

Assessing circularity and sustainability

A survey-based analysis of companies with circular economy practices

Anna M. Walker¹, Katelin Opferkuch^{2,3}, Erik Roos Lindgreen⁴, Andrea Raggi¹, Alberto Simboli¹, Walter J.V. Vermeulen⁵, Sandra Caeiro^{2,3}, Roberta Salomone⁴

¹*Dept. of Economic Studies, University "G. d'Annunzio", Pescara;*

²*Universidade Aberta, Lisbon*

³*Center for Environmental and Sustainability Research (CENSE), Nova University, Lisbon*

⁴*Department of Economics, University of Messina*

⁵*Copernicus Institute of Sustainable Development, Utrecht University, Utrecht*

Abstract

The circular economy (CE) concept has become a major trend among companies, promising new business opportunities and a decrease in harmful environmental impacts. Though research on circular business models has recently increased, only few scholars have investigated whether CE practices also yield the sustainability results they promise. Therefore, establishing the empirical *status quo* of circularity and sustainability assessments provides a way forward and enables targeted improvements of applied assessment approaches with academic findings. This paper presents the results of an empirical analysis conducted through a qualitative survey in the Netherlands and Italy, where the major part of research on the nexus of circularity and sustainability assessments has been produced. The survey was distributed online to over 800 representatives of companies. Purposive sampling was employed to target only firms associated with national and international CE networks, assuming these companies already implement and assess CE best practices at varying levels of maturity. They thus can be defined as "front-running CE businesses". Within a three months' timeframe, 155 companies provided information on their understanding of the CE concept, its relationship with sustainability, as well as the assessment approaches used for the monitoring and reporting of CE and sustainability aspects. The survey answers show that companies view CE as one of the tools to achieve sustainable development improvements, particularly in the environmental domain. Yet, the respondents are ambiguous towards the question of whether CE can also provide economic benefits to firms. Furthermore, self-developed sustainability indicators were the most frequent assessment approach on a company level, while Life Cycle Assessment related methodologies prevailed on a product level. Given the qualitative nature of the survey, the observed tendencies are to be scrutinised through semi-structured interviews in a next step. Further research advancements will also include the survey distribution in other European and non-European countries to enable regional comparisons.

Keywords: Circular economy; qualitative survey; sustainability assessment; measurement; empirical study

1. Introduction

Our current linear model of economic development is often described as unsustainable and non-compatible with our planet's finite boundaries: it depletes natural resources, generates waste, produces harmful emissions, and gives rise to a complex web of interlinked environmental and social concerns (Sauvé et al., 2016). In the past years, the concept of transitioning to a Circular Economy (CE) as a radical solution to overturn such negative trends has increasingly gained popularity in academic-, policy-oriented and business communities. A CE can be considered an umbrella concept, drawing inspiration from a diverse set of resource management concepts and ideas from environmental- and sustainability sciences that have been introduced since the 1960s (Blomsma and Brennan, 2017). While many CE strategies exist, and academic discussions on the impact of such strategies appear to be increasing (Millar et al., 2019), the core of the concept can be described by its aim to retain material value through the process of closing material and resource loops. These actions work to decouple economic growth from resource consumption, with the goals to reduce harmful environmental impacts, stimulate economic growth and, according to some interpretations, generate positive social impact (Korhonen et al., 2018; Schroeder et al., 2018). Many authors have focused on the construction of hierarchical frameworks that list several resource-related strategies (R-strategies) that assist in moving towards a CE (Reike et al., 2018).

Due to CE's previously mentioned core of decoupling economic growth from resource extraction and the many opportunities for profitability that are thus promised by CE, companies are increasingly implementing CE practices (Howard et al., 2019). These companies are, according to some authors, expected to drive the transition due to their production activities, which are

often based on the extraction and transformation of natural resources (Urbinati et al., 2017). Still, literature that studies how companies engage with the concept of CE, and whether CE practices also yield the sustainability results they promise, is relatively scarce. Most academic literature appears to still focus on the conceptual development of CE and its relation to natural resources management and R-strategies in a given context, while less attention is given to CE implications in the context of e.g. managerial sciences and company level interactions (Merli et al., 2018). In addition, it has been signalled that empirical academic work using a medium- or large number of cases ($N > 10$) in CE research is quite uncommon (Kirchherr and Van Santen, 2019).

This paper constitutes the first output of a larger research project which aims to address how front-running companies engaged with CE interpret and adopt CE practices. In this research project, front-running businesses are defined as companies which can be considered early adopters of CE practices and which are involved in cross-sectoral initiatives to further the advancement towards a CE. To strengthen the understanding of how these front-running companies interpret, implement and assess CE practices, cross-sectoral empirical evidence was collected through a qualitative survey (Jansen, 2010). Special attention is paid to the connections between CE and sustainability, as well as the assessment of both circularity and sustainability in a company context. The overarching aim of this survey is to deepen the understanding of company engagement of early adopters with the CE concept, and to provide empirical evidence resulting in impact-oriented knowledge and best practices to be shared and applied between both academics as well as practitioners.

The primary goal of this research paper is to briefly summarize the research process and present a descriptive analysis of the results from companies in Italy or the Netherlands, two countries that are generally considered to be on the forefront of the transition to a CE (Ghisellini and Ulgiati, 2020; Kristensen and Mosgaard, 2020). In a later stage, additional countries will be added to the research process. Additional focus is provided to the theoretical foundation in section 2, and to the survey method, described in section 3, that was employed in order to obtain empirical evidence of company engagement with CE. After a presentation of preliminary results in section 4, the discussion section 5 points out interesting findings by linking results from the different survey themes, and by connecting the findings to literature discussed in section 3. Moreover, and perhaps most importantly, the discussion will also briefly describe questions that have emerged from these results, and summarize some of the next envisioned steps in the research process to answer these emerging questions (i.e. through interviews). The project is still ongoing, with additional planned research outputs expected to arrive in late 2020.

2. Theoretical overview

To better contextualize the present research and justify its academic approach, literature on three central research aspects is reviewed. First, a short overview of the different interpretations of the connections between CE and sustainability is provided. Next, previous work related to the assessment of CE at the company level is reviewed briefly. Lastly, this review considers previously conducted company-level CE surveys from academic literature.

2.1 CE and sustainability

The connections between the deep and multifaceted concepts of CE and sustainability, or Sustainable Development (SD) are contested, and no academic consensus on how exactly these concepts are related appears to have been reached. Some authors have evaluated the relationships between CE and sustainability. For example, Geissdoerfer et al. (2017) identify different conditional, beneficial and trade-off relationships between CE and SD. Millar et al. (2019) took a critical approach and challenged the proposition that implementing CE is driving positive impacts in terms of SD. Another critical perspective is offered by Sauvé et al. (2016), who considered that both concepts are subject to various epistemological problems, complicating research and obscuring academic discussions. Kirchherr et al. (2017) reviewed a large number of available CE definitions and found that only a marginal amount of studies connects CE to all three dimensions of SD (society, economy and

environment). In summary, the connection between the two concepts appears to be undecided and strongly dependent on the interpretation of CE. While the connection has been studied from an academic perspective, there is little research on how companies understand the link between the two concepts and how this understanding is operationalised in business practices.

2.2 CE and sustainability assessment

Recently, the question of how to assess ‘circularity’ at company level has received much attention in academic literature. Various review papers have inventoried and described different methods, tools, and general approaches to evaluate CE. Two first examples are the works by Corona et al. (2019) and Moraga et al. (2019), who find evidence that often-used methodologies consist of mass balance approaches such as Material Flow Analyses (MFAs). They also highlight that Life Cycle Assessment (LCA) is often used by other academics as a relevant methodology to assess CE, although LCA only covers the environmental domain, excluding potentially relevant socio-economic effects. The usefulness of LCA is further described by Mondello et al. (2020), stating that CE decision making processes at the company level could be assisted by the LCA methodology. It is relevant to note that, when using tools based on Life Cycle Thinking, the impact of CE solutions on the environment (or other SD dimensions) are assessed; other authors apply a different perspective and rather see the goal of the assessment to evaluate ‘the degree of circularity’ (see e.g. Howard et al., 2019; Linder et al., 2017; Saidani et al., 2019).

Another relevant review of micro-level CE assessment approaches is presented by Kristensen & Mosgaard (2020). The study collects and reviews micro level indicators for a CE, describing the ‘type and scope’ of the available indicators, and also categorizing them by the nature of their output (singular indicators, analytical tools and composite indicator sets). In addition, the indicators’ connections to nine CE strategies are described. The relations between sustainability, or SD, and the inventoried indicators are also investigated. The authors find that most of the indicators are focused on the economic dimension of sustainability, followed by the environmental one, while the social dimension is very limited. Most of these studies inventory and analyse micro-level CE assessment approaches from academic literature, which poses the question of whether these proposed approaches are actually practicable by companies.

2.3 Previous company-level CE surveys

A number of scientific works have previously investigated the topic of how companies interpret or use the concept of CE through collecting empirical evidence using a survey approach. This short review briefly summarizes them, focusing on the methodological approaches applied throughout the surveys. Their main characteristics are summarized in Table 1.

Table 1. Main characteristics of previous CE-survey papers

Reference	Main research interest	Sampling approach	Survey responses	Geographic region
Mura et al. (2020)	CE practices, enablers, and barriers	Random sample of SMEs	209 (+45 interviews)	Italy
Ghisellini & Ulgiati (2020)	CE practices, cooperation strategies	Purposive sampling (wide range of organizations selected based on occurrence three CE reports)	292	Italy
Bassi and Dias (2019)	Factors that influence CE practices	Uses Flash Eurobarometer 411 database; multi-stage random sampling of European SMEs	10,618 interviews	Europe
Gusmerotti et al. (2019)	Level of implementation of CE, drivers of CE	Random sample of manufacturing firms	821	Italy
Ormazabal et al. (2018)	Implementation of CE, drivers & barriers, symbiotic relationships	‘Convenience sample’ of SMEs	95	Navarre and Basque Country (Spain)

Fonseca et al. (2018)	The level of CE application and the motivations, knowledge and ways of promoting CE	Random sample using commercial database of companies	99	Portugal
Jonker et al. (2017)	Circular Business Models (CBMs)	Sampling process not specified; selection includes organizations, initiatives, individuals	500+	Gelderland and Overijssel (the Netherlands)

Starting with a recent study, Mura et al. (2020) focus on the practical implications of CE involvement of Italian small and medium-sized enterprises (SMEs). Another study with a focus on Italian organizations was conducted by Ghisellini & Ulgiati (2020), who analyze research cooperation strategies among the organizations, which include research centres, universities, and both non-profit and for-profit companies. The characteristics and CE business models of these organizations are extracted from previously conducted surveys by other scholars. Bassi and Dias (2019) aim to assess factors that might influence CE practices in all sectors of European SMEs. The study uses a very large database provided by the Flash Eurobarometer 441 (European SMEs and the circular economy) conducted in the 28 EU Member States (European Commission, 2016). A similar large-scale approach, applying a sophisticated statistical approach in analyzing the results, was conducted by Gusmerotti et al. (2019). Other studies have been carried out in Portugal, Spain, and the Netherlands. Ormazabal et al. (2018) used a survey that focused on SMEs in Navarre and the Basque Country in Spain, while in Portugal, Fonseca et al. (2018) aimed to address the ‘lack of awareness concerning CE among Portuguese companies’. An online survey and subsequent statistical analysis are used to address the study’s key research aims. Jonker et al. (2017) present a whitepaper in which they demonstrate their interest in business models for a CE. Their study includes an empirical part, which uses a pilot survey with the topic of studying the development of Circular Business Models in the provinces of Gelderland and Overijssel in the Netherlands. Their pool of participants is large and diverse including CE-involved SMEs, initiatives, and individuals participating in the questionnaire. Approximately 40 of them were subsequently interviewed by the researchers.

In summary, we identify two popular research themes: i) the practical application of CE strategies, and ii) the drivers and barriers that are important when implementing these strategies. However, the contested connections between CE and sustainability laid out in 2.1, and the tools to assess company-level CE briefly presented in 2.2 have not been discussed in the previously reviewed literature. Next, most of the reviewed studies use sampling approaches that are random or primarily based on convenience, and most of them include organizations in their base of respondents that are not necessarily involved with any CE activities. Therefore, the N of the (random) sample was often much higher than in the current study, requiring more advanced statistical analyses to interpret the results. Moreover, most of the studies indiscriminately surveyed companies on all levels of implementation of CE practices, making it difficult to identify best practices for companies striving towards a CE. Lastly, the geographical scope of the analysed research is limited to a region or a country, preventing the generalisation of results beyond borders.

3. Methods

Given the importance to include the empirical examples of circular companies and their assessment approaches, the method here proposed is a qualitative survey (Jansen, 2010). As opposed to a conventional survey, a qualitative survey does not focus on the frequency of certain respondent’s characteristics within the sample population, but analyses the variety of these characteristics. The explorative nature of this method allows for capturing a wide array of perspectives on CE, the link to sustainability as well as assessment approaches applied by firms.

3.1 Sampling procedure

Building on the studies discussed in 2.1, this paper aims at establishing insights into the connection between CE and sustainability, and identifying approaches companies apply to assess CE practices, rather than a general overview of CE practices in companies. Therefore, the sampling method employed was purposive sampling (Hibberts et al., 2012), as opposed to random sampling, which allows for the identification of best practices from respondents who are already engaged with the

research themes. Because CE is a fairly recent concept, the number of self-identified circular firms is limited (Kalmykova et al., 2018). Hence, the authors focused the sample on companies within existing CE networks, as these firms are projected to be front-runners in conceptualising and applying CE practices. The first round of survey distribution is focused on Italy and the Netherlands, two front-running countries with regards the implementation of CE practices (Ghisellini & Ulgiati, 2020; Kristensen & Mosgaard, 2020). Given the future inclusion of France and Portugal, a more generalized, European view on company-level CE participation is enabled, while still allowing for zooming in on, or even comparing, country-level particularities that might cause differences in CE engagement.

The sampling procedure followed is depicted in Table 2. Special attention was awarded to avoid a sampling bias, especially given the purposive nature (Hibberts et al. 2012), meaning the probability that some of the respondents are chosen is lower than necessary to be representative (Bautista, 2012). Therefore, CE experts in the Netherlands and Italy were consulted to ensure adequate coverage of CE networks. Furthermore, to minimize the coverage error, occurring if companies are missing within the sampling frame, the researchers consulted updated member lists online or directly contacted the CE network coordinators.

Table 2. *Sampling protocol.*

CE networks considered	Atlante Italiano dell’Economia Circolare (IT), Piattaforma Italiana degli stakeholder sull’economia circolare (ICESP) (IT), Circular Economy Network (IT), Mercato Circolare (IT), Circulair ondernemen (NL), Ontertekenaars van Grondstoffakkoord (NL), Circle Economy (NL), Holland Circulair Hotspot (NL), Circulaire Coalitie (NL), Ellen MacArthur Foundation CE 100 (international) and Circular Economy Club (international)
Inclusion criteria for companies	<ul style="list-style-type: none"> • Company is part of a local or international CE network • Company in international networks has primary business operations in either NL or IT • Organisation’s legal form is a company according to local law • Organisation has an official website
Survey delivery and responding period	<ul style="list-style-type: none"> • Delivered online via Survey Monkey, with personalised email invitation and customised links • Three reminder emails sent out within intervals of three weeks • Three months total responding period: July – October 2019

3.2 Survey development and content

The survey was drafted according to the seven-step framework for social scientists by Gideon (2012). Special attention was attributed to the fact that it was an online questionnaire and was sent out with an email invitation (Lozar Manfreda & Vehovar, 2008). It was developed in a participatory way, involving seven researchers, two private partners of the research project specialised in sustainability and life cycle-based assessments and circular companies respectively, as well as four large multi-utility companies, a production firm, and a coordinator of an industrial cluster for testing survey.

The survey covered three relevant topics related to company-level CE engagement requiring additional empirical evidence:

- understanding of CE concept and the link between CE and sustainability,
- companies’ goals of implementing CE practices, as well as drivers and barriers playing a role in this implementation process,
- CE and related sustainability assessment approaches for circular companies.

For additional information on the creation of the questions for the individual parts, refer to Walker et al. (2019). The current paper focuses on the first and last topic presented above; the former topic sets out the context of what companies are expected to assess, given their CE understanding, as well as the link to sustainability. The latter part of the survey describes assessment

approaches applied, their categorization into circularity or sustainability assessment tools as well as potential needs of companies with regards to developing and applying such tools.

3.3 Data description

The survey was sent out online to a total of 809 companies and was completed by 171, of which 155 responses were valid. This represents a survey response rate of 19%, which is considerable for business surveys (Dillman, 2011) and well above of the response rate in the aforementioned CE studies. From these 155 respondents, 46% are based in Italy and 52% in the Netherlands. 2 respondents are part of Italian or Dutch CE networks while being based outside of these countries: 1 from Luxemburg and 1 from Austria. Further descriptive statistics, regarding the company size, department of respondent and company sector of the sample are provided in Table 3, Table 4, and Table 5, respectively.

Table 3. Size of companies.

Company size category	Number of respondents	Percentage
1 to 9	69	45%
10 to 49	33	21%
50 to 249	19	12%
250 to 500	6	4%
501 to 1000	6	4%
1001 to 5000	13	8%
5001 to 10'000	3	2%
10'001+	6	4%
Total	155	100%

According to the EuroStat classification scheme for SMEs (Eurostat, 2018), around 45% of the respondents represent so called micro-companies, as depicted in Table 2. Any company larger than 250 employees is considered a ‘large company’; this category makes up the second largest subgroup in terms of company size with 34 companies. From Table 4 it is evident that the survey has reached both decision makers that have management-level responsibilities, as well as employees that are closely involved with sustainability and CSR activities.

Table 4. Department of respondents.

Department category	Number of respondents	Percentage
General Management	60	39%
Sustainability & CSR	31	20%
Marketing & Sales	23	15%
Research and Development (R&D)	18	12%
Production	13	8%
Accounting and Finance	4	3%
Purchasing	3	2%
Customer Service	2	1%
Quality Assurance	1	1%
Total	155	100%

Using the statistical classification of economic activities in the European Community (NACE) (Eurostat, 2008), companies were asked to indicate in what sector they perform their primary business activities. Though the second largest group in Table

4 is the category ‘Other service activities’, which is mainly designated for repair services (Eurostat, 2008), it became evident after analysing the answers of individual responses that some companies in this category are in fact consultancy firms. According to the NACE subcategories of industry sectors, consultancy activities should be classified under the sector ‘Professional, scientific and technical activities’. This measurement error (Bautista, 2012) will be taken into account in the further analysis of the results in the discussion section.

Table 5. Industry sector of respondents.

Industry sector category	Number of respondents	Percentage
Manufacturing	41	26%
Other service activities	37	24%
Water supply; sewerage, waste management and remediation activities	16	10%
Professional, scientific and technical activities	15	10%
Construction	11	7%
Wholesale and retail trade; repair of motor vehicles and motorcycles	6	4%
Agriculture, forestry and fishing	5	3%
Accommodation and food service activities	4	3%
Electricity, gas, steam and air conditioning supply	4	3%
Information and communication	4	3%
Real estate activities	3	2%
Transportation and storage	3	2%
Arts, entertainment and recreation	2	1%
Human health and social work activities	2	1%
Total	155	100%

4. Results

This section presents a descriptive analysis of the results from the survey. Firstly, the section describes the ‘circular’ characteristics of the sample, namely: the respondents’ position in the value chain, what CE practices they currently (or plan to) implement within their company, and, the respondents perceived maturity of their CE products and/or solutions. Following this, the analysis will detail results on the respondents’ interpretations of the conceptual connections between sustainability and CE and identify the assessment approaches being applied at a company and product level within front-running CE companies.

4.1 Circular characteristics of the sample

Respondents were presented with a diagram detailing seven stages of the value chain adapted from Kalmykova et al. (2018). They were asked to indicate which stage (or stages) of the value chain where the main business operations of their company are situated. Respondents in the sample are most likely to situate themselves in *Recycling and Recovery* (79 respondents), closely followed by *Manufacturing & Remanufacturing* (77 respondents), *Distribution and Sales* (74 respondents), *Design* (72 respondents), *Materials Sourcing* (53 respondents), *Collection and Disposal* (45 respondents) and lastly *Consumption and Use (with reuse and repair)* (41 respondents). Furthermore, respondents are more likely to operate in more than one value chain position, with only 31% respondents considering their company’s operations to involve just one part of the value chain.

Respondents were asked what specific CE practices (strategies, solutions or business models as adapted from Kalmykova et al. (2018)) have been or are planned to be implemented within their company. The respondents were presented with a list of 15 CE practices and there was no limit to the number of practices the respondent could select. As depicted in Figure 1, the most commonly applied CE practice is *Recovery of products, materials or energy from waste*. This was closely followed by the practice of *Increasing energy and material efficiency through reuse, reduction and repurposing*. The least applied CE practices in the sample include *Providing a sharing platform for consumer goods*, *Repairing products*, *Remanufacturing or refurbishing goods* as well as *Product service system models*.

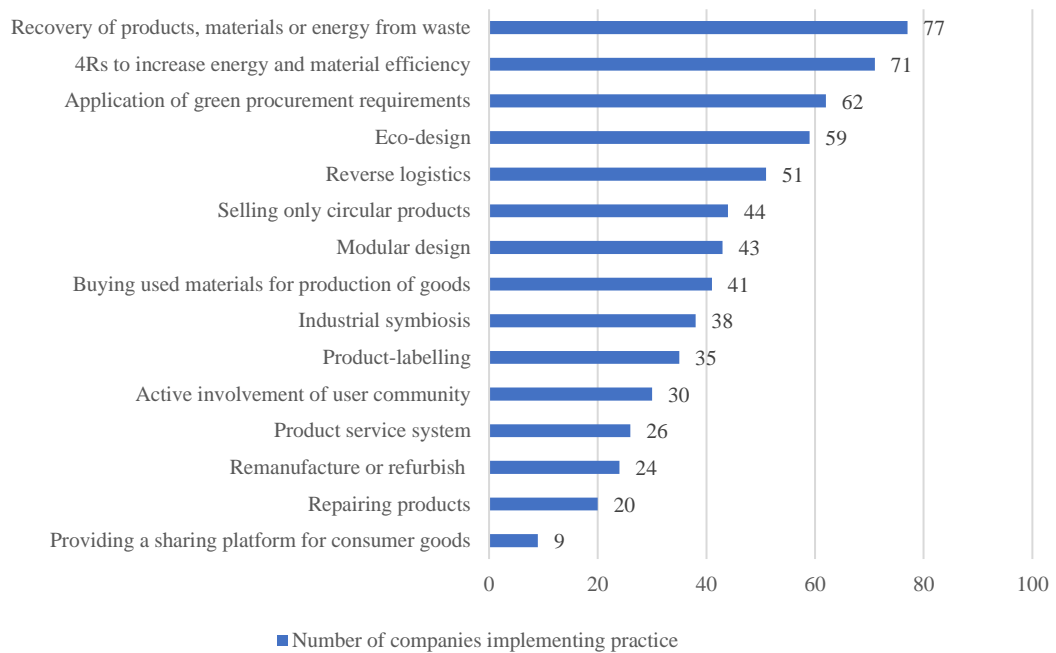


Figure 1. CE practices implemented or planned by respondents, $n=141$.

Regarding the number of CE practices implemented or planned, 72% of respondents indicated they have implemented or planned to implement more than one CE practice. In fact, the most frequent number of CE practices within each company was four, with 19% of companies featuring this.

Companies were asked to rate the perceived maturity level of both their company's products (goods and services) produced with CE practices and/or the overall maturity of the operational solutions involving CE practices. Respondents selected one of four stages of maturity as seen in Figure 2. Overall, companies are more likely to have implemented circular operational solutions for more than 2 years than circular product solutions. Results also show that the sample consists of companies with a range of perceived stages of CE implementation for their products and operational solutions.

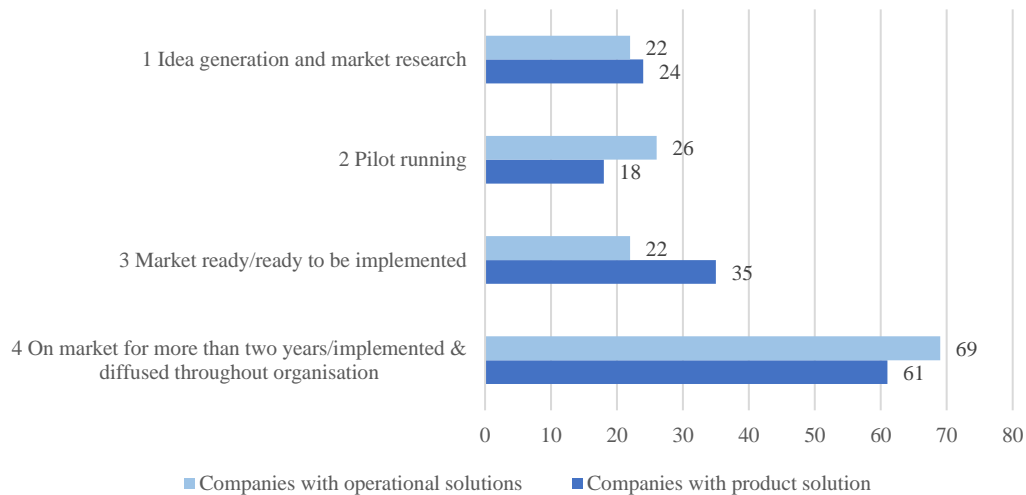


Figure 2. Respondents' perceived maturity of circular products and operational solutions, n=139.

4.2 Circular economy and sustainability

In the survey, various questions were dedicated to gaining insights into the respondent's perceptions of the concept of CE and its connection with sustainability. Figure 3 displays a list of seven characteristics attributed to CE which were presented to the respondents. Overall, respondents most strongly agree that the statement *Products are designed in a way that eliminates waste* has the highest level of importance when characterising CE. Interestingly, companies were least likely to characterise the concept of CE with *Businesses shifting towards offering PSS rather than selling products*. Also, eco-efficiency was perceived to be slightly less important than material efficiency, though responses for both characteristics had a high standard deviation (as seen in Table 6). Besides the seven characteristics mentioned in the survey, several respondents acknowledged the importance of the bioeconomy and the concept of sufficiency to the characterisation of CE through the use of the additional comments section.

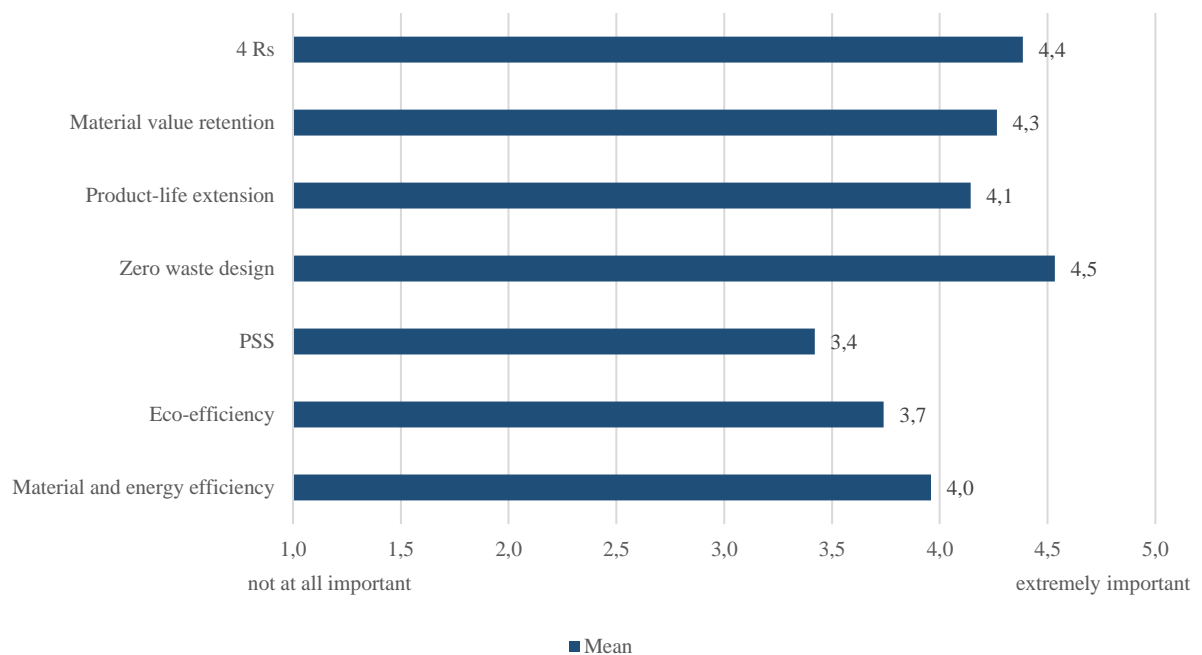


Figure 3. Respondents' understanding of CE concept, assessing importance of characteristics with scale from 1 (not at all important) to 5 (extremely important), 'I don't know' responses were excluded from average, n=155.

Table 6. Respondents' understanding of CE concept with survey statements linked to CE characteristics.

Statements	CE characteristic	N.*	Mean	Standard deviation
During the life cycle of a product (production, use, end-of-life) materials are reduced, reused, recycled, or recovered	4 Rs	153	4,4	0,94
Goods are produced in a way that enables the maintaining and recovery of value of materials such as gold and other scarce materials	Material value retention	151	4,3	0,88
Goods are produced or services are provided in a way that increases the durability of products, before their disposal	Product-life extension	154	4,1	0,97
Products are designed in a way that eliminates waste, because after their end of life, they re-enter the value chain as material input	Zero waste design	150	4,5	0,73
Businesses offer a service to users, instead of selling their products to customers (e.g. renting a car, instead of selling it)	PSS	150	3,4	1,22
More goods and services are produced while causing less negative impact on the environment	Eco-efficiency	146	3,7	1,19
More goods and services are produced while reducing material resource or energy use	Material & energy efficiency	146	4,0	1,17

* excl. 'I don't know' responses

Respondents were asked to indicate their level of agreement with six statements describing the effect of CE on the three pillars of sustainability (environment, economic and social). The results (as seen in Figure 4) indicate that the respondents agree on the concept of CE having a positive relationship with all three pillars of the concept of sustainability. It becomes clear that most respondents agree that CE is *one of the tools* to help achieve the UN sustainable development goals (SDGs), while they do not necessarily agree that it is the *main tool* to achieve them. Answers further indicate that the association of CE with the environmental pillar of sustainability is the strongest, followed by social benefits and economic profitability. Interestingly, it became apparent that respondents do not necessarily think social equality is equally addressed within CE. While not visible from the mean, but from looking at the standard deviation (as seen in Table 7), the second and last statements were also the most contested, with several answers indicating that respondents both strongly disagree and strongly agree.

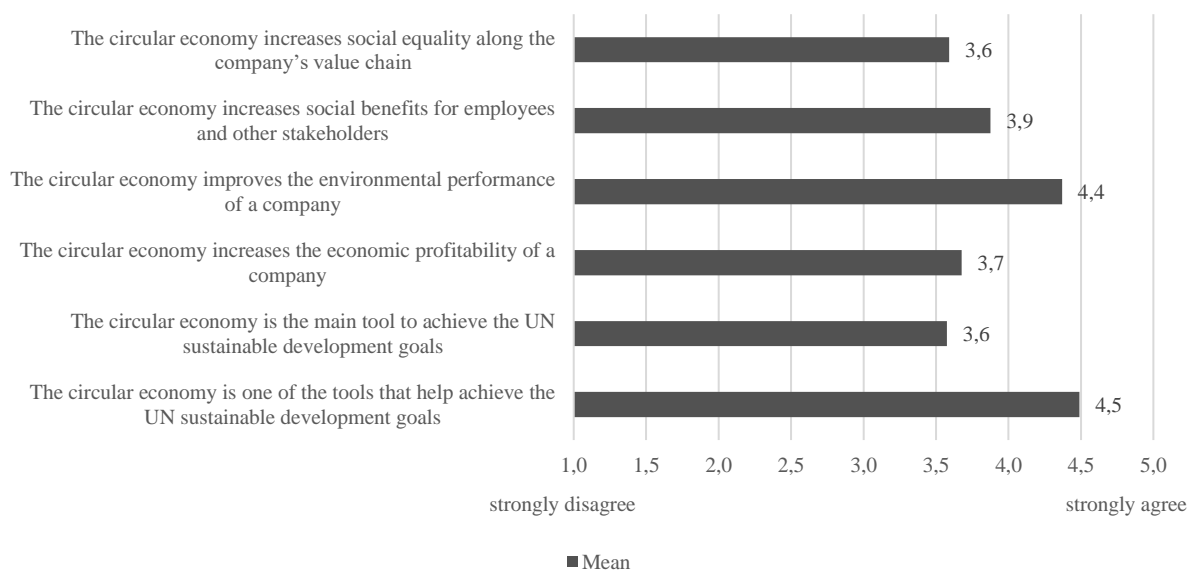


Figure 4. Respondents' understanding of the link between CE and sustainability, indicating level of agreement with scale from 1 (strongly disagree) to 5 (strongly agree), 'I don't know' responses were excluded from average, n=155.

Table 7. Respondents' understanding of the link between CE and sustainability

Statements	N.*	Mean	Standard deviation
The circular economy is one of the tools that help achieve the UN sustainable development goals	153	4,5	0,69
The circular economy is the main tool to achieve the UN sustainable development goals	151	3,6	1,06
The circular economy increases the economic profitability of a company	152	3,7	0,89
The circular economy improves the environmental performance of a company	154	4,4	0,76
The circular economy increases social benefits for employees and other stakeholders	146	3,9	0,91
The circular economy increases social equality along the company's value chain	142	3,6	1,10

* excl. 'I don't know' responses

4.3 Assessment approaches to CE and sustainability

The final section of the survey was designed to establish insights on whether the connection of CE and sustainability is also reflected in the assessment approaches and monitoring frameworks applied within front-running companies implementing CE. In addition, it was designed to determine what are the most commonly applied assessment approaches across the sample.

Respondents were presented with a list of 22 assessment approaches commonly applied by companies, including single indicators, indices and integrated approaches. They were then asked to indicate whether each approach was applied at a company level and/or product level, or if there were plans to implement each approach in the future. As seen in Figure 5, the 22 approaches have been implemented at varying frequencies for both the company and product level. Within this sample, 36% of companies (56 companies) have not applied any of the approaches on either a product or company level.

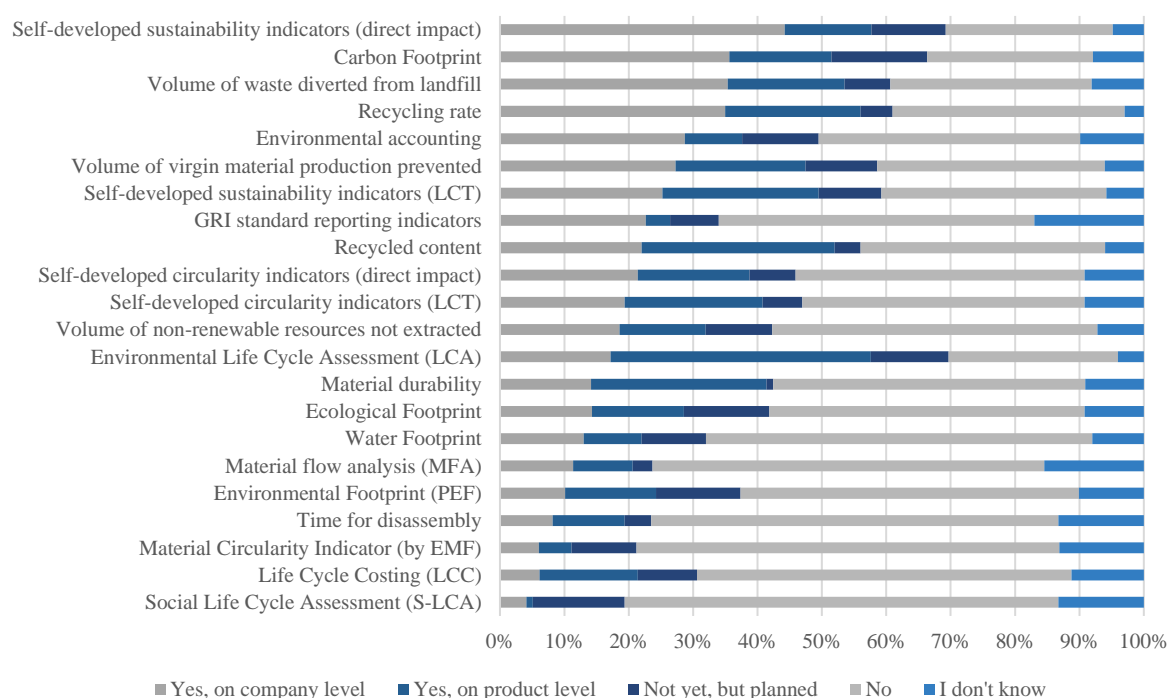


Figure 5. Application of assessment approaches on company or product level, n= 106.

For approaches applied at the company level, the most commonly applied approach is *Self-developed sustainability indicators based on direct impact*. Looking at the frequency of approaches applied per company, 46% of respondents (71 companies) do not apply any approaches on a company level, 10% (15 companies) apply only one approach and the remaining 44% (69 companies) apply two or more approaches. Concerning approaches applied at the product level, the most commonly applied approach is *Environmental LCA*.

Analysing the frequency of approaches applied at each company on a product level, results highlight that, 53% (82 companies) of respondents do not apply any approaches, 7% (11 companies) of respondents apply one approach and the remaining 40% (62 companies) applied two or more approaches. It is interesting to note that *Social-LCA* is the least commonly applied approach on both the company and product levels. However, it is the second most common approach mentioned which is planned to be implemented (with Carbon Footprint being the approach most commonly planned to be implemented).

Zooming in on each of the assessment approaches, Figure 6 displays the share of companies who currently do (either product or company level) or currently do not apply each of the 22 approaches. In an additional question, companies who implemented one or more assessment approaches on the product level were asked which parts of the product life cycle are included within their assessment. From those companies, 38% (36 out of 94 companies) consider processes along the entire life cycle of the product, including the use phase within their assessment.

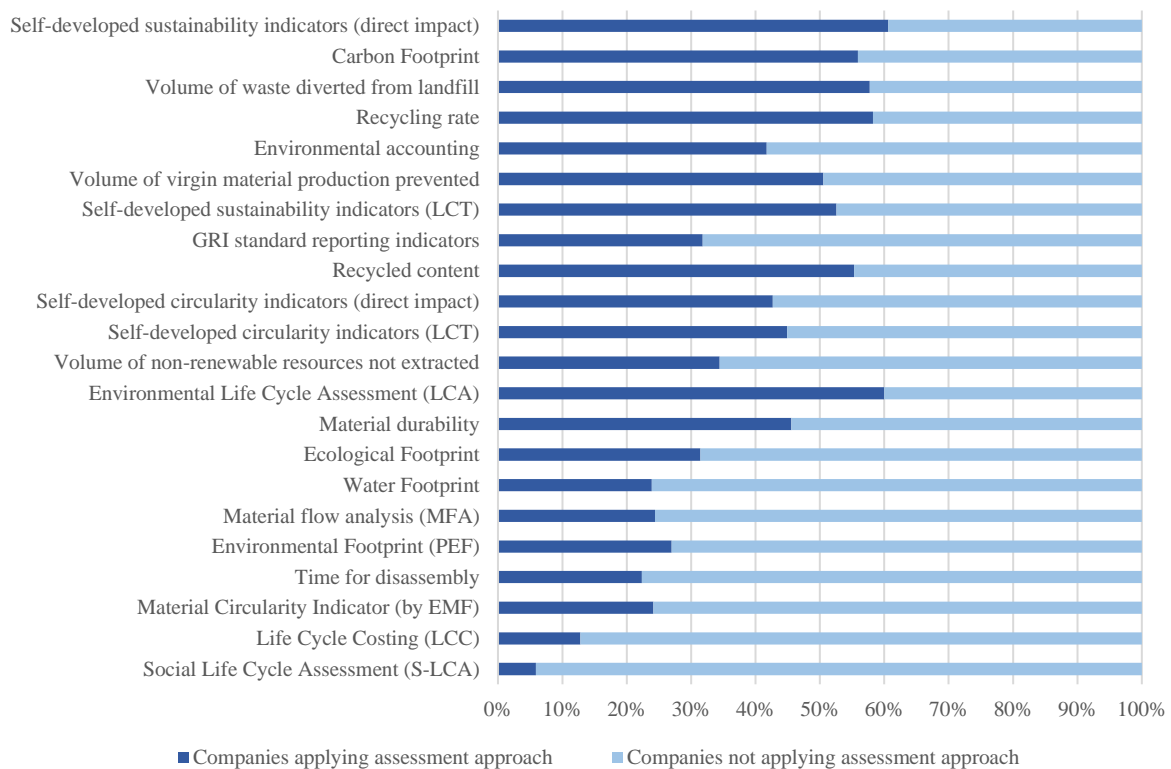


Figure 6. Overall application of assessment approaches within the sample.

Finally, respondents were asked which phases of assessment their company would benefit from external expertise when implementing sustainability assessment approaches or circularity assessment approaches (as seen in Figure 7). Overall, respondents indicated that expert input would be beneficial at each of the eleven phases of assessment listed for both sustainability and circularity assessment processes, except for *Internal communication of results*. Moreover, they indicated that external expertise would be slightly more beneficial for the implementation of circularity approaches than for sustainability approaches at the majority of the assessment phases.

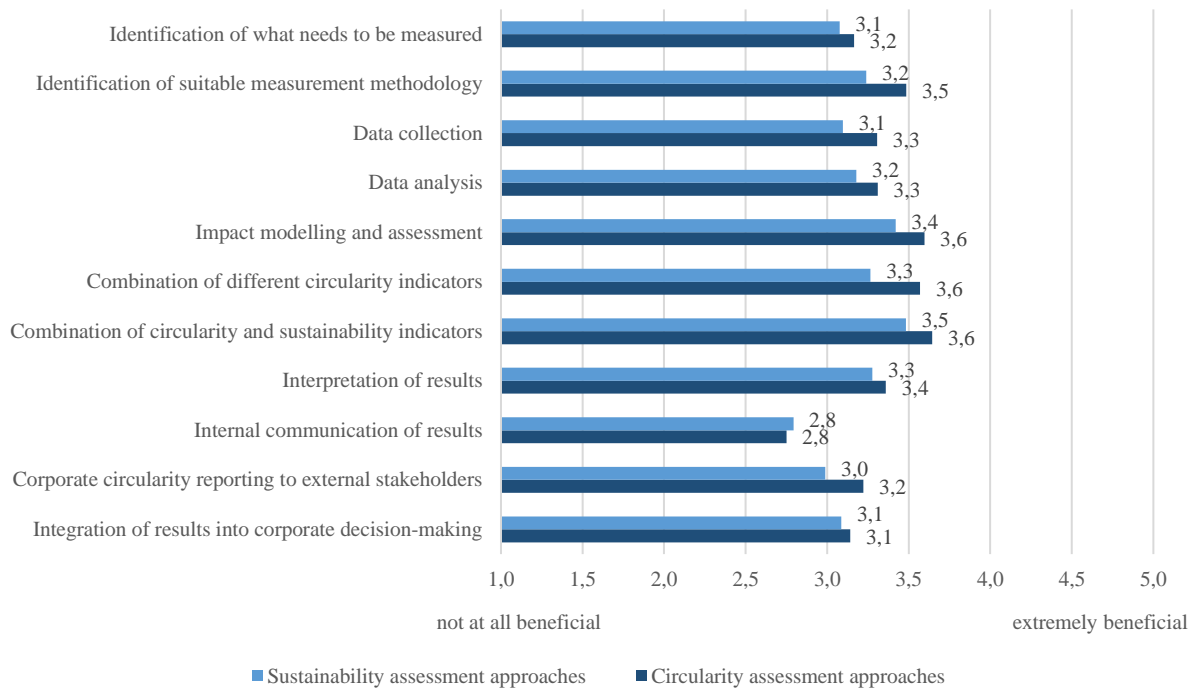


Figure 7. Perceived benefit of external expert input for circularity and sustainability assessment processes.

5. Discussion

The following discussion is structured into two parts. The first part discusses the results presented within this paper, whilst the second part points out directions for future analyses and additional data collection with semi-structured interviews.

5.1 Analysis of results

With respect to the main business activities of the surveyed companies, most results point to a waste management focus. The operations of surveyed companies are situated in all seven value chain positions, with *Recycling and Recovery* being the most present. This was reflected with the types of CE practices being implemented within the sample, with the most common practice being *Recovery of products, materials or energy from waste*, which occurs within the Recycling and Recovery value position. Similarly, as historically derived in literature (Cecchin et al., 2020), companies also indicated that the zero-waste characteristic is the most important one to describe a CE.

Given that the majority of respondents situate their business operations at several value chain positions and 71% of companies implement more than one CE practice, the results suggest that the companies within the sample are not specialised. This is interesting, as 49% of survey respondents can be classified as micro-companies, suggesting individual firms might have less resources to attribute for operations across the value chain. An explanation for this could be the presence of a high number of small, multi-disciplinary CE consulting firms within the sample. This was also noted as a potential reasoning for the large proportion (24%) of companies indicating they operate within the *Other service activities* sector and will be further investigated in future data analysis and interviews.

With respect to the maturity of CE implementation for each of the individual respondents, results showed within the sample that half of respondents (49%) have had a circular product or have implemented circular operational solutions for more than 2 years. This suggests that the CE networks included within this study consist of companies with relatively long-running CE practices, as well as companies which have only recently adopted or are still planning to implement CE practices within both their products and operational solutions. This result also reflects the steadily growing number of companies engaging with CE in recent years as discussed in literature (Kalmykova et al., 2018).

As members of CE networks were assumed to be familiar with the CE concept, it is not surprising that the surveyed companies consider all seven CE characteristics to be more than moderately important. The consistency between responses, indicated through a low standard deviation, also points towards a consensus of the CE concept amongst front-running companies. Surveyed companies also indicated they agree that CE contributes positively to sustainability impacts, albeit results show the lowest level of agreement concerning the economic benefits from implementing CE. The high level of agreement with most statements concerning the links between CE and sustainability, and particularly, with the statement suggesting CE is *one* of the main tools to achieve the SDGs supports this claim. The perceived positive correlation of CE and sustainability also potentially increases companies' motivations to implement CE practices and might be one of the drivers to join the selected CE networks. However, this needs to be confirmed through analysis of drivers for and goals of CE implementation in future research steps.

Concerning the number and types of assessment approaches applied, it was determined that companies within the sample were more likely to apply approaches on the company level rather than on the product level. For those applying an assessment approach on the company level (54%), firms were more likely to utilise some form of self-developed sustainability or circularity indicators (30.5%). This suggests that, despite the breadth of formal assessment approaches available, front-running CE companies are more likely to develop customised assessment approaches internally or with the help of external partners. Furthermore, the fact that most of the respondents represent small firms with limited funds might partially explain the prevalence of non-standardised assessment approaches on a company level. On a product level, a small majority of companies (53%) did not apply any assessment approaches. For companies which do, the most commonly applied approach was a life cycle thinking-based approach, specifically Environmental LCA, which has been predicted by literature (Corona et al., 2019; Moraga et al., 2019). However, as stated earlier, the majority of companies within the sample are micro-companies, who sometimes mentioned that they believe assessment approaches were of no benefit within the additional comments section.

Results suggest that the surveyed companies did not express a significant difference in identified needs for external expertise between sustainability or circularity assessment approaches. This suggests that companies within the CE networks do not differentiate between circularity or sustainability needs; the result could also reflect the companies' perceived existing competence with these processes. This is also supported by companies indicating *Internal communication of results* as the assessment phase which would have the lowest level of benefits for external expertise. This is potentially explained by the companies already being engaged in CE, however, and thus having enough expertise; future analysis will explore this aspect further.

5.2 Future analyses

Based on the findings in this paper, several directions for further analysis have emerged. In a next step, the authors plan to investigate the influence of specific firm characteristics on the outcomes of questions from the survey. A relevant research direction would be to explore whether companies of different sizes, operating in different sectors and countries, and at different positions in the value chain have a diverging understanding of the link between sustainability and CE. Focus will be given to the statements where the respondents' answers had a high standard deviation from the mean, indicating a range of different perspectives amongst the respondents. As pointed out in the results section, it is also important to see whether the lack of companies implementing CE practices of repair and/or a PSS in the sample could be linked to certain barriers for CE implementation indicated, e.g. regulatory barriers. Another promising link to analyse is the level of maturity of a company's CE practice implementation and the likelihood to apply assessment approaches at a company or product level. For example, the responses from companies who have had circular products on the market for more than two years can be compared with those who do not have circular products on the market yet. This comparison could then evaluate the hypothesis that companies with mature CE practices are more likely to implement an assessment approach than those which do not.

Based on the outcomes of this analysis, the authors plan to conduct interviews with respondents from the survey who indicated their willingness to participate. Triangulating deeper insights of semi-structured interviews with the identified data patterns

within the survey results is crucial, given the qualitative character of the survey (Jansen, 2010). Besides posing questions about trends established in the analysis of results, the interview guidelines will also integrate the comments made by respondents, where questions had a section for additional comments with an open text field. The authors will, for instance, take up remarks by respondents about the connection between sustainability and CE, particularly those concerning the somewhat contested social dimension, or comments suggesting the importance of the bioeconomy and sufficiency. Several respondents also highlighted the difficulty of assigning assessment approaches to either circularity or sustainability, with additional comments directly asking for clarification through interviews. Through conducting interviews and engaging further with the respondents, the final research outcomes can also help understand the underlying reasons why companies do or do not measure the performance or impact of their business activities.

6. Conclusions

This paper offered a contribution to the discussion of CE and sustainability practices at a company level. It presents an overview of how front-running companies understand the concept of CE and how they link it with the concept of sustainability. Furthermore, assessment approaches for circularity and sustainability are discussed and their application in the field documented.

The findings show that most front-running CE companies in the sample carry out some of their business activities in the 'Recycling and Recovery' stage of the value chain and conduct related CE practices. About half of the respondents have what can be considered mature circular products and operational solutions, demonstrating that the companies employing CE practices are advancing and CE networks accommodate both experienced and learning members. The companies in the sample have a similar understanding of the CE concept and its link to sustainability. The overall effect of CE on sustainability and the SDGs in particular is seen as positive, though this link is weaker for the economic dimension and issues of social equality. Despite the proliferation of sustainability and circularity assessment approaches in literature, only half of the respondents actually apply such measures. On the company level, self-developed indicators prevail, while on the product level LCA is most widespread. Companies seemed to be only moderately interested in receiving external expert input to further develop their circularity and sustainability assessment processes. A striking result, however, was that the surveyed companies indicated the same level of perceived benefits from external expert input across the assessment stages for both circularity and sustainability, pointing towards a similar operationalisation of the two concepts in terms of assessment.

Given that this paper has mostly focused on describing the immediate results of the questionnaire, the next step is to further analyse the patterns that emerged during this descriptive analysis. Propositions for further analyses include the connection of company characteristics with responses regarding the three overall research themes. The findings will subsequently be triangulated through semi-structured interviews with survey respondents with the aim to identify best practices for companies implementing CE practices. In order to overcome the limitation of covering merely two countries in the EU, the authors further plan to extend the survey to France and Portugal to carry out a cross-country comparative analysis.

Acknowledgements

This study was supported by the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No. 765198. The authors would like to thank all the people involved in the creation, revision, testing and distribution of this survey, as well as the companies completing the survey.

References

- Bassi, F., Dias, J.G., 2019. The use of circular economy practices in SMEs across the EU. *Resources, Conservation and Recycling*, 146, 523–533.
- Bautista, R., 2012. An Overlooked Approach in Survey Research: Total Survey Error, in: Gideon, L. (Ed.), *Handbook of Survey Methodology for the Social Sciences*. Springer New York, New York, NY, pp. 37–49.
- Blomsma, F., Brennan, G., 2017. The Emergence of Circular Economy: A New Framing Around Prolonging Resource Productivity. *Journal of Industrial Ecology*, 21, 603–614.

- Cecchin, A., Salomone, R., Deutz, P., Raggi, A., Cutaia, L. (Eds.), 2020. Relating Industrial Symbiosis and Circular Economy to the Sustainable Development Debate, in: *Industrial Symbiosis for the Circular Economy: Operational Experiences, Best Practices and Obstacles to a Collaborative Business Approach, Strategies for Sustainability*. Springer International Publishing, Cham, pp. 1–25.
- Corona, B., Shen, L., Reike, D., Rosales Carreón, J., Worrell, E., 2019. Towards sustainable development through the circular economy—A review and critical assessment on current circularity metrics. *Resources, Conservation and Recycling* 151, 104498.
- Dillman, D.A., 2011. *Mail and Internet Surveys: The Tailored Design Method -- 2007 Update with New Internet, Visual, and Mixed-Mode Guide*. John Wiley & Sons.
- European Commission., 2016. European SMEs and the Circular Economy (Flash Eurobarometer 411) [database]. https://data.europa.eu/euodp/en/data/dataset/S2110_441_ENG (accessed 09.04.2020).
- Eurostat., 2018. Small and medium-sized enterprises (SMEs). <https://ec.europa.eu/eurostat/web/structural-business-statistics/structural-business-statistics/sme> (accessed 18.02.2020).
- Eurostat., 2008. Statistical Classification of Economic Activities in the European Community, Rev. 2. https://ec.europa.eu/eurostat/ramon/nomenclatures/index.cfm?TargetUrl=LST_NOM_DTL&StrNom=NACE_REV2&StrLanguageCode=EN (accessed 10.02.2020).
- Fonseca, L.M., Domingues, J.P., Pereira, M.T., Martins, F.F., Zimon, D., 2018. Assessment of circular economy within Portuguese organizations. *Sustainability (Switzerland)*, 10.
- Garcés-Ayerbe, C., Rivera-Torres, P., Suárez-Perales, I., Leyva-de la Hiz, D.I., 2019. Is It Possible to Change from a Linear to a Circular Economy? An Overview of Opportunities and Barriers for European Small and Medium-Sized Enterprise Companies. *International Journal of Environmental Research and Public Health*, 16, 851.
- Geissdoerfer, M., Savaget, P., Bocken, N.M.P., Hultink, E.J., 2017. The Circular Economy – A new sustainability paradigm? *Journal of Cleaner Production*, 143, 757–768.
- Ghisellini, P., Ulgiati, S., 2020. Circular economy transition in Italy. Achievements, perspectives and constraints. *Journal of Cleaner Production*, 243, 118360.
- Gideon, L., 2012. The Art of Question Phrasing, in: Gideon, L. (Ed.), *Handbook of Survey Methodology for the Social Sciences*. Springer New York, New York, NY, pp. 91–107.
- Gusmerotti, N.M., Testa, F., Corsini, F., Pretner, G., Iraldo, F., 2019. Drivers and approaches to the circular economy in manufacturing firms. *Journal of Cleaner Production*, 230, 314–327.
- Hibberts, M., Burke Johnson, R., Hudson, K., 2012. Common Survey Sampling Techniques, in: Gideon, L. (Ed.), *Handbook of Survey Methodology for the Social Sciences*. Springer New York, New York, NY, pp. 53–74.
- Howard, M., Hopkinson, P., Miemczyk, J., 2019. The regenerative supply chain: a framework for developing circular economy indicators. *International Journal of Production Research*, 57, 7300–7318.
- Jansen, H., 2010. The Logic of Qualitative Survey Research and its Position in the Field of Social Research Methods. *Forum Qualitative Sozialforschung / Forum: Qualitative Social Research*, 11.
- Jonker, J., Stegeman, H., Faber, N., 2017. The Circular Economy - Developments, concepts, and research in search for corresponding business models. *Radboud University, Nijmegen*.
- Kalmykova, Y., Sadagopan, M., Rosado, L., 2018. Circular economy - From review of theories and practices to development of implementation tools. *Resources, Conservation and Recycling*, 135, 190–201.
- Kirchherr, J., Reike, D., Hekkert, M., 2017. Conceptualizing the circular economy: An analysis of 114 definitions. *Resources, Conservation and Recycling*, 127, 221–232.
- Kirchherr, J., van Santen, R., 2019. Research on the circular economy: A critique of the field. *Resources, Conservation and Recycling*, 151, 104480.
- Korhonen, J., Nuur, C., Feldmann, A., Birkie, S.E., 2018. Circular economy as an essentially contested concept. *Journal of Cleaner Production*, 175, 544–552.
- Kristensen, H.S., Mosgaard, M.A., 2020. A review of micro level indicators for a circular economy – moving away from the three dimensions of sustainability? *Journal of Cleaner Production*, 243, 118531.
- Linder, M., Sarasini, S., Loon, P., 2017. A Metric for Quantifying Product-Level Circularity. *Journal of Industrial Ecology*, 21, 545–558.
- Lozar Manfreda, K., Vehovar, V., 2008. Internet surveys, in: *International Handbook of Survey Methodology, International Handbook of Survey Methodology*. Taylor & Francis Group/Lawrence Erlbaum Associates, New York, NY, pp. 264–284.
- Merli, R., Preziosi, M., Acampora, A., 2018. How do scholars approach the circular economy? A systematic literature review. *Journal of Cleaner Production*, 178, 703–722

- Millar, N., Mclaughlin, E., Börger, T., 2019. The Circular Economy: Swings and Roundabouts? *Ecological Economics*, 158, 11–19.
- Mondello, G., Salomone, R., Roos-Lindgreen, E., 2020. Measuring circular economy at company level: the role of Life Cycle Assessment, in: 29th Italian Congress of Commodity Sciences, Salerno, Italy, 13-14 Feb (in press).
- Moraga, G., Huysveld, S., Mathieux, F., Blengini, G.A., Alaerts, L., Van Acker, K., de Meester, S., Dewulf, J., 2019. Circular economy indicators: What do they measure? *Resources, Conservation and Recycling*, 146, 452–461.
- Mura, M., Longo, M., Zanni, S., 2020. Circular economy in Italian SMEs: A multi-method study. *Journal of Cleaner Production*, 245, 118821.
- Ormazabal, M., Prieto-Sandoval, V., Puga-Leal, R., Jaca, C., 2018. Circular Economy in Spanish SMEs: Challenges and opportunities. *Journal of Cleaner Production* 185, 157–167.
- Reike, D., Vermeulen, W.J.V., Witjes, S., 2018. The circular economy: New or Refurbished as CE 3.0? — Exploring Controversies in the Conceptualization of the Circular Economy through a Focus on History and Resource Value Retention Options. *Resources, Conservation and Recycling*, 135, 246–264.
- Saidani, M., Yannou, B., Leroy, Y., Cluzel, F., Kendall, A., 2019. A taxonomy of circular economy indicators. *Journal of Cleaner Production*, 207, 542–559.
- Sauvé, S., Bernard, S., Sloan, P., 2016. Environmental sciences, sustainable development and circular economy: Alternative concepts for trans-disciplinary research. *Environmental Development*, 17, 48–56.
- Schroeder, P., Anggraeni, K., Weber, U., 2019. The Relevance of Circular Economy Practices to the Sustainable Development Goals: Circular Economy and SDGs. *Journal of Industrial Ecology*, 23, 77–95.
- Urbinati, A., Chiaroni, D., Chiesa, V., 2017. Towards a new taxonomy of circular economy business models. *Journal of Cleaner Production*, 168, 487–498.
- Walker, A. M., Raggi, A., Simboli, A., Vermeulen, W. J.V., 2019. Measuring the sustainability impact of circular economy practices: comparing academia and practice. *Proceedings of ISDRS Conference 2019, Nanjing University, Nanjing*, 450-463.