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Circular economy indicators for organizations considering sustainability and business models: Plastic, textile and electro-electronic cases

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ABSTRACT

Circular Economy is the optimal point of sustainability, given that it offers a set of practices capable of generating more sustainable operations, making sustainability feasible in organizations. To measure the innovations brought by Circular Economy, there is a recent need to develop circularity indicators, mainly for micro level (companies and products). Furthermore, the complexity of Circular Economy implies in a set of multi-dimensional indicators instead of a single one. This paper aims to develop a set of indicators linking Circular Economy principles, Circular Business Model and the pillars of Sustainability. The set of indicators was developed based in the hypothetic-deductive approach, following a number of iterations (cycles) and testing the theory in the empirical world. A mix of research methods (e.g. expert consulting, user's feedback, and case studies) was applied. The proposed indicators should be able to achieve the principles of the Circular Economy, and, at the same time, help to meet the specificities and needs of each circular business model. The main contribution of this paper is the development of a group of indicators, focused in the three dimensions of Sustainability (environmental (from material perspective), economic and social), applied in Circular Business Models to capture the innovations brought by Circular Economy that conventional indicators do not measure. Moreover, they will help any company to identify areas with high importance and potential for improvement, and thus increase Circular Economy performance in an efficient, clear and prompt manner. These indicators were applied in three Brazilian companies which have three different Circular Business Models. The results show that data from economic and social dimensions was not available or was diffused in the companies. It represents a barrier because most of the positive impacts gained with Circular Economy are presented in the social dimension, including job creation, mindset change, etc.

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1. Introduction

Sustainability could be defined as the "balanced integration of economic performance, social inclusiveness, and environmental resilience, to the benefit of current and future generations" (Geissdoerfer et al., 2017, p.766). Some authors affirm that sustainability can help organizations to implement Circular Economy (CE) (Kravchenko et al., 2019; Sehnem et al., 2019). According to Sehnem et al. (2019), sustainability is a driver of CE and is mediated by innovation, Kravchenko et al. (2019) complement that CE is a stepping-stone towards sustainability.

The concept of CE arises with the objective of keeping the products, component, and materials useable and useful to return to the cycles. This economic model is based on restoration and regeneration (Ellen Macarthur Foundation, 2017). It is an economy based on the principles of design out waste and pollution, keeping products and materials in use and regenerate natural systems (Ellen MacArthur Foundation, 2018). A great differential of CE is not minimize negative impacts, as shown by eco-efficiency, but to optimize positive impacts, highlighting by eco-effectiveness (Niero et al., 2017).

Korhonen et al. (2018a) showed a definition for CE based on the

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pillars of sustainability (environmental, economic and social). The environmental goal of CE is to reduce the use of raw material and energy inputs, in addition to minimize waste generation and emissions. The economic goal of CE is to reduce the costs, risks and taxation from environmental pillar as well as to innovate new product designs and market opportunities for businesses. The social goal is the sharing economy, increased employment, participative democratic decision-making and increase a collaborative culture. CE, as an economic system, facilitates sustainable development (Korhonen et al., 2018b; Prieto-Sandoval et al., 2018).

Some authors affirm that a Circular Business Model (CBM) is a type of sustainable business model (Bocken et al., 2016). However, other see that not all CBM consider the dimensions of sustainability (environmental, social, and economic) (Mentik, 2014). CBM may be defined as “the logic of how an organization creates, delivers and captures value within closed circuits” (Mentik, 2014) and also “create, capture, and deliver value to improve resource efficiency by innovation” (Frishammar and Parida, 2019). Defining a business model is complex and requires that all the dimension of a business model be taken into account. Moreover, even moderate transformation of a mature organization’s business model to include CE and sustainability can have positive environmental, economic and social effects (Frishammar and Parida, 2019).

Osterwalder and Pigneur (2010), developed the business model mapping tool named Canvas, which is divided into 9 components. The customer relationship component establishes the relationship that the organization has with its market segment. The value proposition describes how the organization creates value for its customers. The costs involved in operating the business model are also analyzed. The revenue source refers to the money that the organization generates. Key resources and key activities are those needed to operationalize the business model. The channels describe how the organization reaches its customers through communication, distribution and sales. The partners refer to the suppliers’ network (Osterwalder and Pigneur, 2010).

Kiron et al. (2017) conducted a study to assess how organizations are contributing to sustainability. In the survey, 60,000 entrepreneurs were interviewed around the world. The results show that 90% of executives see sustainability as important, but 60% have a sustainable strategy (Kiron et al., 2017). In addition, 50% of organizations have changed their business models in response to sustainable opportunities. In this context, the change to a CE requires organizations to innovate their business models (Ellen Macarthur Foundation, 2017). Business Model Innovation (BMI) is essential to ensure companies competitive advantage and capabilities regarding to circularity and sustainability (Pieroni et al., 2019). BMI is “designed, novel, nontrivial changes to the key elements of a firm’s business model and/or the architecture linking these elements” (Foss and Saebi, 2017, p.201). The innovation in CBM may facilitate the transition to CE (National Confederation of Industry, 2018). The use of indicators to measure circularity performance is essential to improve and assess CBM. However, the measurement and assessment of circularity performance is not yet a common practice in companies (Sassanelli et al., 2019).

According to The British Standard Institution (BSI) BS 8001:2017 (BSI, 2017), there are six types of Business Model which have the potential to fit within the circular economy system. They are based on-demand, dematerialization, product life cycle extension/reuse, recovery of secondary raw materials/by-products, product as service/product-service system (PSS), and sharing economy and collaborative consumption. Table 1 presents a brief description of each one.

CE could be applied in three levels (Yuan et al., 2006): micro (e.g. companies and products), meso (e.g. industrial symbiosis) and macro (e.g. countries). In this paper, we operate at the micro level of CE. Moreover, British Standards Institution published the BSI standard 8001: 2007 “Framework for implementing the principles of circular economy in organizations" (BSI, 2017), to assist in the principles, strategies, implementation and monitoring of the CE in companies (Pauliuk, 2018). However, there is still a need for specific standards and metrics (Saidani et al., 2019; Tecchio et al., 2017).

Circularity might be defined as a fraction of a product that comes from used products (from closed or open-loop cycles) (Linder et al., 2017). But there are some other important aspects like environmental burdens and social gains, which could be included in CE scope. Thus, CE could be experimented in an ecosystem working, sharing values for all stakeholders involved (Zucchella and Previtali, 2019). Moreover, several works emphasize the need to create CE metrics in micro level (Elia et al., 2017; Linder et al., 2017; Lonca et al., 2018), including the link with sustainability (Geng et al., 2012; Mesa et al., 2018).

Previous papers show that Circular Economy aims to reach sustainability (Franklin-Johnson et al., 2016; Mesa et al., 2018). But these indicators only addressed the material aspects (Virtanen et al., 2019). The majority of studies also involving specific CE indicators focused in end of life strategies (Di Maio and Rem, 2015; Figge et al., 2018; Jensen et al., 2019), and eco-efficiency (Laner et al., 2017; Yin et al., 2014; Zhou et al., 2018) instead of economic (Di Maio et al., 2017; Scheepens et al., 2016), environmental (Huysman et al., 2017) and social indicators (Geng et al., 2012). Some existing CE indicators are described below, including the advantages and disadvantages, according to their applicability, practicality, and CE principles, Table 2.

CE indicators are in the initial stage of development (Giurco et al., 2014). Traditional indicators could not express CE in its totality, because they are not designed for the systemic, closed-loop, feedback features that represent CE (Geng et al., 2013). Besides, the complexity of CE implies a need for a set of multidimensional indicators instead of a single one (Griffiths and Cayzer, 2016). Thus, there is a need to propose indicators to assess different Business Model economically, environmentally and socially (Pieroni et al., 2019), in this way, this work tries to fill this gap. Therefore, the research question investigated in this paper is: *How organizations can measure Circular Economy performance considering Sustainability and Business Model perspective?* So, this work aims to develop a set of multidimensional indicators, applied to Circular Economy, in the three dimensions of sustainability: environmental (from material perspective), economic, and social.

The paper is structured in four sections, where Section 2 outlines the Research Method, Section 3 presents the Results and Discussion and Section 4, the Conclusions.

2. Research method

According to Yin (2015) an exploratory study aims to explore a problem and collect information about the subject to build the hypothesis. In addition, an explanatory study identify and explain the roots of a problem; explaining the reality (Yin, 2015). Usually, exploratory studies offer a more detailed view of the subject. Thus, our research is exploratory because we formulated the indicators requirements based on literature and we tested our theory through empirical sections.

The set of indicators was developed based on a hypothetic-deductive approach (Gill and Johnson, 2002), following a number of iterations (cycles) and testing the theory through an empirical work (Kjaer et al., 2018). A mix of research methods (e.g. expert consulting, user feedback and case studies) was applied (see Fig. 1).

Pre-step:

In the pre-step, indicators requirements were formulated (see section 2.1) based on literature review.

Table 1
Description of each circular business model.

Circular Business Model	Description
On-demand	"Producing a product or providing a service only when consumer demand has been quantified and confirmed" BSI (2017) p. 47.
Dematerialization	"Replacing physical infrastructure and assets with digital/virtual services" BSI (2017) p. 47.
Product life cycle extension/reuse	"New products are designed to be durable for a long lifetime (durability). Design improvements might be needed to also facilitate easier repair, particularly by third parties" BSI (2017) p. 47.
Recovery of secondary raw materials/by-products	"Value optimization by creating products from secondary raw materials/by-products and recycling (e.g. polyethylene depolymerization, steel, bio-based materials), whether open or closed loop" BSI (2017) p. 48
Product as service/product-service system (PSS)	"Company delivers product performance or defined results rather than the product or service itself" BSI (2017) p.49.
Sharing economy and collaborative consumption	"Lending or "collaborative consumption" amongst users, either individuals or organizations, but where some form of transactional arrangement (which could be financial) is provided" BSI (2017) p. 50.

Cycle 1:

In this step, we conducted personal semi-structured interviews in companies that were potential users of the indicators (see section 3.1). These interviews provided information about the companies and their strategies through CE. With this information and the indicators requirements, the first version of the indicators was developed through expert consulting. The first version of the indicators was sent to the companies and a workshop was conducted to provide improvement opportunities.

Cycle 2:

Through refinement and consolidation, a second version of the indicators was developed and sent to the companies. In this step a multiple case study was conducted with three Circular Business Models selected (see Table 3). A case study is an empirical research on a contemporary phenomenon in its context, evidencing the importance of doing a multiple case study to support replicable results and reliability (Yin, 2005). The companies collected the data and return the results (see section 3.1). These data were analyzed and after that, the final version of the indicators was confirmed (see section 3).

2.1. Indicators requirements

Sustainability is a goal to achieve in CE, so the indicators applied in many studies are usually multidimensional (Cook et al., 2017; Domingues et al., 2015; Mapar et al., 2017). The set of indicators proposed in this paper assumed three dimensions: environmental (from material perspective), economic, and social, with qualitative and quantitative indicators.

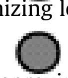
Based on the BSI 8001:2017, we identify that a requirement for a CE indicator is the ability of this indicators to achieve the CE principles at the same time that help to meet the specificities and needs of each CBM. Moreover, we identified through the organization's practices that the CE indicators must address issues related to resources, production and consumption; economics factors and social issues. All these requirements should be linked to the indicators applicability, thus we built the connections among the requirements using an intensity level, based on the BS 8001:2017 levels of circularity maturity and CE principles, to define the relations among the indicators, the CE principles and the CBM.

We used the CE principles proposed by the standard BSI 8001:2017 (BSI, 2017):

1. Systems thinking – a holistic approach to understand the interactions between individuals and activities within the wider systems they are part of;
2. Innovation – continually innovate to create value by enabling the sustainable management of resources through the design of processes, products/services and business models;
3. Stewardship – manage the direct and indirect impacts of their decisions and activities within the wider systems they are part of;
4. Collaboration – collaborate internally and externally through formal and/or informal arrangements to create mutual value;
5. Value optimization – keep all products, components and materials at their highest value and utility at all times;
6. Transparency – organizations are open about decisions and activities that affect their ability to transition towards a more circular and sustainable mode of operation and are willing to communicate these in a clear, accurate, timely, honest and complete manner.

The symbols used in the tables represent the intensity levels based on BSI 8001:2017 maturity model:

 represents a **strong relationship** regarding to the optimizing level.

 represents a **median relationship** regarding to the improving level, and.

 represents a **weak relationship** regarding to the unformed and basic level.

These levels of intensity mean that the indicators with strong connections are very efficient to achieve the defined requirements presenting ways for doing business and creating additional circular values. The indicators with median connections could help in the achievement of the requirements but in the proposition of circular solution regarding to the product/service or process. The indicators with weak connections could be applied in the initial stages of the CE journey once they are useful to explore the opportunities. This are important to guide the organizations in the indicators implementation and the definition of strategies to improve the organization's CE performance. Organizations which apply CBM could gain benefits from this connection to direct CE efforts to the business model and principles to achieve CE.

In Table 4, we present the connections related to the environmental (from material perspective) dimension. Table 5 shows the connections related to the economic dimension and Table 6 to the social dimension.

3. Results and discussion

Literature showed that most indicators in CE focus on material flows (Moraga et al., 2019; Virtanen et al., 2019) and end of life strategies (Gigli et al., 2019; Jensen et al., 2019). But there is a need to create multidimensional indicators (Griffiths and Cayzer, 2016) to measure Circular Economy in its totality (Geng et al., 2013), including the sustainability dimensions. The innovations brought by CBM need to be measured by companies to set targets to

Table 2
Indicators in literature.

Indicator	Advantages	Disadvantages	Reference
BIM-based Whole-life Performance Estimator (BWPE)	Evaluation of the performance of civil construction projects.	Restriction of the CE only in the scope of the reuse and recycling.	Akanbi et al. (2018)
Building Circularity Indicators (BCI)	Application of some CE principles in the context of civil construction, taking into account the types of materials used.	Need for prior technical knowledge about the circularity indicators used. Availability of the Excel spreadsheet dependent on the author.	Verberne (2016)
Circular Economy Index (CEI)	Possibility of assessing recycling linked with economy.	Restriction of the CE only in the scope of recycling, besides the difficulty of applying the because of the absence of a template.	Di Maio and Rem (2015)
Circular Economy Indicator Prototype (CEIP)	Developed according to CE principles. Ease of use due to a spreadsheet developed for calculation.	Availability of the spreadsheet dependent on the author.	(Cayzer et al., 2017; Griffiths and Cayzer, 2016)
Circular Economy Measurement Scale (CEMS)	Developed to measure CE practices in the civil construction sector through a questionnaire on a Likert scale.	Lack of platforms (templates or software) that make the calculations viable.	Nunez-Cacho et al. (2018)
Circular Economy Performance Indicator (CEPI)	Based in Life Cycle Assessment (LCA)	Need for prior technical knowledge about LCA and lack of templates that make calculations feasible.	Huysman et al. (2017)
Circular Economy Toolkit (CET)	Based on life stages of products and services. Ease availability and applicability.	It does not indicate which improvements could be needed to aim circularity.	Evans and Bocken (2013)
Circular Pathfinder (CP)	Based on CE practices, such as: extend, upgrade, reuse, repair, recondition, remanufacture, recycle and biodegrade. Easy access and use.	It provides enhancements to the product only for the redesign or design stages of the product.	ResCom (2017a)
Circularity Calculator (CC)	Developed according to practices of CE focused on the PSS and provides an adequate graphic vision of material and financial flows. In addition to providing quantitative output value for circularity, captured value, recycled content and reuse index.	Financial investment required for unlimited use of the indicator. Free limited use. Moreover, it does not clearly provide the calculation procedures for obtaining the outputs (circularity, captured value, recycled content and reuse index).	ResCom (2017b)
Circularity Index	Practical formulas for calculating the indicator.	Restriction of the Circulating Economy only in the scope of the recycling.	Cullen (2017)
Circularity Potential Indicator (CPI)	Developed through CE Building Blocks. Practical interface for users.	Availability depends on the author.	Saidani et al. (2017)
Ease of Disassembly Metric (eDiM)	Indicator focused on important CE practices such as disassembly of products.	Availability of the spreadsheet dependent on the author.	Vanegas et al. (2018)
Eco-efficient Value Ratio (EVR)	LCA based and economic information.	High complexity for application. Need for prior knowledge of LCA.	Scheepens et al. (2016)
Economic-Environmental Indicators (EEI)	LCA and LCC based.	High complexity for application. Need for prior knowledge of LCA and LCC.	Fregonara et al. (2017)
Economic-environmental remanufacturing (EER)	It allows to couple environmental and economic aspects to remanufacturing.	Restriction of the CE only in the scope of remanufacturing.	van Loon and van Wassenhove (2018)
End-of-Life Recycling Rates (EoL-RRs)	Practical indicator whose calculation procedures are available.	Restriction of the Circulating Economy only in the scope of the recycling.	Graedel et al. (2011)
Input-Output Balance Sheet (IOBS)	Based on information on the quantity and quality of resources used (renewable and non-renewable, recycled, permanently recycled and recyclable, biodegradable and compostable).	Difficulty in making the indicator available, since the authors belong to a private company.	MarcoCapellini (2017)
Longevity and Circularity (L&C)	Two indicators developed to measure product use and durability under some CE practices, such as reconditioning	Difficulties in obtaining some input data such as recycling efficiency, as well as the lack of a practical interface (such as a spreadsheet) available for calculation.	Figge et al. (2018)
Material Circularity Indicator (MCI)	Ease of access and use of the indicator. Quick and practical application, if all the input data is obtained.	Restricting CE in only some practices such as reuse and recycling. Difficulty in obtaining input data, such as: destination of the product after use and efficiency of the recycling process.	Ellen MacArthur Foundation and Granta (2015)
Material Reutilization Part (C2C)	Qualitative indicator that indicates the level of reutilization has the product.	Certification by an outsourced company, restricting CE to recycling practices.	(C2C, 2014)
Mine site MFA Indicator (MI)	Set of indicators for mining based on the economic and environmental dimension.	CE restriction only on waste management. Lack of tools to measure indicators.	Lèbre et al. (2017)
Multidimensional Indicator Set (MIS)	Multidimensional quantitative indicator applied to electrical and electronic waste.	CE restriction on recycling only. Lack of tools to measure the indicator.	Nelen et al. (2014)
Product-Level circularity Metric (PCM)	Relation between recirculation of materials and economic value.	Restricting CE in only some practices such as reuse, remanufacturing and recycling.	Linder et al. (2017)
Recycling Indices (RIs)	Indicator that expresses in percentage the recycling of a product by means of its elements.	Restriction of CE only in the context of recycling. Availability of the tool dependent on the author.	van Schaik and Reuter (2016)
Recycling Rates (RRs)	Indicator that takes into account the open loop and closed loop recycling, besides the rates of waste collection.	Required prior knowledge of MFA. Restriction of CE only in the context of recycling.	Haupt et al. (2017)
Resource Duration Indicator (RDI)	It illustrates the amount of time a material remains in the product system. That is, quantification of an important practice for EC, even the longevity of the product.	Difficulty in obtaining some input data, such as the recycling efficiency.	Franklin-Johnson et al. (2016)
Reuse Potential Indicator (RPI)	Indicator that takes into account the technology available to treat the waste.		Park and Chertow (2014)

Table 2 (*continued*)

Indicator	Advantages	Disadvantages	Reference
		Difficulties in obtaining input data, such as the quality of the material used in the specific application and reasons for substitution.	
Set of Indicators to Assess Sustainability (SIAS)	Group of indicators in three dimensions (economic, social and environmental) focused on the practice of remanufacturing.	Lack of computational tools to facilitate calculations. Restriction od CE only in the context of remanufacturing.	Golinska et al. (2015)
Sustainability Indicators (SI)	Group of indicators focused on EC practices such as design and product modularity, including functionality, reconfiguration, reuse, recyclability.	Difficulties in obtaining data, especially in relation to end-of-life aspects of products.	Mesa et al. (2018)
Sustainable Circular Index (SCI)	Index based on the dimensions of sustainability and circularity.	Lack of computational tools to facilitate calculations. Lack of examples for practical application.	Azevedo et al. (2017)

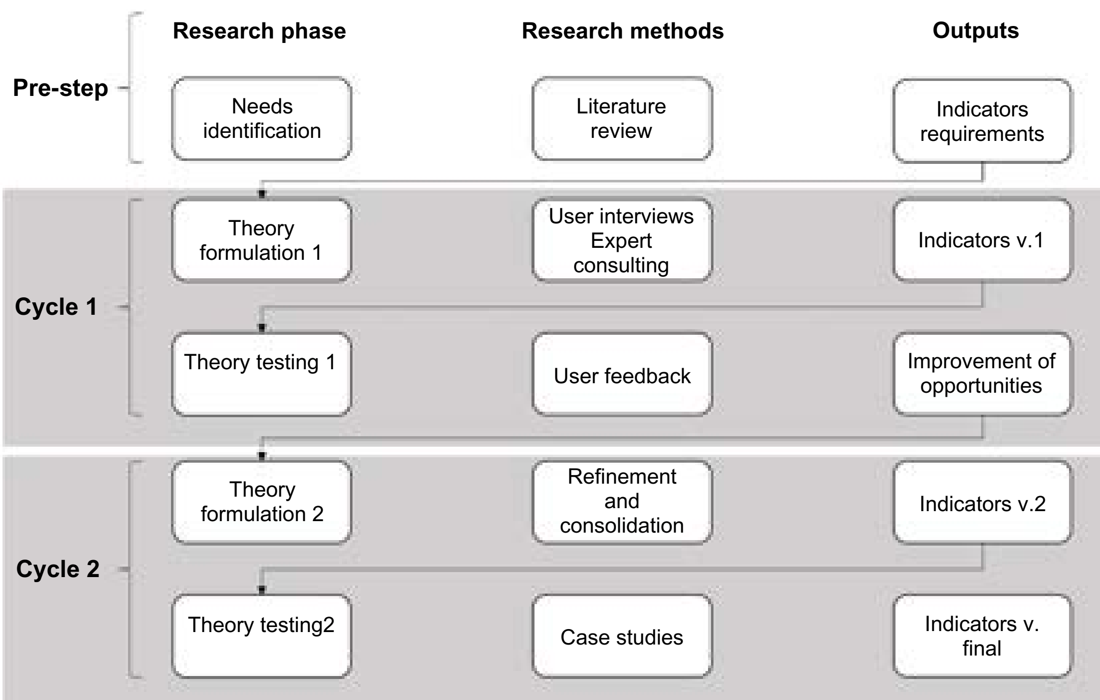


Fig. 1. Development process indicators following the hypothetic-deductive approach (adapted from Kjaer et al., 2018).

Table 3
Characteristics of the three Circular Business Models.

	Circular Business Model	Sector	Size
HP Brazil	Product as service/product-service system (PSS) and Recovery of secondary raw materials/by-products	Electro-electronic	Big
Malwee	Recovery of secondary raw materials/by-products and Product life cycle extension/reuse	Textile and fashion	Big
CIMFLEX	Recovery of secondary raw materials/by-products	Plastic	Small

improve practices and results. They could also propose essential aspects to companies follow to accelerate the transition to CE. The requirements of the indicators proposed in this paper link CE principles, CBM and sustainability.

Eighteen indicators were proposed and described in Table 7. The indicators were grouped considering the pillars of sustainability (environmental (from material perspective) - I, economic - II and social - III). In the environmental pillar we consider indicators for materials eg. reduction of raw materials, recyclability and reduction of toxic substances, in economic pillar were analyzed costs, revenues and taxes, and in social pillar were described employment, market and stakeholder's aspects. The indicators were described according to their applicability and forms of measurement. In addition, for some indicators sub indicators were established in order to clarify their application.

Fig. 2 shows the relations between the Canvas components and the indicators. At first, these novel indicators were classified in all components of Canvas, instead of the conventional indicators, which focused in key activities and resources as shown in Section 1. The indicators related to financial results (II1, II2 and II3) were classified respectively in cost structure and revenue streams. The indicator III4 was classified in customer's segments because is related to the market and the targets that the company want to achieve. The indicators I9, III1 III2. III3 and III5 are classified in key partners because they measure the characteristics of the stakeholders involved in the Circular Business Models, including the

Table 4
Relationship between CE principles and material indicators proposed

Principles	Systems Thinking	●	●	●	●	●	●	●	●	●
	Innovation	○	●	●	○	○	●	●	●	●
	Stewardship	●	●	●	●	●	●	●	●	●
	Collaboration	◍	◍	●	◍	●	○	○	○	●
	Value Optimization	●	●	●	●	●	●	●	●	○
	Transparency	◍	◍	◍	◍	◍	◍	◍	◍	●
Indicators	**Dimension**	**Material**								
	Control Variables	***Reduction of raw materials***	***Renewability***	***Reciclability***	***Reduction of toxic substances***	***Reuse***	***Remanufacturing***	***Refurbishment***	***Product Longevity***	***Stakeholder structure and diversity***
Circular Business Models	Product as a Service	●	○	○	○	●	○	●	●	●
	Sharing Economy	●	◍	◍	◍	●	◍	◍	◍	◍
	Product life extension	●	○	●	●	●	●	●	●	●
	On-demand	●	○	○	○	◍	◍	◍	◍	◍
	Recovery by-products	●	◍	●	●	●	●	●	●	●
	Dematerialization	●	◍	◍	◍	◍	◍	◍	◍	◍

Table 5
Relationship between CE principles and economic indicators proposed

Principles	Systems Thinking	○	○	◍
	Innovation	○	○	●
	Stewardship	●	○	◍
	Collaboration	○	●	◍
	Value Optimization	●	○	●
	Transparency	○	◍	◍
Indicators	**Dimension**		**Economic**	
	Control Variables	***Financial results***	***Taxation or regulatory milestones***	***Circular investment***
Circular Business Models	Product as a Service	●	●	●
	Sharing Economy	●	◍	●
	Product life extension	●	◍	●
	On-demand	●	○	○
	Recovery by-products	●	●	●
	Dematerialization	●	◍	●

employees, the supply partners and its structure. The indicators I5, I6 and I7 are both classified in key activities and value propositions, because they show values the company want to deliver to keeping products, components, and materials valuable and useful to return to the cycles and practical strategies to close these loops. In the same way, indicators I1 and I3 are both classified in key resources and value proposition because these strategies aim to decouple economic growth from resource consumption. The I2 and I4 are classified in key resources because they are prior opportunities in Circular Economy, and according to create restorative and regenerative cycles. Finally, I8 and III6 are indicators related to value propositions because they show intrinsic values to incorporate in products and services to accelerate the transition to Circular Economy.

The development of the indicators was refined from user's feedback. It was consisted by meetings, interviews and workshops within the companies. The measure of the indicators was also clarified and in some cases new indicators were created. At first, the users found difficulties in understand and collect data for indicators. Thus, Table 7 was created to explain and detail the metrics for the companies. After, the application of the indicators brought new opportunities to the companies plan their CBM, values, strategies and also supply chain, stakeholders and product design. These indicators were applied in three Brazilian companies and the

Table 6
Relationship between CE principles and social indicators proposed

Principles	Systems Thinking	●	●	●	●	●	●
	Innovation	●	○	◐	◐	●	●
	Stewardship	○	●	◐	●	●	○
	Collaboration	●	○	●	○	●	●
	Value Optimization	○	●	●	○	○	●
	Transparency	◐	◐	●	◐	●	●
Indicators	**Dimension**	**Social**					
	Control Variables	**Job creation**	**Income generated by jobs**	**Employee participation in the circular business model**	**Market characterization**	**Involvement of stakeholders in decision-making processes**	**Mindset / cultural change**
Circular Business Models	Product as a Service	●	●	●	●	●	●
	Sharing Economy	◐	◐	◐	●	●	○
	Product life extension	●	●	●	●	●	○
	On-demand	●	●	○	●	●	●
	Recovery by-products	●	●	●	●	●	○
	Dematerialization	◐	◐	●	●	●	○

respective results are shown in section 3.1.

3.1. Case studies

3.1.1. HP inc. (HP Brazil)

The electro-electronic sector is composed of industrial automation industries; electrical and electronic components; industrial equipment; generation, transmission and distribution of electricity; computing; electronic installation material; and household utilities (Abinee, 2018). Two business model were studied: PSS and Recovery of secondary raw materials/by-products. In this study, the focus is the PSS based on HP Brazil Managed Printing Services (MPS). The Recovery of secondary raw materials/by-products includes Sustainability indicators related to HP Brazil Circular Economy Ecosystem, with occasional global data.

In 2016, the total revenue of the sector was US$ 31,098 million. In 2017, the company exported US$5844.2 million of electrical and electronic products and imported US$ 29.663,1 million. In January 2017, the total number of employees in the sector was 234,586 employees and in January 2018 the total was 236,882 employees, an increase of 2294 jobs in a year (Abinee, 2018).

According to the Brazilian Association of the Electronic and Electronics Industry (Abinee, 2018) the perspective of Brazilian GDP growth is 2.5% in 2018 and the electronics sector is expected to grow by around 7% considering sales and production. Furthermore, 76% of the companies expect an increase in their activities, showing the importance of this sector for the Brazilian economy. The products that should be at the forefront of this growth in the sector are those in the areas of information technology and telecommunications. The expectation of growth of sales of electrical and electronic products abroad in the year 2018 will be 3% compared to last year, that is, these sales are expected to add up to US $ 6 billion. Regarding to importation, the expectation is also 5% (about US $ 31.4 billion) in 2018 compared to 2017. In relation to employment, it is estimated that there will be an increase of 241 employees, a growth of 2% in 2018 compared to 2017 (Abinee, 2018). Considering this context, HP's business model is described in Table 8.

HP has a global commitment to transform its business model for a more efficient, circular, and low-carbon economy spans across and beyond its value chain. It presents several initiatives to drive CE on products and solutions' design and recovery. Such as developing solutions that keep products and materials in use at their highest state of value for the longer time; reducing the resources required to manufacture and ensuring the materials in products are properly repurposed at end of life. HP presents several business models globally and the PSS includes, HP Device-as-a-Service, HP Subscription Services, HP Managed Print Services (MPS) and HP Instant Ink. Considering Recovery of secondary raw materials/by-products business model, HP offers repair, reuse and recycling programs in more than 60 countries that support responsible collection and processing to recover and re-use as much as possible. HP is considered an organization with circular practices, because they changed their business model to a product as a service whose reflected in changes in the product design, which was measured by the indicator "product longevity", and in the use of recyclable material, which was measured by the indicator "recyclability". Thus, HP's CBM is classified as product as a service and recovery of secondary raw materials/by-products. Table 9 presents the results for the company referring to the application of CE indicators.

3.1.2. Malwee Malhas LTDA (Malwee)

The textile and fashion sector in Brazil presented a revenue of US$29 billion, and generates approximately 1,494,000 jobs in more than 29,500 companies. Therefore, the selected company presents a great development in CE, having inserted in its model of management operations several types of business models as circular inputs and resources recovery for the product, and life cycle extension of manufacturing equipment as remanufacturing.

In informal market the reuse of product is also a strategic operation. Malwee is one of the leading fashion companies in Brazil and one of the most modern in the world. This company is deeply concerned about topics related to sustainability, owning a Strategy Sustainability. This strategic plan aims to look at the future of sustainability related to business model, products and operations and engaging its stakeholders to develop a sustainable value chain. According to this context, the organization's business model is described in Table 8. Hence, Table 9 presents the results for the company referring to the application of CE indicators.

Malwee has circular practices since they no longer consider cotton waste as useless and uses it as raw material again, using in

Table 7
Set of circularity indicators proposed in this paper.

Dimension	Indicator	Sub indicator	Measure	Description
I)Material	1)Reduction of raw materials	a)Manufacturing	Quantity of raw materials reduced in the manufacturing	This indicator measures the reducing quantities of raw materials in the process of manufacturing (e.g. water, carbon dioxide, etc)
		b)Product	Quantity of raw materials reduced in the product	This indicator measures the reducing quantities of raw materials in the product itself, making it lighter
	2)Renewability	a)Renewable energy	Percentage of renewable energy sources in relation to the total energy used in manufacturing processes	The aim is to measure the quantity of renewable energy consumed in the manufacturing
		b)Renewable raw materials	Percentage of raw material from renewable sources in relation to all the materials used in a product	The aim is to measure the quantity of renewable raw materials used in the product
	3)Recyclability	a)Recycled materials	Percentage of recycled materials in the composition of the product	This indicator measure the use of recycled materials in the product
		b)Recyclability potential	Percentage of the product that may be recycled after use	This indicator measure the potential of recyclability of the product after use
	4)Reduction of toxic substances		Quantity of reduction of toxic substances	It aims to quantify the reduction of the use of toxic substances considering RoHS (Restriction of Certain Hazardous Substances).
	5)Reuse	a)Manufacturing process	Quantity of material reused in the supply chain	It aims to quantify the reused materials in the supply chain
		b)Product	Quantity of reused material in the product	It aims to quantify the reused materials in the product
	6)Remanufacturing		Quantity of remanufactured products	It aims to quantify the remanufacturing products
	7)Refurbishment		Quantity of the total recovery or parts (components) of the product, without necessarily going through all stages of the remanufacturing.	This indicator is expressed by the specification and quantity of the products and refurbished parts
	8)Product longevity		Quantity of time added in the lifespan of the product	This indicator may be obtained from consumer information, and/or from the company itself from product return information, average lifetime, replacement or purchase of new product, or time to replenishment
	9)Stakeholder structure and diversity	a)Structure	Qualitative	This indicator may be obtained qualitatively, for example on the structures and synergies or symbiosis of the business of a company with others associated with its supply chain
		b)Stakeholder	Qualitative	It aims to map stakeholders in the circular value chain
II)Economic	1)Financial results	a) Cost reduction	Monetary value from circular business model provided by cost reduction from raw materials, energy, etc	This indicator aims to show the cost reduction of the manufacturing because of the acquisition of less raw materials and energy
		b) Revenue generation	This indicator could be measured by: a) Competitive advantage: percentage of market share of the circular business model compared with the competitors. b) Risks: map the risks associated with the circular business models. c) New revenues: new revenues from circular business models.	This indicator aims to show the billing percentage generated by circular business model
		c)Profitability	Net profit of the Return On Assets (ROA) and Return On Equity (ROE)	This indicator measure the net profit
	2)Taxation or regulatory milestones		Qualitative	This indicator aims to specify the taxation or regulatory milestones that subsidize the circular business model
	3)Circular investment	Innovation	Quantify investments from the innovation process	This indicator aims to quantify in monetary values the financial resources invested to change the business model, from strategic and management actions to capacity building, operational and maintenance
III)Social	1)Job creation		Quantity of job creation from circular business model	This indicator aims to quantify the job creation from circular business model, e.g. quantity of job creation from reverse supply chain activities (maintenance, reverse logistics, reuse, remanufacture, refurbishment, etc)
	2)Income generated by jobs		Monetary value the income generated by job creation from circular business model	It aims to quantify in monetary values the income from new jobs creation from circular business model
	3)Employee participation in the circular model		Percentage of jobs in the company related to circular economy	It aims to quantify the percentage of jobs of the organization and its hierarchical level related to the circular economy
	4)Client mindset	a)Client	Qualitative	It aims to identify the client characterization, e.g. social level, geographical regions, age group, among others, according to the uses of the

Table 7 (*continued*)

Dimension	Indicator	Sub indicator	Measure	Description
				product. Also includes the motivation and intention of the client.
		b)Value	Qualitative	This indicator aims to map perceived and captured values for each type of client, i.e. benefits generated for clients.
		c)Communication	Qualitative	Collection of data or information from consumer surveys, Customer Service Call Centers (CSCC), and other channels, identifying correlations with information on adoption of circular practices or sustainability, which are communicated or available to consumers who make purchasing decisions at the information available to them
	5)Involvement of stakeholders in decision-making processes		Qualitative	It aims to characterize qualitatively the stakeholders who participate in the general business model and those who effectively participate in the organization's decision making. Stratify the stakeholders according to each element of the business model: strategy and management, economic, operational and innovation.
	6)Mindset/cultural change		Qualitative	It aims to describe the process of change resulting from the implementation of the circular business model in the company. Especially cultural and mindset change.

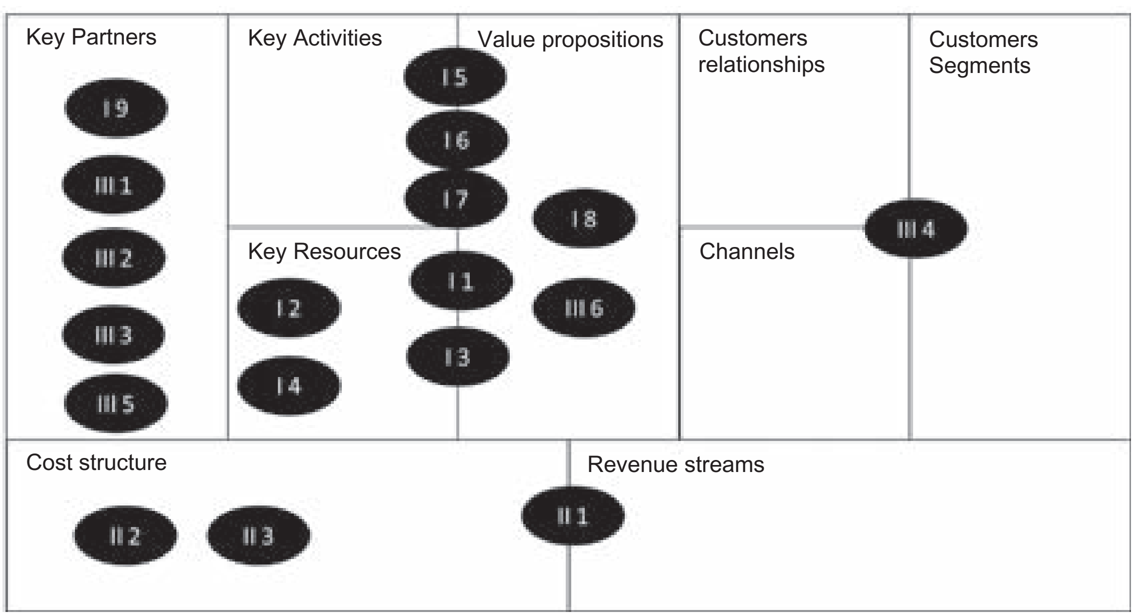


Fig. 2. Relation between indicators and CANVAS components.

this way circular inputs in the production. Moreover, Malwee keeps their manufacturing machines in use for as long as possible through remanufacturing. To identify these real changes we used the indicators "reduction of raw materials" and "remanufacturing". Thus, Malwee's CBM is classified as recovery and product life cycle extension. Hence, Table 9 presents the results for the company referring to the application of CE indicators.

3.1.3. CIMFLEX indústria de comércio de plástico Ltda. (CIMFLEX)

The plastic sector in Brazil has a gross billing of US$ 20 billion, generates approximately 320,000 jobs in plastics materials transformation and recycling industries in more than 12,300 companies (Abiplast, 2017). CIMFLEX was founded in 2004 and aims to offer products to the construction and plastics processing industries, meeting the requirements of these customers through the use of raw material with low environmental impacts. CIMFLEX's CBM is classified as Recovery of secondary raw materials/by-products. The company recycles agrochemicals and lubricating oils packaging (all packaging from high-density polyethylene - HDPE) and transforms them into resins and products used in civil construction, e.g.: ducts and corrugated conduits. CIMFLEX produces, per year, approximately 2000 tons of ducts and corrugated conduits. Moreover, they use reverse logistic to close the loops of agrochemicals and lubricating oils packaging. CIMFLEX operates in a business model to recover plastic resources, we used the indicator "recyclability" to measure its effectiveness as a circular organization. According to this context, the CIMFLEX's business model is described in Table 8. Thus, Table 9 presents the results for the application of CE

Table 8
Description of circular business models of HP Brazil, Malwee, and CIMFLEX.

Component	HP Brazil	Malwee	CIMFLEX
Value proposition	HP Managed Printing Services provide convenience and performance benefits while reducing capital costs by managing maintenance of the technology fleet, freeing up valuable employee time and resources, increasing product longevity, reducing waste and ensuring product repair, reuse, and recycling at the end of service life.	The company has two value propositions: use of a pet knitwear (polyester yarn made from recycled PET bottles), use of biodegradable polyamide in the manufacture of gym clothes, and the remanufacture of the machines that are used to the clothes confection	The company visualized an opportunity to act in the closed loop of agrochemicals and lubricating oils packaging, by recycling them and using as an input to manufacture Tubes, Ducts and Corrugated Conduits to use in civil construction.
Customer Segment	HP Brazil MPS were firstly adopted by large companies as a Business to Business model. Today the public sector, small and medium business are also adopting the model, which can be expanded to other customer segments.	Clients are retail stores that sell clothes (Business to Business)	Clients are large companies (Business to Business).
Relationship with customers	The company identifies customer needs in terms of printing (volume, performance, etc.) and provides printing services and support in accordance to customer's demand, stablishing a service-based relationship.	The company product expresses the identity of the consumer.	The company seeks to meet customer requirements through direct verification.
Channels	Communication with customers and potential customers are made through mailing, events, direct engagements, personal contact, social media, website, among others.	Communication is the key to reaching different audiences. The Malwee Group is committed to disseminating its initiatives and projects, as well as sharing information and content so that people have the opportunity to know and contribute to a more conscious society.	The channels of communication is personal, telephone and internet.
Key resources	The essential resources are human, material and financial.	The main resources are people since the Malwee Group believes that development occurs by people and to the people. With respect to material resources, the Malwee group is active in the search for raw material and processes that have a lower socio-environmental impact. And the financial a structure resources are necessary to the development of the projects related to the sustainable plan.	The essential resources are human, material and financial.
Major partnerships	Sales Channels and recycling partner.	The Malwee Group recognizes that to the construction of a more sustainable value chain is necessary the exchange of knowledge and experiences among its participants. For this, has a partnership with universities and research centers, suppliers and retailers.	The main partner is waste collection cooperatives.
Cost and revenue structure	The customer pays a flat fee per printed page.	Conventional cost and revenue structure	Conventional cost and revenue structure.

indicators.

Considering the three cases, the companies showed difficulties in publishing data from economic and even in social dimensions which were not available or were diffused in the companies. It is a barrier because most of the positive impacts gained with CE are presented in the social dimension, including job creation, mindset change, and others. According to Schröder et al. (2019) social issues are not yet integrated into the concept of CE. There is uncertainty about how to measure the transition from a linear to a CBM and how CE can help sustainability (Schröder et al., 2019). Thus, our paper helps to fill this gap, as it points to develop indicators that measure CE performance considering sustainability in a systemic view.

It is important to emphasize that the indicators could not be applied individually. The set of indicators must be analyzed together because if there is an evolution in one single indicator it not necessarily means an evolution in the company performance in Circular Economy. For example, if the company produced with less raw materials but with low longevity, it is not a representative gain regarding Circular Economy principles.

Regarding the research question "How organizations can measure Circular Economy performance considering Sustainability and Business Model perspective?", we confirmed that the proposed indicators could be applied in companies with CBM to improve their performance according to CE principles and Sustainability. The developed indicators can be used to analyze and assess the current state of the CBM performance, evaluate the achievement of CE goals, and improve benefits for all stakeholders in the value chain (especially with social indicators).

Finally, the novel indicators presented have advanced in relation to those found in the literature because they have a simple and intuitive format and could be applied in various sectors and business models. Also, they not restrict the scope of CE, as conventional indicators do (Table 2), but they cover all CE principles. Besides, they were developed with the companies so they are understandable and easy to be used.

4. Conclusions

According to the results, the paper contributes in the application of CE in Business Models. The novel set of indicators expresses the complex dimensions of sustainability needed, including environmental (from material perspective), economic, and social. The main contribution of this paper is the development of a group of indicators applied in CBM to capture the innovations brought by CE whose conventional indicators do not measure. These innovations include systems thinking, mindset change, diversity, effectiveness, resilience and long term for all stakeholders.

Table 9
Indicators result for HP Brazil, Malwee, and CIMFLEX.

Dimension	Indicator	Sub indicator	HP Brazil	Malwee	CIMFLEX
I)Material	1)Reduction of raw materials	a)Manufacturing	The company didn't buy over 681 thousand boxes of cardboard on 2017 The company saved about 7500 trees by reusing pallets from 2015 to 2017. The company decreased in 8% the intensity of use of materials for personal systems in 2017 (global data). The company decreased in 6% the intensity of use of materials for printers in 2017 compared to 2016 (global data). The water footprint decreases 1% in 2017 compared to 2016 for supply chain, operations and products and solutions (global data). The customer pays a flat fee per printed page.	Reduction of losses in the production processes, and consequently in the consumption of virgin raw materials, and use of recycled raw materials of approximately 7%.	• Reduction of above 75% of raw materials. • Reduction of water use in the milling line of the flow process for lubricants due to the use of hot water by cold water - lower energy use and reduced evaporation rate. • Reduction of water use in the COEX material milling line - changing milling with wash for dry milling. • Reduction of 18% of energy consumption in manufacturing processes. • Reductions in the incorporation of additives in the formulations of several products: 1) Reduction of 33.33% compatibilizer in COEX material; 2) 60% reduction of impact modifier in the PVC conduit; 3) Reduction of 100% in the amount of lubricant incorporated to the conduit PVC DN 20 mm.
		b)Product	Since 2010, the power consumption of HP's personal system products has decreased by 43% on average (global data).	Reduction of 0.06 kg/Piece in 3 years.	Reduction in weight of several products • Corrugated duct DN 63 mm - Reduction of 9.52%; • Corrugated duct DN 90 mm - Reduction of 27.27%; • Corrugated duct DN 110 mm - Reduction of 4.54%; • Corrugated duct DN 160 mm - Reduction of 27.77%; • Reinforced corrugated duct DN 40 mm - Reduction of 29.42%;
	2)Renewability	a)Renewable energy	In 2017, 50% of the energy used in global operations comes from renewable sources (global data).	Use of 100% renewable energy in production processes (still has natural gas and diesel oil in case of emergency); reduction between 12 and 15% of electricity consumption in the last 3 years. Replacement of GMP oil with natural gas since 2000.	100% of the energy comes from renewable sources (Small Hydropower Plants, wind energy, solar energy and thermoelectric plants from the burning of sugarcane bagasse).
		b)Renewable raw materials	Not available.	Not available.	The reuse of the water is done in the washing of the mills - being a closed circuit inside the company.
	3)Recyclability	a)Recycled materials			

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Table 9 (*continued*)

Dimension	Indicator	Sub indicator	HP Brazil	Malwee	CIMFLEX
			The HP printer Deskjet GT 5822 manufactured in Brazil has up to 12% of recycled material on average in its composition by weight, in 2017. It has the potential of using recycled material up to 32%, also by weight.	Waste generated is recycled and projects under development to close the cycle (100% of the recycled textile waste).	Percentages of recycled inputs in the products: • Corrugated duct - 97.50%; • Corrugated conduit - 97.50%; • Corrugated drain - 97.50%; • Sewage Tube - 100%;
		b)Recyclability potential	In Brazil, 95% of all the company's waste is recycled, the other 5% destined for cogeneration of energy. Nothing is sent to landfills.	Reduction of 5–15% of the generated production residues, depending on the type of product produced. Process for drying the ETE sludge, which reduces the volume to 1/7 of normal. Parts may contain 12–50% of their composition, of recycled material (PET or defibrated)	All the products present recyclability potential of 100%.
	4)Reduction of toxic substances		The company does not use toxic substances.	There are no national regulations for such a measure, however, the 2020 Plan provides for a restriction target under international law.	Percentage of dry waste (class I) destined for landfills in relation to the quantity received of lubricating packages is 13%.
	5)Reuse	a)Manufacturing process	Equipment and end-of-life printing supplies plastics are recycled and transformed into new parts and pieces of locally produced printers and packaging.	Water reuse program in the production process since 2003, which has a nominal reuse capacity of up to 200 million liters of water per year (representing 25% of the total water used), and operate in the normal regime with 75% of the nominal capacity of the system.	Not applicable to the company.
		b)Product	The HP printer Deskjet GT 5822 manufactured in Brazil contains up to 12% of recycled material in 2017.	There is no product reuse per se, however, 100% of the waste generated is sent to recycling companies in the region.	Not applicable to the company.
	6)Remanufacturing		Not available.	Not applicable to the company.	Not applicable to the company.
	7)Refurbishment		Products with 10/10 reparability scale (global data) in iFixit.	Not applicable to the company.	Not applicable to the company.
	8)Product longevity		Printers' life time increases, on average, from 3 to 5 years due to the good conditions of operation and maintenance when on MPS model.	As for the consumption link, the products have a useful life of approximately 30 washing cycles and may be extended according to the product line.	The average lifetime of the products is 30–40 years - about 70%–80% of the life expectancy of the virgin materials.
	9)Stakeholder structure and diversity	a)Structure	Since 2008, the company works along with its manufacturing partners to build an end-to-end supply chain.	Not available.	Not available.
		b)Stakeholder	Not available.	Involvement to create businesses associated with the use of textile waste.	Creation of a network of companies associated with the collection, sorting, sorting and recycling of packaging. Involvement with ABIPLAST and with the PICPlast - Plastic Chain Incentive Plan, a partnership between ABIPLAST

					and Braskem to train employees in the transformation and recycling industries of plastic materials and to show the benefits of the material to society. For more information visit: www.picplast.com.br. Activities in development for the organization of the sector - National Chamber of Recyclers of Plastic Materials - CNRPLAS - horizontal policies, training of cooperatives, quality seals - SENAPLAS - National Seal of Recycled Plastic - certification for companies and soon certification of recycled plastic resins
II)Economic	1)Financial results	a) Cost reduction	The recycled plastic resin is in average 15%–30% cheaper than virgin plastic resin.	The launch of products is focused on best practices and with low environmental impact in development, such as jeans and knitwear. Association for Global Best Practices (Sustainable Apparel Coalition) and ABVTEX certification schemes.	Constant development of new applications for recycled products.
		b) Revenue generation	Confidential.	Products that excel for the quality and durability in relation to the average of its competitors.	Confidential.
		c)Profitability	Confidential.	Not available.	Not available.
	2)Taxation or regulatory milestones		Monthly, the company is taxed in ISS 2% + PIS/Cofins 9.65% + eventually INSS where they have people allocated by contract on MPS.	Tax regime as a limiting factor for the adoption of practices and circular processes. (e.g. double taxation on waste)	Tax and tax policies are a problem for circular business model involving the plastics chain. Fiscal asymmetry between States does not foster competitiveness. Suggestion of the adoption of credit granted to the sector.
	3)Circular investment	Innovation	Confidential.	Innovations in water use since 2002, TECNOBIO, with optimization of the effluent treatment system. Use of new natural fibers and natural inputs of this 2011. New treatment systems using ozone in the production of denim jeans. Replacement of harmful chemicals. Use of biodegradable polyamide, helping at the end of the product life cycle.	Confidential.
III)Social	1)Job creation		Confidential.	Not available.	Confidential.
	2)Income generated by jobs		Not available.	Not available.	Confidential.
	3)Employee participation in the circular model		Not available.	Not available.	Confidential.
	4)Client mindset	a)Client	Confidential.	Not available.	Not available.
		b)Value	Confidential.	Not available.	Not available.

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Table 9 (*continued*)

Dimension	Indicator	Sub indicator	HP Brazil	Malwee	CIMFLEX
		c)Communication	Confidential.	Since its foundation, the company has adopted practices associated with longer-lasting business models. The process of internal transformation has already occurred in several areas of the company. Having pioneered water management, reducing impacts on dyeing and printing processes, and the use of raw materials with sustainable bias. The 2020 Plan, drawn up in 2014, mapped the entire value chain and defined 14 goals for the Group in 5 main areas.	Confidential.
	5)Involvement of stakeholders in decision-making processes		Not available.	Not available.	Not available.
	6)Mindset/cultural change		Not available.	Not available.	Not available.

CE aims to seek sustainability, in this work the proposed indicators are intrinsic related to Sustainable Development Goals and help to achieve: Clean water and sanitation (Goal 6), Affordable and clean energy (Goal 7), Decent work and economic growth (Goal 8), Industry, innovation, and infrastructure (Goal 9), Responsible consumption and production (Goal 12) and Climate action (Goal 13).

This paper investigates how companies could measure their performance in CE and proposed a multi-dimensional set of indicators to demonstrate benefits to measure at the micro level. These indicators were developed based on a hypothetic-deductive approach and were applied in a multiple case study. The main point is to create simple and clear indicators (Folan and Browne, 2005) to be applied in diverse sectors and contribute with this area of research.

New findings in both theory and practice aspects were achieved, because the indicators in literature were analyzed and with the user's feedbacks were possible to improve and develop this novel set of indicators. The link between empirical data and theory could enrich the research, since CE emerges from the practice (Agrawal et al., 2019).

4.1. Implications for theory and practice on sustainability

Theory is a way of establishing a conceptual order to the empirical complexity of the phenomenal world (Suddaby, 2014), for the author the true knowledge arises from different assumptions about the proper use of a theory. Moreover, abstract reasoning is a way of constructing knowledge. Additionally, theory proposal clearly presents why its development, which brings again to the area of knowledge and the relationship between theory and practice (Whetten, 1989). So, this paper contributes theoretically, because it presents a list of CE indicators of and sustainability not yet identified in the literature. Traditional indicators could not express CE in its totality, because they are not designed for the systemic, closed-loop, feedback features that represent CE (Geng et al., 2013). As well, the novelty of this paper remains to join sustainability, CBM and performance measurement for CE.

At the practical side, the results will help any company to identify areas with high importance and potential for improvement, and thus increase the CE performance in an efficient, clearly and prompt manner. Besides, the indicators allow companies to create their own improvement targets according to their defined CE strategy. Measuring CE and sustainability performance through the proposed indicators can help organizations find improvements and consequently operational, business model and strategy innovations.

4.2. Limitations and future work

The limitation of this work remains in the confidentiality of data involving the economic indicators and the availability of social indicators. Furthermore, the indicators were applied in only three case studies.

For future work, there is a need to apply these indicators in other sectors and companies for measuring also positive impacts from Circular Economy, for example, involvement of stakeholders in decision-making processes and the mindset, as core indicator. Also, it will be important to create an index with involves all the indicators and a scale to set targets for Circular Economy principles.

Declaration of competing interest

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

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