Circularity assessment in companies: conceptual elements for developing assessment tools

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Abstract

Circularity assessment is a relatively new term that started to be used by organizations promoting the circular economy, but that has not been adequately defined in the scientific literature yet. Following this, different actors have developed proposals for circularity assessment at the company level, however they have different understanding about what elements should be included. Based on interviews with experts and literature review of the founding disciplines of the circular economy, a framework has been put together that is composed of purpose, scale, criteria and principles. This framework aims at providing a common basis regarding the definition of circularity, its criteria and assessment approaches at the company level, thus, it expects to reduce the risk of the circular economy becoming inconsequential.

The framework has been used to evaluate four existing circularity assessment proposals at the company level (Circle Economy and PGGM, Ellen Macarthur Foundation, Viktoria Swedish ICT and VBDO) resulting in a gap analysis that identifies alignments and misalignments. From this analysis, it is possible to conclude that the main disagreements relate to what principles and criteria of circularity are used in the proposals. While, scale and purpose of the assessment are the most agreed upon elements. The results of the analysis suggest that there is still room for improvement of existing circularity assessment tools for companies, if they aim at supporting the implementation of a comprehensive circular economy strategy.

Keywords: Circular economy, assessment, companies, circularity

1. Introduction

Circularity assessment is a relatively new term that started to be used by entities promoting the circular economy. As of 2015, organizations such as Circle Economy (Circle Economy & PGGM, 2014), VBDO (VBDO, 2015), the Ellen MacArthur Foundation (Ellen MacArthur Foundation & GRANTA, 2015) and, Viktoria Swedish ICT (Viktoria Swedish ICT, 2015) had launched initiatives to either measure or assess circularity in a company context. Other initiatives include Geng et al., (2012) who provide a set of indicators for evaluating the circular economy program in China at the country level and Haas et al., (2015) who offered a way to measure how circular the global economy is by using material flow analysis.

A circularity assessment tool is suggested by IMSA & Circle Economy (2013) as the first step in the transition towards a circular economy. In their report, they lay down a set of phases that need to happen to move into a circular future including bottom-up and top-down perspectives. The report calls for an "index of circular performance [that] the maximum of companies can join" (p. 20), i.e. a general metric that can be used by different organizations to assess their own performance and that of their partners. Such measurement would allow them to make informed decisions about procurement and incentives. From a

governmental perspective, it could also help deciding what front-running companies to support. The report also encourages companies to develop their own metrics to evaluate their own achievements while the index is developed.

After a rapid review of the existing proposals for circularity assessment, measurement and metrics, a lack of agreement on critical aspects was found. Such discrepancies may arise from an incomplete understanding of what circular economy means at the company level. In this sense, and taking into account the objective of tools such as the one proposed by IMSA & Circle Economy (2013) it is important to minimize such disagreement if comparisons are going to be made. Having in mind this, the present paper aims at providing insights regarding ways to improve current proposals for circularity assessment. To do so, three research questions are defined: what critical elements are required to assess the circularity of companies? What elements have been considered by existing circularity assessment proposals? And, what gaps exist between what experts suggest and what existing proposals include? By answering these questions, this article aims at contributing to the advancement of the circular economy by providing a common basis for understanding circularity at the company level that would allow for more coordinated assessment tools to measure performance.

The rest of the paper is divided in four sections, methods, results, discussion and conclusions and areas for future research.

2. Methods

Given the type of questions defined, the approach selected to analyze the data collected is based on a hermeneutics inquiry that:

"(a) seeks understanding rather than explanation; (b) acknowledges the situated location of interpretation; (c) recognizes the role of language and historicity in interpretation; (d) views inquiry as conversation; and (e) is comfortable with ambiguity." (Kinsella, 2006, p. 2).

To answer the research questions several steps were taken. First, a reference framework was developed by collecting information through literature review and semi-structured interviews from expert sources. Expert sources were defined as scientific and non-scientific literature as well as individuals working on the topic of circular economy or related. Information was classified according to the following categories which were predefined based on an initial review of the existing circularity assessment proposals, in order to organize the information collected:

- Purpose: is defined here as the aim that a circularity assessment has, what is the objective after implementing it.
- Scale: refers to the system level at which the assessment is addressed;
- Criteria: refer to the different features that are actually evaluated by the assessment in terms of criteria that would make a company circular;
- Principles: guiding values or ideas that support the evaluation proposal that help identify what criteria are right or wrong.

Second, four different circularity assessment proposals developed by stakeholders were reviewed and their propositions were organized following the categories mentioned in the first step.

Third, the described circularity assessment proposals were analyzed against the reference framework to find gaps. As a result of such analysis alignments and misalignments were identified.

2.1 Data collection

To collect the information for the analysis, reviews of the documents developed by the organizations behind the proposals were conducted as well as interviews with key individuals. The gaps found were then presented as areas for future improvement and strengthening for circularity assessments at the company level.

Literature review

A literature review of critical documents from expert sources, as well as of the proposals by the stakeholders was conducted. Fifteen (15) expert sources were reviewed, eight (8) of which were peer-reviewed. Four (4) proposals from stakeholders were reviewed. The information collected for both type of sources was organized in four categories: purpose, criteria, scale and principles.

The experts' literature review focused on two sets of documents. The first set included reports on circular economy (non-scientific publications) such as the reports developed by McKinsey for the Ellen Macarthur Foundation (Ellen MacArthur Foundation, 2013), reports from other consulting firms (Accenture, 2014), non-governmental organizations (Preston, 2012) and regional governmental proposals (Rabobank & Port of Rotterdam, 2013). The second set included the founding peer reviewed articles from Industrial Ecology, and Cradle to Cradle that are cited as foundational to the circular economy (Ellen Macarthur Foundation, 2013).

The stakeholders' literature review included internal working papers and presentations facilitated by the contact individual in each organization. These documents are not peer-reviewed and were being developed at the time of the study.

Qualitative interviews

To complement the information gathered from the literature reviews, qualitative interviewing was conducted following the principles proposed by Seale et al., (2004). A core set of individuals, organizations and literature was identified based on their work on circular economy or topics related. The group of people to be interviewed expanded using the snowballing method. The definition of the topics to be addressed and the questions to be asked through interviews was done based on the following elements:

- The type of actor to be interviewed (Expert or Stakeholder)
- Their area of work
- The sector they belong to
- Their previous work on the topic

In this sense, comparable actors (belonging to similar categories) shared the same questions with the aim of allowing for patterns, similarities and shared meanings to emerge. However, given the nature of the method, additional topics and questions were asked, and in some cases, entirely different questions were used. The initial set of questions was sent to the interviewees in advance so they could prepare their answers. Interviews were recorded, or the researcher took notes that were later included in the systematisation matrix alongside the notes from the recordings.

Table 1. *Expert interviews by sector.*

Sector	**Interviewed**	**Recorded**
Government	1	0
Academia	8	6
Private	5	5
Total	**14**	**11**

The interviews were divided in three main sections: an introduction where the researcher presented herself, the aim of the research and of the specific interview. This was followed by the questions and at the end a wrap-up section. The information collected was then summarized and entered in a matrix that was used for the data analysis. For the interviews, four sets of questions were asked depending on the level of familiarity of the participant with the idea of circular economy and circularity assessment. This was assessed based on the background information available for each expert/stakeholder interviewed.

In total, fourteen (14) interviews were conducted with experts and stakeholders in three (3) different sectors. They were conducted between March and May 2015. A brief with a description of the research project and questions to be asked was sent via email to the potential interviewees. Interviews were conducted via Skype, phone and personally. Each interview lasted between 45 and 60 minutes. The information gathered was organized in an Excel sheet summarizing answers for each question based on the notes and recordings.

3. Results

Based on the data collected and analysed, this section presents the results of the studies. They include critical elements suggested by expert sources that should be considering when evaluating circularity at the company level; an evaluation of existing proposals regarding such critical elements and, finally it detects gaps that need to be filled in order to have an integral and robust tool.

3.1 Critical elements for a circularity assessment tool: a general framework

According to the expert sources consulted and reviewed, a circularity assessment tool at the company level should include the following elements:

Purpose

From an academic perspective, two aspects are relevant when discussing the purpose of a circularity assessment: it should contribute to closing the material loops and keep resources for future generations. On the other hand, sources from the private sector indicated that a circularity assessment should allow companies to understand what natural resources they depend on and what internal opportunities they have from waste streams. Other actors from the same sector mentioned that this kind of assessment could be key to encourage strategies towards circularity and to communicate the importance of the transition. In sum, *the purpose of a circularity assessment tool at the company level is three-folded: resource stewardship, management tool for decision-making and engagement tool.*

Scale

The suggestions here are quite varied, depending on the type of organization consulted. Academic experts suggested that the value chain was the most adequate level, taking into account the need for a life cycle perspective. However, product offerings and components were also mentioned; nonetheless, another source from academia contradicted this last argument by stating that the smaller relevant scale for assessing circularity was the company and not the product, if a systems perspective was to be considered. In the case of the private sector, different scales and approaches were proposed: life cycle, value chain, the business model and the product. Thus, *circularity assessment is considered as a multi-scale tool that needs to address the component level, the product level, the value chain, the business model and the company as a whole and should have a life-cycle perspective.*

Criteria

The experts consulted also provided input about what the relevant aspects to assess are when evaluating the circularity of a company. The experts from academia mentioned recycling, refurbishment, closing loops in a strict sense, reuse, smartness, energy use, costs, dependency on future materials, ability to retain value and waste reduction. Another expert from the same sector mentioned that these aspects are not general but depend on the product offerings. From the perspective of private sector the relevant aspects include the number of times the product is used, renewability, the origin of inputs, type of business model, material intensity and waste generation.

In Table 2 the different criteria are presented with an explanatory question companies should ask to assess their level of circularity, according to the sources consulted. An additional step was conducted to group the different criteria under wider categories regarding scale. The criteria were clustered under product if they were referring to component, material aspects;

processes when they referred to how the company creates the product or delivers it; business model when discussing how value was created and, a more general group dealing with the role of the company at the system's level. This classification is arbitrary and is only suggested for the purpose of clarity.

Table 2. *Criteria for circularity, suggested by expert sources.*

Criteria	**Explanation**	**Scale**
Use intensity	How many times is the product used per unit of time?	Product
Recycling	How much of the value proposition is derived from recycled inputs?	Product
Refurbishment	How much of the value proposition is derived from refurbished products?	Business model/product
Remanufacturing	How much of the value proposition is derived from remanufacturing processes?	Product
Renewability	How much of the energy/material inputs is derived from renewable sources?	Process
Repairing	How much of the value proposition is derived from repairing processes?	Business model
Reusability	How much of the value proposition is derived from reused materials, components or products?	Business model/Product
Waste generation	How much waste is generated to deliver a unit of value?	Process
Waste reduction	How much waste is reduced as a result of the value proposition?	Process
Raw materials	How much of the value proposition comes from raw materials?	Product
Dependency of future materials	How much of the value proposition depends on materials that are going to be needed in the future?	Product
Costs	How much do costs increase by implementing circularity?	Business model
Retained value	How much of the value proposition returns to the company in a specific period of time?	Business model
Smartness	How tight do materials, components or products of a company circulate?	Process
Hazardousness	How much of the materials used to deliver the value proposition are toxic?	Product
Energy use	How much energy is used to deliver the value proposition?	Process
Material intensity	How much material inputs are needed to deliver a unit of value?	Process
Efficient use	How efficient is the use of materials and energy to deliver the value proposition?	Process
Circulating of materials	How much does the company contribute to the closed circulation of materials at a society level?	System
Type of business model	How much of the value proposition comes from circular business models?	Business model

Principles

In this section, a review of the principles and guidelines from industrial ecology (Frosch, 1992; Gallopoulos, 2006; Garner & Keoleian, 1995; Lifset & Graedel, 1997) and cradle to cradle (McDonough & Braungart, 2002) is provided, as the founding disciplines of the circular economy (Ellen MacArthur Foundation, 2013).

Industrial ecology seminal papers provide a set of principles or guidelines that offer researchers a framework for developing analysis and prescriptions. A first issue highlighted by the Industrial Ecology authors (Gallopoulos, 2006; Garner & Keoleian, 1995; Lifset & Graedel, 1997), is the need for a system approach to understanding problems. A second issue raised by these experts, connects to the concept of strong sustainability or how human systems are dependent on their ecological environment. They emphasized that ecosystems should be models regarding cycling, community and diversity and consequently environmental considerations should be considered ex-ante any business decision. Another relevant element suggested by

Industrial Ecology as a guiding principle is the need for closing the loops by moving from a linear approach to a cyclical one to reduce waste, achieve dematerialization and environmental impact reductions. In addition to this, the also emphasized the need for a future-oriented perspective or forward-looking type of analysis. In summary, common principles from the literature in Industrial Ecology can be recapped as *systems thinking, strong sustainability, closing the loop, resilient systems and future orientation.*

The Cradle to Cradle literature also provides guidance on what elements should orient the development of business and solutions that can be used in the circular economy. In their pivotal book McDonough & Braungart (2002) add three principles, first the idea of creating safe objects with long term value, which is counter-intuitive to a throwaway economy; second, the need to rely on natural energy flows (e.g. renewable) and, finally, they promote the idea of positive support. Here it is suggested to denominate these principles as maximize *value, use renewable energy sources and positive footprint.*

Resulting from this analysis, the following categories of principles are proposed:

Table 3. *Principles suggested by the expert sources*

Principle	Explanation
Closing the material loops	refers to the need to close the material loops by decoupling growth from materials, transforming waste into valuable streams and managing non-renewable material flows in such a way that do not leak.
Systems thinking	refers to the need of understanding the economy as a system within other systems and consequently of acknowledging the complexity that entails. This principle requires that any circularity effort incorporates a systems approach.
Resilient system	establishes the need to consider both efficiency and resilience as goals of the economic system, in order to achieve effectively its ultimate aim of satisfying human needs sustainably.
Maximize value	deals with the need of the economic system to maximize returns from all types of capitals (natural, financial, human, social, etc.)
Collaboration	refers to the need of a new approach to interaction between economic agents based on cooperation rather than competition in order to maximize all types of values.
Renewable energy sources	addresses the need to rely on renewable energy sources including labor for all economic processes.
Positive footprint	calls for the aspirational aspect of the economic system in terms of being capable of restore and regenerate what is depleted by the system instead of only mitigating.
Strong sustainability	requires economic agents to acknowledge sustainability from a top-down perspective where economy depends on society, which in turns depends on the environment, instead of a bottom-up perspective where all dimensions are equally relevant.
Future based orientation	which refers to the need of conducting analysis that look into the future and provide solutions that are free from lock-in and path dependence effects.

Circularity assessment scorecard

Table 4 summarizes the findings from the expert interviews and literature review in the form of a general framework to assess circularity for companies or "scorecard". It consists of four building blocks, each of them with a set of components that could help understand how circularity is embedded at the company level.

Table 4. *Circularity assessment framework scorecard*

Building Block	**Experts input**					
Purpose	Closing the material loops	Keep resources for future generations	To know what natural resources they depend on	To identify internal opportunities, they have from waste streams	To make decisions that would encourage strategies towards circularity	To communicate the importance of the transition

Scale	The value chain
	Product offerings and components
	Company
	Life cycle
	Business model

Criteria	Recycling	Smartness	Waste reduction	Use intensity	Waste generation	Material intensity
	Refurbishment	Energy use	Costs	Renewability	Dependency on future materials	Repairing
	Closing the material loops	Retain value	Reuse	Origin of inputs	Remanufacturing	Hazardousness
	Value proposition	Type of business models				

Principles	Closing the material loops
	Systems thinking
	Resilient system
	Maximize value
	Collaboration
	Renewable energy sources
	Strong sustainability
	Positive footprint
	Future- based orientation

3.2 Existing circularity assessment proposals

Given the attractiveness of the circular economy, researches and other stakeholders (IMSA; Circle Economy, 2013), have developed initiatives to assess circularity in recent years:

- **Circle Economy** (Circle Economy & PGGM, 2015)
- **VBDO** (VBDO, 2015)
- **The Ellen MacArthur Foundation** (Ellen MacArthur Foundation; Granta Design; 2015)
- **Viktoria Swedish ICT** (Viktoria Swedish ICT, 2015)

These proposals have different approaches, as well as levels of development, targets and goals, but all have the aim of assessing circularity at the company level. The summary of the different proposals is presented in Table 4.

Table 5. *Circularity assessment proposals*

Dimension	Circle Economy	VBDO	EMF	Viktoria ICT
Purpose	To evaluate organizations based on how well they are upholding circular economy principles and implementing their policies and intentions to move towards a circular economy.	To measure to what extent a company is taking concrete steps towards a circular business.	To develop a methodology that measures how well a product or company performs in the context of a circular economy in order to help companies design more circular products, compare different products for internal reporting or procurement purposes, or to compare departments/companies.	To help companies progress along a path towards CE. It could be used mainly internally to focus business strategies, calculating potential cost savings. It can be used to benchmark and compare companies and products to encourage race to the top. It will also quantify costs of different degrees of circularity.
Scale	Organization/system	Organization/system	Product/Organization	Business model/ Product offerings
Aspects	Materials, energy and labor: Renewability, recyclability, criticality, geopolitical risk, locality, competition.	Strategy and governance: which includes how circular thinking is embedded in the strategy, the long-term strategy, targets and accountability.	Inputs: virgin, re-used or recycled	Materials: LCA or MFA are tools relevant to assess material use and environmental impacts.
	Activities: smart, efficiency, modular, extended lifetime, degradability, hazardousness, precaution.	Implementation: revenues from circular products and services, product design and procurement.	Use: length and intensity	Costs: cost savings due to reduction of material costs
	Practices: transparency, collaboration, integrity	Innovation: circular business models, innovation budget and strategic partnerships.	End-of-life: landfill, re-use, recycle	Value retained: portion of added value that comes back to the company
	Impact: global impact on land, water, atmosphere and society	Communication and engagement regarding circular economy customer, stakeholders, raising awareness	Complementary indicators for assessment: Energy use, CO2, water use, cost, price variation, toxicity,	Recirculation: costs of input coming from reuse, recycle, remanufacturing

3.3 Gap analysis

Each of these proposals was analyzed regarding the elements proposed in the circularity assessment framework scorecard presented in the previous section. The question asked was whether an element of the scorecard was present in the proposal or not. Three answers were allowed, yes, no or not explicitly. Then this information was translated into arbitrary scores: a "yes" being 1 (green), "No" a 0 (red) and "Not explicit" 0,5 (orange). Normalized scores were used to find levels of alignment.

Table 6. *Comparative analysis for Circle Economy*

CIRCLE ECONOMY ANALYSIS							
Component	**Experts input**						
Purpose	closing the material loops	keep resources for future generations	to know what natural resources they depend on	to identify internal opportunities they have from waste streams	to make decisions that would encourage strategies towards circularity	to communicate the importance of the transition	
Scale	the value chain						
	product offerings and components						
	company						
	life cycle						
	business model						
Aspects	recycling	smartness	waste reduction	number of times the product is used	waste generation	material intensity	type of busines models
	refurbishment	energy use	costs	renewability	dependency on future materials	repairing	value proposition
	closing the material loops	retain value	reuse	origin of inputs		remanufacturing	hazardousness
Principles	Closing the material loops						
	Systems thinking						
	Resilient system						
	Maximize value						
	Collaboration						
	Renewable energy sources						
	Strong sustainability						
	Positive footprint						
	Future- based orientation						

Table 7. *Comparative analysis for VBDO*

VBDO ANALYSIS							
Component	**Experts input**						
Purpose	closing the material loops	keep resources for future generations		to know what natural resources they depend on	to identify internal opportunities they have from waste streams	to make decisions that would encourage strategies towards circularity	to communicate the importance of the transition
Scale	the value chain						
	product offerings and components						
	company						
	life cycle						
	business model						
Aspects	recycling	smartness	waste reduction	number of times the product is used	waste generation	material intensity	type of busines models
	refurbishment	energy use	costs	renewability	dependency on future materials	repairing	value proposition
	closing the material loops	retain value	reuse	origin of inputs		remanufacturing	hazardousness
Principles	Closing the material loops						
	Systems thinking						
	Resilient system						
	Maximize value						
	Collaboration						
	Renewable energy sources						
	Strong sustainability						
	Positive footprint						
	Future- based orientation						

Table 8. *Comparative analysis for Viktoria Swedish ICT*

VIKTORIA ANALYSIS							
Component	**Experts input**						
Purpose	closing the material loops	keep resources for future generations		to know what natural resources they depend on	to identify internal opportunities they have from waste streams	to make decisions that would encourage strategies towards circularity	to communicate the importance of the transition
Scale	the value chain						
	product offerings and components						
	company						
	life cycle						
	business model						
Aspects	recycling	smartness	waste reduction	number of times the product is used	waste generation	material intensity	type of busines models
	refurbishment	energy use	costs	renewability	dependency on future materials	repairing	value proposition
	closing the material loops	retain value	reuse	origin of inputs		remanufacturing	hazardousness
Principles	Closing the material loops						
	Systems thinking						
	Resilient system						
	Maximize value						
	Collaboration						
	Renewable energy sources						
	Strong sustainability						
	Positive footprint						
	Future- based orientation						

Table 9. *Comparative analysis for the Ellen Macarthur Foundation*

ELLEN MACARTHUR FOUNDATION							
Component	**Experts input**						
Purpose	closing the material loops	keep resources for future generations	to know what natural resources they depend on	to identify internal opportunities they have from waste streams	to make decisions that would encourage strategies towards circularity	to communicate the importance of the transition	
Scale	the value chain						
	product offerings and components						
	company						
	life cycle						
	business model						
Aspects	recycling	smartness	waste reduction	number of times the product is used	waste generation	material intensity	type of busines models
	refurbishment	energy use	costs	renewability	dependency on future materials	repairing	value proposition
	closing the material loops	retain value	reuse	origin of inputs		remanufacturing	hazardousness
Principles	Closing the material loops						
	Systems thinking						
	Resilient system						
	Maximize value						
	Collaboration						
	Renewable energy sources						
	Strong sustainability						
	Positive footprint						
	Future- based orientation						

From an overall perspective, none of the proposals is completely aligned with the framework suggested as it can be concluded from figure 2. Circle Economy's circle assessment tool integrates most of the elements followed by VBDO and Viktoria ICT, while the Ellen MacArthur Foundation seems to be the least aligned initiative. Regarding the particular building blocks, scale is the aspect over which stakeholders most agree upon, considering at least 50% of the elements suggested by experts. On the contrary, 'principles' is the category which exhibits less agreement among stakeholders, some companies include most of the principles offered by the experts while others only include just one or two. Criteria to evaluate circularity is the aspect that does not closely follow experts' suggestions. Finally, perspectives regarding purpose are fairly aligned with what the framework suggests.

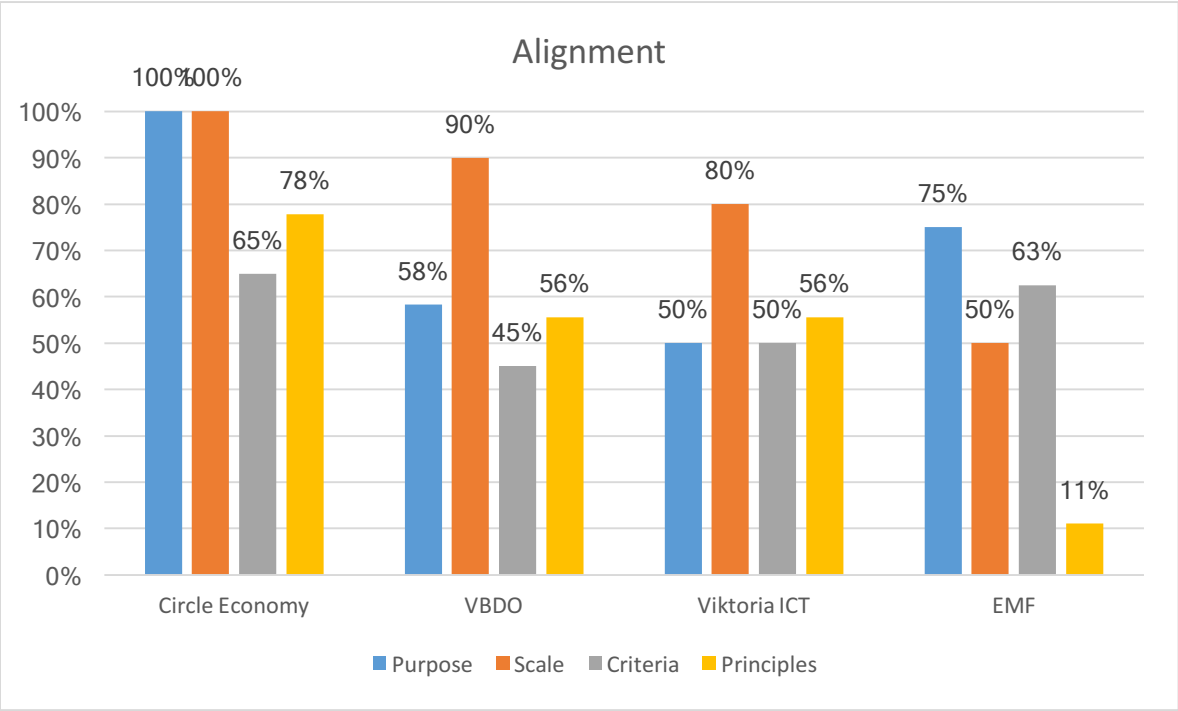

Figure 1. *Level of alignment between the stakeholder's proposal and the framework by building block.*

Looking into more detail, in terms of purpose the least popular topic is 'Keep resources for future generations', while the most prevalent is 'To encourage decisions towards circularity'. As it is evident, most of the purposes offered by the expert sources are integrated in the different proposals.

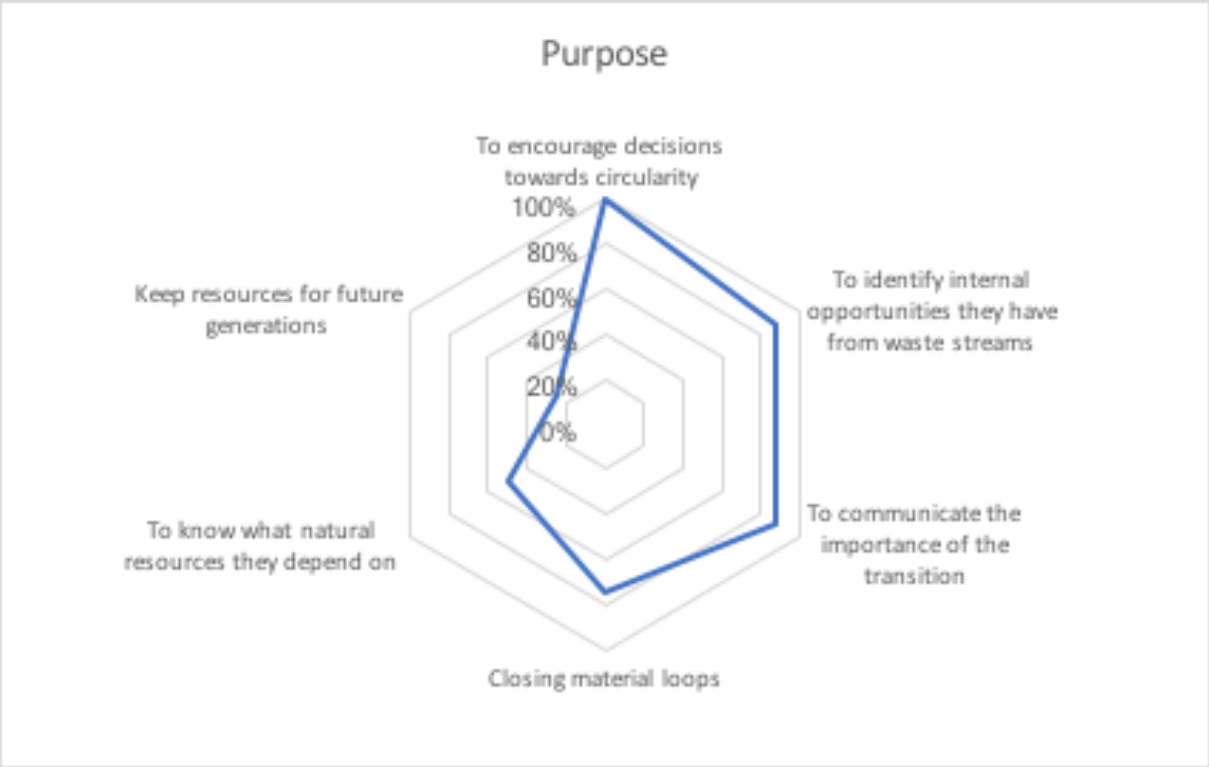

Figure 2*. Level of alignment for different purposes of a circularity assessment tool*

Regarding **the scale** at which the assessment should be implemented, only the Ellen MacArthur Foundation does not include the business model and lifecycle perspectives while all other proposals have a multi-level approach, which was strongly suggested by the expert sources. It is important to highlight that the value chain and product/offerings perspectives are predominant, with all stakeholders agreeing that these levels have to be included in the assessment, while the lifecycle perspective was not so strongly advocated for.

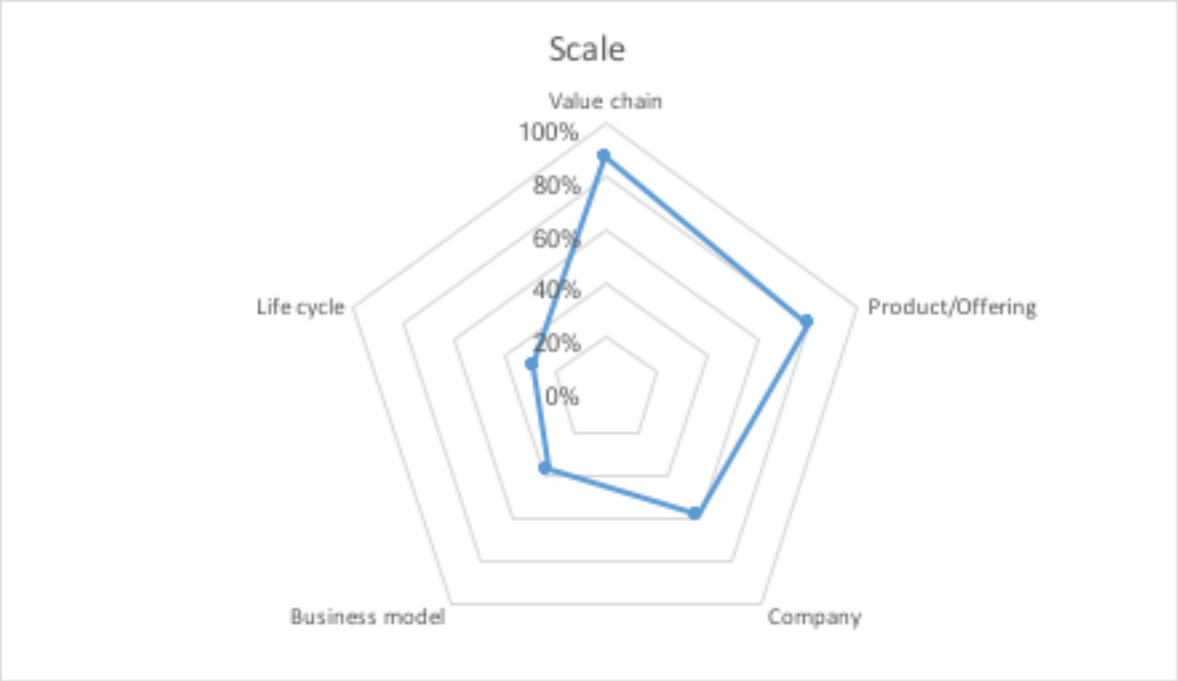

***Figure 3**. Level of alignment for different scales relevant for a circularity assessment tool*

In Figure 4, different **criteria** considered by the stakeholders' proposals are analyzed in order to see which ones are more common. Retain value and recycling were the most considered aspects, with all stakeholders including them in their proposals. Less mentioned aspects are value proposition, smartness, refurbishment, dependency on future materials and remanufacturing.

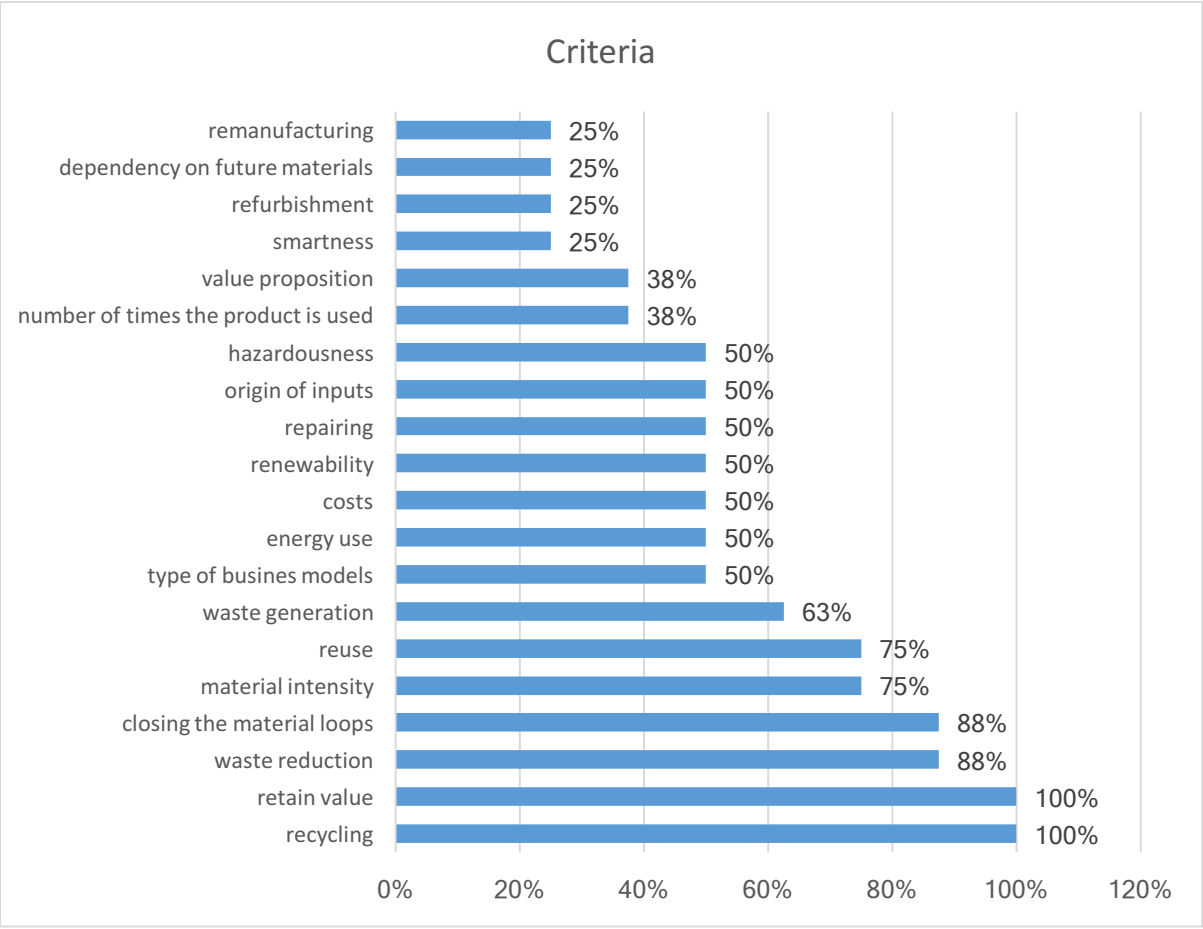

Figure 4. *Level of alignment for each criterion of circularity*

Regarding the principles, none of the proposals considered all the principles identified from expert literature. Moreover, none of the proposals took into account the principle refer here as 'Future-based orientation', but all other principles are in one or more proposal. After this principle, the two less considered were 'Strong sustainability' and 'Collaboration'. Most of the proposals agreed that 'Closing the material loops' was a principle to be considered, while the least agreement is connected to the principles 'Systems thinking', 'Resilient system' and 'Positive footprint'

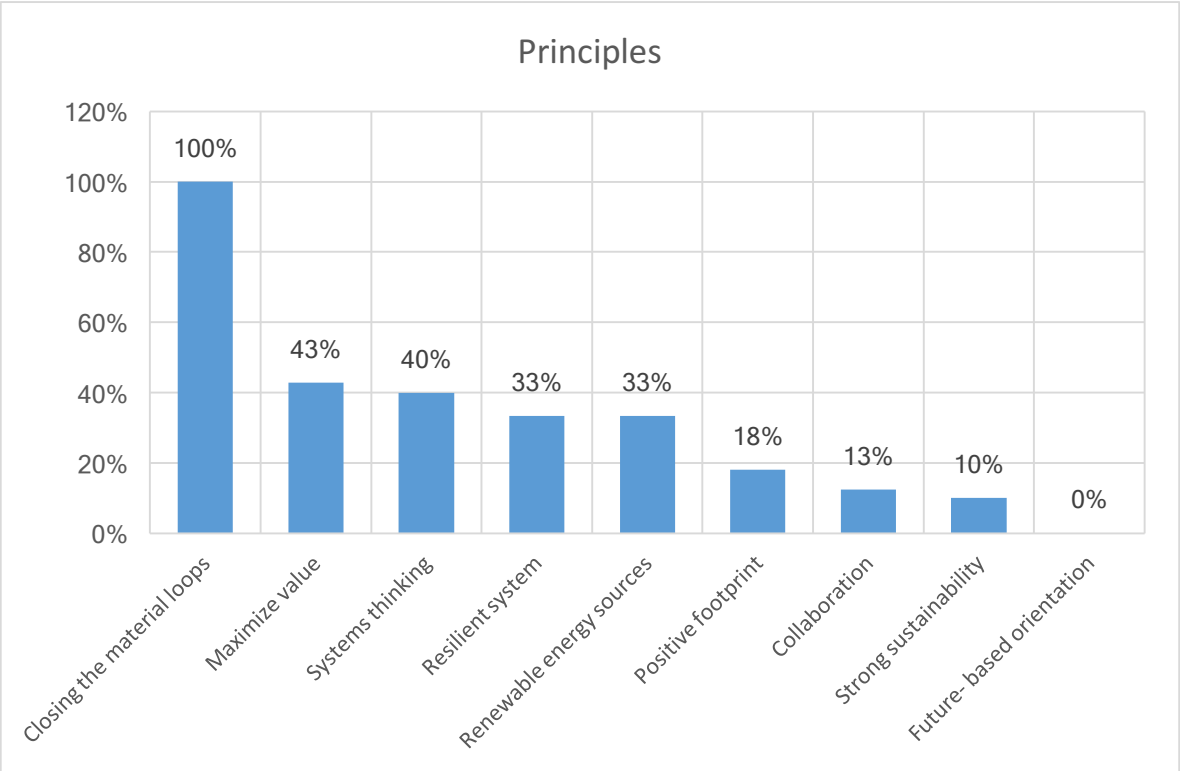

Figure 5. *Level of alignment for principles*

To conclude, regarding purpose, it is important that assessment tools help companies plan for the future identifying dependencies and sustainability issues. Current proposals focus more on current challenges than future ones. Concerning scale, the business model and company level are less considered, and the life-cycle perspective is still missing from the proposals. From the perspective of criteria, it was found that refurbishing, remanufacturing, smartness and dependency on future materials are less considered by existing tools. Finally, the principles regarding future-based orientation, strong sustainability, collaboration and positive footprint are only partially integrated.

4. Discussion

In this section, important findings that were not explored in detail and would offer opportunities for further inquiry are presented. A first element that affects the evaluation conducted here is the understanding of assessment in itself. Although throughout the text the concepts of assessment, measurement and evaluation were used as equivalents, they are different and this may affect comparisons between the different proposals.

Moreover, the lack of agreement between sources about the relevant scale for a circularity assessment might come from the diversity of backgrounds and the novelty of the circularity assessment concept. Since there were input from academics, non-academic researchers and consultants and from a variety of areas, the scale at which they work is different and integration efforts are not evident.

In this line, different experts raised the question about the relationship between circularity assessment and tools such as Life Cycle Assessment or Material Flows Analysis. This was slightly mentioned by the stakeholders in two contradictory senses: on the one hand, the Ellen MacArthur Foundation and Viktoria Swedish ICT proposed that their circularity measurement can be part of Life Cycle Assessment. On the other, Circle Economy and VBDO expressed that these tools can in turn, be part of the circularity assessment. In sum, if circularity assessment is understood as only concerning circulation of materials, it will be part of broader tools, and if it is defined as more than just materials, for example organizational aspects, it will use these tools for its own evaluating process.

Finally, a key aspect brought up by academics is the role of context in the assessment process. This was not introduced in the framework as it was only mentioned once, but it would be important to address it. This aspect, the role of site-specific conditions, is also mentioned as a key aspect to take into account for sustainability assessments. In the literature, this is referred as situational indicators, however, experts not only mentioned this but also specificities about the company's offering as key aspects to consider in a circularity assessment. The challenge here lies on how to incorporate context specificities into an assessment tool.

In sum, the framework suggested here is specific to the type of expert sources consulted both in terms of literature and interviews. Moreover, both the interviewees' context and the interviewer background shape the information and results in this report, making it necessary to recognize this influence and to read the results and conclusions under this light.

In addition to this, the definition of the questions to be asked also affected the contribution received and therefore, the results obtained. In this sense, this research has been more a process of interpreting what the sources of information provided rather than just registering them so they could be understandable and useful for answering the research questions. Another key element was the questions that guided the analysis process in itself yielding the categories and basic elements of the suggested framework.

Taking into account the above-mentioned elements, several particularly interesting findings were identified: first, circularity cannot happen just at one scale, mirroring the complexity of this phenomenon; second, stakeholder proposals are different and rather complementary, which could be explained by their different aims at measuring and assessing circularity. Third, a gap was identified between what the expert literature suggests as principles and what the experts consulted consider as relevant aspects, but this was not further explored. Finally, an important challenge lies on how to incorporate context specificities into an assessment tool. These findings offer opportunities for further research if the issue of circularity assessment is to be explored and strengthened.

5. Conclusions

The aim of this inquiry was to establish the fundamental elements of a circularity assessment framework that effectively contributes to improving resource efficiency. Such a framework was structured based on experts input from literature sources and interviews. Perspectives from academia, private sector, government and civil society were combined in order to identify the purpose, scale, criteria and principles that should guide a circularity assessment.

This framework was used to evaluate existing efforts for developing tools to assess circularity at the company level and identify alignments and misalignments. In total 15 articles and reports were reviewed and 20 experts interviewed while 4 proposals were assessed using similarity analysis under an interpretative inquiry approach.

The proposed framework has four building blocks: a purpose for circularity assessment; the relevant scales at which it should be implemented; the criteria that allow to define if a company is circular or not; and finally, what principles need to support the assessment.

In terms of the purpose, a circularity assessment assists companies in addressing their role in society as resource stewards, in making management decisions and in engaging with a wider audience. Regarding scale, circularity does not happen only within the boundaries of the company, it is a property of the broader system in which the company is embedded. In this sense circularity assessment has to be multi-scale and have a life cycle approach. Circularity is about reducing resource use and environmental negative impacts and creating value as much as making our economic system resilient and future proved while delivering wellbeing.

Existing efforts to assess circularity consider these aspects partially; in some cases, like in the case of the Circle Economy and VBDO proposals, they are closer to the framework proposed here than the proposals suggested by the Ellen MacArthur

Foundation and Viktoria Swedish ICT. The first group has a more comprehensive approach to the assessment, while the other two are more focused on measuring circularity. In this sense, it is concluded that the different proposals are complementary and elements of all could be combined to have an integral proposal that more closely follows the suggestions made by the experts.

In sum the main contribution of the circular economy is the systems' approach to understanding the economy, which in turn requires a change in mindset by key actors in society. This is only achieved if the operationalization of the idea follows the principles proposed as a result of decades of systems thinking and sustainability work. It is not enough to just mention the principles and acknowledge them but it is mandatory to translate them into measurable practices.

Circularity, as any social phenomenon, is not a technical fix or a management solution; it is a complex approach that requires a complex understanding and complex solutions. In this sense, a circularity assessment requires collaboration between experts from academia, private and government sectors. Additionally, it demands integrating approaches from other sectors of society, like consumers, civil society and unions. Current proposals come from either technical or management experts, and some input from a narrow definition of civil society (companies and business associations) has been incorporated by some organizations but this needs to be taken further if complexity is to be addressed.

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References

Accenture. (2014). Circular Advantage, 24.

Circle Economy, & PGGM. (2014). *Circularity Assessment for Organizations : Draft Indicators*.

Ellen MacArthur Foundation. (2013). *Towards the circular economy 1: economic and business rationale for an accelerated transition* (Vol. 1). Retrieved from http://www.ellenmacarthurfoundation.org/business/reports

Ellen MacArthur Foundation, & GRANTA. (2015). Project Overview: An Approach to Measuring Circularity. *Ellen MacArthur Foundation*, 12. https://doi.org/10.1016/j.giq.2006.04.004

Frosch, R. A. (1992). Industrial ecology: a philosophical introduction. *Proceedings of the National Academy of Sciences*, *89*(3), 800–803. https://doi.org/10.1073/pnas.89.3.800

Gallopoulos, N. E. (2006). Industrial ecology: An overview. *Progress in Industrial Ecology*, *3*(1–2), 10–27. https://doi.org/10.1504/PIE.2006.010038

Garner, A., & Keoleian, G. (1995). *Industrial Ecology : An Introduction*. *Industrial Ecolog*.

Geng, Y., Fu, J., Sarkis, J., & Xue, B. (2012). Towards a national circular economy indicator system in China : an evaluation and critical analysis. *Journal of Cleaner Production*, *23*(1), 216–224. https://doi.org/10.1016/j.jclepro.2011.07.005

Haas, W., Krausmann, F., Wiedenhofer, D., & Heinz, M. (2015). How circular is the global economy?: An assessment of material flows, waste production, and recycling in the European union and the world in 2005. *Journal of Industrial Ecology*, *19*(5), 765–777. https://doi.org/10.1111/jiec.12244

IMSA, & Circle Economy. (2013). Unleashing the power of the Circular Economy, 98. https://doi.org/10.1089/ind.2013.1564

Kinsella, E. A. (2006). Hermeneutics and critical hermeneutics: Exploring possibilities within the art of interpretation. *Forum Qualitative Sozialforschung*, *7*(3). Retrieved from http://www.qualitative-research.net/index.php/fqs/article/view/145/319

Lifset, R., & Graedel, T. E. (1997). Industrial ecology : goals and de fi nitions.

McDonough, W., & Braungart, M. (2002). Cradle to Cradle: Remaking the way we make things. *Chemical and Engineering News*, 193. https://doi.org/10.1177/0276146704264148

Rabobank, & Port of Rotterdam. (2013). Pathways to a Circular Economy: What is possible in the Rotterdam Delat Region, 1–73.

Seale, C., Gobo, G., Gubrium, J. F., & Silverman, D. (2004). Introduction : inside qualitative research. In *Qualitative Research Practice* (pp. 1–12). https://doi.org/http://dx.doi.org/10.4135/9781848608191

VBDO. (2015). *Company Assessment Criteria Theme: Circular Economy*.

Viktoria Swedish ICT. (2015). *Measuring business model circularity as a means to promote resource productivity*.