Research article

Circular Business Ecosystem Innovation: A guide for mapping stakeholders, capturing values, and finding new opportunities

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ABSTRACT

The transition towards Circular Economy (CE) is strongly linked to collaborative relationships between stakeholders, whose main goal is to create and capture differential values. However, the literature is not clear about who these stakeholders are, how they are connected and what kind of values they share. Thus, this paper proposes a guide for mapping stakeholders, capturing circular values and finding new CE implementation opportunities. To achieve this goal, we used an iterative approach comprising a literature review to identify the circular captured values, fuzzy cognitive map (FCM) application to assess the relations between captured values and CE principles, as well as multiple case studies to test the applicability and validity of the guide. As results, we obtained a stakeholder classification applied to CE, identified a list of circular values these stakeholders could capture, and proposed a guide that drives the organizations toward identifying new opportunities and solutions for CE implementation. This paper stands out for identifying new opportunities to improve organizational performance towards CE, as well as for providing a systemic view of the business ecosystem, integrating stakeholders in decision-making processes.

Introduction

Circular Economy (CE) is perceived as a valuable approach to achieve sustainable development and to create a more resilient and effective system. CE emerged with the mission of dealing with the damage caused by the linear model and promoting a more sustainable system (Ellen MacArthur Foundation, 2012; Fonseca et al., 2018). According to the Ellen MacArthur Foundation, (2012), CE is defined as "restorative and regenerative by design aiming to keep products, components, and materials at their highest utility and value all times distinguishing between technical and biological cycles." Based on that definition, the standard BS8001 (British Standards Institution, 2017) proposed guiding principles as an essential basis for decision making towards the implementation of CE:

- Systemic thinking: understands the complex, non-linear and interconnected nature of any system in which an organization is part of.

- Innovation: continually innovate to create value by enabling the sustainable management of resources through the design of processes, products/services and business models.
- Stewardship: organizations are responsible for managing all its decisions and activities, from inception to fulfilment and end-of-life.
- Collaboration: collaborate internally and externally through formal and/or informal arrangements to create mutual value.
- Value optimization: keep all products, components and materials at their highest value and utility at all times.
- Transparency: communicate decisions and activities related to the transitions towards CE in a clear, accurate, timely, honest and complete manner.

The task of incorporating CE concepts and principles is complex, interconnected, uncertain and requires the company's ability to propose differentiated values and transform business models (Pieroni et al., 2019). The business models are the main source of value creation in organizations (Richardson, 2008). To be considered circular, a business model should be designed to create, deliver, and capture economic value while simultaneously con-

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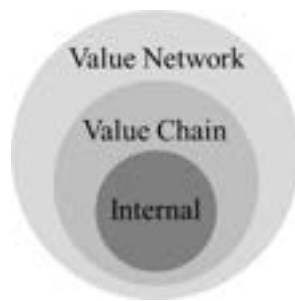
Fig. 1. Stakeholders of the Circular Business Ecosystem.

tributing to environmental and social aspects (Bocken et al., 2014; Lüdeke-Freund et al., 2018).

In addition to the transformation of business models, the transition towards CE requires that the configuration of the current system changes its cultural and normative values to promote the development of radical and disruptive innovations in niches that have the potential to grow and to 'break' the rules of the current business and activities (Geels, 2012). These disruptions in the current linear model need investment and collaboration between stakeholders to scale-up.

Disruptive innovations are complex and usually involve a set of stakeholders that share values (Jay et al., 2016) in a business ecosystem in order to develop new offerings to consumer needs. According to Adner and Kapoor (2009), the business ecosystem is a value-oriented network, composed of numerous stakeholders and represented by transactions between the stakeholders. The concept of ecosystem applied to business is used to describe collectives of heterogeneous yet complementary organizations that collaboratively create some kind of system-level values (Jacobides et al., 2018). Thus, companies co-evolve cooperatively and competitively around innovations (Jacobides et al., 2018; Moore, 1993) in a dynamic, collaborative, network-oriented, and externally focused perspective (Fuller et al., 2019) while redefining business capabilities in order to collaborate with stakeholders to enable value capture (Kramer and Pfitzer, 2016).

Value is a core concept for the transition towards CE. Values are a set of benefits resulting from an exchange delivered to different stakeholders (Yang et al., 2014). For circular captured values, we understand the gains/benefits that the implementation of a circular business model allows to all the business ecosystem stakeholders. The circular captured values are inherent to the business models (Bocken et al., 2018), however, they can change from one stakeholder to another (Dagevos and van Ophem, 2013; Yang et al., 2014). Thus, stakeholder is an extremely important concept to understand the distribution flow of the circular captured values.

Stakeholders are groups or individuals that can affect or be affected by the organization's activities (Freeman, 1984). There are several classifications of stakeholders in the literature, but they do not take the CE perspective under consideration. Generally, organizations believe that stakeholders are the only actors directly integrated in its core business, such as consumers/users, suppliers and employees. However, a CE is marked by a systemic vision which encompasses exchange and interactions between all actors in a business ecosystem. Thus, we classified stakeholders as (see Fig. 1): internal stakeholders (actors that are responsible for the organization's decisions and activities comprising, for example, shareholders, employees, supervisors, managers, and departments); value chain stakeholders (actors directly affected by or directly influencing the organization, such as consumers, users, suppliers, retailers, and recycling cooperatives); and value network stakeholders (actors directly or indirectly related with the organization such as

government, competitors, inspection agencies and regulatory bodies, society, environment, universities, and local communities).

The internal and the value chain stakeholders are the most common and intrinsic in the organizations; on the other hand, value network stakeholder is a new concept. A value network is characterized by a set of interactions in which individuals and groups of individuals interact with each other and are engaged in the exchange of values (Allee, 2008). On the other hand, the value network stakeholders comprise all the stakeholders that do not deploy specific activities in the organization's core business, but who are affected (positively or negatively) by the activities performed by a particular company.

The literature on business models and value propositions for CE is increasing. However, most studies are related to defining concept (Kirchherr et al., 2017; Korhonen et al., 2018), CE implementation approaches (Asif et al., 2018; Gorissen et al., 2016; Lieder and Rashid, 2016) and, proposition and creation of value through business model innovation (Bocken et al., 2015; Manninen et al., 2018; Nußholz, 2018). Few publications address in a systemic perspective the innovations and discussions of the ecosystem as regards sustainability and CE (Bocken et al., 2019; de Sousa Jabbour et al., 2019; Rosa et al., 2019). A small number of publications address the agenda of sustainable and/or circular values (Bocken et al., 2015; Manninen et al., 2018; Yang et al., 2017), confirming the need for efforts to advance research in this field.

Some authors (Antikainen et al., 2017; Lüdeke-Freund et al., 2018; Ritala et al., 2018) have proposed tools and methods in order to innovate circular business models considering the captured values. Others have proposed solutions for circular value proposition and creation (Kristensen and Remmen, 2019; Mishra et al., 2018a; Zacho et al., 2018) without addressing the importance of stakeholders. Frequently, this results in solutions focused on short-term strategies considering only internal or value chain stakeholders in decision-making. Moreover, circular organizations operate in a multistakeholder ecosystem, which increases the complexity of identifying successful innovations (Ihrig and MacMillan, 2017).

Given this background, this paper aims to propose a guide for mapping stakeholders, capturing circular values and finding new opportunities for CE implementation. The following are the research questions that drive the guideline proposition:

1 What are the circular values that can be captured by stakeholders involved in a circular business ecosystem?
2 How can organizations identify new opportunities to innovate CE considering the values captured by the business ecosystem stakeholders?

While there have been several recent CE studies in the literature in terms of circular business model innovation, and creation and delivery of circular values, in our understanding, none have specifically aimed to cover all these aspects. Moreover, to the best of the authors' knowledge, there is a lack of studies related to guidelines for organizations to manage the values and stakeholders' complexity to identify systemic innovations. This lack of theoretical insights means that organizations often do not have a systemic perspective and are unable to consider captured values and stakeholders during the proposition of strategies for CE implementation.

This paper allowed identifying a list of circular captured values, assess relations between those values and CE principles, and provide a practical reference that integrates knowledge from both literature and business in the development of the guideline. This study brings a strategic perspective to the transition towards CE and the promotion of sustainability. The guide proposed here serves to facilitate identifying stakeholders, helping organizations to consider all the stakeholders in the proposition of circular solutions. Moreover, the list with the importance of each circular cap-
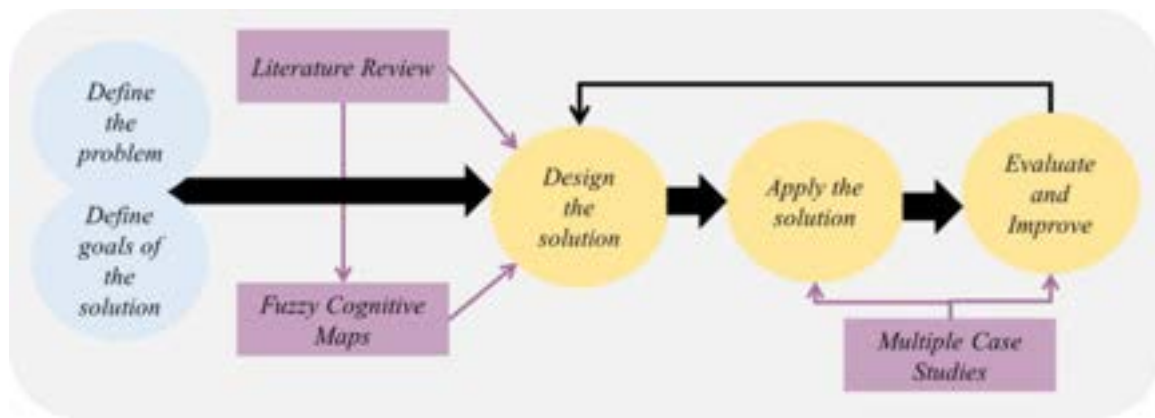
Fig. 2. Methodological Approach.

tured value serves as a map, where the organization can choose the most essential values for implementing CE in their organization, and set up strategies to incorporate these values into its business.

This paper is organized in four sections. Section 2 describes the research methodology. Section 3 presents the results and discussions. Section 4 presents the conclusions.

Methods

Fig. 2 shows the multistep and iterative process used to develop the guide. First, we set up the problem to be solved and then define the solution goals to solve this problem. Subsequently, a literature review was performed, combined with the FCM whose results became the inputs to design the guide. Next, the guide was applied, evaluated and improved through the application of multiple case studies.

Definition of problem and goals

Organizations are concerned with doing less harm, ignoring the importance of business success that lies in creating new values opportunities. A source of this problem is the lack of systemic approaches for the proposition, creation, and capture of values focused on fulfilling the stakeholder's needs. The knowledge of circular value proposition, creation, and capture is ambiguous (Geissdoerfer et al., 2016; Yang et al., 2017); and interactions among stakeholders are misunderstood (Antikainen et al., 2017; Hazen et al., 2017). A solution should drive the process of mapping stakeholders; identifying circular captured values and prioritizing innovation opportunities. Based on those premises, we proposed the phases and activities of the guide.

Designing the Guide

First, a literature review was conducted to identify the circular captured values, as well as a search for the requirements that should be included in a solution for mapping stakeholders, capturing values, and finding new circular opportunities. The literature review procedure followed the guidelines proposed by Tranfield et al., (2003): (i) literature search – definition of the database, keyword, inclusion and exclusion criteria; and (ii) literature analysis and synthesis – interpretations and associations between the studies within an analytical and systemic perspective. Table 1 presents a short description about the criteria used to perform the literature review.

The search resulted in 377 unique publications, and in addition to this sample, influential non-peer-reviewed publications from

Table 1
Criteria for literature review.

Databases	Scopus and Web of Science
String	(("circular economy") AND ("captured value" OR "circular value" OR "value" OR "value chain"))
Searched by	Title, keywords and abstract
Inclusion Criteria	• English language • Original Article or Review • Specifically address the theme "captured values" applied into CE or sustainability context • If it is not suitable with the previous criteria, it should clearly present gains/benefits that could be captured by the CE implementation
Exclusion Criteria	• Non-English language • Papers that superficially address the theme captured values • Paper that to do not present any kind of captured value, gains/ benefits related to the CE implementation
Reading Schema	• Title, Abstract, Keywords • Introduction and Conclusion • Full paper

non-profit organizations or knowledge platforms on CE were included. In total, we selected 65 publications considering only the publications that present types of circular captured values. This literature review resulted in a list of 55 circular captured values (Appendix – Table A1). This list was used as input for the application of the FCM.

The evaluation of the relationship between circular captured values and CE principles is affected by subjectivity since it is executed based on the expert's judgment. To deal with this matter, the computational processing of human language is recommended (Zadeh, 1999). The FCM is a soft computing technique that incorporates ideas from artificial neural networks and fuzzy logic, allowing the relationship between concepts to be represented linguistically with an associated fuzzy set rather than requiring them to be precise (Feyzioglu et al., 2007), therefore with the potential to provide novel results regarding the evaluation of the relationship between circular captured values and CE principles. Most of the cause and consequence relationships are affected by uncertainty and, therefore, difficult to be analyzed, especially when they are not directly measurable (Papageorgiou and Stylios, 2008). Thus, fuzzy cognitive maps are computational tools used to handle and overcome the presence of subjectivity in these cases (Kosko, 1986).

FCMs have been recently applied to CE subjects, such as Trappey et al., (2010) that used operational indicators to evaluate the performance of a reverse logistics system using FCM and ge-
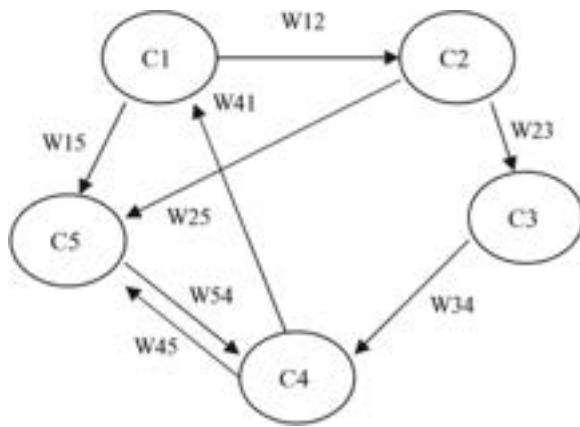
Fig. 3. The visual representation of a Fuzzy Cognitive Map. Source: Based on Papageorgiou and Stylios (2008).

netic algorithms. Morone et al., (2019) propose the application of FCM in order to identify and recommend the most effective initiatives that may modify the current unsustainable food consumption model. Haeri and Rezaei, (2019) apply FCM for selecting green suppliers. Gnoni et al., (2017) propose the application of FCM for enabling CE strategies for electric and electronic equipment.

A FCM consists of nodes that represent the different system components, which interact with each other and are connected through directional edges that indicate the strength of the causal relationships (Stylios et al., 2008). The value of A_i characterizes each FCM concept and w_{ij} corresponds to the weight of the interconnection from concept C_j to C_i, both determined linguistically and converted to fuzzy numbers in the interval [0, 1]. Fig. 3 presents the visual and matrixial representations of the expert-based FCM model.

$$W = \begin{bmatrix} w_{ij} \end{bmatrix} = \begin{pmatrix} w_{11} & \cdots & w_{15} \\ \vdots & \ddots & \vdots \\ w_{51} & \cdots & w_{55} \end{pmatrix}$$

When the system is activated by the sigmoid threshold function (Eq. 1), the value A_i of a concept C_i is calculated by computing the influence received by the concepts C_j's (Eq. 2), where $A_i^{(k+1)}$ is the value of concept C_i at the step $k+1$ and $A_j^{(k)}$ is the value of concept C_j at the step k (Stylios et al., 2008). The sigmoid function f was selected due to the fact that the FCM values lie within the range of [0,1], where λ ($\lambda > 0$) is a parameter that determines its steepness (Bueno and Salmeron, 2009).

$$f = \frac{1}{1 + e^{-\lambda x}} \tag{1}$$

$$A_i^{(k+1)} = f \left(A_i^{(k)} + \sum_{\substack{j \neq i \\ j = 1}}^{N} A_j^{(k)} w_{ij} \right) \tag{2}$$

It is noteworthy that – due to the fact that experts' knowledge was used to obtain the aforementioned values and for conserving readability for the non-fuzzy expert – the weights were not trained by any method, such as the heuristic optimization method for example. We applied the FCM technique to identify the relation between circular captured values and CE principles, and to calculate the relative importance that CE principles have in the circular business ecosystem. The application has four main phases, as illustrated in Fig. 4.

Table 2
Linguistic terms and respective fuzzy numbers.

Linguistic term	l	m	u
Null	0	0	0
Very low	0	0	0.2
Low	0	0.2	0.4
Medium	0.2	0.4	0.6
High	0.4	0.6	0.8
Very high	0.8	1	1

Firstly, we contacted a group of four academic practitioners with research expertise in CE. The experts are researchers who have worked with CE topics for at least three years. The experts evaluated the relation between the captured values and the CE principles through the linguistic terms associated with triangular fuzzy numbers presented in Table 2. The definition of suitable linguistic terms can help decision makers in evaluating the interactions between variables. They are usually set as causal intensity qualitative measures associated with fuzzy numbers in a normalized scale: "very low", "low", "medium", "high" and "very high". Linguistic variables can be determined and associated with fuzzy numbers to capture a decision maker's subjective judgment in a quantitative way (Zadeh, 1973). Thus, imprecision is considered by the possibility of the same element simultaneously belonging to more than one set, which is based on the parameterization of pertinence functions (Zadeh, 1965). Fuzzy numbers are described by their respective pertinence functions, with the triangular and trapezoidal as the most commonly used function types (Lima Junior et al., 2013). Therefore, let l, m and u be real numbers. Thus, F consists of a triangular fuzzy number if l is its lower value, m its medium value and i its upper value (l <m <u), where F is given as F = [l, m, u] (Zimmermann, 2010).

In the second phase, we identified the variables FCM concept obtained as the output of the literature review. In the third phase, we asked the experts to evaluate the relationship level between these concepts through the linguistic terms in Table 2, as well as their relative importance in the circular business ecosystem. These linguistic evaluations were converted into their correspondent fuzzy numbers and aggregated. Subsequently, they were defuzzified according to the center of gravity method (CoG), given by Eq. 3 (Baykasoğlu and Gölcük, 2015). With this information, and applying Eqs. 1 and 2, the system could be activated. The last phase consists in the analysis of the third phase outputs, after the FCM convergence. The software MATLAB used for developing the FCM based model and the software Microsoft Excel was used for analyzing results.

$$CoG = l + [(m - l) + (u - l)]/3 \tag{3}$$

Applying, Evaluating and Improving the Guide

The nature of the study is exploratory, making the multiple case study an adequate approach since the phenomenon can be studied in its natural setting and it augments the external validity and diminishes observer bias (Voss et al., 2002). The method of multiple case studies was used to evaluate the applicability and usability of the guide, as well as to identify improvements that could be made to propose a more relevant solution.

The guide was applied in order to explore and position the organizations in relation to the CE values. The application followed a workshop and interview section (see Appendix – Table A2) in three organizations, whose characteristics are presented in Table 3. Our goal was to select organizations of different sizes and from different sectors to evaluate the applicability of the guide in different contexts.
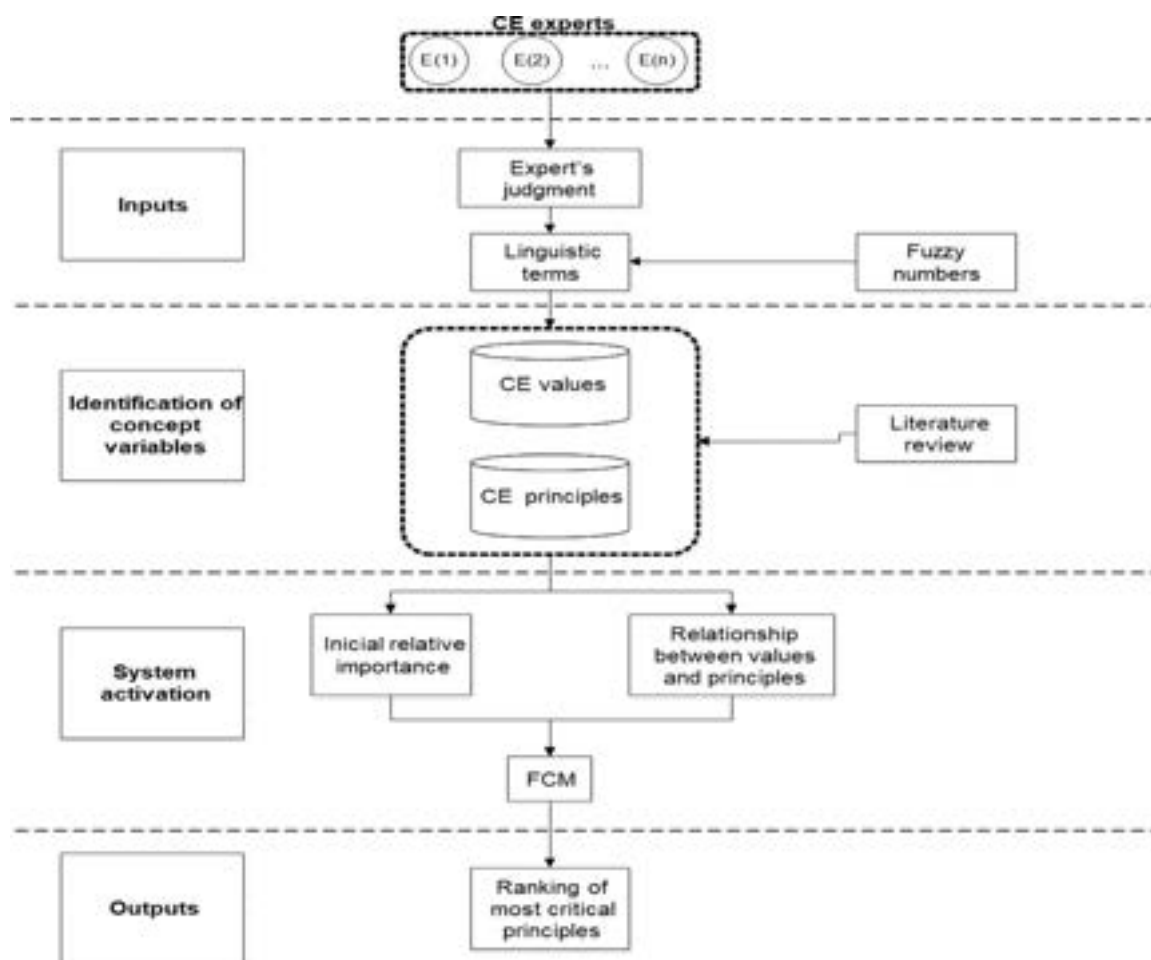
Fig. 4. Fuzzy Cognitive Map application phases.

Table 3
Focal companies.

Company	Company Size (Employees)	Business Model	Participants
A *A joint-venture between a Brazilian company from the metal-mechanical sector and a Swedish powder metal manufacturer*	22	Production of sugarcane cutting system	CEO Marketing Manager
B *A family-owned company, with national capital (Brazil), founded with the proposal of repairing automotive diesel engines*	150	Production of devices for application in internal combustion engines	CEO Project Manager
C *A multinational organization from the steel sector whose main commitment is "act to guarantee the quality life of future generations"*	4456	Steel mining and sale to overcome multiple functions for society such as construction, transportation, support material for cleaner technologies	CEO Sustainability Manager

The workshop and interviews were divided into four sections of two hours, applied individually in each organization, and facilitated by three PhD researchers. An alignment meeting and a brief interview were held before the workshop, and additionally, the general steps of the guide were presented to the participants with relevant guidelines for the application. During the workshop, the participants were stimulated to use this time to discuss and review their decisions to search for the best CE opportunity. Moreover, they were also stimulated to give feedback and suggestions on how we could improve the guide. The proposition of the guide

phases and the guide application were conducted in an iterative procedure supported by constant reviews of the guide to evaluate its relevance and applicability.

The application of the guide was based on using a set of posters and cards. The posters were used for arranging and organizing the information, and the cards helped in defining some concepts. The cards were gradually presented to the participants, along with the step-by-step of each phase presented in the guide. At each step and each phase, the participants presented a number of actions that must be taken, in order to advance to the next phase. At the end of the workshop, the participants proposed an action plan for CE implementation.

Results and discussion

In this section we present the obtained research results, we discuss how the results are interconnected and how they contribute to the research field.

Circular captured values and Principles relations

With FCM aggregation, we quantified the relations between circular captured values and CE principles. Table 4 represents the strength of each relation in a color scale map, where red is as-

Table 4
Relations among circular business ecosystem stakeholders, circular captured values and CE principles.

Stakeholders	Circular Captured Values	Systems Thinking	Innovation	Stewardship	Collaboration	Value Optimization	Transparency
Internal	Better corporate reputation	0.22	0.25	0.30	0.30	0.30	0.35
	Increases the market value of shareholders' equity	0.33	0.33	0.33	0.38	0.35	0.23
	Customer retention	0.22	0.30	0.27	0.27	0.33	0.33
	Cash flows growth	0.17	0.28	0.25	0.27	0.37	0.30
	Increase firm's market value	0.12	0.28	0.20	0.23	0.37	0.32
	Lower manufacturing costs	0.23	0.28	0.23	0.33	0.38	0.27
	Create new business opportunities	0.37	0.38	0.33	0.37	0.37	0.30
	Cost savings	0.22	0.28	0.30	0.33	0.35	0.30
	Minimize the risks of price variations	0.27	0.20	0.33	0.33	0.37	0.37
	Maintaining the highest value of materials and products	0.35	0.38	0.35	0.35	0.40	0.33
	Improving innovation	0.33	0.40	0.33	0.37	0.35	0.33
	Creating higher barriers for competitors	0.10	0.33	0.28	0.17	0.33	0.15
	Generating new and resilient revenue streams	0.33	0.37	0.27	0.33	0.37	0.30
	Pioneer of technical innovations	0.28	0.38	0.32	0.35	0.32	0.28
	Access to new market segments	0.32	0.37	0.30	0.32	0.37	0.33
	New and innovative business models	0.35	0.38	0.32	0.35	0.38	0.33
	Investment attraction	0.28	0.35	0.28	0.32	0.33	0.33
	Increasing the economic value of materials and products	0.27	0.37	0.30	0.30	0.40	0.33
	Pioneering standards and regulations	0.27	0.27	0.33	0.38	0.28	0.37
	Closer relationship with customers / companies	0.33	0.30	0.30	0.40	0.33	0.37
	Improved customer loyalty	0.17	0.28	0.30	0.32	0.38	0.30
	Legitimacy and image	0.20	0.37	0.27	0.25	0.33	0.40
	Brand loyalty	0.10	0.32	0.27	0.28	0.37	0.37
	Behavior and mindset change	0.33	0.37	0.33	0.33	0.37	0.33
	Resource security	0.38	0.32	0.35	0.38	0.35	0.37
	Economic growth	0.25	0.30	0.28	0.32	0.37	0.28
	Competitive advantage	0.33	0.30	0.20	0.15	0.33	0.15
	Produce additional revenue from multiple use cycles	0.33	0.32	0.27	0.35	0.40	0.23
Tech	Reduce waste	0.32	0.32	0.32	0.30	0.28	0.27

Table 4 (continued)

Energy savings	0.28	0.33	0.30	0.27	0.30	0.23
More durable and innovative products	0.33	0.38	0.32	0.32	0.38	0.28
Use internal waste materials for new products	0.32	0.28	0.37	0.27	0.40	0.30
Reduce use of materials (virgin or not)	0.32	0.33	0.37	0.32	0.37	0.25
Use of sustainable materials	0.35	0.33	0.35	0.32	0.35	0.30
Increasing recyclability	0.25	0.33	0.35	0.37	0.30	0.27
Collaboration	0.35	0.27	0.30	0.40	0.33	0.37
Improve relations with different stakeholders	0.40	0.27	0.37	0.40	0.33	0.37
Longer relationship among stakeholders	0.32	0.18	0.28	0.38	0.35	0.32
Increase resource efficiency	0.22	0.37	0.37	0.33	0.38	0.23
Carbon reductions	0.22	0.28	0.37	0.22	0.22	0.30
Pollution prevention	0.30	0.23	0.30	0.25	0.22	0.28
Emissions reduction	0.25	0.28	0.33	0.18	0.25	0.27
Decrease of negative environmental impacts	0.28	0.27	0.35	0.28	0.27	0.33
Minimizes the risks of scarcity of raw materials	0.32	0.35	0.35	0.33	0.38	0.30
Reduction of disposal activities	0.28	0.28	0.35	0.35	0.35	0.28
Elimination of toxic waste	0.38	0.37	0.40	0.30	0.27	0.27
Increase the use of renewable resources	0.35	0.35	0.37	0.35	0.33	0.27
Less greenhouse gas emissions	0.28	0.28	0.37	0.33	0.32	0.30
Less food loss	0.33	0.30	0.35	0.38	0.37	0.28
Job creation	0.37	0.32	0.32	0.37	0.35	0.32
Prosperity of low income families	0.30	0.10	0.10	0.35	0.23	0.20
Protect of humans and the environment	0.28	0.30	0.22	0.33	0.33	0.33
Better quality of life	0.35	0.25	0.28	0.32	0.33	0.27
High-quality jobs	0.23	0.32	0.32	0.35	0.30	0.35

(Left row group label: Value Network)

Color scale: Very high — High — Medium — Low — Very low — Null

sociated with higher intensities and green with the lower ones. These relations are important for identifying the essential circular captured values that organizations should have to implement more circular value propositions. These identify the circular values already captured by the stakeholders, those not captured yet, and those that the stakeholders should focus on to improve their circularity.

The circular captured values are divided by the stakeholders that usually capture these values. This classification was done based on the literature and case study findings. Some values are broader than others, and usually, the broader the values, the broader the stakeholders' classification, which means that the specific values related to gains in production, products, processes and internal activities are captured by internal stakeholders. Values that can be shared with customers and suppliers (for example) could be captured by the value chain stakeholders, and the values that are shared within the entire system are usually captured by the stakeholder value networks and shared in the business ecosystem.

FCM application also results in the importance of CE principles in the circular business ecosystem considering their relation with the captured values (see Table 5). Every company has scarce resources to implement any kind of change, and it is difficult to ex-

Table 5
CE principles importance.

CE Principles	Calculated Importance
Systems Thinking	0.706
Innovation	0.720
Stewardship	0.718
Collaboration	0.725
Value Optimization	0.736
Transparency	0.714

pend resources to implement all CE principles all at once. Thus, organizations should start their circularity path developing strategies for the implementation of the most important CE principle (value optimization) and continue with the implementation following the list of important items. It is noteworthy that the principle "Systems thinking" was classified as the one with low relative importance when compared with the others, this was due to some reasons: first, this classification was done by a group of experts in CE and in accordance with their answers this principle received this score; second, systems thinking is a broad, complex and not so 'technical'
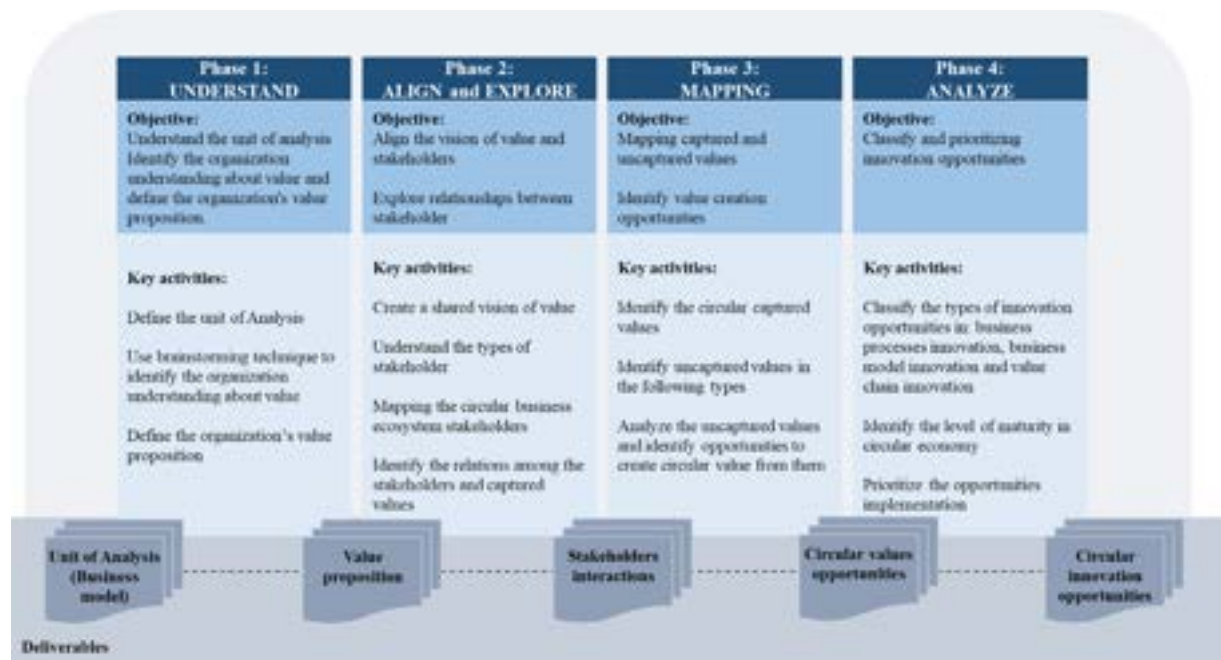
Fig. 5. Guide for mapping stakeholders, capturing values, and finding new opportunities.

concept and it can sometimes give the impression that it is difficult to propose actions and activities to achieve this principle, while the other principles are more practical and easier to propose activities to achieve them; and finally, since we are talking about captured values, it is likely that the principles of value optimization, collaboration and innovation are better classified, since they are the key for increasing circular captured values. Developing the strategies will require the organization following the most important circular captured values that contribute to each principle achievement.

Guide for mapping stakeholders, capturing values, and finding new opportunities

Fig. 5 shows our four-phase guide. Each phase was proposed based on literature findings, which was then validated by conducting the case studies. The phases of the guide were planned to cover from the beginning of identifying the need to change until the end of creating a plan to implement the change. Such changes are only to know what should be changed in the current scenario (Geissdoerfer et al., 2018), thus, the first phase is always "Understand" the "as is" situation. After understanding the real context, "Align and Explore" is the next phase as the proposition of solutions is supported by CE principles and values; and by the collaboration between stakeholders (Manninen et al., 2018; Ünal et al., 2019). "Mapping" is the next phase where the circular captured and uncaptured values are mapped and used as the basis to drive the proposition of innovations (Yang et al., 2017). Finally, "Analyze" and prioritize the implementation innovation opportunities are essential to allocate the resources and plan the right strategy. One limitation of the guide is that it is not intuitive, so it requires continuous applications to become easier to use, and to improve the opportunities already implemented. Below, we present in detail each phase of the guide combined with the results collected from its application in the three case studies.

Phase 1: Underkstand

This phase is quite important since it enables the organization to identify how distant they are from a circular business. This phase helps the organization to search for the right information

about their current situation in order to access their real data and facilitate a better view of the current system. In our collected cases, we perceived that each company was in a different "as is" scenario".

Company A was a company that works with laser technologies applied in developing solutions in the agricultural sector. The value proposition of Company A is selling sugarcane cutting systems for sugarcane and alcohol mills. They used laser technology for coating metals and providing preventive surface treatment in the product, which extends the product life cycle and makes them more resistant. In this business model, the organization was not exploring and capturing all the values that could be captured from its business. In fact, they only saw economic benefits as essential to their business, and they were only concerned with their direct clients since they did not consider other types of stakeholders as interested actors in their value proposition.

Company B is a manufacturer of turbocharges whose current value proposition is to offer products for the parts replacement market for heavy-duty vehicles. Their value proposition has some ideals from CE concepts; however, as Company A, they consider value as only the economic gains delivered to the direct stakeholders involved in their value chain. They had not seen other kinds of values that are more related to society and the environment; and the stakeholders were not directly involved in the business solution. Company C, on the other hand, as a steel producer, gives attention to values related to social and environmental wellbeing beyond the economic values. Their current value proposition is the delivery of steel to promote life quality and achieve society's basic needs, such as housing, transportation, and support material for cleaner technologies.

Based on the perceptions of the cases, we concluded that the majority of organizations are still premature when addressing CE concepts. This shows us that the organizations, even when their intention is to become circular, really need guidance to go through the transition process.

Phase 2: Align and explore

Aligning concepts, perceptions and expectations are important in all types of change and transition processes. In this situation,

increasing the capture of circular values between stakeholders in a business ecosystem is essential, since all the stakeholders should be aligned in order to reach the best advantages of being in an ecosystem. In addition, more important than creating alignment is knowing who the stakeholders are and how they are connected to each other. Thus, this phase was considered in order to create a common vision regarding types of values, identify the stakeholders presented in the business ecosystem, and explore the relationships and connection between the stakeholders.

According to Yang et al., 2017, we have three types of value:

- Captured values: gains delivered to the stakeholders;
- Uncaptured values: existing values but not exploited, existing conditions that eliminate the value, a value that exists but is not required, or a value that is required but does not exist;
- Value opportunities: new opportunities for capturing and creating additional value through new activities and relationships.

During the guide application in the workshop sections, the participants had to identify all the stakeholders that are directly or indirectly enrolled in their business ecosystem, and try to imagine the types of values they share. This exercise was carried out with the three cases, and we concluded that the organizations usually know the majority of stakeholders that are in their business ecosystem, but they did not know how to bring closer the stakeholders value network for the postposition of circular solutions.

In Company A, a total of 21 stakeholders was identified (6 internal; 7 value chain; 8 value network). Of this total, just a few of them have collaborative and close relations with the focal company. The strongest collaboration relation is with a design company, since together, they redesign part of the sugarcane cutting system, and establish product recovery/recycling strategies. In addition, the company has close relations with universities. The newest project is a partnership with a Brazilian public university aimed at developing materials to increase resistance of the components of the sugarcane cutting system.

Company B identified 18 stakeholders (4 internal; 7 value chain and 7 value network), however, they do not have any action or strategy focused on creating close relations with their stakeholders. For the CE implementation, this is a huge obstacle that must be solved by the company since collaboration is the second most important principle that an organization must follow in order to become circular.

Company C identified 17 stakeholders (5 internal; 4 value chain, 8 value network) that are part of the strategic decisions of the organization. Company C establishes a good partnership and collaboration relation with their stakeholders as a way to fulfil their commitment of life quality guarantee for future generations. The goals of Company C are based on three main values that guide all their strategies and actions, approximating them to their stakeholders value network:

- Sustainability: long-term approach taking into account the basic aspects and needs of the people they invest in, and the communities they operate in;
- Quality: engage and stimulate the development of best talents to offer superior solutions for clients;
- Leadership: future vision with entrepreneurial spirit.

We observed that organizations have different types and levels of relations with their stakeholders and that shared values with stakeholders are the key to enable and foster the CE transition.

Phase 3: Mapping

With the business ecosystem stakeholders and the relations between them defined, we start the process of mapping the values that these stakeholders are capturing and those that must be captured in order to move towards the CE. During the guide appli-

cation, the participants were stimulated to discuss and identify the circular values they were capturing and the ones that some of their stakeholders were probably capturing. Then, they were encouraged to think about the circular values they must be capturing but were not. Finally, the participants carefully analyzed the uncaptured values and identified and proposed opportunities to capture these circular values and share them with their business ecosystem stakeholders.

The three cases presented a good amount and quality of circular captured values, and they were able to identify opportunities and propose good solutions to capture the uncaptured values. It is noteworthy that the companies identified values that were not contemplated in our list, thus enriching our collection of circular captured values. Company A captures 28 circular values (4 of them were not in our list, e.g. better cutting system durability, improving sugarcane cutting quality and reducing impurities in production) and 11 uncaptured values. From the uncaptured values, they identified 9 circular value opportunities. Company B identified 11 circular captured values, all of them presented in our list; 9 uncaptured values and 5 circular value opportunities. On the other hand, Company C identified 37 circular captured values (9 of them were not in our list, e.g. lighter and stronger products, maintenance of large preserved areas, maintenance of ecosystem services, improved scrap picking performance, products free of social-environmental problems, information for the composition of environmental studies, meeting legal requirements, cultural activities, retention of local communities in rural areas through partnerships). Then, they identified 8 uncaptured values and 12 circular value opportunities.

More important than identifying the captured values, is identifying the uncaptured values since it is based on the last one that the organizations will be able to plan their strategic actions towards the CE transition. The uncaptured values were similar for all the organizations, such as rework excess, cultural/mindset change, product life extension, product modularity, low reuse rates. The uncaptured values that are more 'technical' are easier to be contemplated by innovation opportunities such as to increase the reuse rates and extend shelf life of products. However, when the topic is 'soft', like cultural/mindset change, it is harder to propose actions that will easily enable the organization to overcome this obstacle and capture this kind of circular value. In fact, cultural and mindset change is one of the key factors for CE transition and it is the most difficult and long-term part of the transition.

Phase 4: Analyze

This phase is essential for the organizations to propose the action plan that will guide their entire journey towards the capture of circular values. Here the aim is to classify the previously identified opportunities into types of innovation opportunities.

Innovation is the effort to create purposeful, focused change in an enterprise's economic, environmental, or social potential (Drucker, 2002). We determined three types of innovation: innovations in business processes, business models innovation (BMI), and business ecosystem innovations. A business process innovation is a new or improved business process that differs significantly from the previous one (OECD, 2018). BMI is characterized by changes in the core business processes and in the main products (OECD, 2018). BMI enables designing systems and value chains for circularity, as well as for reverse cycles. This facilitates integrating value chains with different circular functionalities and developing strong business ecosystems.

Even when the respondents are able to classify the circular opportunities, it does not mean that the organization has the right level of maturity to implement all of the opportunities. Thus, it is necessary to identify the organization's level of circularity maturity. For that purpose, we use the level of organizational circular-

ity maturity presented in the standard BS8001 (British Standards Institution, 2017). Then, we prioritize innovation implementations based on the circular organizational maturity.

Company A classified their circular opportunities in 4 business innovation processes, 1 BMI, and 4 value chain innovations. Their level of circularity maturity is "improving", which means they applied process improvements aligned with CE. Considering this level of maturity, the organization selects the business model innovation as urgent opportunities. Thus, they proposed a new business model focused on a product-service system (PSS) program for sugarcane cutting with the value proposition to increase the plants' life, reduce impurities in production processes and extend the shelf life of cutting system components. Thus, the new revenue source comes from the leasing of the sugarcane cutting system, which results in a closer relationship with the user while increasing the product life cycle.

Company B is in the basic level of circularity (starting to understand CE) and the opportunities are simpler and focused on business process innovations (4) and only 1 opportunity in the business model. Company C is highly engaged (value proposition aligns with CE principles) in CE, so their innovation opportunities are 3 in business processes, 5 in the business model, and 4 in the value chain. In Company B they started the implementation of opportunities with the design of a remanufacturing system, and Company C established a platform among the stakeholders to support creating a partnership in the business ecosystem.

Analyzing the innovation opportunities and proposing a strategic plan to conduct the changes related to them is challenging for organizations and requires multiple cycles of feedback and continuous improvement so that it can become part of the organizational culture.

Conclusions

Although system thinking is a key concept for CE implementation, it is very broad and difficult to address with simple solutions. System thinking is commonly misunderstood by practitioners, and thus, it is frequently not addressed in the proposition of circular solutions. Our guide helps dealing with this issue, since it stimulates the practitioners to think within the entire system before proposing any solution towards CE implementation. The guide brings a systemic perspective integrating all the essential elements to define a desired future performance in a circular business ecosystem. It can be considered as a support tool for promoting the CE, driving organizations to identify new opportunities to improve their performance towards a CE. Moreover, it enables the stakeholder to create a systemic view of all stakeholders in the business ecosystem of organizations in order to integrate them in the decision-making processes.

Our case studies showed the effectiveness of our guide in identifying new opportunities to improve organizational performance towards CE, as well as provide a systemic view of the business ecosystem, integrating stakeholders into decision-making processes, since the organizations were able to identify a set of CE solutions to be implemented.

The list of circular captured values shows that CE may create an effective system that allows to achieve numerous improvements and benefits in the organizations. These values may appear at various stages of the business ecosystem and spread to a wide range of stakeholders. With the FCM, we demonstrate the relations between these values and the CE principles, and the important role each CE principle plays in the circular business ecosystem as a whole. Considering the level of importance of each circular captured value is essential and relevant as they contribute to the definition and implementation of practical actions and strategies for the CE transition.

The following are the main findings of this study: a classification of circular business ecosystem stakeholders; a list with 55 different types of circular values; definition of relations between the stakeholders classification and the circular captured values; definition of the relations between the circular value that should be captured to achieve specific CE principles; a practical reference to guide organizations towards promoting CE; a guide that gives organizations a systemic vision since it connects stakeholders and values in the proposition of circular solutions.

In addition, some studies must be conducted to complement the results presented in this paper. It would be important to have a larger sample of case studies to identify if there are more values in practice that were not identified in the literature. More experts could be approached to assess the relation and relative importance between CE values and principles. Application of the guide in organizations of different sectors. Validation of CE principles and circular captured values, and of the guide with more experts. Re-evaluating and identifying new CE principles and circular values. Check how these principles and values are developed in companies that have a high level of CE maturity and double-check if they match those that were identified as the most important. There is still a need to carry out research applied to focus CE aspects so that the CE transition can be divided into actions designed for the short, medium and long term.

Declaration of Competing Interest

None.

Acknowledgements

Appendix

Table A1 and A2

Table A1
Circular Captured Values.

Circular Captured Values	Authors
1- Increase resource efficiency	Fonseca et al., 2018; Ranta et al., 2018; Velenturf et al., 2018
2-Carbon reductions	De los Rios and Charnley, 2017; Stahel, 2007; Velenturf et al., 2018
3-Pollution prevention	Bodova, 2017; De los Rios and Charnley, 2017; Velenturf et al., 2018
4-Emissions reduction	Fonseca et al., 2018; Hazen et al., 2017
5-Decrease of negative environmental impacts	Fonseca et al., 2018; Kalmykova et al., 2018; Urbinati et al., 2017; van Buren et al., 2016
6-Reduce waste	Bressanelli et al., 2017; Chen, 2018; Kobza and Schuster, 2016; Ranta et al., 2018
7- Energy savings	Bodova, 2017; Hazen et al., 2017; Kobza and Schuster, 2016; Stahel, 2007
8- Minimize the risks of the scarcity of raw materials	Fonseca et al., 2018; Mishra et al., 2018b
9- More durable and innovative products	(Antikainen et al., 2017)
10- Use internal waste materials for new products	(Mishra et al., 2018b)
11- Reduce use of materials (raw materials or not)	(Bodova, 2017; Bressanelli et al., 2017; De los Rios and Charnley, 2017; Hazen et al., 2017; Kobza and Schuster, 2016; Rizos et al., 2016; van Buren et al., 2016)
12- Reduction of disposal activities	(Tolio et al., 2017; Urbinati et al., 2017)
13- Use of sustainable materials	(Tolio et al., 2017)
14- Elimination of toxic waste	(De los Rios and Charnley, 2017)
15- Increase the use of renewable resources	(Bodova, 2017)
16- Increasing recyclability	(Bodova, 2017)
17- Less greenhouse gas emissions	(Kobza and Schuster, 2016)
18- Less food loss	(Kobza and Schuster, 2016)
19- Resource security	(19- De los Rios and Charnley, 2017; Kalmykova et al., 2018; Kobza and Schuster, 2016);
20- Economic growth	(Kalmykova et al., 2018; Muranko et al., 2018; Velenturf et al., 2018)
21- Competitive advantage	(Bodova, 2017; Fonseca et al., 2018; Linder and Williander, 2017; Muranko et al., 2018; Stahel, 2007)
22- Produce additional revenue from multiple use cycles	(Ranta et al., 2018)
23- Better corporate reputation	(Romero-Hernández and Romero, 2018)
24- Increases the market value of shareholders' equity	(Aboulamer, 2017)
25- Retention of customers	(Aboulamer, 2017)
26- Growth of cash flows	(Aboulamer, 2017)
27- Increase in the market value of the firm	(Aboulamer, 2017)
28- Lower manufacturing costs	(Hazen et al., 2017)
29- Create new businesses opportunities	(Kalmykova et al., 2018; Manninen et al., 2018)
30- Cost savings	(Fonseca et al., 2018; Kalmykova et al., 2018; Kobza and Schuster, 2016; Rizos et al., 2016; Tolio et al., 2017)
31- Minimize the risks of price variations	(Fonseca et al., 2018; Kalmykova et al., 2018)
32- Maintaining the highest value of materials and products	(Fonseca et al., 2018)
33- Improving innovation	(Pieroni et al., 2019)
34- Creating higher barriers for competitors	(Bressanelli et al., 2017)
35- Generating new and resilient revenue streams	(Bressanelli et al., 2017; De los Rios and Charnley, 2017)
36- Pioneer of technical innovations	(De los Rios and Charnley, 2017)
37- Access to new market segments	(Spring and Araujo, 2017)
38- New and innovative business models	(Kobza and Schuster, 2016)
39- Investment attraction	(De los Rios and Charnley, 2017)
40- Increasing the economic value of materials and products	(De los Rios and Charnley, 2017)
41- Pioneering standards and regulations	(McDowall et al., 2017)
42- Job creation	(Fonseca et al., 2018; Hill, 2015; Kalmykova et al., 2018; Kobza and Schuster, 2016; Linder and Williander, 2017; Manninen et al., 2018; Muranko et al., 2018; Rizos et al., 2016; Tolio et al., 2017; van Buren et al., 2016)
43- Collaboration	(Rizos et al., 2016)
44- Improve relations with different stakeholders in the value network	(Bressanelli et al., 2017; Romero-Hernández and Romero, 2018)
45- Longer relationship among stakeholders	(Aboulamer, 2017)
46- Prosperity on low income families	(Rizos et al., 2016)
47- Protect of humans and the environment	(De los Rios and Charnley, 2017)
48- Better quality of life	(De los Rios and Charnley, 2017)
49- High-quality jobs	(Velenturf et al., 2018)
50- Closer relationship with customers / companies	(Aboulamer, 2017)
51- Improved customer loyalty	(De los Rios and Charnley, 2017)
52- Better consumer behavior	(Kobza and Schuster, 2016)
53- Legitimacy and image	(Hart and Milstein, 2003)
54- Brand loyalty	(Bocken et al., 2015)
55- Behavior and mindset change	(Bocken et al., 2015)

Table A2
Interview Questions.

General Information
Sector
Number of Employees
Country
Offerings (product/service)
Interviewee
Position
Time in the organization
Structure of the area
Current Situation
What are the current business models?
Is the business model circular? If affirmative, what are the organization definitions about circular business model?
When the organizations begin the transition towards the CE?
What were the main motivators for the transition?
Are the CE principles incorporated into management, business processes and decision making of your organization? How and where it is applied?
Organizational Improvements from CE implementation
Does the CE implementation improve the organization's performance? In what aspects?
How does the company measure the benefits (values) that come from the CE principles implementation?
Does moving to the circular business model bring sustainable financial results?
Does the values proposition and value capture foster the development of new products/services and business model?
Does the organization relates the values proposition and captured values with the stakeholders of the business ecosystem?

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