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DIFFERENT APPROACHES TO MEASURING THE CIRCULARITY OF BUSINESS MODELS

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Purpose: Since the circularity concept gained momentum while business is involved, the issue of measuring progress towards it has become more and more significant. There is still a lack of a single coherent and standardized approach towards measuring the circularity of businesses, and different methodological options are available here. The objective of the paper is to evaluate existing methodological options to measure *circularity* from the perspective of its usefulness for business units, their business models, and their reporting capabilities.
Design/methodology/approach: The objective is realized through a review of existing literature and solutions to measure circularity in business.
Findings: There is still no commonly recognized circularity measurement system, but several different metrics are used. Despite the active ongoing development of circularity measures, the recommendation could be to combine existing evaluation frameworks. Such an adaptive assessment framework could focus on using existing circularity, environmental performance, and sustainability metrics and combine them for a specific organizational context and scope of its use.
Practical implications: Practical implications of the circularity metrics review could be the development of an adaptive assessment framework that would use existing metrics and adjust them to specific cases. The desired mode of its use could be related to existing guidance and quality standards, while specific methods and metrics are concerned.
Originality/value: The paper critically assesses the need to develop circularity-specific complex metrics. The paper presents the circularity assessment framework that could be used for the purpose of assessing business models and directing them towards more circular performance.
Keywords: circular economy, circularity metrics, business circularity, circular business models, sustainability indicators, circulation and recycling rates.
Category of the paper: viewpoint, literature and general review.

1. Introduction

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, Previtali, 2019). Moreover, several works emphasize the need to create CE metrics at the 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 CE 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 involved specific CE indicators focused in end of life strategies (Di Maio, Rem, 2015; Figge et al., 2018; Jensen et al., 2019), and eco-efficiency (Laner et al., 2017, Yin et al., 2023) instead of economic (Di Maio et al., 2017; Scheepens et al., 2016), environmental (Huysman et al., 2015; Nitkiewicz, 2021), and social indicators (Geng et al., 2012).

Circular business models (CBM) formulate sustainable business strategies. To evaluate sustainable business strategies, it is necessary to be able to measure the actual performance of all processes in a circular business model (Vegter et al., 2020). Research on integrating circular business models with the business model canvas has led to several framework adaptations. Scholtysik et al. (2023) developed a Circular Business Model Canvas (CBMC) that enriches existing Business Model Canvas elements and adds five new components, including reverse logistics, to guide systematic circular business model development. Similarly, Lewandowski (2016) identified two additional components—take-back systems and adoption factors—creating an extended circular business model canvas framework. Islam & Iyer-Raniga (2023) proposed the "Circular Business Model Value Dimension Canvas" for innovation and validation, while Jamadagni et al. (2024) introduced the Circular Business Ecosystem Model Canvas for ecosystem-level circular value chains. Mentik et al. (2014) created the Business Cycle Canvas to support closed-loop material systems, and Lauten-Weiss & Ramesohl (2021) developed the Circular Business Framework based on circular economy principles. These adaptations address the limitations of traditional business model canvases in capturing circular economy requirements (Reim et al., 2019; Upadhayay, Alqassimi, 2020).

Recent research has focused on developing metrics to measure circularity in business models. Various approaches have been proposed, including circularity measurement indices and assessment tools applicable at micro, meso, and macro levels (Barros et al., 2024). Some studies introduce novel metrics like RCE, SCI, and KSI to quantify circularity in open innovation-enabled business models (Geetha et al., 2024). Others suggest linking circular economy principles with business models and sustainability pillars (Rossi et al., 2020).

Common challenges include a lack of standardization and data availability (Das et al., 2022). Researchers have also proposed frameworks connecting circular economy strategies and material flows (Brändström, Eriksson, 2022), and identified six strategic approaches to circular business models (Bocken, Ritala, 2022). Additionally, studies have conceptualized supply chain processes and performance objectives in circular business models, identifying eight key processes and various performance metrics (Vegter et al., 2020). These developments aim to help businesses assess, compare, and improve their circularity.

On the macro level (global or regional), circularity is often referred to as the ratio of cycled material at EOL, or circulation (Wit, Haigh, 2022). The system level below macro is called meso and mostly targets eco-industrial parks and industrial symbiosis (Linder et al., 2017). Metrics on this system level commonly measure recycling rates, reuse rates, and maintenance aspects and generate circularity results based on multiple dimensions (Saidani et al., 2019). Existing research on micro and nano level (product or company) C-metrics shows that many metrics on this system level are either focused on economic aspects (Kristensen, Mosgaard, 2020) or are heavily focused on resource efficiency (de Oliveira, Oliveira, 2023). Resource efficiency C-metrics tend to focus on the circulation of material, or closeness of loops, such as the ratio of circulated input (Linder et al., 2017) or material flows at EOL (Di Maio, Rem, 2015). What's more important, these criteria need an adequate measuring and assessment framework that is done within specific and standardized tools and frameworks, including such tools as life cycle assessment or carbon footprint assessment (Nitkiewicz, 2021). The different levels and their respective circularity metrics are shown in **Figure 1**. It is clear that getting to the lower levels leads to the diversification of assessment metrics and their scopes.

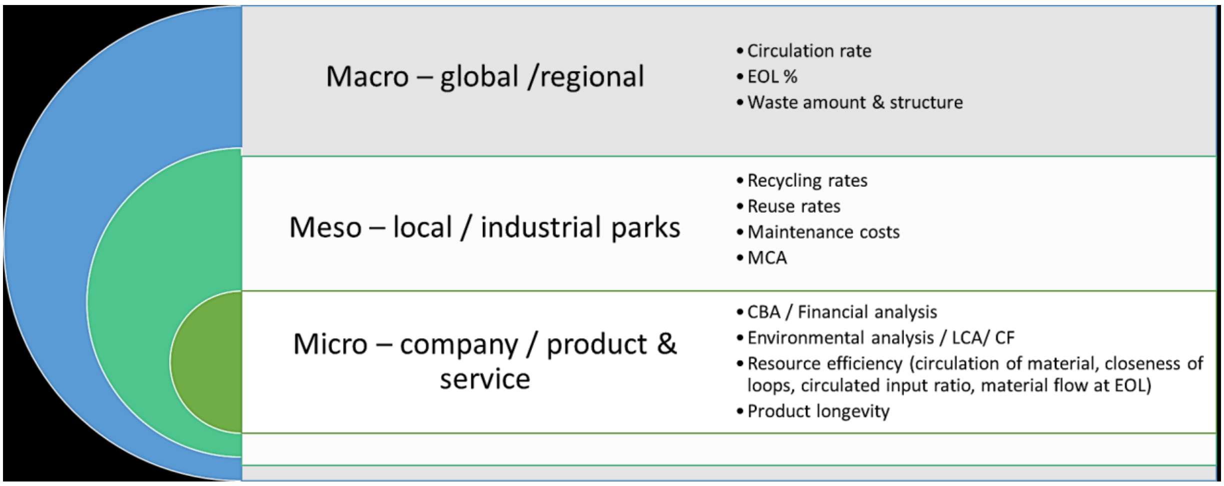

Figure 1. Circularity levels and their metrics.

CBM assessment criteria encompass recycling measures, efficiency improvements, use phase extensions, intensifying use phases, dematerialization, material flows, product lifecycles, and production efficiency (Nitkiewicz et al., 2024). These criteria are crucial for businesses to measure and enhance their circularity performance in alignment with circular economy principles, but also generate key information for communication with external stakeholders and non-financial reporting. The circularity concept has highly dematerialization-oriented priorities and therefore any product or packaging manufacturing issues gain additional importance (Wojnarowska et al., 2022).

There are, however, those who also consider longevity aspects in the use phase (Franklin-Johnson et al., 2016). The most commonly cited metric, the Material Circularity Indicator (MCI), developed by the Ellen MacArthur Foundation, is a quantitative C-metric that considers both circulation and longevity aspects by calculating the linearity of material flows over time (Goddin et al., 2019). A similar metric, Product Circularity Indicator (PCI), can be used to assess circularity on the product level based on MIO throughout the product life cycle (Bracquené et al., 2020). Both MCI and PCI generate a circularity value by calculating a Linear Flow Index (LFI) and a utility factor (X) (Bracquené et al., 2020). The LFI is a factor that measures the fraction of material flowing in a linear fashion compared to a fully linear system, while the utility factor is used to calculate the expected lifetime and use rate compared to a fully linear system (Bracquené et al., 2020). The most prominent difference between these metrics is that PCI captures material losses in multiple production stages, while manufacturing production losses are summarized in one value in MCI. Both MCI and PCI are quantitative material flow-based C-metrics that can capture both closeness and slowness of loops.

Since the diversity of approaches in defining CBM leads to the development of quite diversified business circularity metrics, the issue at hand is to provide a commonly recognized framework for reliable and transparent circularity assessment. The objective of the paper is to evaluate existing methodological options to measure *circularity* from the perspective of its usefulness for business units, their business models, and their reporting capabilities. The research questions are:

1. What is the coverage of business circularity within existing circularity metrics? and
2. Does it satisfy the needs of business organizations and fit their reporting capabilities?

The objective of the paper, and its research questions, are aimed at relating the research to the underlying issue of the need to develop new complex circularity metrics for business.

2. Methods

The methods used for the assessment are organized within a two-step process. Firstly, the literature review is performed. The focus is on circularity metrics and existing circularity assessment indicators and frameworks. Secondly, the existing metrics are examined from the perspective of complexity. The complexity is approached from the perspective of CBM and business in general. The complexity of CBM metrics is based on distilling assessment areas from existing circularity metrics and matching the areas with the most common assessment frameworks and indicators.

The construction of almost every circularity metric, at least those that aspire to be complex enough to cover circularity in its holistic understanding, starts with the 3R strategy (Reduce, Reuse and Recycle) as proposed by Ellen MacArthur Foundation (EllenMacArthur Foundation, 2013), or one of its further extensions (Wojnarowska et al., 2022). As shown in **Figure 2**, the idea is to follow the hierarchy and to prioritize the most valuable and feasible for CE strategies (Reduction over Reuse and Reuse over Recycle).

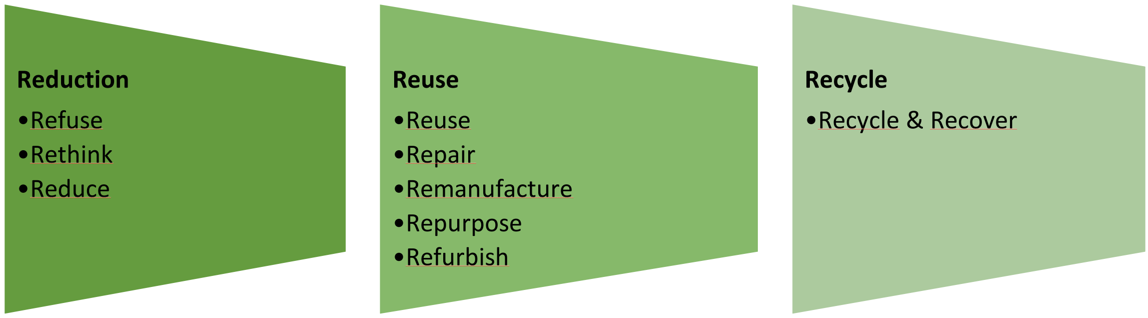

Figure 2. Strategies of 3R and 9R for setting circularity priorities.

3. Results

The importance of adjusting circularity metrics to CBM is related to the sector, size, target group, or technology, but also could be sensitive to the CBM archetype used. The most commonly recognized CBM archetypes are (Woldeyes et al., 2023):

1. Product-as-a-Service.
2. Resource Recovery Models.
3. Sharing Platforms.
4. Life-extension models.

The scope of each one of the archetypes suggests the metrics that could be dominant within circularity evaluation. The Product-as-a-Service type will be focused on the change of general material flow and will have a strong competitive advantage orientation. The Resource Recovery Models will be oriented on finding an appropriate way for material and waste recovery scenarios. Sharing platforms will be focused on the manufacturing and use phase, progressing towards dematerialization of the product life-cycle and providing a strong boost to customer empowerment, aimed at rethinking the demand for products and their use models. Life-extension models will be searching for increasing product durability and longevity, and avoiding overproduction and overconsumption.

For more than a decade, the CE concept has been equipped with complex metrics and indicators. For example, the Material Circularity Indicator (MCI) focuses on the restoration of material flows at product and company levels and is based on the following six principles(EllenMacArthur Foundation, 2013; Goddin et al., 2019):

a. Sourcing biological materials from sustainable sources.
b. Using feedstock from reused or recycled sources.
c. Keeping products in use longer (e.g., by reuse/redistribution/increasing durability).
d. Reusing components or recycling materials after the use of the product.
e. Making more intensive use of products (e.g. via service, sharing or performance models).
f. Ensuring biological materials remain uncontaminated and biologically accessible.

The approach presented in MCI is also common for the Product Circularity Indicator (Bracquené et al., 2020), Material Efficiency Metric (MEM) (Brändström, Eriksson, 2022) or Resource Circularity Efficiency (RCE) (Geetha et al., 2024) indicators. The coverage for the CE concept is focused and, somehow, limited to the material flow within existing value chains.

The issues that remain out of the scope of material-oriented metrics, like customer or market-related issues, tend to be covered within some extra indicators and metrics. Geetha et al. (2024) proposed to combine the Stakeholder Collaboration Index (SCI) and the Knowledge Sharing Index (KSI) with RCE to measure aspects of open innovation-enabled circular business models. While environmental impact is concerned, the circularity metrics are supplemented or developed on the basis of life cycle-based metrics, like life cycle assessment (LCA), carbon footprint (CF) or even its extensions to measure sustainability, like life cycle sustainability assessment (LCSA), or social aspects, like social life cycle assessment (S-LCA). The reference to the life cycle remains valid also for economic aspects of circularity and CBMs (Nitkiewicz, Cappelletti, 2022). An example of it is the use of the life cycle costing (LCC) framework to assess circularity (Kambanou, Sakao, 2020). But the list of economic and market-related measures that could contribute to circularity metrics is long and diversified among sectors or even business units, and could hardly even be mapped within the framework of this paper. on the most general level, the assessment and analytical instruments should provide market performance indicators, as well as some financial and cost-benefit related insights. Cost-benefit analysis (CBA), which is discussed later in the text, should be understood as a measure to balance the potential benefits and costs of introducing CBM, including also profits that are lost due to the strategic switch towards circularity.

As explained above, if the business perspective is taken into account, it seems that the material focus is often not enough to feed circular business models. In the literature on CBMs a few common circularity criteria for business models have been identified:

1. Degree of Circularity: CBMs are classified based on the degree of adoption of circularity principles, particularly in the customer value proposition and interface (Urbinati et al., 2017). CBMs tend to prioritize end-of-life management strategies, such as recycling and recovery, to ensure that remaining materials are reused or repurposed rather than treated as waste (Stewart, Niero, 2018).

2. Value Creation Logic: A key aspect of CBMs is the conceptual logic for value creation, which involves utilizing the economic value retained in products after their initial use to produce new offerings (Kanda et al., 2021). Another essential aspect of CBMs is to emphasize circular product design. This involves designing products that are easily recyclable, reusable, or compostable to minimize environmental impact (Stewart, Niero, 2018).
3. Resource Efficiency: CBMs aim to improve resource efficiency by extending the lifespan of products and their parts, leading to environmental, social, and economic benefits (Frishammar, Parida, 2019).
4. Orchestrating Circular Networks: Effective CBMs often involve a focal actor orchestrating a circular ecosystem that includes suppliers, customers, research centers, and public authorities (Koszewska, Bielawska-Zakrzewska, 2024; Zucchella, Previtali, 2019). Establishing collaborative ecosystems within the manufacturing industry, involving stakeholders such as suppliers, manufacturers, and waste management companies, is essential for the successful implementation of CBMs (Nitkiewicz et al., 2024).
5. Loop Closure Strategies: CBMs are characterized by strategies that close, narrow, slow, intensify, and dematerialize material loops to reduce material inputs and waste leakage (Voukkali et al., 2023). CBMs often incorporate the use of reverse logistics systems to facilitate the collection and recycling of used materials, contributing to a more closed-loop system (Guarnieri et al., 2020).
6. Innovation and Differentiation: CBMs can help organizations increase differentiation, reduce costs, generate new revenues, and mitigate risks associated with resource scarcity (Husain et al., 2021). Developing innovative product designs that promote circularity, such as incorporating recycled materials or designing for easy disassembly and recycling, is a key aspect of CBMs (Liu et al., 2023).
7. Communication Strategies: Effective communication with consumers regarding the disposal and end-of-life pathways of product remaining, construction materials or packaging is integral to CBMs. Clear communication can guide consumers in proper waste disposal practices (Baskoro et al., 2024).

Table *1* presents key characteristics of metrics that are related to specific circularity criteria.

Table 1.
Circularity criteria and their characteristics

Circularity Criteria [Acronym]	Characteristics
Degree of Circularity [DC]	Share of material volume that is recovered at every life-cycle phase
Value Creation [VC]	Relative economic value retained in products after their initial use to produce new offerings
Resource Efficiency [RE]	Decrease of materials use in manufacturing, extending the lifespan of products and parts, leading to environmental, social, and economic benefits
Loop Closure [LC]	Share of closed loops within life cycle; implementing strategies that close, narrow, slow, intensify, and dematerialize material loops to reduce material inputs and waste leakage
Innovation and Differentiation [ID]	increase of differentiation, reduction of costs, generation of new revenues, and mitigation of risks associated with resource scarcity
Communication Strategies [CS]	Effective communication with consumers regarding the disposal and end-of-life pathways of packaging materials is integral to circular business models in the packaging industry
Circular Networks [CN]	orchestrating a circular ecosystem that includes suppliers, customers, research centers, and public authorities

After identifying circularity criteria that could be used to drive CBMs, they are evaluated vs. their potential significance for CBM archetypes. The assessment is made with a simple 3-star scale where a 1-star mark denotes relatively weak significance, while a 3-star mark denotes strong significance. As **Table** *2* shows, the technical circularity, as mapped by DC, RE and LC criteria, is not always the most significant for specific CBM types. Only Resource Recovery Models have a definite material circularity orientation, while life-extension models are very sensitive to product types, and Product-as-a-Service and Sharing Platform CBM are heavily dependent on communication and networking activities.

Table 2.
Evaluation of the significance of circularity criteria for CMBs archetypes

Circularity criteria	Product-as-a-Service	Resource Recovery Models	Sharing Platforms	Life-extension models
DC	★	★★★	★	★
VC	★★★	★	★★	★★★
RE	★★	★★★	★★	★
LC	★	★★★	★★	★★
ID	★★★	★	★★	★★
CS	★★	★	★★★	★★
CN	★★	★★	★★★	★

It seems that metrics dedicated to CE and CBMs, which usually have a more technical focus, are not capable enough to cover all the circularity criteria. They certainly contribute to the assessment of any CBM type, but in most cases, only to some extent. Therefore, the use of additional metrics and indicators can significantly contribute to making the assessment more complex and better cover the CE concept in its holistic form.

4. Discussion

Since the current developments in the field of CE metrics are directed towards getting more complex measures of circularity, it is important to map the coverage of all CBMs assessment criteria within existing tools and frameworks. Geetha et al. (2024) proposes a novel set of metrics to cover the complexity of CE, while some authors (Brändström, Eriksson, 2022; Rossi et al., 2020) propose to combine the typical CE metrics with existing metrics and frameworks. In order to have an overview of the coverage of circularity criteria with CE dedicated and external metrics, the mapping process is shown in **Figure 3**. The metrics are divided into four categories: CE-oriented metrics (CE), environmental metrics (ENV), economic and business-specific metrics (ECON), and social metrics (SOC). The list of metrics that are applicable is limited to some commonly recognized items in each of the categories. We could observe that the group of CE-oriented metrics has a limited range of use, while the circularity criteria are considered. This conclusion is shared by several different researchers (Bracquené et al., 2020; Brändström, Eriksson, 2022; Geetha et al., 2024; Jerome et al., 2022; Kambanou, Sakao, 2020) and confirms the limited scope of the currently developed metric and the CE-specific toolbox.

Instead of proposing new metrics or arguing for using more complex metrics, we suggest focusing on what is available and combining CE metrics with existing, preferably business-oriented metrics, that could contribute to showing the complexity of CBMs, but without engaging business owners in further development of monitoring and reporting schemes. It seems that referring to business-specific KPIs together with existing ESG reporting data should enable quite complex fulfilment of circularity criteria for any CBM.

Circularity Criteria [Acronym]	Metrics
Degree of Circularity [DC]	MCI LCA / CF MEM
Value Creation [VC]	KPI LCC CBA
Resource Efficiency [RE]	KPI RCE / MCI / MEM LCA / CF
Loop Closure [LC]	MCI MEM LCA
Innovation and Differentiation [ID]	KSI CBA
Communication Strategies [CS]	KPI SCI NPS
Circular Networks [CN]	KPI SCI / KSI S-LCA

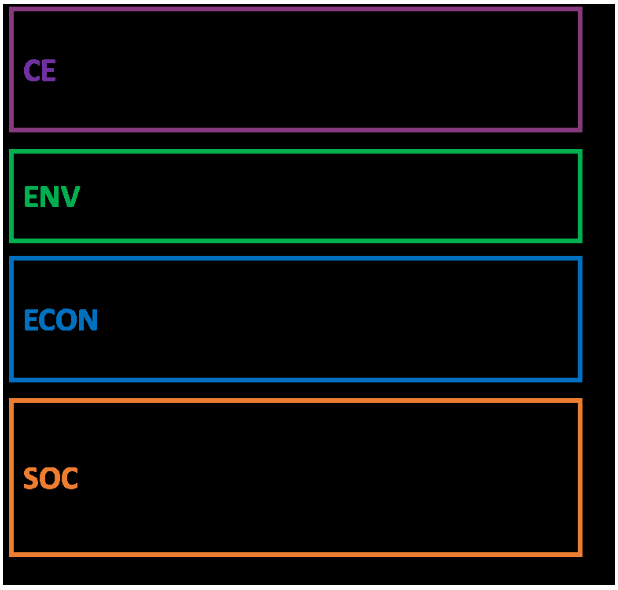

Figure 3. Application of existing metrics to CBM circularity criteria.

The authors suggest that for the current reporting needs of CE, its current toolbox is enough. The reasoning for that is twofold. Firstly, CE-related reporting still remains voluntary and is only occasionally determined by some market-driven circumstances. In the case of an existing specific need, business units could use their own and ESG-originating metrics and reporting schemes. Secondly, the role of business circularity and the concept of CE seems to be still subordinate to the concept of sustainable development and business sustainability, and it provides a specific path towards sustainability. Bearing that in mind, the existing toolbox of sustainability metrics could be used to complement the adaptive assessment framework and should allow for a complex assessment of CBMs.

5. Summary

Traditional indicators could not express CE in its totality, because they are not designed for the systemic, closed-loop, feedback features that represent CE. Comprehensive evaluation of CBM is highly determined by the profile and scope of the unit under evaluation. Designing comprehensive integrated metrics may lead to evaluation overprocessing and could bias the results, especially on macro and meso levels. The recommended approach is to develop an adaptive assessment framework and possibly to engage it within sectoral evaluation. Another approach could simply use a combination of existing ESG reporting schemes or sustainability metrics and incorporate them with CE metrics.

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