threatening concept to consider when envisioning the transition towards a circular economy and specifically circular textiles, directly building on the previous work done on CER (e.g. Zink and Geyer, 2017; Makov and Vivanco, 2018). A more comprehensive understanding of what the rebound effect means in relation to CE will help avoid the overstatement of environmental benefits and generate meaningful criticism on CE strategies and CBMs. Identifying such caveats can support the further development of truly sustainable business practices.

This study investigates awareness of CER amongst stakeholders, CBMs in which CER could manifest and current and potential CER mitigation. First, a conceptual framework is described in which the literature is reviewed. This includes a short revisiting of the rebound effect in a slightly different context, the merging of rebound effects with the concept of CE, and a clarification on CBMs and CE strategies. In addition, current mitigation efforts and some of the associated problems are covered. Subsequently, the research methodology and setting are explained, before describing the results as guided by the voices of the informants. Results of the study lead to the formulation of several propositions that serve as theory-building cornerstones. The article closes with limitations and concluding remarks.

2. Conceptual framework

Current literature on the topic of CER specifically is lacking. Zink and Geyer (2017) attempted to unify and connect future studies around this topic through coining and defining the term "Circular Economy Rebound". In doing this, an explicit call for the extension of the body of research on this topic was launched. Since then, only a handful of papers in relation to the topic have been published, providing only limited understanding of how to get a grip on this problem (Korhonen et al., 2018; Makov and Font Vivanco, 2018; Kjaer et al., 2018; Figge and Thorpe, 2019). The integration of these previously unconnected phenomena is highly significant if the true environmental benefits of the transition to CE are to be uncovered.

2.1. The Environmental Rebound Effect

Now, as the 'classic' rebound effect discussed above particularly relates to energy efficiency, there is a need to broaden the scope to include a wider, more comprehensive understanding of the effect in an environmental, sustainability or CE context. Font Vivanco et al. (2016a) attempted to shed light on how the debate on rebound effects has 'outgrown' the energy efficiency domain and can now be understood as a set of economic (and behavioral) mechanisms. In doing this, they created a separation to distinguish the classic rebound effect in the early energy literature from the broader environmental rebound effect (ERE), which is rooted in 'lifecycle thinking' (Font Vivanco et al., 2016a). The ERE perspective allows the study of technological innovations beyond energy efficiency improvements to include a wider array of environmental consequences, whilst it avoids becoming a substitute term for any economic cause-effect mechanism.

Apart from cases in which the ERE detracts from or diminishes the realized environmental benefits of a certain technological improvement, there are also cases in which a 'negative rebound effect' can be observed (with an actually positive effect). Font Vivanco and colleagues (2014, 2016b) encountered this phenomenon when investigating the ERE of electric cars, finding that in some cases, high capital costs can actually generate a decline in net environmental pressures, reversing the direction of rebound. This occurs when a consumer buys a car that has clear environmental benefits and is relatively more expensive than its alternatives, binding more income otherwise spent on high impact goods (re-

spending effect), and therefore "reinforcing the environmental benefits" (Font Vivanco et al., 2014, p. 12068). This means that producers might also be underestimating achieved environmental benefits following a technological innovation.

2.2. Rebound in the circular economy

CER occurs when CE strategies fail to deliver on their environmental promise, in ways very similar to the ERE. As touched upon, there is a small groundwork of literature about rebound effects occurring particularly in relation to CE strategies (Zink and Geyer, 2017; Makov and Font Vivanco, 2018; Kjaer et al., 2018; Korhonen et al., 2018; Laurenti et al., 2018). Albeit small, these studies provide a strong theoretical foundation of rebound in the CE. Their findings build upon a larger body of work concerning the economics of secondary production methods and their respective environmental consequences (e.g. Geyer et al., 2016; Geyer and Doctori Blass, 2010; McMillan et al., 2012; Ekvall, 2000; Cooper, 2008; Braungart and McDonough, 2009; Braungart et al., 2007). In fact, many of these studies are essentially about CE strategies, yet simply before the term had become popularized, as CE strategies include the recycling, remanufacturing, refurbishing and reusing of materials. The net environmental impact of these strategies is determined by the difference in impact between primary and secondary production in combination with the accompanying change in production quantity, as illustrated by Zink and Geyer (p. 597, 2017). The environmental benefits of these secondary production strategies can thus only fully materialize if and when they actually displace or at least significantly lower primary production. A lack of displacement/substitution can be the result of the inferior quality of secondary goods (e.g. recycled plastics and paper), or when a new market is opened up due to the vastly different price at which the new good is being sold (e.g. refurbished smartphones (Geyer and Doctori Blass, 2010; Makov and Font Vivanco, 2018). Therefore, only in some cases CE strategies will displace primary production through superior performance in competition.

As a result, assuming that every unit of secondary production achieves environmental benefits directly proportional to the difference between the secondary and primary good's impact seems a premature conclusion (Cooper and Gutowski, 2015; Geyer et al., 2016; Geyer and Doctori Blass, 2010; Kjaer et al., 2018; Zink et al., 2016). Nevertheless, this assumption is often implicitly made in CE strategies, as rebound effects continue to be omitted from Life Cycle Analyses (LCAs), and corporations benefit from this lack of disclosure through promoting inflated environmental achievements (Chalmers et al., 2015; Atherton, 2007). Therefore, to recognize and account for the rebound effect is essential to safeguard both environmental and market integrity in the CE.

2.3. Circular business models and CE strategies

What characterizes or defines a CBM, and how does it relate to a CE strategy? Nussholz (2017) provides a useful review on the increasing volume of discourse surrounding these concepts. After a careful assessment of the existing literature on these notions, she defines a CBM as follows: "A circular business model is how a company creates, captures, and delivers value with the value creation logic designed to improve resource efficiency through contributing to extending useful life of products and parts (e.g., through long-life design, repair and remanufacturing) and closing material loops" (Nussholz, 2017 p.12). Furthermore, she emphasizes the reality that resource efficiency strategies, which often equate to CE strategies, do not by definition lead to increased resource efficiencies or environmental benefits. Rather, innovating the business model towards a CBM "can help create an offer that embeds a circular strategy and successfully operates it" (Nussholz, 2017, p.12). Therefore in this paper, the focus will be on specific CE strategies, as they, if inappropriately embedded in the overarching business model, are hypothesized to be the cause of rebound. Note that in certain cases, a business model can be entirely focused on one specific CE strategy, and the terms could then be seen as synonymous.

The categories of existing strategies in the CE are commonly illustrated by the Value Hill (Achterberg et al., 2016). Fischer and Pascucci (2017) applied this conceptual framework to the Dutch circular textile industry in their study on institutional incentives, providing a valuable contribution. The model divides CE strategies into four categories: Circular Uphill Development (CUP; design products and materials, e.g. Cradle to Cradle Products (Braungart and McDonough, 2009), Circular Peak Use (CPU; Product-as-a-Service (PaaS), support usage and sharing platforms, e.g. Mud Jeans or clothing libraries), Circular Downhill Recovery (CDR; secondary production, e.g. House of Denim) and Circular Network Support (CNS; network coordination and management, e.g. Dutch aWEARness) (Fischer and Pascucci, 2017). In this study, new example cases that fit into these categories are used to investigate whether vulnerability to rebound effects in the CE is related specifically to certain types of CE strategies.

2.4. Mitigation efforts

Drawing from the early literature mainly focused on the classic and environmental rebound effect, several historic and current mitigating approaches have been explored. In a paper by Font Vivanco et al. (2016c) an accumulation of suggested pathways is described. First, the authors note that no binding act or policy currently exists that explicitly mentions the rebound effect, and therefore there is no enforced policy on the subject yet. In a small yet significant amount of different legal acts by the European Commission the term is mentioned, though remaining suggestive (Font Vivanco et al., 2016c). In the academic world, mitigating strategies have often revolved around changing consumer behavior, stressing the need to consume more efficiently, differently and less in general (Jackson, 2014; Sorrell, 2010). Also, market-based instruments centered on carbon and energy pricing have been discussed (Saunders, 2011). The European Commission produced the most substantive and comprehensive report on rebound effects, including a wide range of suggested policy pathways (Maxwell et al., 2011). The need for simplified measuring tools is also mentioned, as well as the potential for smart meters to mitigate direct rebound, and attentiveness towards perverse green advertising that promotes moral licensing and compensation behavior following (efficiency) innovations (Dütschke et al., 2018; Font Vivanco et al., 2016c; Maxwell et al., 2011). Despite the absence of the CE concept in these mitigation approaches, they could possibly be applied to the current paradigm and prove useful in the transition.

Concerning mitigating CER specifically, Zink and Geyer (2017) provide a threefold of conditions that, when adhered to, they propose will minimize CER. Firstly, products and/or materials from secondary production need to be presented as true alternatives for primary production, with comparable quality, price and marketing efforts. If a product from secondary production cannot seriously compete with its primary alternative, meaningful substitution - as well as the accompanying environmental benefits - will likely not occur. Secondly, circular substitutes should, at least, have no effect on the total demand, or decrease total demand for the given good on the macro scale. Therefore, markets with a somewhat satiable demand or low-price sensitivity would be less vulnerable to rebound effects (e.g. home appliances would be more satiable than

clothing or electronics). Thirdly, even in the case that the first two conditions are met, it needs to be made sure that introducing a new product from secondary production to the market indeed diverts buyers away from primary production. This is especially difficult since the usual methods to draw consumers (searching niche markets or lowering prices) should not be used to ensure the environmental benefits by avoiding CER (Zink and Geyer, 2017). Therefore, although theoretically attainable, fostering business circumstances that reduce the creation of CER will prove difficult for businesses that try to transition towards circular practices as they are competing with other businesses that do not.

2.5. Rebound and inequality

Mitigating rebound effects could have detrimental outcomes for the lowest income-group of society (Galvin, 2015). As illustrated in a case study of smartphone reuse, this happens because the low prices of refurbished smartphones enabled a whole new group of consumers to purchase them, significantly increasing the total demand of smartphones. Placing too much value on the attempts to reduce re-spending and macroeconomic rebound would therefore exclude consumer groups from the option to purchase a certain good (Makov and Font Vivanco, 2018). Jarringly, enabling new consumer groups access to a good often is exactly the point in such cases, often making rebound mitigation strategies socially undesirable.

To illustrate how this problem manifests in rebound quantifications, consider again the 'negative rebound effect', which occurs when the rebound effect 'reverses', and causes extra environmental benefits (Font Vivanco et al., 2014). This effect could be observed when a good is both a better alternative environmentally and more expensive, binding extra income that could otherwise be spent on high impact goods. The Environmental Rebound Effect (ERE) model, and specifically the re-spending effect, captures this tendency, or as Font Vivanco and colleagues say, "In other words, it [the ERE model] describes how income that was liberated or bound due to cost changes will or will not be re-spent over the various consumption categories" (2015, p. 73). According to this logic, increasing the price of environmentally friendly goods would be more beneficial for the environment because it would stop people from consuming other goods. By extension it also means that the poorer people are, the better it is for the environment. Therefore, when discussing rebound mitigation options based on calculations with a model that captures this effect, especially in relation to policy, these considerations concerning what is (socially) desirable for society should be taken into account.

After having discussed the literature on rebound effects, its place in the CE, and the trouble with crafting effective policy for its mitigation, it is clear that a complex economic problem exists in the transition to a CE. Relevant stakeholders from business, government and academia were consulted to shed light on this problem and discuss more effective mitigation strategies, as described in the following chapters.

3. Methodology

This study uses inductive reasoning to learn general lessons about CER from actors in the Dutch textile industry and their efforts to become circular. Through snowball sampling, different relevant experts and stakeholders in the textile industry were consulted through the use of semi-structured interviews (Kumar, 2014). Finally, the accumulated knowledge from the various angles represented by the interviewees was analyzed according to the Gioia method (2012) to produce comprehensive recommendations and insights on the role of CER in the future of the textile industry as it transitions towards circularity.

3.1. Research setting

More than 1.2 billion tons of carbon emissions are produced each year from textile production (Ellen McArthur Foundation, 2017). Over the past 15 years, clothing production has approximately doubled, mainly due to the 'fast fashion' trend, with more rapid changes of styles and collections. Large amounts of non-renewable resources are extracted to produce clothes that are often used for only a short period after which the materials are sent to landfill or incinerated. As consumers we buy much more clothes, of lesser quality and we wear them much shorter. It is estimated that more than half of fast fashion produced is discarded in less than a year (Ellen McArthur Foundation, 2017; Hole and Hole 2019). Increased textile recycling rates would therefore reduce the negative environmental impact that occurs from the use of landfill space and from the production of new textiles (Cuc and Vidovic, 2011). In the Netherlands, UK and the Nordic countries it is estimated that 61% of these discarded garments (post-consumer textiles), are lost in household waste, ending up in landfill or incineration.

From the 39% of textiles that are collected, 84% is reused and 16% is recycled (FFact, 2014). When translated into numbers, the reality is shocking: on an annual basis, 240 million kg of textile was thrown away in the Netherlands in 2015 (Maldini et al., 2017). Only one third of this amount is recycled, processed and finally disappears between walls (as isolation material), under car hoods and is used as moving blankets. In other words: textile gets downcycled and is in its new function often not visible as textile at all. In the Netherlands, an extensive system of textile recycling containers is in place: people are encouraged to collect the clothes they don't wear any longer and bring them to these containers. Unfortunately, of the 240 million kg of textile waste, 130 million kg ends up amidst regular waste in the assigned grey bins (Maldini et al., 2017).

In the Netherlands, efforts to transition the textile industry towards circularity have progressed relatively far compared to most of the developed world. Following the vision of the Dutch government to develop the icon project Dutch Circular Textile Valley (DCTV) to achieve a significant amount of circular textiles by 2030 (Transitieteam Consumptiegoederen, 2018), this governing body launched in 2019. The aim of the DCTV is to reduce the Dutch apparel and textile's impacts on water, raw materials and climate (Platform Circulair Textiel, 2017) and to spur transition by collaborating on an eco-system level (Ministerie van Infrastructuur en Waterstaat, 2019). This icon project involves the creation of four different 'hubs' in the country, each revolving around their specific area of expertise. The region of Amsterdam has specific expertise on business and brands, Twente on fiber- and recycling techniques, Tilburg on workwear and Arnhem/Wageningen on circular design and bio-based materials (Week Circulaire Economie 2018: Icoon-project Dutch Circular Textile Valley in transitieagenda, 2018. At the time of writing this article, these hubs, both in content and vision, were being developed through workshops in which the relevant stakeholders from different areas of the sector came together.

3.2. Data collection

In order to illustrate the data collection approach, the table below (Table 1) identifies the individuals and the corresponding organizations that were interviewed. Each individual brings his or her own perspective to the table, as their backgrounds differ significantly. Interviews were performed with industry experts from businesses and NGOs, circularity experts and the participants of the aforementioned DCTV workshops. This variation of stakeholders allowed for triangulation of observations and to study the

Table 1
Research informants.

Name	Organization	Function/Role	Active in the DCTV
Douwe Jan Joustra (DJJ)	Fashion For Good, C&A Foundation	Head of Circular Transition	Yes
Traci Kinden (TK)	REvolve Waste, Circle Economy	Founder, Circular Textiles Expert	Yes
Gerard Taat (GT)	Province of Gelderland	Energy Transition & Economy	Yes
Esther Munoz Grootveld (EMG)	State of Fashion	Head of Projects	Yes
Luc Kikkert (LK)	Kiemt – Circular Accelerator	Director	Yes
Peter Koppert (PK)	Modint – Branch-organization Textiles	Initiator DCTV Roadmap	Yes
Pals Brust (PB)	UpSet Textiles, (Formerly C&A)	Founder (Former Director of Country C&A Benelux)	No
Iris van Wanrooij (IvW)	EMMA Safety Footwear	CSR Manager	No
Jeroen van den Eijnde (JvdE)	ArtEZ	Professor of Applied Sciences in Product Design	Yes
Michiel Westerhoff (MW)	Circulus Berkel	Manager Strategy & Development	Yes
Rosanne van Miltenburg	Fashion For Good	Project Manager	Yes
Michiel van Yperen	MVO Nederland	Transition Manager	Yes

concept of CER across the developing circular ecosystem.

Between October and December of 2018, three workshops took place at Wageningen University & Research (WUR), 2018 with the goal to create a regional hub with an accompanying vision that facilitates and stimulates the circular transition of the textile industry in the Gelderland province, and the Netherlands at large. These workshops were in fact triple helix collaborations with participants from industry, government and knowledge institutes including WUR itself. The workshops were observed to identify whether rebound is treated as a salient topic, either explicitly or implicitly.

During the final workshop, the topic of rebound and its potential relevance to the hub and its vision were introduced to the group, after which individual appointments were made with the workshop participants for 1-h face-to-face interviews. The participants were questioned about the role of rebound in the future of the circular textile industry, their associations with rebound from the perspective of their organization and the hub they helped to envision. The interviews were adjusted to the particular interviewee, as their individual expertise, role in the industry transition and accompanying perspectives on CE strategies differed (Gioia et al., 2012). After the first couple of interviews, the semi-structured nature of the interviews became increasingly unstructured. This was done purposefully, as it facilitated exploratory conversations, and, according to Corbin and Strauss (2015), unstructured interviews constitute the richest form of data collection. The aim of the interviews was to disclose the real magnitude of importance of the rebound effect in the CE, both in the current transition and in the future, whilst also gathering data on possible areas of occurrence.

3.3. Data analysis

To ensure scientific rigor, the data was analyzed with Atlas. TI according to a general structure adapted from Gioia et al. (2012). The data was structured in first- and second order coding, after which aggregate dimensions were formed (see Fig. 1). The first order codes are the categories that emerge from the raw data with minimal influence from pre-existing theory.

Naturally, speaking of a concept with this level of complexity requires a certain level of jargon and explanation of the topic of conversation. During the interviews, care was taken not to overimpose a certain narrative and accompanying terminology. From these categories, themes (code families) were distinguished as a second order code. Then, aggregate dimensions (or third order themes) were incorporated in a data structure that was combined with the theory to form new understandings, which can be seen in the illustration (Fig. 1; Gioia et al., 2012). As this study attempts to make sense of a rather abstract notion applied in a more palpable setting, this approach can help ground the theory in a structured manner, combining the existing theory with the knowledge of those individuals that are closest to the theorized effect, and should have real agency to influence its manifestations.

3.4. Validity and reliability

In this study, the researchers were generally more broadly educated on the specific topic of rebound than most of the informants themselves. Therefore, concepts such as the informants' understanding of the topic could be assessed, and sense and meaning could be given to data that had a more indirect or associative bearing on the topic, building upon the assumption that the researcher is a "knowledgeable agent" (Gioia et al., 2012, p.20). Respondent validation was assured through a feedback round in which all informants were asked to read and give comments on their contributions as well as other claims made in this research. Their comments and notes were processed, and all informants gave consent for publishing their names, organizations and quotes. After the first round of reviews and analysis of the data leading to five propositions, another two members of DCTV were interviewed in order to validate the examples found, and comment on the propositions that we describe in the discussion section. In addition, to avoid logical fallacies and missteps, two scholars were consulted and included in checking the analysis for possible shortcomings.

4. Results

In this section, the empirical results are discussed. This concerns the level of awareness and understanding of the informants, the manifestations of rebound in their organizational practices and how they relate to CE strategies, and the role rebound and mitigating strategies can have in their transition activities.

4.1. Awareness

Drawing from both the observations of the workshops and the interviews, it is safe to conclude that the level of awareness about rebound effects amongst stakeholders in the Dutch textile industry is very low to nonexistent. Although it is still possible that organizations 'accidently' consider rebound effects through strategic decision-making by focusing on substitutability for example, there are still very large steps to be made. The salience of this finding lays in the fact that spreading awareness to help organizations consciously consider rebound effects in their operations could help

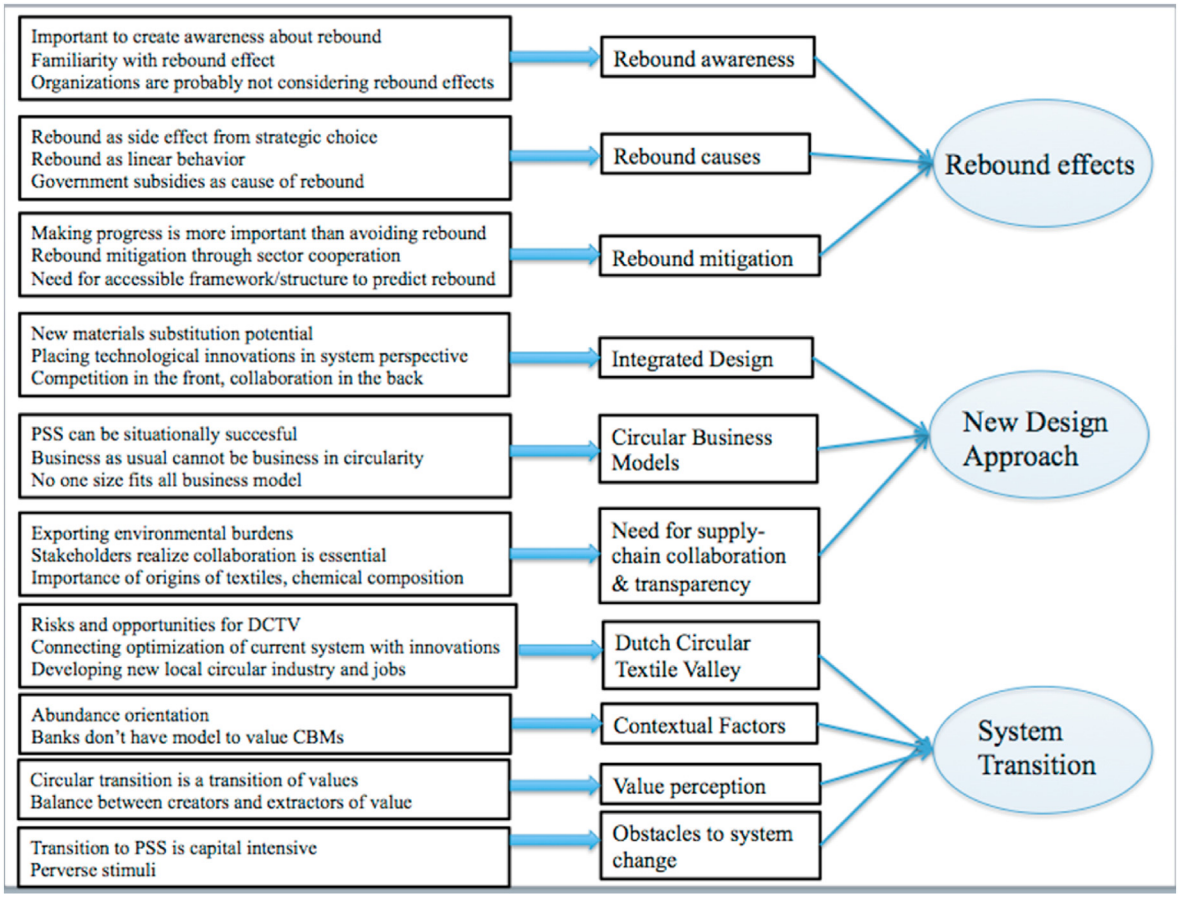

Fig. 1. Data coding: first and second order codes and aggregate dimensions.

realize large potential environmental benefits. In addition, teaching organizations about what rebound effects are and how they can be averted can bring about a more comprehensive understanding of what an effective CBM is.

4.2. Manifestations and causes of CER

There are multiple ways in which CER manifests in the textile industry. Specific examples surfaced after interviews and discussions with industry stakeholders (Table 2). The specific examples can be generalized to reveal a broader spectrum of comparable rebound effects, as they might occur similarly in other sectors or slightly different forms, whilst constituting the same type of rebound. In Table 2, these examples, their original quote and generalized form, as well as main cause/driver, related CE strategy (as seen in section 2.3) and suggested mitigation are displayed.

One of the insights of this study is that rebound is not bound to any particular CE strategy or business model. As illustrated by the table, CER manifests in multiple ways. This means that no CE strategy or practice is inherently void of rebound, as the source of rebound often does not reside in the strategy. However, some areas are more prone to generate rebound than others. This has more to do with the market-form of the industry or sector that the organization operates in than the strategy it applies, as well as the demand and price elasticity of the goods. The reason for this is that the rebound effect is in its nature a relativistic measurement indicator, dependent on the price and impacts of alternatives and the level of competition in the market.

In addition, as shown in Table 2, there is a wide range of identified causes or drivers of CER, whilst the differences in CE strategies remain minimal and not mutually exclusive. Some causes were clearly psychological (moral licensing), others economic (high competition/insufficient substitution) or technological (automation). Whether a company employs a strategy in the category of CUP, CPU or CDR does not necessarily influence the risk of generating CER. Only for CDR, or secondary production, there is an increased vulnerability to unnecessary downcycling (leading to insufficient substitution), emphasizing the need for smart recycling practices. Although this list of potential rebound manifestations is certainly non-exhaustive, it does indicate that seeking relations between CE strategies and CER will likely not deliver significant results.

Some rebound effects are direct causes of the transition towards circularity. This includes the need for infrastructure and transportation between organizations that can now benefit from each other's waste streams, and the increased necessity for (dis-) assembly practices due to modular design. This type of rebound is inherent to the transition, as it embodies the energy required to move from one system to the next. It could be seen as the 'necessary evil' of the transition, retaining its 'evil' aspect only as long as energy consumption/production still has the large environmental impact that it has today. Although perhaps still blurry, there appears to be a distinction between rebound that is inherently caused by the transition towards a circular system and rebound caused by other factors (economic, psychological). As inspired by suggestions of the informants, separating *transitional CER* and *strategic, design or behavioral CER* could be useful. This is an important distinction to make when confronted with a potential rebound effect, to prevent

Table 2
Manifestations and causes of CER.

Specific example	Associated quote	CER generalized	CER Cause/Driver	CE Strategy/CBM from Value Hill
Biodegradable clothing (mycelium, kombucha, fruit leather)	"The throw-away culture, if we can put it like that, could maybe even increase when we start showing how bio-based or circular a product is, because it might stimulate an image that says it's okay to simply throw it away. This is partly true of course, but then we quickly forget the fact that a long use-phase is still desirable." – GT	BBehavioral	Insufficient substitution Moral licensing/ moral hazard behavior	All strategies/CBMs that include products & services with use-phase (CUP – CPU (Paas) – CDR)
Algae production for garments	[Talking about algae project] … He compares his materials to cotton, and sees that he's winning something here, and loses somewhere else, but improves on total environmental impact. In the production process he does not cut energy use, actually it increases slightly, which is not sustainable you could say, but he wins hugely on water use." – JvdE	Economic/ Environmental	Insufficient substitution Competition in markets Environmental tradeoffs	All strategies/CBMs requiring sales in a market (CUP – CPU – CDR)
Return Logistics	"The only thing I can think of is our return logistics and disassembly. Disassembly happens by hand by people with a distance to the labor market, but we eventually want to automate it, which will of course require extra energy, just as the logistics involved, as now trucks will be driving that would not drive otherwise." - IvW	New circular infrastructure and logistics	Circular resource management – energy use	All strategies/CBMs involving physical products (CUP – CPU – CDR)
Automated Disassembly	See quote 'return logistics'	Automation & mechanization	Technological innovation – Energy use	All strategies/CBMs
Jeans as wallpaper	"So we want to go from one textile-application to another textile-application. And not suddenly say we can use jeans material as wallpaper because it is hip, as then the fibers leak out of the system as a new application is created for something that did not require any textile in the first place, so the reuse of the material does not replace any virgin material." – PK	Creative material reuse/unnecessary downcycling	Strategic/Design decision – Unnecessary downcycling	Secondary production – CDR

the implementation of ultimately counterproductive measures.

4.3. Mitigating rebound in the transition

As discussed above, the role that rebound and the mitigation of it should most definitely *not* have is the one of obstacle or barrier to positive change, or reason for inaction. This was one of the main concerns of the participants in this research. On a more practical level, producers of circular textiles need to be aware of the substitution potential of products in order to reach the desired environmental benefits. The quality, comfort and security of a product need to be safeguarded for it to compete with its alternatives, and to avoid becoming too much of a niche product. Furthermore, it was indicated that rebound mitigation measures that would exclude customer groups are not acceptable, as it interferes with the core ideas of the CE.

The existence of rebound relating to transportation and infrastructure in the transition emphasizes the critical importance of clean energy sources, and the realization that there will be no effectively functional circular economy without it. Setting up the circular economy requires financial, material, logistical and infrastructural investments, which is accompanied by an inevitable increase in energy use. This increased energy use is in fact a rebound effect of the transition that will bring about tremendous environmental benefits, and can and should therefore not be avoided altogether. Identifying rebound as such will constitute a powerful argument for the acceleration of the energy transition as a precursor to the transition towards a circular economy.

4.3.1. Suggestions for mitigation

During one of the interviews, when contemplating mitigation strategies for the rebound originating from circular infrastructure and automation, an informant reflected as follows:

"In the future perhaps we will produce for our competitors in our production facility, since there is plenty of room left in the building for another mill. And, in that spirit, we could cooperate working with our return logistics system." – IvW.

Two firms in the same industry might be in competition for customers, but in cooperation to secure effective and smooth resource flows. Especially when, as in the example of safety shoe producer Emma Safety Footwear, their waste stream has a considerable distance to travel before connecting to an organization that can make use of their stream, or in other words, make it part of the circular economy. Since it is likely that their competitors have similar resource flows and thus waste streams, it would make economic and environmental sense to cooperate (Table 3). In this way, this type of transitional rebound can be reduced significantly.

Another consideration for organizations to mitigate rebound is to re-calculate environmental performance metrics when certain demand or sales benchmarks have been exceeded. To avoid a direct rebound effect resulting from a rise in sales and thus production (for example through lowering prices), perhaps sales cannot be allowed to exceed a certain number in order for the initial environmental assessment to hold, as mentioned by the director of a CE accelerator organization:

"Let's say I'm doing something circular, sustainable and I can prove that, but it is successful to a degree that I have to complement it, because demand has risen enormously. Then I have to say no to that increased portion of demand until I can guarantee or secure that the same conditions apply as with the first batch, perhaps with a lower demand-estimate." - LK.

In other words, you need to be able to justify scaling up. If your calculations held true for producing your product or delivering your service at a certain demand level, do they still hold true for larger numbers? Especially in the context of the fast fashion culture with an increasingly insatiable demand, these considerations could prove valuable.

4.3.2. New design approach

A recurring theme that was put forward persistently when discussing the rebound effect and how to avoid it was the necessity for a new approach towards design. The 'traditional' designer often works as a self-contained entity within the production process, focusing mainly on aesthetics, cost-efficiency and acceptance by

Table 3
Mitigation strategies and related causes.

Suggested mitigation	Rebound cause
Maximize displacement potential (quality & comfort)	Insufficient substitution – competition
Government intervention in markets (eco-taxes, subsidies, policy)	
Sustainability communication & awareness	Moral licensing
New design approach	Strategic/design decisions, unnecessary downcycling
Use renewable energy	Automation
	Increase in transportation
Collaborate within sector	Circular resource management

the consumer. The 'new' designer needs to have a more comprehensive approach to design, seeing through the whole supply chain, taking away the heavy burden of complex EoL practices from the recycler by anticipating the continuous cycling of materials and resources in the system. In this way, systems can be intelligently constructed from the outset, as opposed to current practices in which responsibilities are simply transferred when goods/materials switch hands, and recyclers end up with the often-impossible task of retrieving valuable resources from monstrous hybrids.

"Closing the circle is not only a matter of recycling techniques, but it's also about purposeful design, design-for-recycling, and design-for-longevity." – PK.

Diving into what this means opens up a wide range of possibilities and implications. The first and foremost aspect of this new design approach concerns the realization that value chains need to become more collaborative, open and transparent. This entails among others the need to know the origins and composition of the materials that designers work with, and more scientific involvement in the process to approach higher technical effectiveness in product design and recycling. The realization that a lot of contemporary recycling technologies are actually solutions to problems that can be averted in the first place by taking a new approach to design is extremely important.

4.3.3. Systems thinking and the role of value

As can be seen in the summarizing table above (Table 3), many of the mitigation suggestions attempt to bring about systemic, structural change. The participants emphasized the need for systems thinking and a change in our notion of value, as without a more comprehensive view on both transition-enhancing policy and rebound mitigation policy, the efforts will be in vain.

"From the art-context we think about more radical innovations. Well, that never really resonates within an industry, since radical innovation always means that you have to start developing something that you will become the victim of." – JvdE.

This entails reshaping design and business models, rethinking consumption and ownership practices, and eliminating perverse incentives or value drivers amongst many more. As frequently stressed in the interviews, optimizing the current system through endless incremental efficiency increases rebound effects and actually becomes an inhibiting barrier for real meaningful change.

Whilst circularity is a broad concept that can be approached through different lenses, the way in which goods and services are valued and how value is created and extracted lies at the heart of the shift between linear and circular economics.

"So, how do you approach the value of a product? Do you look at it from a possession principle, which is what our model is based on, it is not based on what function it has for me and what value I attach to that function, no, it is determined by the value of possession. That is what is fundamentally wrong in our value-pattern, and why many perceive possession as wealth. Whilst I think, no, rich experience is wealth. But that is the climb that we as humanity need to make." – LK.

Not only are consumers disconnected from the true value of (textile) products; also valuation models applied by banks are lagging behind. New circular business models require a new approach to what value means, and how circular asset management is conducted. These issues often go below the radar of conventional policy-makers. This is why proponents of the CE transition need to incorporate them in their considerations for policy, and bring them to the attention of the public.

5. Discussion and theory building

Building on the reviewed literature and the insights from the informants, several lessons could be learned. In order to conceptualize these lessons for theory building, propositions are presented as they were drawn from the theoretical and practical implications of the results.

Proposition A. *Rebound effects in the CE are not necessarily tied to specific CE strategies or CBMs; they rather emerge due to market dynamics and the level of competition.*

The development of business models and strategies in the CE is still in its early stages, and when it concerns potential for rebound, the market/industry within which the organization operates is more relevant than the strategy it applies. The level of competition from primary or linear goods determines the level of substitution that can occur. Sometimes, goods from CUD (Achterberg et al., 2016) or secondary production create new market segments and cause absolute demand to rise (Zink and Geyer, 2017). Whether this is a good thing depends on who embodies these new market segments and what the goods are: would it be desirable for everyone to start using this good?

Rebound effects from infrastructure and logistics are also not particular to one CE strategy. The only type of rebound to which secondary production (CDR) strategies are more vulnerable concerns those of suboptimal reuse, as in the example of the jeans as wallpaper. This indicates a certain responsibility for organizations that engage in the reuse of raw materials, and in the case of textiles, avoid that valuable fibers leak out of the system unnecessarily.

Besides economic or design factors, psychology also plays a role in the occurrence of rebound. Moral licensing behavior can emerge when the 'virtuous' act of buying circular goods is followed by immoral use of the good (Dütschke et al., 2018). This, however, also happens irrespective of the strategy employed, as it can occur for any good that can cause impact after purchase, or shorten its lifecycle. In addition, CPU strategies such as lease-models or PaaS could be prone to reckless behavior, as the user does not hold ownership (and thus some degree of responsibility) of a good. In this case, being able to use a good continuously and without limits might tacitly condone irresponsible behavior. This constitutes a rebound effect when use goes up or an increasing amount of repairs are needed that require extra logistics and materials. Despite the fact that this model is in many cases still superior to its traditional ownership-based counterpart, actively seeking to reduce these

types of effects could prove essential for realizing the projected environmental benefits.

Proposition B. *Making a distinction between transitional CER and design, economic and behavioral CER can lead to more targeted and effective mitigation as well as help weigh the relevance of the effect in the transition.*

The main concern about rebound mitigation strategies or policy is that they could form obstacles to the transition. If we want to combat rebound effects without compromising the progress of the transition, it is important to make a distinction between rebound that originates from efforts to transition (such as the extra required energy of return logistics) and rebound dwelling in linear economics, behavior and design (such as the inability of circular goods to compete, moral licensing behavior and unnecessary downcycling). Making this distinction will signal to policymakers that the amount of rebound itself is not the most relevant factor, but whether the initiative/strategy fits into a circular system is crucial. Rebound originating in energy increases due to the creation of new circular infrastructure or facilitating activities can for example be alleviated through increased collaboration between competitors in the sector, and through applying systems thinking in the design stage.

Proposition C. *New assumptions and quantification models are needed to accurately describe rebound in the context of the Circular Economy, and multidisciplinary qualitative approaches constitute useful temporary alternatives in order to avoid misleading research results.*

One of the implications of this study is that there is a need for a new approach not only for design, but also for the research methods commonly used to investigate rebound. As discussed, sometimes mitigation strategies can exclude consumer groups, or pose obstacles for the transition. Although there is a need for more accessible metrics to assess the rebound effect, the neoclassical assumptions that underlie some of the conventionally used metrics might not hold anymore in the new paradigm. These assumptions include the rational, utility maximizing consumer (debunked by Kahneman, 2011), and ultimately profit maximizing firm (as discussed in Proposition D, incompatible with CE). Quantifications of rebound with econometric models based on neoclassical assumptions (e.g. Sorrell & Dimitripoulos, 2008; Sorrell et al., 2009; Saunders, 1992; Khazzoom, 1980; Greening et al., 2000, Zink et al., 2016; Font Vivanco et al., 2014 and Font Vivanco et al., 2015) should therefore be used with caution, as these assumptions belong to the economic paradigm from which we are attempting to depart. This is not the first time that neoclassical assumptions for economic calculation have been criticized; in fact most authors seem to be aware of the limitations of these rigid assumptions. Berkhout et al. (2000) note the following as they elaborate on the use of these assumptions: "The reason for its perseverance is the minimal requirement of behavioral axioms, and the elegance of graphical and mathematical presentation, and the fair explanatory power" (p. 426). In other words, these assumptions might be inaccurate, but they are simple, easy to work with and alternatives are not plentiful. So, since the concept of CE is fundamentally incompatible with the neoclassical assumptions used by these models, new models are required that work with updated and suitable frameworks and assumptions in line with the principles of circular systems.

A recent study (Santarius et al., 2018) has similarly suggested the need for a different, more multidisciplinary approach beyond economics only, to study rebound effects. They propose that perspectives from psychology, sociology, industrial ecology, physics and broader trans-disciplinary approaches are necessary to gain a more comprehensive understanding of rebound, and place it in a real-world context. In support of these suggestions, this research supports mapping the economic landscape more extensively can provide a vivid picture of the obstacles and conditions that need to be overcome. Many sectors are still uninvestigated with regards to CER. Qualitative inquiries such as employed in this study can be a starting point to identify and make stakeholders aware of rebound effects in their operations. Further categorization and mapping of rebound effects within sectors and product types could create increased accessibility to effective mitigation strategies, and help policymakers and businesses design for models with low rebound.

Proposition D. *Structural economic incentives systemically reinforce rebound effects in the CE.*

The rebound avoiding conditions put forward by Zink and Geyer (2017) clearly oppose conventionaleconomic incentives. As McKinsey & Company (Zils, 2014) advise, applying CE strategies becomes most profitable when seeing secondary production possibilities as an additional market to re-sell original goods, not cannibalizing existing sales: a practice with a near-certain rebound (and thus environmentally undesirable) outcome (Geyer & Doctori Blass, 2010; Geyer et al., 2016; Zink et al., 2014; Zink and Geyer, 2017). Hence, CE practices are likely to result in rebound effects within large companies, as secondary production increases whilst companies aim to retain profits, and in doing so purposively limit substitution (which would be market cannibalization) as goods from primary materials are still the company's main business.

The CE's true environmental message therefore essentially encourages market cannibalization, as the displacement of primary production by secondary production is desired to drive down environmental impacts and avoid resource depletion. However, from any 'rational' economic perspective, market cannibalization by remanufactured products is a threat to earnings, as secondary products can 'eat up' the demand or market share for primary products (Guide and Li, 2010; Cooper and Gutowski, 2015). Partly because of this, large manufacturers are generally reluctant towards investing in radically new products and business processes, as they would make their own current operations obsolete in the long run. Consequently, businesses must make sure secondary production does not lower demand for their primary products by finding a niche market or targeting different consumer segments, leading to rebound as discussed. In fact, multiple examples exist in which active measures are taken (by nation states or industries) to make sure goods from secondary production cannot seriously compete with primary goods because displacement is feared, not encouraged (Guide and Li, 2010; Pelletiere and Reinert, 2002; Power, 2008; Ghose et al., 2006). This strengthens CER, as without material displacement the secondary products simply add to the impact of primary production. In other words, the pursuit of profit maximization inevitably entrenches rebound effects in the CE. Therefore, the challenge remains to create structural incentives and nudges for the actual displacement of primary production, if a real transition away from the linear economy is the goal.

In addition, the existence of economic externalities poses a structural obstacle for the mainstream diffusion of CE goods and practices, as they embody the lack of environmental or societal impact accounted for in the value of linear goods and services, giving them a competitive advantage. A core issue the CE is thus facing concerns the structural inaccurate valuation of goods. This disproportionately incentivizes operations that impact the environment negatively and in ways that are not accounted for by the market. This also feeds (CE) rebound effects as consumers are lured to switch to cheap, linear goods leading to the insufficient

substitution of those goods, and keeping circular products in niches.

5.1. Practical implications

Now, how do these findings and insights translate into a course of action for the stakeholders involved? Table 4 provides an overview of practical implications and recommendations based on the propositions and literature.

First of all, it should be noted that there is no silver bullet to combat rebound effects as they take many shapes and forms. Mitigating approaches can have temporary benefits, but can also make it more difficult to avoid rebound altogether. Consider energy efficiency increases versus creating a system of renewable energy: investing in and optimizing the current system might partly mitigate rebound temporarily, but it entrenches the current system even more, whilst the real solution lies in the inception of a completely new system. This analogy also applies to optimizing recycling systems versus fundamentally rethinking design. Therefore, a balance needs to be found between optimizing current systems and creating new ones.

Second, since the study did not find a clear link between CBMs and rebound effects, general education and creating awareness about rebound effects within CE circles (e.g. strategy & design departments) are recommended, in combination with systems theories of change. A lack of understanding in this field could place an exaggerated importance on rebound effects in the transition. Furthermore, recommendations to mitigate rebound would involve taking action against moral licensing (Dütschke et al., 2018), increasing cooperation with organizations with similar resource streams, maximizing the localization of the CE network, and working exclusively with renewable energy.

Third, to reiterate, it is imperative that rebound considerations do not deter initiatives that progress the transition. Despite the possibility that environmental benefits of CE initiatives might not deliver on impact reductions, it is more important for such an initiative to fit into a circular ecosystem and to progress the transition, than for the LCA to show spectacular benefits. Take for example the case of peer-to-peer boat sharing, as investigated in article by Warmington-Lundström and Laurenti (2020). This type of sharing platform clearly has both environmental and social benefits, yet the calculation of relatively large rebound effects add doubts to whether it should be continued, which for a large part is based on the re-spending effect: because money is saved and spent on other goods, additional environmental impact is generated. Yet this additional impact is fully determined by the nature of the available alternatives, and is therefore a systemic issue, not directly attributable to the investigated case. So, we don't need "greater awareness of the consequences of re-spending among users" (Warmington-Lundström and Laurenti, 2020, p.8), but we need to incentivize widespread circular business practices so that the majority of possible goods/services to re-spend money on has a low, or positive environmental impact. We should not want people to simply spend less; we should want them to spend more on positive outcomes. This relates closely to Proposition B, and the necessity to make distinctions between relevant and less relevant instances of rebound in light of the transition.

6. Conclusion

This study has investigated rebound effects in the Dutch circular textile industry. Relevant stakeholders were questioned, resulting in real examples of manifestations of CER within and possibly beyond the investigated industry. It was discovered that some forms of CER could be attributed to the steps taken towards circularity, whilst other forms of CER manifest *despite* these transitional steps. In addition, it was found that increased collaboration amongst competitors and a more systemic approach to design could be effective mitigation strategies. Diving deeper into what rebound means in the transition revealed structural economic incentives that reinforce CER, as features of linear thinking applied in a CE context. The ramifications of this discrepancy could be harmful if this confounding logic is applied to shaping mitigation policy, as it can lead to the exacerbation of inequality and other socially undesirable outcomes. Limitations of this study include the relatively low number of informants (12) and their lack of education on the phenomenon of rebound effects, putting more responsibility on the knowledge of the researchers. The many different forms and interpretations of rebound effects made drawing specific, rigorous scientific conclusions troublesome.

To sum up, CER is what we measure when a technically (and environmentally) superior good does not manage to outcompete its higher-impact alternative or is not produced in the first place because of perverse value drivers, economic incentives and the lack thereof. CER is also the environmental punishment that is the consequence of the lack of change in our behavior following an

Table 4
Practical implications & recommendations.

Proposition	Practical Implication	Recommendation	Literature/Reference
A: Circular Business Models	View your CBM/strategy in light of the systemic context: the market, the behavior it rewards and stimulates, and the role it plays in progressing/fitting into a circular ecosystem	Raise awareness about rebound: communicate environmental benefits with more precision; include lessons in systems-thinking. Increase collaboration within sector to optimize resource use and share facilities/logistic capabilities.	Kjaer et al. (2018)
B: Transition	The current trajectory positions rebound as obstacle for the progress of the transition. A distinction between *transitional* rebound and rebound originating from linear incentives, design or behavior can help weigh the importance of rebound measurements.	Focus on transition towards circular systems. Weigh rebound effects with care.	Warmington-Lundstrom and Laurenti (2020)
C: The problem with rebound effect quantification models	Quantitative analysis inherently follows eco-efficiency-logic. It does not account for what is needed to be effective in the transition or what is socially desirable. Qualitative inquiry and new interdisciplinary research methods and including social desirability into rebound research are therefore essential.	Reconsider CER research methods. Work with new assumptions and use qualitative, multidisciplinary inquiry.	Makov and Font Vivanco (2018); Santarius et al. (2018)
D: Economic incentives	Both profit maximization and economic externalities as systemic forces lead to CE rebound. The economic context and incentives for CE success therefore need to be facilitated by the government/ institutions.	Integrate true pricing measures such as a carbon tax. Incentivize circular business practices through subsidies. Systems-thinking required to alter incentive structure.	Zink and Geyer (2017)

efficiency increase: the increase allows us to dwell in our routine behaviors whilst creating the illusion of lowered environmental impacts. It is thus the consequence of linear (neoclassical), one-dimensional thinking in a networked system with complex reaction chains of cause and effect. Therefore, rebound will inevitably be measured in the transition towards a CE, but should never become an obstacle for change or an argument for inaction. Rather, the accumulating knowledge on rebound effects and how to avoid them should become a funnel for effective action.

CRediT authorship contribution statement

Thomas Siderius: Conceptualization, Funding acquisition, Formal analysis, Writing - original draft. **Kim Poldner:** Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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