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Circular economy-induced global employment shifts in apparel value chains: Job reduction in apparel production activities, job growth in reuse and recycling activities

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ABSTRACT

There is no evidence-based discussion on the intended and unintended global social impacts, such as changes in employment, of the European Union's (EU) transition towards the Circular Economy (CE). Consequently, its ethical implications are nebulous. Therefore, this paper assesses CE-induced global employment shifts using the example of the apparel value chains of apparel imported to the EU from the top five exporting countries: China, Bangladesh, India, Turkey and Cambodia. The discussion of the results is based on the ethical framework for global transformative change that applies justice considerations on sustainability transitions. This paper is the first sector-specific quantitative study on the employment effects of the EU transition on a global scale, including ethical dimensions of those effects, as far as we are aware. Overall, this paper contributes to the broader discussion of CE-induced social effects of sustainability transitions. Its results indicate that employment could significantly decrease in low- to upper-middle-income countries outside the EU, in particular in labour-intense apparel production. Employment could increase in less-labour intense downstream reuse and recycling activities in the EU and second-hand retail in- and outside the EU. From an ethical perspective, the benefits and disadvantages of the circular transition seem to be unevenly distributed, with the main adverse effects to be carried by non-EU stakeholders.

1. Introduction

Actions to achieve sustainability are complicated, ambiguous and ambitious. Sustainable development "provokes dispute because it calls into question concepts, institutions and everyday practices that are based on faith in progress and articulates a responsibility of society for the outcome of these complex interactions" (Voß et al., 2007, p.193). Thus, the transition towards sustainability requires "long-term, multi-dimensional, and fundamental transformation processes through which established socio-technical systems shift to more sustainable modes of production and consumption" (Markard et al., 2012, p.956). Corresponding transition research has emerged significantly in recent years, but it has drawn little attention on the ethical dimension (Jenkins et al., 2018; Köhler et al., 2019). Hence, transition research is in a "moral vacuum" as it lacks to understand its social effects (Köhler et al., 2019, p.16).

The Circular Economy (CE) is a concept that intends to enable the transition towards sustainability. It aims for business models that reduce the material footprint of goods and services by promoting measures such as the reduction of raw material input, the reuse of goods, and the recycling of materials. These three measures of reducing, reusing, and recycling are the so-called '3R' approach, the most prominent one (Kirchherr et al., 2017). However, there is a variety of conceptualisation, with circular strategies entailing up to '10R's (Potting et al., 2017; Reike et al., 2018). Most CE scholars relate the CE to only environmental and economic sustainability (Geissdoerfer et al., 2017). Only a small number sees the CE as an approach to achieve sustainable development in all three dimensions of social, economic and ecological sustainability (Ghisellini et al., 2016; Kirchherr et al., 2017; Merli et al., 2018). Specifically, only 20 per cent of the publications defining the CE include social sustainability as one of the CE's primary objectives (Kirchherr et al., 2017). In consequence, many scholars disregard that the transition towards the CE has an ethical dimension as its social effects could either contribute to or contradict with social sustainability.

Employment can be seen as significant levers of social sustainability, as it affects the social well-being and socio-economic standing of an

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individual (International Labour Office, 2013). The EU's CE transition is likely to affect the size and distribution of employment because it aims for process and product innovation that will change resource inputs, production patterns and the provision of goods (Pianta, 2006). Most studies on employment effects of the CE transition in the EU limited their employment effects to those in the European Union (EU) respectively its Member States. However, almost all affected industry sectors, such as the apparel industry, are now fully globalised with employment spread in global value chains (GVCs) across different geographical locations including developed and developing countries (Gereffi, 1999; see also Schroeder et al., 2018). However, over 95 per cent of CE research focus on developed countries, and only 5 per cent on developing countries (Kirchherr and van Santen, 2019). Only three studies estimated broader global employment effects, but do not discuss social implications. The first found that increased global plastics, glass, wood pulp, metals and minerals recycling will results in an additional 6,000,000 jobs, with significant growth in the Americas (+10.000.000) and the EU (+500.000) and decrease in Asia and Pacifics (-5.000.000), Africa (-1.000.000) (International Labour Organization, 2018). The second, based on a global transition scenario, reported global employment growth of 2,4 per cent, with loss of employment in mining and manufacturing (Wiebe et al., 2019). The third, based on an EU transition scenario, reports a decline of 5,3 per cent, with a loss of 16 million jobs in the EU and 150 million in the rest of the world, mainly driven by the assumption of extended product lifetimes (Donati et al., 2020). Hence, we believe that we need to asses global employment effects of the EU's transition in more detail, including effects on low- to middle-income countries, and discuss those regarding the CE's contribution to social sustainability.

The apparel industry could be a suitable sector for a first analysis for two reasons. First, it is a labour-intense industry that relies on GVCs (Gereffi, 1999). Second, the EU promotes circular practices in the apparel industry. For example, it obliged all its Member States to collect textile waste separately from other household waste by 2025 to increase the share of recycling and reuse (European Commission, 2018a). Hence, we aim to answer the following research question: What global employment shifts could the CE transition happening in the EU cause, using the example of the apparel value chains?

This paper is the first sector-specific quantitative study on the employment effects of the EU transition on a global scale, including ethical dimensions of those effects. The results are discussed based on the ethical framework for global transformative change that applies justice considerations on sustainability transitions. It contributes to the broader discussion of CE-induced social effects of sustainability transitions. Furthermore, it provides implications for policymakers of benefiting and disadvantaged economies as well as practitioners to decide on the level of the CE's inclusiveness and justice.

Our results confirm that the CE transition could lead to a significant decrease in employment in low- to upper-middle-income countries outside the EU, in particular for labour-intense apparel production. Employment could increase in less-labour intense downstream reuse and recycling activities in the EU and second-hand retail in- and outside the EU. Overall, our scenarios for apparel imported from China (CN), Bangladesh (BD), Turkey (TR), India (IN) and Cambodia (KH) indicate that a circular shift in the apparel industry in the EU could result in a decline of employment in non-EU low- to upper-middle-income countries of -297 to -437/ -513 to -756 thousand FTE (scenario I/scenario II). In the EU, we expect positive employment effects of 35 to 51/ 60 to 85. Hence, the benefits and disadvantages of the circular transition seem to be unevenly distributed, with the main adverse effects to be carried by non-EU stakeholders. Overall, we find that the EU's transition compromises issues of justice.

The remainder of this paper is structured as follows: In Section 2, we provide the theoretical background for this paper. In Section 3, we explain our methods to assess employment shifts. In Section 4, we provide an overview of the data used. In Section 5, we discuss our results. In Section 6, we summarise our argument and conclude with suggestions for further research.

Table 1
The evaluative and normative contributions of energy justice (Jenkins et al., 2016).

Dimension	Evaluative	Normative
Distributional	Where are the injustices?	How should we solve them?
Recognition	Who is ignored?	How should we recognise?
Procedural	Is there a fair process?	Which new processes?

2. Background

In this section, we provide the theoretical background for this paper. First, we introduce the theoretical lens underlying our study (2.1). Second, we describe the state of discussion on the social dimension of the CE (2.2), including employment effects (2.3). Finally, we introduce the textile apparel industry sector, including its historical development (2.4.1), sustainability issues (2.4.2) and the concept of circular fashion (2.4.3).

2.1. Theoretical lens

We base our theoretical lens for this study on Jenkins et al.'s (2018) ethical framework for global transformative change. Jenkins et al.'s (2018) applied the concept of energy justice to the broader concept of sustainability transitions, exemplarily the multi-level perspective (MLP) model, to advance the understanding of the justice of sustainability transitions.

The MLP, developed by Geels (2002, see also Rip & Kemp, 1998) is one of the most prominent approaches to understand transitions of socio-technical systems (Lachman, 2013), for example, the low-carbon transition of energy systems (Rogge et al., 2017). Such systems consist of various components such as "technology, regulation, user practices and markets, cultural meaning, infrastructure, maintenance networks and supply networks" (Geels, 2005, p.446). The MLP builds on a nested hierarchy of three levels, the niche, regime, and landscape, that are no "ontological descriptions of reality, but analytical and heuristic concepts to understand the complex dynamics of sociotechnical change" (Geels, 2002, p.1259). The niche is the most dynamic level, in which radical innovations emerge protected from market pressure of the existing regime (Geels, 2002; Kemp et al., 1998). The regime describes predominant technologies and practices that provide societal functions. Those are relatively stable but can change over time (Holtz et al., 2008). Innovations occur only incrementally (Geels, 2002). The landscape contains diverse, external factors that often only change slowly, but can also change suddenly, such as "wars, emigration, broad political coalitions, cultural and normative values" (Geels, 2002, p.1260). Transitions emerge when change intervenes and occurs on all three levels. It can result from different transitions pathways depending on the timing and nature of the interaction, in particular from the niche and landscape-level on the regime level (Geels and Schot, 2007).

Jenkins et al.'s (2018) derive her considerations on justice from the relatively new field of energy justice research. Energy justice is a research field that applies justice criteria to areas related to energy, such as "energy policy, energy production and systems, energy consumption energy activism, energy security" (Jenkins et al., 2016, p.175). For example, Heffron et al. (2015) develop an Energy Justice Metric to support decision-makers to decide between energy infrastructure types. Three tenets are central to the concept of justice (Jenkins et al., 2016; McCauley et al., 2013): distributional justice, i.e. where injustice emerge (Fuller and Bulkeley, 2013); recognition justice, i.e. which affected sections of society are ignored (McCauley et al., 2013); procedural justice, i.e. what processes exist for remediation (Fuller and Bulkeley, 2013). These dimensions can be approached by evaluative and

Table 2
Energy justice applied to MLP (Jenkins et al., 2018).

Level	Application
Niche	Exposes exclusionary and/or inclusionary technological and social niches before they develop; leading to potentially new and socially just innovations
Regime	Provides an approach to normatively judge regimes; potentially destabilising existing regimes using moral criteria
Landscape	Framing justice as a matter of priority could exert pressure on the regime, leading to a widespread reappraisal of choices, and the integration of moral criteria

normative research designs (Jenkins et al., 2016), as shown in Table 1.

The framework for global transformative change applies the three "tenets" of energy justice on the three levels of the MLP to identify and mitigate injustices in transitions. According to Jenkins et al. (2018), it should help to identify ex- and inclusive socio-technological innovations on the niche level before they emerge and enhance socially just innovations. On the regime level, it could enforce to question existing socio-technical systems normatively. On the landscape level, it allows framing justice as an overarching priority that could increase pressure on the existing regime. Table 2 provides an overview of the application on the MLP.

2.2. CE and social sustainability

While the objectives of the CE have reached acceptance among European policy-makers and the wider public, the CE does now experience a "validity challenge period" (Blomsma and Brennan, 2017, p. 610). Scholars controversially discuss its applicability and impacts (de Jesus and Mendonça, 2018; Hanumante et al., 2019; Heshmati, 2015; Kalmykova et al., 2018; Kirchherr et al., 2018; Korhonen et al., 2018; Zink and Geyer, 2017). In this context, scholars have started to discuss whether the CE aims for socially sustainable development, or just for environmental and economic sustainability. There are two main perspectives. Some scholars argue that the CE aims to sustain economic prosperity through environmentally benefiting approaches. At the same time, social effects, such as work or effects of better environmental conditions on human-beings, are by-products of the transition

Table 3
Estimates on CE-induced employment effects.[1]

Author(s)	Geographical focus	Employment effect (in jobs)	Time horizon	Remarks
Wiebe et al., 2019	Global	+2,4 per cent (net)	2030	Baseline scenario: International Energy Agency's Energy Technology Perspective 6-degree scenario
Donati et al., 2020	Global	-5,3 per cent (net)	N/A	Includes an assumption of product lifetime extension, but no assumptions on investment or price changes
International Labour Organization, 2018	Global	+6.000.000 (net)	2030	The scenario includes only recycling of plastics, glass, wood pulp, metals and minerals
European Commission, 2018	EU	+700.000 (net)	2030	
European Commission, 2014a	EU	+2.000.000 (net)	2030	Employment effects of resource productivity improvements, not specifically on CE (see Cambridge Econometrics and BIO Intelligence Service, 2014)
European Commission, 2015a, 2015b	EU	+580.000 (gross)	2030	No information on method; includes +170.000 jobs in waste management by 2035
Mitchell and James, 2015	EU	+1.200.000 to 3.000.000 (gross); +250.000 to 520.000 (net)	2030	Includes an EU Member States breakdown; same method as Coats and Benton (2015); Mitchell (2015); Morgan and Mitchell (2015a, 2015b)
Wijkman and Skånberg, 2016, 2015a, 2015b	Finland/ France/the Netherlands/ Spain/Sweden/ Czech Republic/Poland/Norway	+50.000/+50.000/+100.000/ +200.000/ +300.000/+100.000/N/ A/+45.000	2030	Employment effects based on material efficiency scenarios. Reports include other (renewable and energy efficiency) scenarios
Coats and Benton, 2015	Italy/Poland/Germany	+89.000 to 199.000/+68.000 to 124.000/ +122.000 to 287.000	2030	Same method as Mitchell (2015); Mitchell and James (2015); Morgan and Mitchel (2015a, 2015b)
Bastein et al., 2013	Netherlands	+54.000 (net)	2020	
Stegeman, 2015	Netherlands	+83.000 (net)	2015	
Circle Economy and Erasmus Happiness Economics Research Organisation, 2017	Netherlands	810.000	2017	Baseline estimate
Morgan and Mitchell, 2015a, 2015b	UK	+205.000 to 517.000 (gross); +54.000 to 102.000 (net)	2030	Same method as Coats and Benton (2015); Mitchell (2015); Mitchell and James,(2015)
Mitchell, 2015	London (UK)	+16.000 to 40.000 (gross); +5.500 to 12.000 (net)	2030	Same method as Coats and Benton (2015); Mitchell and James (2015); Morgan and Mitchell (2015a, 2015b)
Geerken et al., 2019	Belgium	Decrease of 1.000/43.000 (recycling/reuse) working hours per million Euro of substitution	N/A	Reports the gross decrease of employment in current activities (substitution potential)
Willeghems and Bachus, 2019	Flanders (Belgium)	+31.000 (net)	2030	Scenario limited to shift of metal-electro sector
Ministère de l'Economie et al., 2015	Luxemburg	+2.000 (net)	2017	
Ferrão et al., 2016	Portugal	+3.000 (net)	2020	The scenario is limited to jobs in municipal solid waste management
Deboutière and Georgeault, 2015	France	+200.000 to 400.000 (gross)	N/A	Baseline estimate: 600.000 jobs
Chen et al., 2019	Greece/Europe	Sectoral employment in the most efficient scenario similar to a conventional production scenario	N/A	The employment effect of AgroCycle rice paddy production in Greece is compared to conventional production
Beccarello and Di Foggia, 2018	Italy	+600 (net) (+15 per cent compared to baseline)	2020	Scenario limited to higher packaging waste recycling quotas
Unay-Gailhard and Bojnec, 2019	Slovenia	Statistically significant increase in employment for very large dairy farms and crop farms	N/A	Limited to job creation on farms caused by agri-environmental measures

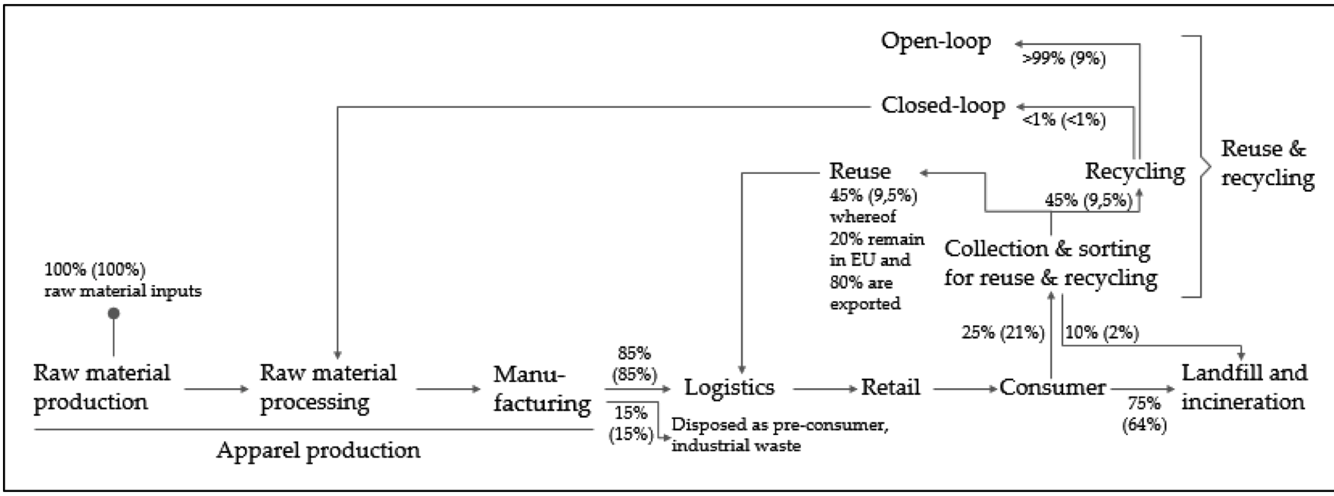

Fig. 1. '3R' baseline along the apparel value chain including reuse and recycling activities, numbers in brackets as share of raw material inputs (linear apparel value chain adapted from Appelbaum and Gereffi, 1994).

(Geissdoerfer et al., 2017). Other scholars argue that social sustainability is the ultimate objective for the CE because human well-being is "inherent in sustainable development" (Murray et al., 2017, p.369; Corona et al., 2019; Moreau et al., 2017). Schroeder et al. (2018, p.77) state "that issues of growing inequality are not sufficiently addressed by current circular economy approaches". However, most empirical studies that assess social effects only underline the positive economic growth and employment effects in the EU, respectively its Member States. Comprehensive answers to the questions of the social effects of the CE remain unanswered until now.

2.3. Employment and the CE

The innovation of products or processes is often linked to the assumption of positive net employment effects on the macro level. However, some empirical studies show inconclusive results in terms of such effects (Pianta, 2006). The applied methodology influences the results for net employment effects. Computable general equilibrium and Input-Output model studies that include induced effects and those with a near-future time horizon report the lowest employment effects (Stavropoulos and Burger, 2020). In contrast, policy reports state higher net employment effects than scholarly studies (Stavropoulos and Burger, 2020).

Except Donati et al. (2020), other EU transition studies only regard effects in the EU and consistently report positive net employment effects. A study of the European Commission (2018) states a net job creation potential of up to 700,000 jobs in the EU. In particular, employment in waste management (+660,000) could increase because labour-intensive recycling replaces less labour-intensive landfilling. However, the authors state that automation, technology and improved recyclability of materials could reduce the assumed labour intensities in recycling activities. Another study, less advanced in terms of methods, estimates the potential of 250,000 to 520,000 jobs (Mitchell and James, 2015). Overall, it is difficult to compare these forecasts as methods and assumptions differ (Horbach et al., 2015; Pianta, 2006; Stavropoulos and Burger, 2020). For example, the results of Donati et al., (2020) are considerably driven by the assumptions on extended product lifetimes, that most other studies did not assume. Burger et al. (2018) argue that most studies underestimate employment as they do only consider 'green jobs' such as recycling, but disregard enabling jobs, for example, in design and management. Table 3 provides an overview of CE-related studies that provide employment effect estimates.

2.4. The textile apparel sector

2.4.1. Historical development

The European textile apparel sector has relied on global commodity chains for centuries (Beckert, 2006). Already in 1700, Great Britain exported more than 50 per cent of its textiles, mainly wool, production (O'Brien et al., 1991). At the same time, 37,5 per cent of domestic textile consumption relied on imported linen, silk and cotton (O'Brien et al., 1991). Within Great Britain, the cotton, wool and linen textile industry competed with each other. Cotton producers invented mechanical processes to improve their competitive position as cotton was easier to be processed mechanically (Hudson, 2011). The cotton textile industry became the "first fully mechanised factory industry to emerge during the first industrial revolution" (O'Brien et al., 1991, p.445). While processing raw materials into fabrics became more efficient, producing apparel from fabrics remained a manual exercise. Mechanical sewing technics emerged in the mid and late 19^{th} century. Apparel factories emerged where low-skill workers produced standardised ready-to-wear garments (Farley Gordon and Hill, 2015). Nevertheless, the industry has remained labour-intensive because the cutting and sewing of textiles requires manual dexterity (Taplin, 1989).

From the late 1960s on, the industry started to reorganise production. Labour-intensive activities could be decoupled from capital-intensive activities and were relocated to low-wage countries due to improved logistics and communications (Fröbel et al., 1977). Cost pressure increased, and the European industry restructured. Textile apparel companies had to either target niche markets or to decrease

[1] To identify relevant studies, we first searched Web of Science, Scopus and Google Scholar for relevant scholarly publications (journal articles, books, book chapters, conference proceedings etc.), using the search string ""circular economy" AND ("employment" OR "job" OR "labour" OR "labor")". We identified seven studies estimating employment effects. We then searched Google, using the same search string, to identify non-scholarly publications. We then reviewed all publications for references to further studies. In total, we identified 25 scholarly and non-scholarly publications.

Table 4
Limitations of the approach.

Limitation	Rationale	Directions for future research
Two different equations to calculate baseline employment: Results are based on two approaches Eq. (1) and ((2)) that both are approximations of more complex employment relationships.	We needed to use two different approaches to rebuild employment in global textile apparel chains due to available data as well as the required depth of sector detail.	Standardise approaches to calculate sector-specific employment in emerging global circular value chains.
Analysis restricted to employment in the apparel value chains: We only assessed effects on major employment sectors in apparel value chains and its indirect employment. We disregarded effects outside these chains, including induced employment.	We focused on direct and indirect employment, as most other studies did (see Table 3), as this allows us to identify significant trends and discuss its ethical implications.	Widen approach to effects of induced employment and outside initial the value chains.
Scenarios limited to the '3R' approach: The assumption underlying the scenarios affect results significantly; compare, for example, the different results of Donati et al. (2020) and Wiebe et al. (2019). We limited our scenarios to the measures of the reduce, reuse and recycling.	The '3R' approach is the most prominent one, as it is used in around 42-46 per cent of CE studies (Kirchherr et al., 2017), and to some extent already established in the industry (Sandin and Peters, 2018).	Design comprehensive and standardised, but modifiable CE transition scenarios frameworks to improve comparability of results

Table 5
Input values for baseline employment $E_{prod,proc,manu}$

	w					***e***					***t***
	working hour inputs per 1 U.S. dollar					imports in a million U.S. dollar[6]					annual working hours
Origin	CN	BD	TR	IN	KH	CN	BD	TR	IN	KH	All
$E_{prod,proc,manu}$	See appendix A					36.903	20.764	12.992	6.804	5.010	2.300-3.400

production costs, particularly by relocating production (Christerson and Appelbaum, 1995). For example, the revenues from German domestic production decreased from 99 to 83 per cent between 1960 and 1975 (Fröbel et al., 1977). The share of imports from developing countries of all imports almost tripled from 16 to 45 per cent between 1962 and 1976 (Fröbel et al., 1977). Between 1980 and 1995, employment in the EU decreased by 40 per cent (Stengg, 2001). The replacement of the 1974's Multi Fibre Agreement, that limited exports from developing countries, by the less strict Agreement of Textiles and Clothing in 1995 and the abolishment of quota-restrained trade from China in 2005 lead to a massive relocation of European production to low-wage countries (Pickles and Smith, 2011; Taplin and Winterton, 2004). Most of the industry now builds on global value chains (Gereffi, 1999; Macchion et al., 2015).

In recent years, the trend of fast fashion has emerged. It requires "low cost and flexibility in design, quality, and speed to market" (Bhardwaj and Fairhurst, 2010, p.165) to meet customer demands (Bhardwaj and Fairhurst, 2010; Niinimäki and Hassi, 2011). European apparel players have started to consider 'nearshoring' its production to low-cost locations in North Africa, Turkey or the EU to increase flexibility and decrease lead times. Other trends include the automation of production that could result in lower labour inputs, and increasing sustainability demands of customers (McKinsey & Company, 2018).

2.4.2. *Sustainability issues*

The apparel industry has been subject to severe environmental and social issues (Boström and Micheletti, 2016; Eryuruk, 2012; Resta et al., 2016; Shen et al., 2017). Environmental issues include high energy consumption throughout the lifecycle, excessive water and chemicals consumption, the generation of waste as well as direct CO_2 emissions resulting from global supply chain logistics (Beton et al., 2014; Holmquist et al., 2016; Resta et al., 2016; Roos et al., 2017). In line with the recent trend of fast fashion, the utilisation of a clothing piece has decreased over the last years, for example, the utilisation of dresses to 60 per cent compared to 2002 (Ellen MacArthur Foundation, 2017). In terms of social issues, apparel manufacturing, especially in low- and middle-income countries, is associated with indecent work issues, such as low wages and long working hours as well as unhealthy working environments and safety issues (Boström and Micheletti, 2016; Vaughan-Whitehead, 2015).

2.4.3. *Circular fashion*

Circular fashion addresses some of these sustainability issues. It stresses a less resource-intense fashion industry, ultimately resulting in environmentally sustainable value chains (cf. Ellen MacArthur Foundation, 2017; Watson et al., 2017). A primary strategy to achieve this is to reduce virgin materials required to produce a piece of apparel, for example through reduction of pre-consumer, industrial textile waste, i.e. the first 'R' of the '3R' CE approach. Another measure is to use a piece of apparel second-hand after the end of its first life, i.e. the second 'R' of the '3R'. The complementing 'R' of the '3R' is recycling. Pre-consumer industrial waste and post-consumer apparel is recycled into new materials. Closed-loop recycling recycles materials into apparel of the same quality, for example, new denim jeans made from recycled fibres. Open-loop recycling recycles materials into goods of lower quality such as insulation materials or cleaning cloth. Some scholars state that recycling could result in a rebound effect of increased consumption because of low prices due to the increased overall amount of available fibres on the market (Sandin and Peters, 2018; Zink and Geyer, 2017). Moreover, critics argue that reuse and recycling itself do not aim to lower the consumption of apparel as the root cause of several sustainability issues (Niinimäki and Hassi, 2011). In this context, circular fashion could include various other strategies to decrease overall consumption. For example, MUD jeans leases its denim jeans and offers free repairs (MUD Jeans, 2018). Nevertheless, the share of circular fashion is still marginal, and the most advanced circular fashion player are of small size (Franco, 2017; Stål and Corvellec, 2018).

For the EU, we can draw the following baseline for the prevailing '3R' strategies. For reduce, we estimated that around 15 per cent of input materials are lost as pre-consumer waste during the apparel production process (Rissanen, 2013). For reuse and recycling, around 25 per cent of apparel are collected separately from household waste (European Commission, 2002).[2] Of this, 10 per cent is disposed due to quality issues, 45 per cent are recycled, and 45 per cent are reused (Korolkow,

[2] This share differs between EU Member States, for instance around 75 percent in Germany while 22 percent in Sweden (Korolkow, 2015; Watson and Palm, 2016). Estimates on EU-wide collection range between 20-25 percent (European Commission, 2002; Sandin and Peters, 2018; Textile Recycling Association, 2005). A population-weighted average of data for Sweden, Finland and Denmark percent (Watson and Palm, 2016) results in a quota of around 30 per cent.

2015; Textile Recycling Association, 2005). 20 per cent of the apparel for reuse remains in EU, while 80 per cent are exported to mainly low- to lower-middle-income countries (Jongerius, 2012; Korolkow, 2015; Textile Recycling Association, 2005; United Nations Statistics, 2020). Within recycling, more than 99 per cent is recycled open-loop, and less than 1 per cent is recycled closed-loop as the technology still in the prototyping stage (MacArthur Foundation, 2017). Fig. 1 shows the baseline along the apparel value chain.

3. Methods

Our analysis aimed to assess what effects a CE transition for apparel sold in the EU could have on employment along its value chains, in particular the distribution across geographies. For this, we first determined baseline employment in the value chains of apparel sold in the EU. We then defined two CE transition scenarios. Finally, we assessed the effects of these scenarios on employment.

3.1. Approach

We analysed effects on seven major employment sectors along the value chain: raw material production (E_{prod}), raw material processing (E_{proc}), manufacturing (E_{manu}), logistics (E_{logi}), retail (E_{reta}) and post-consumer processing, including landfill and incineration (E_{land}) as well as reuse and recycling (E_{reus}).

We followed two different approaches to estimate baseline employment in full-time equivalents (FTE) given different availability of data. For apparel production activities ($E_{prod,proc,manu}$), we derived our approach from social life cycle assessment (SCLA) methodology. SLCA databases provide inputs of worker hours per country-specific sectors (CSSs) for a given product (Eisfeldt, 2017; Norris et al., 2012; Norris, 2006). Following this, we calculated employment in the sectors of apparel production as

$$E_{prod,proc,manu} = \frac{w \times e}{t}, \tag{1}$$

where w are the required working hours for the apparel of 1 U.S. dollar value, e is the U.S. dollar value of apparel exports to the EU[3], and t are the average annual working hours per FTE. We also used Eq. (1) to calculate employment in sectors of indirect employment.

For the other sectors, we assessed employment by dividing the volume of apparel processed by the volume capacity per FTE, similarly applied for example by Access Economics (2009), Cascadia (2009), Murray (1999), Friends of the Earth (2010) and Tellus Institute (2014). Correspondingly, we calculated employment as the following:

$$E_{logi,reta,land,\ reus} = \frac{v \times q}{p}, \tag{2}$$

where v is the annual consumption of apparel in tonnes of raw materials, q is the share of apparel processed by a sector, and p is the annual processing capacity in tonnes per FTE. We calculated indirect employment using a multiplier *em*.

We then defined two circular transition scenarios to assess employment effects. We applied the measures of the '3R' approach, i.e. reduce (*red*), reuse (*reu*), closed-loop recycling (*rec*) and open-loop recycling (*reo*). These measures are, to some extent, already established in the industry (Sandin and Peters, 2018). For each measure, our scenarios estimated the changes in the quantity of processed raw materials. We assessed corresponding changes in employment, applying the following equation:

$$\Delta E_{prod,proc,manu,logi,reta,land,reus} = \frac{a \times |\Delta red| + b \times |\Delta reu| + c \times |\Delta rec| + d \times |\Delta reo|}{q}, \tag{3}$$

where *a, b, c* and *d* are the effects of the changes in processed raw materials on the employment sectors: If a measure has no effects it is 0; if it has an effect it is >0 and ≤1 for a positive and ≥-1 and <0 for a negative effect, with 1 respectively -1 if there is no indication that the effect is limited.

3.2. Limitations

Assessing employment effects is methodologically complex, given that estimation models need to rebuild and simplify various relationships (Lambert and Silva, 2012; Pianta, 2006). Most studies limit their analysis to specific sectors, levels of analysis and geographies (Calvino and Virgillito, 2018), see Table 3. Overall, it is difficult to compare the results of different studies (Stavropoulos and Burger, 2020). Our approach included several limitations (see Table 4) that limit the accuracy and range of our findings. Nevertheless, we that this did not restrict us in identifying major trends to discuss corresponding ethical implications. We outline further limitations resulting from data inputs and underlying assumption in the corresponding section 4.

4. Data

In this section, we describe the data used as inputs and main underlying assumptions (4.1) as well as corresponding limitations (4.2). We underline that the availability and quality of data varied. Therefore, we cross-checked our inputs and worked with ranges where exact data was not available.

4.1. Inputs and assumptions

We decided to assess employment shifts related to apparel imported to the EU from the top five countries exporting to the EU, i.e., CN, BD, TR, IN and KH. Those represent around 75 per cent of all apparel imports to the EU (EURATEX, 2018).

Inputs for Eq. (1)

We used data from the Social Hotspots Database (SHDB) for w (Benoit Norris et al., 2018). The SHDB contains a Global Input-Output database of 191 countries and 57 sectors with the above-described worker hours model (Norris et al., 2012). Thus, we could identify a wide range of CSSs involved in the production of apparel, including indirect employment.[4] EURATEX (2018) data for 2017 was used an input for e.[5] For t, we used a range of 48 and 71 working hours per week, with a total of 48 working weeks.[6] The lower range is based on the maximum legal hours (International Labour Organization, 1930, 1919), the higher range on reported working hours (Vaughan-Whitehead, 2015). Table 5 shows the input values to calculate $E_{prod,proc,manu}$.

Inputs for Eq. (2)

We calculated v as the share on the total annual consumption of

[3] Currencies were converted using the European Central Bank's (2019) Euro foreign exchange reference rates. Volatilities over time were harmonised using Eurostat's (2019) Harmonised Consumer Index Price (HCIP).

[4] SHDB modelled supply chains networks often include several thousand CSSs. To limit this number, we only included CSSs that contributed at least 0,5 per cent of the total working hours for apparel of a given value. If these CSSs represented less than 85 per cent of the total working hours, we added additional sectors until CSSs represented 85 per cent.

[5] EURATEX's (2018) 2017 values in Euro for e were converted to 2011 U.S. dollar values using Eurostat's harmonised consumer price index for clothing and the annual average Euro-U.S. dollar exchange rate (European Central Bank, 2019; Eurostat, 2019a) as the SHDB reported w in 2011 U.S. dollar values.

[6] The ILO defines a minimum of three weeks of paid leave plus national holidays (International Labour Organization, 1970).

Table 6
Input values for baseline employment $E_{logi,reta,land,reus}$

	v					***p***						***q***	***em***
	imports/consumption in thousand tonnes					capacity per FTE in thousand tonnes						share of apparel processed	indirect employment multiplier
Origin	CN	BD	TR	IN	KH	CN	BD	TR	IN	KH	Post-consumer	All	All
E_{logi}	1.524	857	536	281	207	0,045-0,067	0,050-0,075	0,085-0,127	0,055-0,083	0,044-0,066	0,113-0,170[a]/ 0,106-0,159[b]	0,85[c]/ 0,10[d]	2,0
E_{reta}	1.524	857	536	281	207	0,002-0,003	0,002-0,003	0,002-0,003	0,002-0,003	0,002-0,003	0,002-0,003	0,87[a]/ 0,08[b]	1,4
E_{land}	1.524	857	536	281	207	0,500-0,800	0,500-0,800	0,500-0,800	0,500-0,800	0,500-0,800	N/A	0,21	1.8
E_{reus}	1.524	857	536	281	207	0,050-0,070	0,050-0,070	0,050-0,070	0,050-0,070	0,050-0,070	N/A	0,66	1.8

Note. [a] Within EU
[b] Non-EU
[c] Transport of new apparel
[d] Transport of second-hand apparel and apparel for closed-loop recycling

Table 7
Input values for Eq. (3).

	Δred		***Δreu***		***Δrec***		***Δreo***		***a***	***b***	***c***	***d***	***q***
	changes in the quantity of processed raw materials								effect factor				share of processed raw materials in the baseline
Scenario	I	II	I	II	I	II	I	II	I, II	I, II	I, II	I, II	I, II
E_{prod}	0,01	0,02	0,11	0,19	0,01	0,03	0,11	0,16	-1,00	-0,50	-0,90	0,00	1,00
E_{proc}	0,01	0,02	0,11	0,19	0,01	0,03	0,11	0,16	-1,00	-0,50	0,00	0,00	1,00
E_{manu}	0,01	0,02	0,11	0,19	0,01	0,03	0,11	0,16	0,00	-0,50	0,00	0,00	1,00
E_{logi}	0,01	0,02	0,11	0,19	0,01	0,03	0,11	0,16	0,00	-0,50[a]/ 1,0[b]	0,00[a]/ 0,90[b]	0,00	0,85[a]/0,10[b]
E_{reta}	0,01	0,02	0,11	0,19	0,01	0,03	0,11	0,16	0,00	0,50	0,00	0,00	0,87[c]/0,08[d]
E_{land}	0,01	0,02	0,11	0,19	0,01	0,03	0,11	0,16	0,00	-1,00	-1,00	-1,00	0,66
E_{reus}	0,01	0,02	0,11	0,19	0,01	0,03	0,11	0,16	0,00	1,00	1,00	1,00	0,21

Note. [a] Transport of new apparel
[b] Transport of second-hand apparel and apparel for closed-loop recycling
[c] Within EU
[d] Non-EU

apparel, using Eurostat data reported by Gray (2017) and EURATEX (2018). To determine *q*, we used several sources, as described above. Therefore, we cross-checked all values to ensure sufficient data accuracy. For *p*, we took capacities for employment in post-consumer processing ($E_{reus,land}$) from other waste management employment studies (European Commission, 2001; RREUSE, 2015; Tellus Institute and Sound Resource Management, 2011). For employment in logistics and retail ($E_{logi,reta}$), we similarly calculated *p* based on employment data and the annual volume of apparel processed.[7] We used ranges for *p* as we do not want to pretend absolute accuracy. We took values for the multiplier *em* from the UK's Office of National Statistics (Office for National Statistics, 2017). We determined the EU as the location of employment for sales of new apparel and all post-consumer processing ($E_{reus,land}$) (Korolkow, 2015).[8] (Jongerius, 2012). Employment in logistics to transport new apparel was divided equally between exporting countries and the EU while exports of second-hand sale and closed-loop recycling were divided equally between the EU and a cluster of non-specified rest of world (RoW) cluster, mainly low- to lower-middle-income countries (United Nations Statistics, 2020).

Inputs for Eq. (3)

We determined two scenarios, a policy target scenario (scenario I) and a more ambitious benchmark scenario (scenario II), see Fig. 2. The scenario I is based on EU legislation that by 2025 Member States are obliged to collect households' textile waste separately and to process 55 per cent of the overall household waste for reuse or recycling (European Commission, 2018a). We, therefore, assumed that 55 per cent of apparel is separately collected and sorted, including a moderate increase in closed-loop recycling as well as moderate pre-consumer waste reduction. In Scenario II, we assumed an average EU collection quota at the level of Germany's current quota of around 75 percent (Korolkow, 2015) as well as 10 percent closed-loop resource cycles and a reduction of pre-consumer waste of 10 percent based on the Dutch Ministry of Infrastructure and Water Management and Platform Circulair Textiel roadmap objectives (Dutch Ministry of Infrastructure and Water Management and Platform Circulair Textiel, 2017; Platform Circulair

[7] For E_{reta}, we interpolated Eurostat data on employment in clothing retail in specialised stores that accounted for 54 per cent of sales in Europe and divided it by the annual consumption of apparel (Euromonitor International, 2018; Eurostat, 2019b; Gray, 2017). For employment in E_{logi}, we needed to consider different types of transport (sea, air, road) and distances. We calculated employment by transport type per tonne-mile based on World Maritime University (2018), and assumed for new apparel that 92 per cent is transported by sea and 8 per cent by air freight plus an additional 600 kilometres of road transport (Beton et al., 2014). For post-consumer transport, we assumed transport by sea freight of the average miles from EU to CN, BD, TR, IN and KH plus an additional 600 kilometres of road transport for exports, and 600 kilometres of road transport for destinations in the EU. Distance was based on the distance between the major cargo ports/airports in the exporting country and the EU (EU: Rotterdam/Frankfurt, CN: Shanghai/Hongkong, BD: Chittagong/Dhaka, TR: Istanbul/Istanbul, IN: Mumbai/New Delhi, KH: Sihanoukville/Phnom Phen).

[8] To date, most closed-loop (cotton) recycling processors are located either in the US or Europe (see appendix C). We assume that these activities will remain in high-technology economies until the technologies are mature and cost-effective. At a later stage, facilities might be relocated.

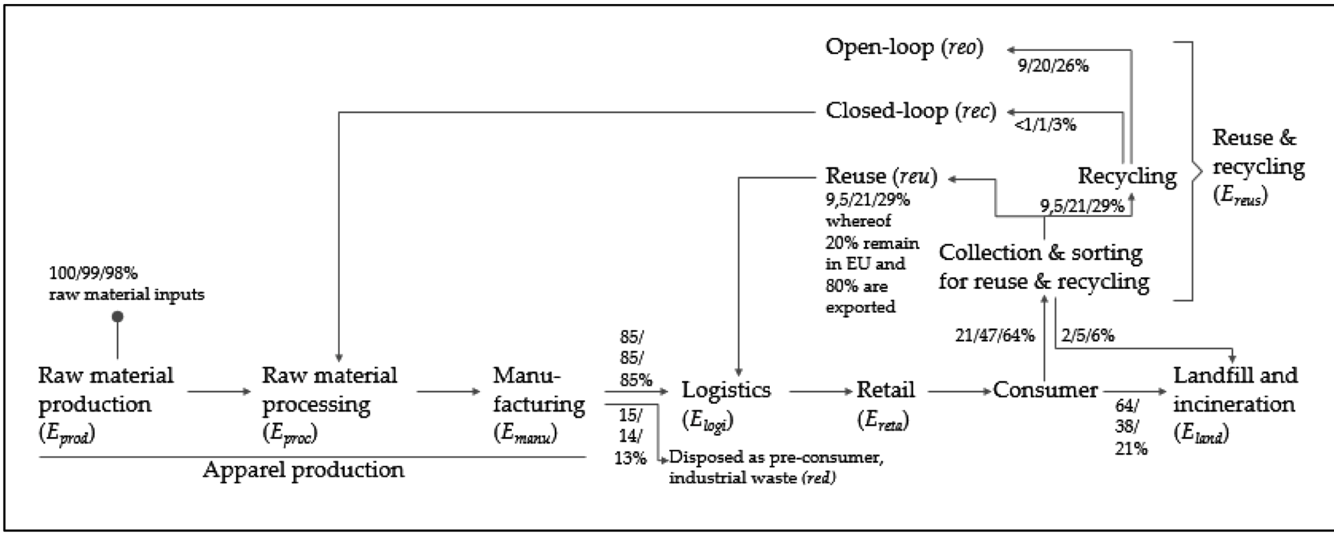

Fig. 2. Baseline and CE scenarios (baseline/scenario I/scenario II), percentages rounded.

Textiel, 2017).

We then determined if the scenarios, i.e. changes in *red, reu, rec, reo*, could affect the employment and to what extent. We assumed the following:

- *red:* Less demand for raw materials results in decreasing $E_{prod,proc}$, with an effect factor *a* of -1,0. Other sectors are not affected.
- *reu*: The purchase of a second-hand piece substitutes 0,5 pieces of new apparel (Castellani et al., 2015; Nørup et al., 2019) that results in decreasing $E_{prod,proc,manu}$ and increasing $E_{reta,}$ with the effect factor *b* limited to -0,5, respectively 0,5. E_{logi} increases for the transport of second-hand apparel by factor 1,0, while E_{logi} decreases by factor -0,5 for the transport of new apparel. E_{reus} increases while E_{land} decreases, with *b* at 1,0, respectively -1,0.
- *rec, reo*: A higher recycling share results increasing E_{reus} while E_{land} decreases, with factors *c* and *d* at 1,0, respectively -1,0. E_{prod} decreases for *rec* as recycled inputs replace raw material as virgin materials, while E_{logi} increases due to transport of recycled materials. The effect factor *c* is limited to -0,9, respectively 0,9, as recycled materials lose replacement quality with each recycling cycle (Sandin and Peters, 2018). Contrary, *reo* does not affect $E_{prod,proc,manu,logi,reta}$ as recycled materials do not re-enter apparel value chains.

We projected effects per country-specific employment sector for effects within the value chains for apparel imported to the EU from CN, BD, IN, TR, and KH. As a large degree of second-hand apparel is exported from the EU to 164 different countries, mainly to low- to middle-income countries (United Nations Statistics, 2020), we also included employment effects of *reu* on apparel value chains of second-hand apparel importing non-EU countries and its apparel imports, respectively production. For example, Pakistan received around 13 per cent of all EU exports. These partly substitute consumption of new apparel that was either produced in Pakistan or imported through GVCs. For these chains, we used the weighted average of inputs used value chains for apparel imported to the EU from CN, BD, IN, TR, and KH as approximations and reported the location as low- to middle-income RoW.

4.2. Limitations

Our study, similar to other studies (Pianta, 2006), needed to include numerous assumptions and deal with the challenge of a lack of adequate data. Overall, we used data of varying quality and derived our assumptions from various sources. Even though we cross-checked our assumptions and the quality of the data, our approach includes a certain degree of inconsistency and inaccuracy. Though this might not affect the overall direction and scale of shifts, employment effects in absolute numbers might have been over- or underestimated. Therefore, generalizability, comparability and forecasting accuracy are restricted. Nevertheless, this does not limit us to identify and discuss the implications of major CE-induced global employment trends. Table 8 outlines the major limitations and corresponding directions for future research.

5. Results and discussion

In this section, we present and discuss the implications of our results. For this, we first present the fundamental dynamics of CE-induced employment effects using the results of our analysis of apparel value chains based on the approach described above. We then assess the results in the light of Jenkins et al.'s (2018) global framework and discuss the implications for different stakeholders, including policy-makers and practitioners.

5.1. CE-induced employment effects

Overall, our results indicate that a circular shift in the apparel industry in the EU could result in a decline of employment in low- to upper-middle-income countries outside of the EU of -297 to -437/ -513 to -756 thousand FTE (scenario I/scenario II), in particular in apparel production ($E_{prod,proc,manu}$). In the EU, employment could increase by 37 to 54/ 63 to 91, especially in the retail of second-hand apparel (E_{reta}) and reuse and recycling activities (E_{reus}).

Employment in apparel production decreases the largest. E_{prod} decreases by 83 to 122/153 to 226, E_{proc} by 70 to 103/119 to 177 and most significantly E_{manu} by 162 to 240/271 to 400 thousand FTE. Indirect employment through apparel production declines by 59 to 88/99 to 146, especially in trade and other business services. E_{logi} remains almost constant as shrinking transport of new apparel is outweighed by rising transport of second-hand apparel. E_{reta} increases substantially by 68 to 102/113 to 170 plus indirect employment of 25 to 38/42 to 63 as sales of second-hand apparel generate additional retail activities. Employment in post-consumer processing rises as E_{reus} increases by 11 to 16/19 to 26 plus indirect employment of 9 to 13/16 to 22. At the same time, E_{land} decreases by -1/-1 to -2 and related indirect employment of up to -1/-1.

Our results, in line with the ILO's (2018) and Wiebe et al.'s (2019) findings, indicate that positive and negative employment effects could be unevenly distributed across geographies depending on the spatial spread of value chain activities and that the EU might benefit in terms of

Table 8
Limitations resulting from assumptions and data used.

Limitation	Rationale	Directions for future research
Analysis limited to apparel from CN, BD, TR, IN, and KH: We did not assess the effects of the scenarios on employment from apparel produced in the EU or other countries.	Included countries represent 75 per cent of all apparel imports to the EU (EURATEX, 2018). They are lower- and upper-middle-income countries (World Bank, 2018).	Extend the selection of countries of origins while keeping sector-specific country levels.
Calculation of baseline $E_{prod,proc,manu}$ based on SHDB's worker hours model and annual working hours: Inputs are approximations. The worker hours model is based on various assumptions and sources (Norris et al., 2012). The annual working hours are estimated based on ILO regulations (International Labour Organization, 1930, 1919) and a study by Vaughan-Whitehead, 2015.	The SHDB is a widely applied database, see, for example, Zamani et al. (2018). We chose this database because of its sector and country breakdown. We included a range for annual working hours to avoid pretending absolute accuracy.	Verify the worker hours model, for example, by comparing PSILCA's (Eisfeldt, 2017) and SHDB's values. Determine detailed working hours per FTE in raw material production, processing and apparel manufacturing for different countries.
Calculation of baseline $E_{logi,reta,land,reus}$ based on processing capacities per FTE: The 'capacity per FTE' approach is prone to inaccuracy if assumptions are imprecise. For $E_{logi,reta,}$ we needed to calculate capacities based on available data. We could not refer to capacities reported by other studies.	Several other studies (European Commission, 2001; RREUSE, 2015; Tellus Institute and Sound Resource Management, 2011) applied the 'capacity per FTE' approach. We used ranges to avoid pretending absolute accuracy and cross-checked capacities where possible.	Analyse processing capacities, in particular for different post-consumer activities per waste type to improve the accuracy of employment effects projections.
Value chains of new apparel consumption for countries importing EU second-hand apparel simplified: We modelled apparel value chains of second-hand apparel importing non-EU countries and its apparel imports, respectively production based on a weighted average of inputs used value chains for apparel imported to the EU from CN, BD, IN, TR, and KH and reported the location as low- to middle-income RoW.	Second-hand apparel is exported from the EU to 164 countries. For most of these, no split of the origin of apparel consumption is available. Moreover, a detailed analysis would result in more thousands of new value chains to be modelled. In line with Pianta (2006), employment estimations need to simplify relationships to the degree that allows analysis and is relevant to answer the research question.	Conduct an empirical study on country-specific global employment effects of second-hand consumption in low- and lower-income countries.
Employment effects limited to direct relationships: We did not consider further indirect effects, such as rebound mechanisms. Those could, for example, arise from additional consumption through price effects (Zink and Geyer, 2017).	We did not include further effects, similar to other studies, for example, Donati et al. (2020).	Extend the analysis on employment effects to induced employment and outside value chains effects, including the use of standardised CE transition scenarios frameworks to increase comparability of future results.

employment. Our finding of significant negative employment effects in apparel production seems to contradict with the positive global net employment effect that the ILO and Wiebe et al. have calculated for the CE. However, we did not calculate net employment effects, applied different approaches and scenarios and assessed different sectors. For example, the sectors assessed by the ILO (plastics, glass, wood pulp, metals and mineral) might differ in terms of labour-intensity of downstream production and upstream recycling activities. For instance, plastic recycling requires around twice as much labour inputs as textile reuse and recycling processing (Beton et al., 2014). Thus, the comparison does not seem to be appropriate, as discussed by Donati et al. (2020). They reported a global negative net employment effect.

Moreover, our results coincided with EU-focused studies that underline the labour-friendly dynamic of the CE of creating jobs within the EU (European Commission, 2018b, 2015b, 2015a, 2014a; Mitchell and James, 2015). Following other studies (Bastein et al., 2013; Circle Economy and Erasmus Happiness Economics Research Organisation, 2017; Deboutière and Georgeault, 2015; European Commission, 2018b, 2015a, 2015b, 2014a; Ministère de l'Economie et al., 2015; Mitchell, 2015; Mitchell and James, 2015; Morgan and Mitchell, 2015b; Stegeman, 2015), new jobs in the circular apparel value chain will emerge in downstream reuse and recycling activities located in the EU. Even though these activities will replace jobs in landfill and incineration activities, the employment effect is positive. The reason for this is, that reuse and recycling activities require a more significant amount of manual work, such as apparel quality sorting than landfilling and incineration activities (Beton et al., 2014; Hawley, 2006). Interestingly, and not yet discussed in the context of the CE, employment in retail increases, as sales of second-hand apparel increases do not partly substitute sales of new apparel. This results in additional retail employment both in the EU and low- to upper-middle-income countries because most second-hand apparel is consumed outside of the EU.

As stated by Stegeman (2015) as well as Mitchell and James (2015), positive effects in the EU might be outweighed by less employment outside the EU. Our results now underpin these remarks with the finding for apparel value chains that such job decline is likely in labour-intense upstream activities outside the EU. For apparel imported to the EU, based on the value chains analysed, this would mean that especially major apparel producer such as China, Bangladesh, India, Cambodia,

Table 9
CE-induced employment effects in the EU and non-EU low- to upper-middle-income countries for apparel imported from China, Bangladesh, India, Turkey and Cambodia to the EU, in thousand FTE.

Region	Change in employment in FTE Scenario I	Scenario II
EU	37 -54	63 -91
Non-EU (low- to upper-middle-income countries)	-297 –437	-513 –756

Note. Change in employment based on totals of results reported in Table 11 and 12.

Table 10
CE-induced employment effects per employment sector for apparel imported from China, Bangladesh, India, Turkey and Cambodia to the EU, in thousand FTE.

E		Change in employment Scenario I	Scenario II
Prod	Direct	-83 –122	-153 –226
Proc	Direct	-70 –103	-119 –177
Manu	Direct	-162 –240	-271 –400
Prod, Proc, Manu	Indirect	-59 –88	-99 –146
Logi	Direct	1 -1	2 -3
Logi	Indirect	1 -1	2 -3
Reta	Direct	68 -102	113 -170
Reta	Indirect	25 -38	42 -63
Land	Direct	-1 –1	-1 –2
Land	Indirect	0 –1	-1 –1
Reus	Direct	11 - 16	19 -26
Reus	Indirect	9 -13	16 -22

Note. Baseline employment and change in employment based on totals of results reported in Table 11 and 12.

Table 11
CE-induced employment effects per sector and location for employment in the value chains for apparel imported from China, Bangladesh, India, Turkey and Cambodia to the EU, in thousand FTE.[9][10][11][12]

E		Location	Baseline employment	Changes in employment Scenario I	Scenario II
Prod	Direct	CN	508 -751	-15 –23	-33 –48
		BD	283 -418	-9 –13	-18 –27
		IN	183 -271	-6 –8	-12 –17
		XSU	36 -53	-1 –2	-2 –3
		KH	36 -53	-1 –2	-2 –3
		PK	33 -49	-1 - -1	-2 –3
		RoW	5 -7	<0 -<0	<0 -<0
		TR	4 -7	<0 -<0	<0 -<0
Proc	Direct	CN	521 -770	-11 –17	-20 –30
		BD	347 - 513	-7 - -11	-14 –20
		IN	95 -140	-2 - -3	-4 –5
		TR	25 - 38	-1 –1	-1 –1
		KH	23 -35	-1 –1	-1 –1
		RoW	21 - 32	<0 –1	-1 –1
Manu	Direct	BD	1.220 - 1.803	-14 –21	-23 –34
		CN	612 - 905	-7 –10	-12 - -17
		KH	638 -943	-7 –11	-12 –18
		IN	259 -383	-3 –4	-5 –7
		TR	104 -153	-1 –2	-2 –3
Prod, Proc, Manu	Indirect	BD	607 -897	-7 –10	-12 –17
		CN	190 -280	-2 –3	-4 –5
		IN	129 -190	-1 –2	-2 –4
		KH	45 -66	-1 –1	-1 –1
		TR	53 -79	-1 –1	-1 –2
		RoW	9 -13	<0 -<0	<0 -<0
Logi	Direct	EU	20 -31	1 -2	2 -3
		CN	10 -15	<0 -<0	<0 -<0
		BD	5 -7	<0 -<0	<0 -<0
		IN	2 -3	<0 -<0	<0 -<0
		TR	1 -2	<0 -<0	<0 -<0
		KH	1 -2	<0 -<0	<0 -<0
		RoW	1 -1	1 -2	2 -3
Logi	Indirect	EU	21 -31	1 -2	2 -4
		CN	10 -15	<0 -<0	<0 -<0
		BD	5 -8	<0 -<0	<0 -<0
		IN	2 -3	<0 -<0	<0 -<0
		TR	1 -2	<0 -<0	<0 -<0
		KH	1 -2	<0 -<0	<0 -<0
		RoW	1 -1	1 -2	2 -3
Reta	Direct	EU	858 -1.287	11 -17	19 -28
		RoW	76 -113	113 -170	189 -283
Reta	Indirect	EU	317 -476	4 -6	7 -10
		RoW	28 -42	42 -63	70 -105
Land	Direct	EU	1 -3	-1 –1	-1 –2
Land	Indirect	EU	1 -2	<0 –1	-1 –1
Reus	Direct	EU	10 -14	11 -16	19 -26
Reus	Indirect	EU	9 -12	9 -13	16 -22

Note. We calculated baseline employment using Eq. (1) and Eq. (2), as described in section 3 and 4. Change in employment calculated using Eq. (3). Employment for logistics decreased for the transport of new apparel, while it increased for the transport of second-hand apparel.

and Turkey would be affected. For an economy as Bangladesh that is heavily reliant on apparel production, accounting for 80 per cent of the country's total exports (Bangladesh Garment Manufacturers and Exporters Association, 2018), such effects could have economy-wide socio-economic consequences. Effects would be stronger in India, Bangladesh and Cambodia as in China and Turkey as the former are less efficient, thus requiring more labour inputs to produce apparel. Table 11 shows the corresponding results for effects on employment in the value chains for apparel imported to the EU from CN, BD, IN, TR, KH.

[9] See appendix D for country abbreviations.
[10] BF, EG, ET, ID, KG, TH, UA, US, VN.
[11] EG, ET, ID, KR, MY, PK, TH, VN, XSU.
[12] EG, ID, PK, UA, US, VN, XNF, XSU.

Table 12
CE-induced employment effects per employment sector in RoW low- to middle-income countries due to second-hand apparel imports from the EU for apparel imported from China, Bangladesh, India, Turkey and Cambodia to the EU, in thousand FTE.

E		Change in employment Scenario I	Scenario II
Prod	Direct	-50 –74	-83 –123
Proc	Direct	-47 –70	-79 –117
Manu	Direct	-130 –192	-217 –320
Prod, Proc, Manu	Indirect	-47 –70	-79 –117
Logi	Direct	-1 –2	-2 –3
Logi	Indirect	-1 –2	-2 –3
Reta	Direct	-57 –85	-94 –142
Reta	Indirect	-21 –31	-35 –52

Note. We calculated the change in employment using Eq. (3), with a weighted average of inputs used for value chains for apparel imported to the EU from CN, BD, IN, TR, and KH as approximations, as described in section 3 and 4#sec4.

However, major employment would also take place outside value chains for apparel imported to the EU from CN, BD, IN, TR, KH. These are effects caused by the consumption of second-hand apparel from the EU in non-EU economies. The consumption of second-hand apparel in these countries substitutes the consumption of new apparel in these countries and not the EU. This means that for the 80 per cent of EU's second-hand apparel that is mainly exported to low- to lower-middle-income countries employment effects take place are decoupled from the value chains producing new apparel for the EU. Table 11 shows the corresponding trends.

Our assessment implies that negative employment effects for countries involved in apparel production are the higher, the more upstream the activities take place. For example, in scenario II the relative employment effect is -14 per cent for E_{prod} in comparison to -10 per cent for E_{manu}. The reason for this is, that while all circular strategies aim for less raw material production, some do not target later upstream processes such as manufacturing. For example, recycling strategies as prominent approaches in a circular fashion, do not necessarily aim for less apparel manufacturing, but less production of virgin materials such as cotton. Consequently, major raw cotton producers, such as China, India, and Uzbekistan, could be urged to develop strategies to deal with the implementation of circular strategies in downstream activities.

5.2. Implications

Employment is a critical condition for the achievement of social sustainability (Littig and Grießler, 2005). In low- and middle-income countries, individuals require employment to cover their living expenses, as there are no or minimal social security benefits in the case of unemployment (Ginneken, 1999; Jütting, 2000; Majid, 2001). Previous studies that we discussed earlier in this paper forecasted employment or economic growth effects. Scholars often discussed positive social effects in the EU such as lowering unemployment rates or overall economic growth (see, for example, Mitchell, 2015; Mitchell and James, 2015; Morgan and Mitchell, 2015). However, they did not discuss those regarding their ethical implications, including the contribution to social sustainability. Other scholars that explicitly discussed if the CE should contribute to social sustainability argued normatively but did not assess this question empirically (see Moreau et al., 2017; Murray et al., 2017). Therefore, we assess the implications of our empirical results from a distributional, recognition and procedural perspective, based on the ethical framework for global transformative change. Overall, our CE scenarios assume changes on the regime level.

On the distributional level, our results indicate that the transition could result in unevenly distributed benefits and disadvantages. Low- to upper-middle-income economies that are reliant on raw material production, processing or apparel manufacturing could experience decrease shortfalls resulting in job losses. In contrast, economies in the EU could capture economic benefits resulting in increased employment. More generally, we see that low- and middle-income-countries that rely on resource extraction, processing or manufacturing, might face socio-economic risks. At the same time, innovative and advanced industries might benefit from new circular value creation. In this context, (Schroeder et al., 2018) underline that "powerful countries and transnational corporate actors already control the majority of GVCs, and even in a circular system, they are likely to continue to capture the resources and capital they need, exacerbating existing inequalities" (p.77).

For the recognition and procedural level, we recognise that corresponding legislation enforcing the circular transition in the EU lacks global ethical considerations and corresponding procedures. While the EU's transition will have global effects, its policy promotion seems to follow a rather regional approach. Gregson et al. (2015) argue that EU policies follow an 'imperative' to create jobs and growth within the EU. Moreover, a recent study commissioned by the European Commission disregarded employment effects outside the EU (European Commission, 2018b). In terms of policies, the EU's 2015 CE action plan (European Commission, 2015c) does not include specific remarks on employment or other social objectives outside the EU. It only refers to the EU's 2014 Green Employment Initiative that vaguely states that the EU "will […] encourage partner countries in adopting the integrated approach for greening their economies" (European Commission, 2014b, p.12). The 2017 review of the implementation of the 2015 CE action plan neither included a review of the social impacts nor stated any action taken in line with the above statement (European Commission, 2017). On the recognition level, therefore, one could argue that the EU's CE transition focusses on benefits for EU citizens and economy. In contrast, non-EU economies, in particular workers outside the EU, are disregarded. In line with this, on the procedural dimension, the process of implementing the CE transition in the EU does not systematically involve views of other relevant stakeholders of GVC. Overall, we find that the EU's transition compromises issues of justice that result in implications for different stakeholders.

Policymakers in the EU could reassess the ethical dimension of its CE policies and to align those with global sustainability goals. Specifically, policies should be assessed against and include social criteria, such as justice dimensions of the ethical framework for global transformative change (Jenkins et al., 2018). Policymaker need to recognise that corporate sustainability practices cannot be achieved without trade-offs within and across different sustainability dimensions (see Unay--Gailhard & Bojnec (2019) for a recent empirical example) (Hahn et al., 2010; Walsh and Margolis, 2003). They need to question the universal notion of a win-win situation for all stakeholders (Hahn et al., 2010; Walsh and Margolis, 2003). Instead, policies include trade-offs between different dimensions and time horizons and should. Consequently, revised policies should include measures to counterbalance one-sided EU interests, for example, through programmes supporting CE developments in low- and middle-income non-EU countries. Metrics and CE understandings that include social consideration could enhance informed decision making (Alaerts et al., 2019; Badri Ahmadi et al., 2017; Corona et al., 2019; Moraga et al., 2019; Reike et al., 2018).

Policymakers from low- to middle-income countries, including those analysed, should consider promoting a more substantial involvement of their economies in circular practices. While in China the promotion of the CE is a priority on the national agenda (McDowall et al., 2017), the discussion and implementation in other countries are rather in its early stages (Geng et al., 2019; Goyal et al., 2018; Güngör, 2019; Okay, 2019). Low demand from customers, little financial benefits and a lack of government regulations impede the implementation of environmental practices in the Bangladeshi textile industry (Tumpa et al., 2019). Similarly, the lack of regulations and tax relief schemes are two main barriers to implement circular supply chains in India (Mangla et al., 2018). Policies could include promotion schemes, sector knowledge enhancement, reskilling schemes for workers (Burger et al., 2019), research funds, public awareness campaigns (Moktadir et al., 2018) and collaboration programmes with partner countries along GVCs.

Circular fashion players can be seen as the leading actors in value chains as their decisions significantly influence up- and downstream activities (Köksal et al., 2018; Seuring and Müller, 2008; Stål and Corvellec, 2018). Stål and Corvellec (2018) report that some larger fashion players decouple their circular measures from their core businesses models by outsourcing or internal separation. This question their willingness to adjust their business models to reduce the material footprint of their goods. Our results now imply that companies should, also, consider the employment impact of their circular measures following distributional, recognition as well as procedural justice dimensions. This could involve collaboration with up- and downstream partners in the transition towards circularity to avoid one-sided (employment) effects and build competencies along the value chain. For the development of the overall industry, our scenarios project a decrease in demand for labour if in a smaller material footprint, including less consumption, is achieved. This would be major disruption for an industry that, until now, relied on increasing consumption. No matter if one of these scenarios will become reality, the current combination of enforcing and supporting circular policies and emerging circular fashion practices will likely change the configuration of apparel value chains of the European apparel industry. Following Gregson et al. (2015), recycling and reuse loops for valuable apparel could be closed within the EU, while non-valuable apparel would be exported. In combination with other trends, such as nearshoring to decrease lead times and increasing sustainability demands by customers to produce locally, this could result in the relocation of jobs to the EU or neighbouring countries. However, its remain questionable, if this development would include remarkable justice consideration.

Hence, all stakeholders, including the wider society, need to agree on the CE's role within sustainable development to allow an informed assessment of its progress and limitations: Do circular practitioners that also want to contribute to social sustainability call their approach "fair" CE or does CE already imply this intention? What impact do customers expect when they buy a circular product? This discourse could start with a discussion around the distribution of benefits and disadvantages as well as trade-offs between economic, environmental and social objectives. Minimum requirements per sustainability dimension could help to set a bar for a socially fair, economic sustaining and environmentally benefitting CE.

Overall, the CE is as a global approach with the need for global policies and collaboration. The application cannot be limited to regional boundaries as this does not correspond with the global flow of materials and impacts (see also Geng et al. (2019)). While our research approach focused on the CE, implications from our results raise similar questions for the broader concept of sustainable development on achieving 'just' sustainability. The target function of sustainable development, specified for example in the SDGs, shows the diverse and potentially conflicting mix of objectives ranging from ending poverty to protecting environmental services to enabling decent work and economic growth (cf. Singh et al., 2018). Moreover, the implementation of sustainable measures itself depends on complex and varying contexts that all "exemplify challenges of ambivalence, uncertainty and distributed power, but to varying degrees" (Voß et al., 2007, p.194). Advanced economies that promote the design of sustainable business models and technologies have the power to change existing practices along GVCs and can take significant benefits from such transitions. Other, less powerful economies might just reactively adjust their services and products. In order to achieve global, not regional, sustainable development decisions on sustainability measures, in particular on the final distribution of benefits and disadvantages as well as trade-offs between different objectives, should be made independent of power structures. Stakeholders should admit that decisions on sustainability are normative and based on complex sets of interests.

6. Conclusion

Only a small number of scholars sees the CE as an approach to achieve sustainable development in all its dimensions. Many scholars disregard that the transition towards the CE will have intended and unintended social impacts that could either contribute to or contradict with social sustainability. However, the CE transition in the EU, and elsewhere, is likely to affect employment, as a critical dimension of social well-being. Most available studies on employment effects of the CE transition in the EU limited their employment effects to those in the European Union (EU). At the same time, many industry sectors, such as the apparel industry, now operate GVCs with employment spread across different geographical locations (Gereffi, 1999). This study provides the first sector-specific empirical study on the employment effects of the EU transition on a global scale, with a focus on the ethical dimensions of those effects. Furthermore, it contributes to the broader discussion of CE-induced social effects of sustainability transitions and provides implications policy-makers and circular fashion enterprises.

For this, we exemplarily assessed potential CE-induced major employment shifts in the value chain of apparel imported to the EU from the top five exporting countries, i.e., China, Bangladesh, India, Cambodia and Turkey. We discussed the results from a distributional, recognition and procedural perspective, based on the ethical framework for global transformative change. On the distributional level, the results indicate that the transition could result in unevenly distributed benefits and disadvantages. The CE transition could lead to a significant decrease in employment in low- to upper-middle-income countries outside the EU, in particular for labour-intense apparel production. Employment could increase in less-labour intense downstream reuse and recycling activities in the EU and second-hand retail in- and outside the EU. For the recognition and procedural level, we recognise that corresponding legislation enforcing the circular transition in the EU lacks global ethical considerations and corresponding procedures. While the EU's transition will have global effects, its policy promotion seems to follow a rather regional approach.

Overall, the EU's transition compromises issues of justice that result in implications for different stakeholders. Policymakers in the EU could reassess the ethical dimension of its policies and align those with sustainability goals. Policymakers from low- to middle-income countries should consider promoting a more substantial CE involvement of their economies. Circular fashion companies should make more informed decisions on the employment impact of their circular measures following distributional, recognition as well as procedural justice dimensions. Furthermore, all stakeholders need to agree on the CE's role within sustainable development to allow an informed assessment of its impacts.

Our study has several limitations. Overall, our estimation model needed to rebuild and simplify various relationships, included data of varying quality and relied on our assumptions from various sources. Even though we cross-checked our assumptions and the quality of the data, our approach includes a certain degree of inconsistency and inaccuracy. Though this might not affect the overall direction and scale of shifts, employment effects in absolute numbers might have been over- or underestimated. Therefore, generalizability, comparability and forecasting accuracy of this study are restricted.

The discussion of our results, as well as the limitations of our study, provide promising paths for future research. First, further research could help corporate and policy decision-makers to make more informed trade-off decision on intended social effects of the CE by researching actual social, environmental and economic effects of different circular business models, designs of downstream and upstream commodity chains as well as CE regulations. This would require a more comprehensive analysis of social effects beyond employment. Second, empirical studies could investigate to what extent current circular businesses aim for social, economic and environmental objectives to enhance the discussion of whether the CE aims for all dimensions of sustainable development. Finally, we believe that research on the CE needs to extend its *macro* perspective to the global scale; as the *macro level* is often defined as only up to national level (cf. Merli et al., 2018). Analytical limitations should not necessarily follow regional or national borders without justification. graphical abstract

No graphical abstract for this paper

Declaration of Competing Interest

There are no conflicts of interest. The study did not receive specific funding from any organization.

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Appendices

Appendix A

Table A.1

Table A.1
Input values for w (Benoit Norris et al., 2018).

Exporting country	*E*		Activity	Location	*w*
CN	Manu	Direct	Wearing apparel	CN	5,64E-02
CN	Proc	Direct	Textiles	CN	3,54E-02
CN	Prod	Direct	Plant-based fibers	CN	9,25E-03
CN	Prod	Direct	Chemical, rubber, plastic products	CN	6,14E-03
CN	Prod	Direct	Vegetables, fruit, nuts	CN	6,13E-03
CN	Prod	Direct	Cereal grains nec	CN	5,40E-03
CN	Prod	Direct	Bovine cattle, sheep and goats, horses	CN	5,24E-03
CN	Manu	Indirect	Business services nec	CN	4,55E-03
CN	Manu	Indirect	Trade	CN	4,26E-03
CN	Proc	Direct	Leather products	CN	2,90E-03
CN	Prod	Direct	Paddy rice	CN	2,82E-03
CN	Manu	Indirect	Transport nec	CN	2,67E-03
CN	Prod	Direct	Forestry	CN	2,58E-03
CN	Manu	Indirect	Financial services nec	CN	2,49E-03
CN	Prod	Direct	Plant-based fibers	IN	2,18E-03
CN	Prod	Direct	Wool, silk-worm cocoons	CN	2,02E-03
CN	Prod	Direct	Wheat	CN	1,94E-03
CN	Proc	Direct	Paper products, publishing	CN	1,79E-03
CN	Prod	Direct	Animal products nec	CN	1,59E-03
CN	Prod	Direct	Plant-based fibers	XSU	1,51E-03
CN	Manu	Indirect	Machinery and equipment nec	CN	1,27E-03

(continued on next page)

Table A.1 (*continued*)

Exporting country	*E*		Activity	Location	*w*
CN	Manu	Indirect	Electricity	CN	1,10E-03
CN	Prod	Direct	Oil seeds	CN	1,02E-03
CN	Manu	Indirect	Recreational and other services	CN	9,40E-04
BD	Manu	Direct	Wearing apparel	BD	2,00E-01
BD	Manu	Indirect	Trade	BD	7,50E-02
BD	Proc	Direct	Textiles	BD	5,34E-02
BD	Prod	Direct	Plant-based fibers	BD	4,59E-02
BD	Manu	Indirect	Transport nec	BD	1,24E-02
BD	Prod	Direct	Plant-based fibers	IN	1,04E-02
BD	Proc	Direct	Textiles	CN	9,10E-03
BD	Manu	Indirect	Water transport	BD	7,42E-03
BD	Prod	Direct	Plant-based fibers	PK	4,58E-03
BD	Manu	Indirect	Financial services nec	BD	4,02E-03
BD	Proc	Direct	Textiles	IN	3,52E-03
BD	Proc	Direct	Paper products, publishing	BD	2,87E-03
BD	Prod	Direct	Plant-based fibers	CN	2,48E-03
TR	Manu	Direct	Wearing apparel	TR	2,71E-02
TR	Manu	Indirect	Trade	TR	7,40E-03
TR	Proc	Direct	Textiles	TR	5,90E-03
TR	Prod	Direct	Plant-based fibers	XSU	2,89E-03
TR	Manu	Indirect	Financial services nec	TR	2,09E-03
TR	Proc	Direct	Textiles	ID	1,75E-03
TR	Prod	Direct	Wool, silk-worm cocoons	XSU	1,52E-03
TR	Proc	Direct	Textiles	CN	1,39E-03
TR	Manu	Indirect	Business services nec	TR	1,32E-03
TR	Prod	Direct	Plant-based fibers	PK	1,25E-03
TR	Prod	Direct	Plant-based fibers	IN	1,10E-03
TR	Manu	Indirect	Electricity	TR	1,05E-03
TR	Proc	Direct	Textiles	VN	9,44E-04
TR	Proc	Direct	Textiles	IN	8,39E-04
TR	Manu	Indirect	Trade	BD	8,27E-04
TR	Manu	Indirect	Transport nec	TR	8,17E-04
TR	Proc	Direct	Textiles	BD	8,08E-04
TR	Prod	Direct	Plant-based fibers	BD	7,07E-04
TR	Proc	Direct	Leather products	TR	6,12E-04
TR	Prod	Direct	Chemical, rubber, plastic products	CN	4,55E-04
TR	Prod	Direct	Vegetables, fruit, nuts	XSU	4,42E-04
TR	Manu	Indirect	Trade	ID	
					4,06E-04
TR	Proc	Direct	Textiles	PK	3,85E-04
TR	Prod	Direct	Plant-based fibers	CN	3,66E-04
TR	Manu	Indirect	Transport nec	PK	3,31E-04
TR	Proc	Direct	Textiles	EG	3,17E-04
TR	Proc	Direct	Textiles	ET	3,08E-04
TR	Manu	Indirect	Water transport	TR	3,04E-04
TR	Proc	Direct	Textiles	TH	2,84E-04
TR	Prod	Direct	Vegetables, fruit, nuts	CN	2,71E-04
TR	Prod	Direct	Plant-based fibers	TR	2,65E-04
TR	Proc	Direct	Textiles	XSU	2,56E-04
TR	Prod	Direct	Minerals nec	TR	2,28E-04
TR	Manu	Indirect	Recreational and other services	TR	2,14E-04
TR	Prod	Direct	Cereal grains nec	CN	2,12E-04
TR	Prod	Direct	Vegetables, fruit, nuts	TR	2,02E-04
TR	Prod	Direct	Bovine cattle, sheep and goats, horses	CN	1,97E-04
TR	Manu	Indirect	Trade	EG	1,91E-04
TR	Manu	Indirect	Trade	IN	1,85E-04
TR	Prod	Direct	Forestry	CN	1,60E-04
TR	Manu	Indirect	Communication	TR	1,58E-04
TR	Prod	Direct	Chemical, rubber, plastic products	TR	1,53E-04
TR	Manu	Indirect	Business services nec	PK	1,53E-04
TR	Proc	Direct	Leather products	IN	1,53E-04
TR	Manu	Indirect	Transport nec	IN	1,51E-04
TR	Manu	Indirect	Business services nec	EG	1,50E-04
TR	Prod	Direct	Plant-based fibers	EG	1,45E-04
TR	Proc	Direct	Paper products, publishing	TR	1,39E-04
TR	Manu	Indirect	Trade	CN	1,36E-04
TR	Prod	Direct	Plant-based fibers	ET	1,35E-04
TR	Prod	Direct	Oil seeds	ET	1,33E-04
TR	Prod	Direct	Wool, silk-worm cocoons	ET	1,33E-04
TR	Prod	Direct	Raw milk	TR	1,32E-04
TR	Prod	Direct	Chemical, rubber, plastic products	TH	1,27E-04
TR	Proc	Direct	Textiles	MY	1,23E-04
TR	Manu	Indirect	Business services nec	US	1,23E-04
TR	Manu	Indirect	Business services nec	CN	1,22E-04
TR	Manu	Indirect	Electronic equipment	TR	1,20E-04
TR	Prod	Direct	Vegetables, fruit, nuts	KG	

(continued on next page)

Table A.1 (*continued*)

Exporting country	*E*		Activity	Location	*w*
					1,20E-04
TR	Manu	Indirect	Construction	TR	1,19E-04
TR	Manu	Indirect	Water	TR	1,18E-04
TR	Manu	Indirect	Business services nec	IN	1,14E-04
TR	Manu	Indirect	Financial services nec	PK	1,13E-04
TR	Prod	Direct	Paddy rice	CN	1,11E-04
TR	Manu	Indirect	Electricity	UA	1,08E-04
TR	Prod	Direct	Forestry	TR	1,08E-04
TR	Prod	Direct	Plant-based fibers	BF	1,08E-04
TR	Prod	Direct	Chemical, rubber, plastic products	ID	1,07E-04
TR	Manu	Indirect	Transport nec	BD	1,06E-04
TR	Manu	Indirect	Machinery and equipment nec	CN	1,05E-04
TR	Manu	Indirect	Public Administration, Defense, Education, Health	TR	1,01E-04
TR	Manu	Indirect	Gas	XNF	1,00E-04
TR	Prod	Direct	Oil seeds	IN	9,69E-05
TR	Manu	Indirect	Electricity	VN	9,53E-05
TR	Manu	Indirect	Trade	PK	9,35E-05
TR	Manu	Indirect	Transport nec	XSU	9,14E-05
TR	Prod	Direct	Chemical, rubber, plastic products	US	9,12E-05
TR	Manu	Indirect	Transport nec	ID	9,07E-05
TR	Prod	Direct	Oil seeds	UA	8,87E-05
TR	Prod	Direct	Animal products nec	XSU	8,75E-05
TR	Manu	Indirect	Trade	XNF	8,64E-05
TR	Prod	Direct	Wool, silk-worm cocoons	CN	8,49E-05
TR	Manu	Indirect	Transport nec	CN	8,39E-05
TR	Manu	Indirect	Gas	XSU	8,35E-05
TR	Manu	Indirect	Financial services nec	EG	8,35E-05
TR	Prod	Direct	Cereal grains nec	TR	8,32E-05
TR	Manu	Indirect	Financial services nec	CN	8,27E-05
TR	Manu	Indirect	Manufactures nec	TR	8,26E-05
TR	Manu	Direct	Wearing apparel	CN	8,24E-05
TR	Proc	Direct	Textiles	KR	7,81E-05
TR	Prod	Direct	Vegetables, fruit, nuts	VN	7,75E-05
TR	Prod	Direct	Wheat	CN	7,69E-05
TR	Prod	Direct	Chemical, rubber, plastic products	IN	7,52E-05
TR	Prod	Direct	Wheat	XSU	7,42E-05
TR	Prod	Direct	Oil seeds	PK	

Table A.1 (*continued*)

Exporting country	*E*		Activity	Location	*w*
					7,36E-05
TR	Manu	Indirect	Insurance	TR	6,94E-05
TR	Manu	Indirect	Financial services nec	IN	6,88E-05
IN	Manu	Direct	Wearing apparel	IN	1,29E-01
IN	Prod	Direct	Plant-based fibers	IN	3,54E-02
IN	Proc	Direct	Textiles	IN	3,48E-02
IN	Manu	Indirect	Trade	IN	2,35E-02
IN	Manu	Indirect	Transport nec	IN	1,24E-02
IN	Manu	Indirect	Business services nec	IN	9,40E-03
IN	Manu	Indirect	Financial services nec	IN	6,85E-03
IN	Manu	Indirect	Construction	IN	4,82E-03
IN	Prod	Direct	Forestry	IN	2,49E-03
IN	Manu	Indirect	Electricity	IN	2,44E-03
IN	Manu	Indirect	Insurance	IN	2,26E-03
IN	Prod	Direct	Bovine cattle, sheep and goats, horses	IN	2,23E-03
IN	Prod	Direct	Chemical, rubber, plastic products	IN	2,22E-03
IN	Manu	Indirect	Communication	IN	1,73E-03
IN	Prod	Direct	Oil seeds	IN	1,62E-03
IN	Prod	Direct	Wood products	IN	1,56E-03
KH	Manu	Direct	Wearing apparel	KH	4,33E-01
KH	Manu	Indirect	Trade	KH	2,75E-02
KH	Proc	Direct	Textiles	CN	1,69E-02
KH	Proc	Direct	Textiles	KH	1,59E-02
KH	Prod	Direct	Bovine cattle, sheep and goats, horses	KH	5,66E-03
KH	Prod	Direct	Vegetables, fruit, nuts	KH	5,08E-03
KH	Prod	Direct	Animal products nec	KH	4,71E-03
KH	Prod	Direct	Fishing	KH	4,50E-03
KH	Prod	Direct	Plant-based fibers	CN	4,42E-03
KH	Prod	Direct	Crops nec	KH	4,19E-03
KH	Proc	Direct	Textiles	VN	3,04E-03
KH	Manu	Indirect	Business services nec	KH	2,77E-03

Appendix B

Table B.1

Table B.1
Assumptions underlying red, reu, rec and reo for scenarios I and II.

Measure	Variable	Assumptions	Sources
Reduce	*Red*	Neither the EU legislation nor the benchmark data from Germany provided any specific objectives as those deal with post-consumer, and not pre-consumer waste measures. We supposed a reduction of 10 per cent reduction of pre-consumer waste for scenario II, and 5 per cent for the scenario I according to the Dutch Ministry of Infrastructure and Water Management and Platform Circulair Textiel roadmap objective of a 10 per cent circular textile share in 2025.	Dutch Ministry of Infrastructure and Water Mangement and Platform Circulair Textiel, 2017; Platform Circulair Textiel, 2017
Reuse, Recycling	*Reu, rec, reo*	We assumed that the split between reuse (*reu*) and recycling (*reo, rec*) will remain constant as future trends are not yet clear. For example, the share of reuse could increase because of broader public acceptance and availability of high-quality second-hand apparel or could decrease because of the lower quality of fast fashion apparel, as claimed by the association of German textile recyclers	Bundesverband Sekundärrohstoffe und Entsorgung e.V., 2018
Recycle	*Rec, reo*	Within recycling, we expected that the share of *rec* would increase given the emerging number of closed-loop (cotton) recycling technologies in the fibre recycling industry (see appendix C). We used the Dutch Ministry of Infrastructure and Water Management and Platform Circulair Textiel roadmap objective of 10 per cent closed-loop resource cycles by 2025 for the benchmark scenario, and 5 per cent for the policy target scenario.	Dutch Ministry of Infrastructure and Water Mangement and Platform Circulair Textiel, 2017; Platform Circulair Textiel, 2017

Appendix C

Table C.1

Table C.1
Post-consumer plant-based textile fibres upcycling processors (adapted from Textile Exchange (2016) and updated).

Name	Location	Focus	Remarks
Evrnu	USA	Chemical cotton recycling	Collaborated with Levi's to prototype first jeans made of 100 per cent recycled cotton
Re:newcell	Sweden	Chemical cellulosic recycling	
Recovertex	Spain	Mechanical cotton recycling	
Lenzing	Austria	Chemical cotton recycling	Refibra fibre products for example sold by Patagonia
Worn Again Technologies	United Kingdom	Chemical polyester and cellulose recycling	Industrial demonstration plant planned for 2021
Relooping Fashion	Finland	Chemical cotton recycling	Pilot facility by VTT Technical Research Centre of Finland Ltd.

Appendix D

Table D.1

Table D.1
Country abbreviations.

Abbreviation	Country/Countries	Country classification by GNI per capita (World Bank, 2018)
BD	Bangladesh	Lower-middle-income
BF	Burkina Faso	Low-income
CN	China	Upper-middle-income
EU	European Union Member States	N/A
EG	Egypt	Lower-middle-income
ET	Ethiopia	Low-income
ID	Indonesia	Lower-middle-income
IN	India	Lower-middle-income
KG	Kyrgyzstan	Lower-middle-income
KH	Cambodia	Lower-middle-income
KR	Republic of Korea	High income
MY	Malaysia	Upper-middle-income
PK	Pakistan	Lower-middle-income
TH	Thailand	Upper-middle-income
UA	Ukraine	Lower-middle-income
US	United States	High income
TR	Turkey	Upper-middle-income
VN	Vietnam	Lower-middle-income
XNF	Algeria/Libya/Western Sahara	Upper-middle-income/upper-middle-income/n/a
XSU	Tajikistan/Turkmenistan/Uzbekistan	Low-income/upper-middle-income/lower-middle-income

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