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SYSTEMATIC REVIEW OF THE CIRCULAR ECONOMY PERFORMANCE ASSESSMENT SYSTEM UNDER INTERNATIONAL MANAGEMENT PARADIGMS

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ABSTRACT

Objective: To present a Systematic Literature Review (SLR) on Performance Evaluation in the Circular Economy (PECE), addressing its temporal evolution and critically analyzing the metrics found in empirical studies.

Theoretical Framework: The research starts from theoretical contributions on the characteristics of a metric and the levels of performance assessment systems, compared with the evolution of performance assessment in the management of natural resources until we reach the circular economy.

Method: Utilization of Systematic Literature Review following the Knowledge Development Process-Constructivist approach (ProKnow-C), assessing secondary data from articles comprising the Research Portfolio (RP).

Results and Discussion: The literature presents a variety of circularity metrics at different scales, yet there is a predominance of individual metrics and a lack of comprehensive focus on Performance Evaluation Systems (PES).

Research Implications: Identifies the need for more comprehensive and integrative metrics aligned with CE principles and capable of encompassing multiple levels of action. Future research has the potential to significantly enrich society by exploring the development of more comprehensive metrics, considering the interaction between levels of circularity and environmental performance.

Originality/Value: Highlights the growing concern with metrics in the Circular Economy (CE), identifies gaps in understanding the full impacts of each approach in the supply chain, and underscores the need for more robust and integrative metrics aligned with CE principles.

Keywords: Circular Economy, Performance Evaluation System, Systematic Review, Measures, Metrics.

REVISÃO SISTEMÁTICA SOBRE O SISTEMA DE AVALIAÇÃO DE DESEMPENHO EM ECONOMIA CIRCULAR SOB OS PARADIGMAS DE GESTÃO INTERNACIONAL

RESUMO

Objetivo: Apresentar uma Revisão Sistemática da Literatura (RSL) sobre a Avaliação de Desempenho na Economia Circular (ADEC), abordando sua evolução temporal e analisando criticamente as métricas encontradas nos estudos empíricos.

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Referencial Teórico: A pesquisa parte das contribuições teóricas sobre as características de uma métrica e os níveis dos sistemas de avaliação de desempenho, confrontadas com a evolução da avaliação de desempenho na gestão dos recursos naturais até chegarmos na economia circular.

Método: Utilização da Revisão Sistemática da Literatura seguindo a abordagem Knowledge Development Process-Constructivist (ProKnow-C), avaliando dados secundários de artigos que compõem o Portfólio de Investigação (PI).

Resultados e Discussão: A literatura apresenta uma variedade de métricas de circularidade em diferentes escalas, porém há predominância de métricas individuais e ausência de um enfoque abrangente nos Sistemas de Avaliação de Desempenho (SAD).

Implicações da Pesquisa: Identifica a necessidade de métricas mais abrangentes e integrativas, alinhadas com os princípios da EC e capazes de englobar múltiplos níveis de atuação. Futuras pesquisas têm o potencial de enriquecer significativamente a sociedade ao explorar o desenvolvimento de métricas mais abrangentes, considerando a interação entre os níveis de circularidade e o desempenho ambiental.

Originalidade/Valor: Destaca a crescente preocupação com métricas na Economia Circular (EC), aponta lacunas na compreensão dos impactos completos de cada abordagem na cadeia de abastecimento e ressalta a necessidade de métricas mais robustas e integrativas alinhadas com os princípios da EC

Palavras-chave: Economia Circular, Sistema de Avaliação de Desempenho, Revisão Sistemática, Medidas, Métricas.

REVISIÓN SISTEMÁTICA DEL SISTEMA DE EVALUACIÓN DEL DESEMPEÑO DE LA ECONOMÍA CIRCULAR BAJO PARADIGMAS DE GESTIÓN INTERNACIONALES

RESUMEN

Objetivo: Presentar una Revisión Sistemática de la Literatura (RSL) sobre Evaluación del Desempeño en la Economía Circular (ADEC), abordando su evolución temporal y analizando críticamente las métricas encontradas en los estudios empíricos.

Marco Teórico: La investigación parte de aportes teóricos sobre las características de una métrica y los niveles de los sistemas de evaluación del desempeño, comparados con la evolución de la evaluación del desempeño en la gestión de los recursos naturales hasta llegar a la economía circular.

Método: Uso de Revisión Sistemática de Literatura siguiendo el enfoque del Proceso de Desarrollo del Conocimiento-Constructivista (ProKnow-C), evaluando datos secundarios de los artículos que conforman el Portafolio de Investigación (PI).

Resultados y Discusión: La literatura presenta una variedad de métricas de circularidad en diferentes escalas, sin embargo, hay un predominio de métricas individuales y una ausencia de un enfoque integral en los Sistemas de Evaluación del Desempeño (SAD).

Implicaciones de la investigación: Identifica la necesidad de métricas más integrales e integradoras, alineadas con los principios de la EC y capaces de abarcar múltiples niveles de acción. Las investigaciones futuras tienen el potencial de enriquecer significativamente a la sociedad al explorar el desarrollo de métricas más integrales que consideren la interacción entre los niveles de circularidad y el desempeño ambiental.

Originalidad/Valor: Destaca la creciente preocupación por las métricas en la Economía Circular (CE), señala brechas en la comprensión de los impactos totales de cada enfoque en la cadena de suministro y destaca la necesidad de métricas más sólidas e integradoras alineadas con los principios de la CE.

Palabras clave: Economía Circular, Sistema de Evaluación del Desempeño, Revisión Sistemática, Medidas, Métricas.

1 INTRODUCTION

Over the past few years, there has been a noticeable increase in interest from researchers and professionals in the manufacturing industry in Circular Economy (CE) and in ways to assess its performance (Elia et al., 2020; Shevchenko et al., 2024). This phenomenon denotes an incessant search for approaches that foster a more sustainable and efficient use of natural resources (Laasch & Conaway, 2015; Weetman, 2019).

This is mainly driven by pressure from the current global market, which is increasingly sensitive to environmental approaches, especially after the recent negative results of climate reports, showing that if humanity does not set new economic guidelines for the coming years, there could indeed be material scarcity and extreme weather conditions (Miatto et al., 2024; Oliveira & Teixeira, 2023).

In aiming to better utilize natural resources throughout the product life cycle, strategies such as CE allow for both competitive advantage and improved organizational performance, both internally and externally (Franco et al., 2021). To achieve this competitive advantage, organizations have sought to adopt sustainable operations strategies to reduce their negative environmental impacts, as well as to possess and implement specific capabilities that enable CE (Gorokhova et al., 2023; Liu et al., 2018; Zhu et al., 2011).

Meeting global aspirations in sustainability management strategies for their operations is one of the current challenges for organizations, based on the premise of incorporating economic, social, and environmental aspects into management in a cross-cutting manner (De Almeida et al., 2023; Franco et al., 2021). In this scenario, the growing interest in CE prompts experts to develop evaluation metrics regarding the shift from a linear to a circular logic.

Cooper et al. (2017) argue that to fully understand the impacts of each circular economy approach, it is crucial to consider the entire affected supply chain. Although such topics have been addressed in the scientific literature, there is a significant gap regarding the detailed elaboration of the direct implications of these approaches.

Despite this, the circular economy faces a dilemma because an organization interested in reporting and improving the circularity of its product or service may choose from a growing

range of circularity assessment tools, and some organizations may even feel compelled to develop their own (Boyer et al., 2021; Shevchenko et al., 2024). The challenge of the circularity concept is to maintain its power to stimulate changes on a social scale for companies, public agencies, and other organizations to choose to define and measure circularity in the way that is most convenient for them, and inconsistent or contradictory with all others.

The study conducted by Mio et al. (2022) highlights the presence of research on circular economy in business performance management, which can contribute to both theory and practice. A deep understanding of these metrics can not only guide companies in maximizing their impacts for positive sustainability but also strengthen organizational resilience in the face of contemporary challenges.

Although it presents limitations and simultaneously adopts various approaches to evaluate performance in CE, recent literature stands out for its enrichment with a diversity of circularity metrics. These metrics span various scales, such as nano (products), micro (companies), meso (industrial symbiosis), and macro (governments), as evidenced by Baratsas et al. (2022), Calzolari et al. (2022) e de Oliveira et al. (2021).

By contextualizing this within the scope of the Performance Evaluation System (PES), which integrates metrics to analyze organizational strategies, as proposed by Neely et al. (2005) and Melnyk et al. (2014), an advanced bibliometric analysis opens up space for a deeper understanding of the application of PES in the circular economy.

Although companies recognize the benefits of Circular Economy (CE), they face challenges in justifying and evaluating these benefits, mainly due to reluctance to use available performance measurement tools (Nandi et al., 2021). This dilemma becomes more evident when considering aspects such as sustainability and other non-traditional benefits.

Given such a relevant topic, this study aims to address the following questions: Does the performance evaluation addressed in empirical studies of CE encompass the characteristics of a Performance Evaluation System (PES) as proposed by Neely et al. (2005)? Do the metrics presented in empirical studies encompass the constituent elements of a metric as proposed by Melnyk et al. (2014)?

Thus, the objective of this research is to present the state of the art of Performance Evaluation in Circular Economy (PECE), through a systematic review, addressing its evolution over time and conducting a critical analysis of the metrics found in empirical studies.

2 RESEARCH METHODOLOGICAL PROCEDURES

This research is classified based on Gil (2022) and Marconi & Lakatos (2022), characterized as basic research of an exploratory-descriptive nature, with a qualitative approach, and employing the literature review method through a Systematic Literature Review (SLR). According to Lopes et al. (2024), literature reviews should be conducted using a structured approach to ensure rigor and traceability in the study.

The research utilizes the assessment of secondary data from articles comprising the Research Portfolio, operationalizing the following stages of the Knowledge Development Process-Constructivist (ProKnow-C) method: (i) selection of a Bibliographic Portfolio (BP) on Performance Evaluation in the Circular Economy (PECE); (ii) bibliometric analysis of the selected portfolio; (iii) systemic analysis of articles from the BP; and (iv) research question and opportunities evidenced based on the knowledge constructed during the process. For this research, steps (i) and (ii) were operationalized: the selection of the BP and the bibliometric analysis of the defined variables.

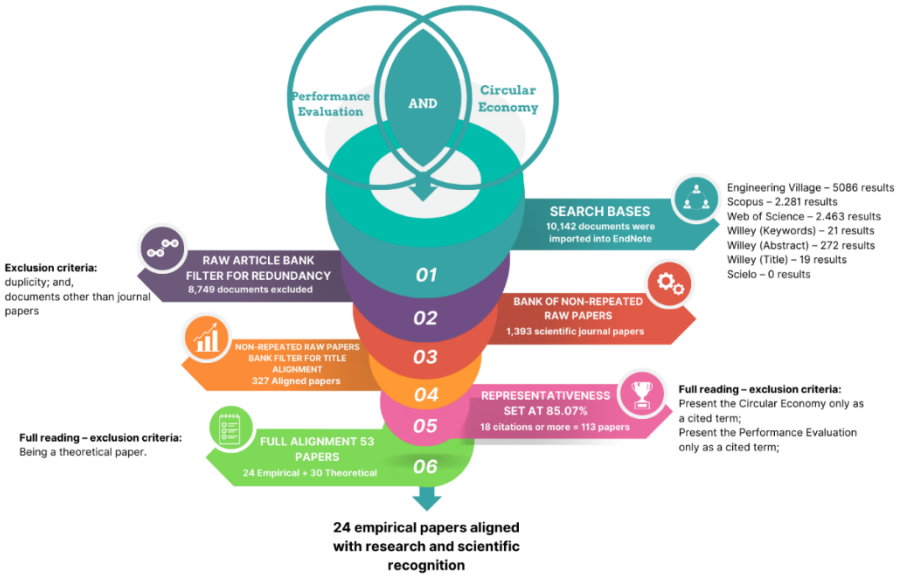
The process of selecting the BP begins with the identification of a set of articles that meet the researchers' delineations, defining search commands (keywords and their combinations).

It was considered the scientific databases Scopus; Web of Science; Wiley; Copemdex; Scielo. The following search string was applied: [("*Performance Management*" *OR "Performance Measuring" OR "Performance Evaluation" OR "Performance Measurement" OR "Performance Measurements" OR "Performance Evaluate" OR "Performance Measure" OR "Performance Indicator" OR "Performance Indicators" OR metrics OR "Performance Assessment" OR "Measurement System") AND ("Circular Economy" OR "Circular Model" OR "Circular Business" OR "Circular Supply Chain" OR "Closed loop" OR Circularity*)].

The search term consists of two parts: the first part ensures results within the scope of performance evaluation, while the second part narrows the search to studies addressing circular economy. The search considered research in the title, keywords, and abstract. Results were limited to documents of the journal article type, following the procedures for selecting the BP, as illustrated in Figure 1.

Figure 1

Schematic representation of the BP selection process using ProKnow-C



The tool used for managing the BP was EndNote, enabling the filtering process dynamically, allowing for cross-reference analysis, which culminates in obtaining a bibliographic portfolio of relevant and representative scientific articles from the studied literature fragment (Ensslin et al., 2013).

The bibliometric analysis of 54 selected articles revealed advanced aspects of performance evaluation in the circular economy within 24 empirical articles. Temporal evolution and the literature map were examined, highlighting relevant elements for the scientific community, such as the levels of the Performance Evaluation System (PES) and metric components as defined by Neely et al. (2005) and Melnyk et al. (2014) (Table 1).

Table 1

Advanced bibliometric variables

THEORETICAL CONTRIBUTION	ADVANCED VARIABLE	DEFINITION OF THE STAGE
Neely et al. (2005)	Levels of Performance Evaluation Systems	Only Individual Performance Measures (yes; no)
		Individual Performance Metrics (yes; no)
		PES as an Entity (set) (yes; no)
		PES as an ad hoc Entity (set) (yes; no)
		PES relates to the Environment (yes; no)
Melnyk *et al.* (2014)	Constituent Elements of a Metric	Presents Performance Measure (yes; no)
		Presents Ordinal Scale (yes; no)
		Presents Cardinal Scale (yes; no)
		Declared (Qualitative/Quantitative)
		Presents Reference Standard (yes; no; Target; Target-Minimum)
		Presents Numeric Score and/or Final Evaluation - Performance Consequences? (yes; no)

The evolution of the theme was carried out in contrast to the theoretical contributions presented by (Bititci et al., 2012) and by (Weetman, 2019). While, to construct the literature map, the aim was to represent how performance evaluation, in the light of the CE, is presented in the articles of the BP.

In this context, PECE has the potential to empower organizations to operate with excellence, allowing them to stand out ahead of their competitors, presenting significant differentiators. Thus, measuring performance in the circular economy plays a central role in assessing how companies effectively respond to stakeholder pressures and demands.

3 RESULTS AND DISCUSSIONS

3.1 CHARACTERISTICS OF METRICS AND LEVELS OF PES IN CIRCULAR ECONOMY

When evaluating the results through the BP, it is observed that in terms of their profile, most articles do not present a performance evaluation system as studied in the literature, especially that of Neely et al. (2005) and Melnyk et al. (2014).

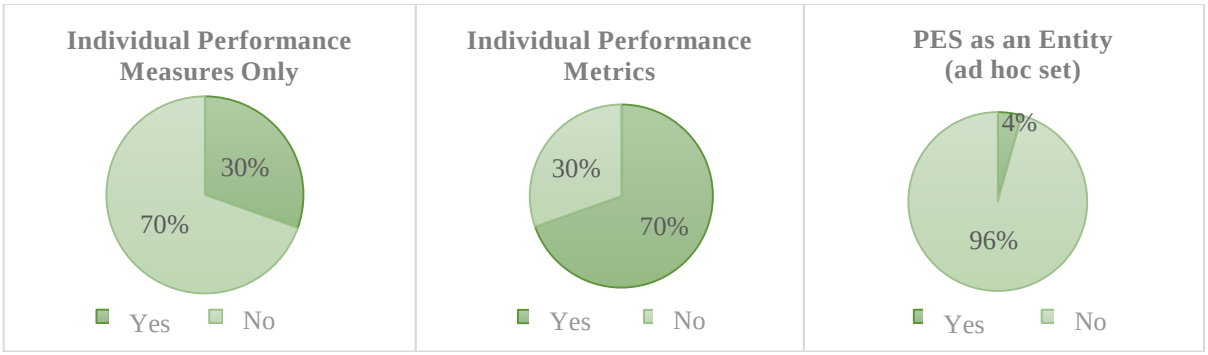
According to Neely et al. (2005), a performance measure is a metric used to quantify the efficiency and/or effectiveness of an action, meaning it is quantifiable and verifiable. Melnyk et al. (2014) further states that a metric is a verifiable measure, expressed in quantitative or qualitative terms and defined in relation to a reference point.

It was observed in the BP that the level of performance evaluation addressed in the literature is limited to the use of individual measures and isolated metrics, as an indicator of performance in the circular economy, as illustrated in Figure 2. It is also noted that only one study presents characteristics of an ad hoc Performance Evaluation System. This specific study proposes a Performance Evaluation System for the Construction Industry (Núñez-Cacho Utrilla; Górecki; Maqueira, 2020).

During the categorization of articles, it was observed that, in terms of evaluating the circular economy, 30% present isolated measures, while 70% present individual metrics. However, those studies presenting metrics cover different forms and characteristics.

Figure 2

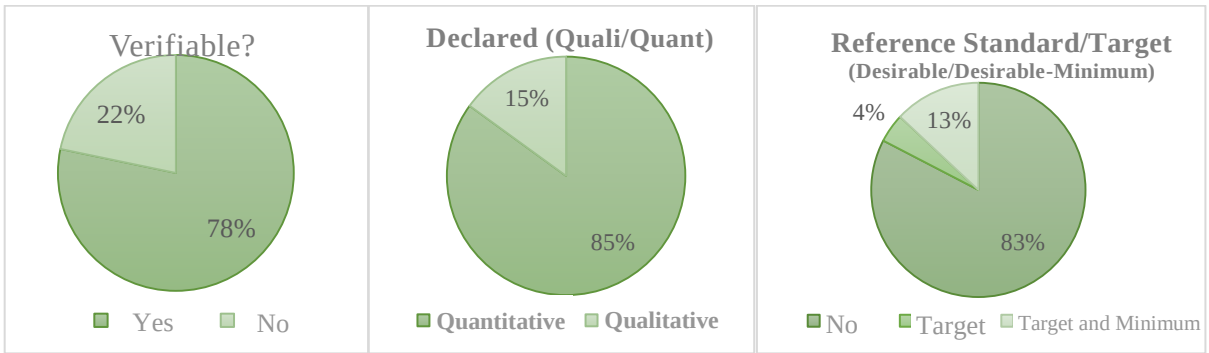
Graphs of advanced variables according to Neely et al. (2005)



When evaluating the BP based on the variables proposed by Melnyk et al. (2014), it is noticeable that the most evident profile is of research with verifiable, quantitative measures, which do not present target and minimum, as well as do not define consequences in case of performance close to the acceptable minimum or even below the target.

Figure 3

Graphs of advanced variables according to Melnyk et al. (2014)



It is possible to observe in Figure 3 that some studies do not present a reference standard, and only 13% of the BP presents "target" and "minimum", with little involvement with stakeholders and low interaction with the external environment.

3.2 TEMPORAL EVOLUTION: PERFORMANCE MEASUREMENT FROM ORGANIZATIONAL AND ENVIRONMENTAL PERSPECTIVES

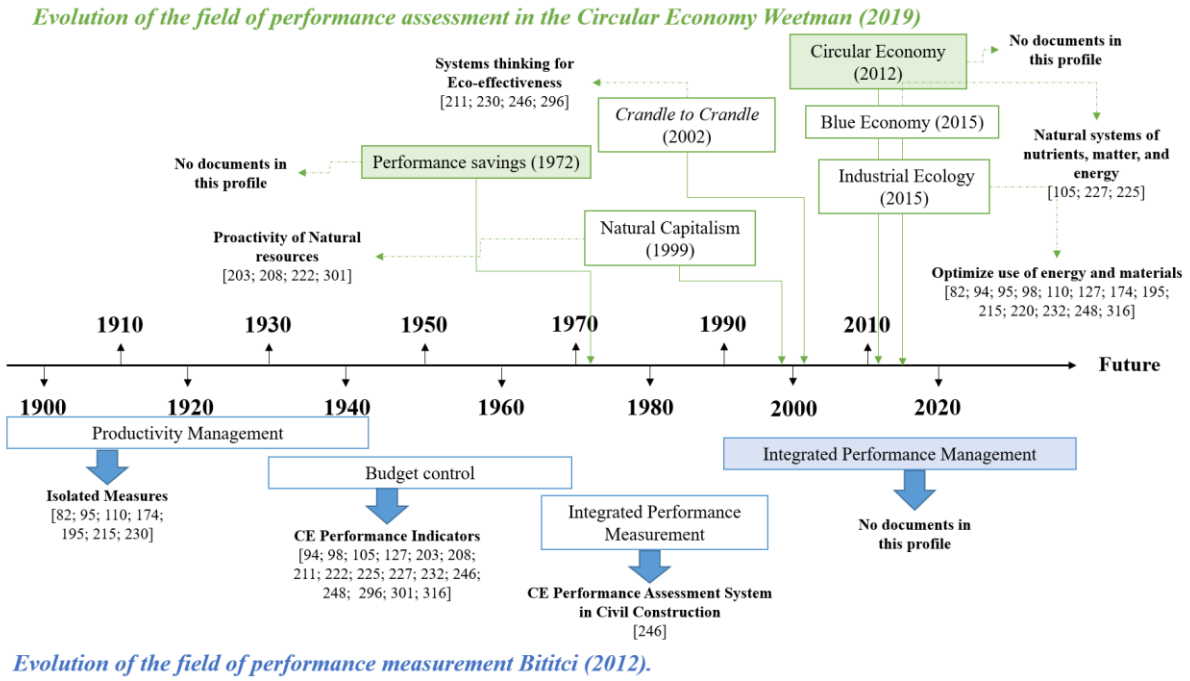
This section proposes a chronological analysis of relevant literature on performance evaluation in the Circular Economy. This review aims to highlight transformations over time, both from an organizational and environmental perspective, exploring how approaches and metrics have evolved to reflect the increasing importance of sustainability and efficiency in the circular economy.

This critical examination aims to provide an in-depth understanding of changes in performance measurement strategies, outlining significant contributions to the field and identifying gaps to be addressed in future studies. It is noteworthy that this analysis was based on the works of Bititci *et al*. (2012), regarding the evolution of empirical research from the BP regarding performance evaluation (Figure 4); and, Weetman (2019) regarding the evolution of empirical research from the BP regarding the circular economy.

Figure 4 shows that research from the BP, in the context of performance evaluation, has evolved little, indicating a need to develop more robust systems that allow for a more comprehensive assessment of the circular economy. Out of the 24 empirical articles, only one presented characteristics of a PES; however, it does not address stakeholders, nor does it include aspects related to the involvement of actors at the macro level of the circular economy. The articles were coded in numbers in the order they appeared in the raw portfolio.

Figure 4

Evolution of performance measurement in the circular economy based on Bititci et al. (2012) and Weetman (2019)



In relation to the evolution of the PB regarding the evolutionary factors of the circular economy, it is important to know the main temporal contributions brought in the literature by Weetman (2019), which are classified as follows: the era of Performance Economy (1972); era of Natural Capitalism (1999); Industrial Ecology (2015); Blue Economy (2015); Cradle to Cradle (2002); until the Circular Economy (2012).

3.2.1 Performance Economy

It refers to the mid-1970s, where concerns about the overexploitation of important ecosystems and non-renewable natural resources began to manifest, or even not respecting the time for the renewal of these resources. In addition, there is concern about increasingly unstable climatic conditions, air, soil, water, and atmospheric pollution.

This model aims to open new frontiers of economic development for an economy of functional services, rather than goods, internalizing costs through systemic design, technical and commercial innovation, recommercialization of goods (reuse), extending the life cycle of goods and components, driving local job creation, and improving resource management and conservation.

3.2.2 Natural Capitalism

Introduced through the publication of the book "Natural Capitalism: Creating the Next Industrial Revolution" by Paul Hawken, Amory B. Lovins, and L. Hunter Lovins in 1999, which aims to show that companies can simultaneously improve profits, solve environmental problems, and have positive feelings about their impacts (Hawken et al., 2014).

This movement focuses on increasing the productivity of natural resources, using models and production materials inspired by biology, adopting continuous flow service business models, and reinvesting in natural capital.

For them, natural capital is the natural resources and ecological systems that provide vital life support services to living organisms. To illustrate this situation, the book cites the example of a bee pollinating a flower compared to manual or robotic pollination and questions how much it could cost and how it could be made viable.

3.2.3 Industrial Ecology

A movement began in 2015 to enable management models inspired by ecology, facilitating recycling and material reuse through a collaborative network between companies.

Industrial ecology aims to incorporate the preservation of materials and energy into a product, as it helps companies understand how they use their key resources, monitor material, energy, and water flows, and take responsibility for the product throughout its life cycle, thus introducing closed-loop production. This model points to a key environmental impact indicator for a country: "what the country consumes?" rather than "what the country produces?"

3.2.4 Blue Economy

Conceived by Gunter Pauli in 2015 and promoted in his book "Blue Economy," this concept bases its solutions on physics, utilizing natural systems of nutrients, matter, and energy as an ideal model (Weetman, 2019). In this context, gravity emerges as the primary source of energy, followed by solar energy, which stands out as the most significant renewable fuel. Additionally, water plays a fundamental solvent role, suggesting the elimination of toxic catalysts, complex and harmful chemicals. This approach results in a completely biodegradable system, aligning with environmentally sustainable principles.

In this model, the absence of waste is highlighted as a fundamental principle. Any byproduct generated is considered a potential source for creating new products. Sustainable businesses maximize the utilization of available materials and energy, reducing the unit price for the consumer while respecting resources, culture, and local traditions.

3.2.5 Cradle to Cradle

Inspired by the work of William McDonough and Dr. Michael Braungart in their book "Cradle to Cradle: Remaking the Way We Make Things," published in 2002, this concept emphasizes the importance of treating materials as biological or technical nutrients and extending the period of use for all materials through a systemic approach that seeks eco-effectiveness instead of eco-efficiency.

This mindset aims to value materials as nutrients for safe and continuous cycles, promoting material reuse, the use of renewable energy, water management through treatment and reuse, and social justice.

3.2.6 Circular Economy

To categorize the collected metrics and identify the main areas of assessment within the Circular Economy (CE), an initial classification attempt was made. This classification was based on the most recognized CE frameworks, namely:

- CE system diagram (EMF, 2015);
- CE Structure from the Circular Economy Lab (Bonassi et al., 2016);
- The CEPS framework (Taranic et al., 2016);
- The 9R framework (Potting et al., 2017);
- The Circularity Compass (Blomsma, 2016, 2018);
- The Circular Value Chain (Pavel, 2018).

However, the alignment between micro-level CE metrics and the categories extracted from these frameworks was not complete. Overall, existing CE frameworks allow for the categorization of metrics related to commonly shared CE principles, such as resource consumption and recovery, circular product design, and waste creation.

On the other hand, several assessment fields, perhaps considered secondary, are inadequately represented in the available frameworks, such as employee training and the

economic performance of green products.

Upon closer examination of Figure 4, it is observed that, within the context of the circular economy, the literature comprehensively addresses the topic, although it does not fully explore all its dimensions. A parallel can be drawn with the temporal trajectory of performance evaluation, revealing substantial gaps in research related to performance evaluation in the context of the circular economy.

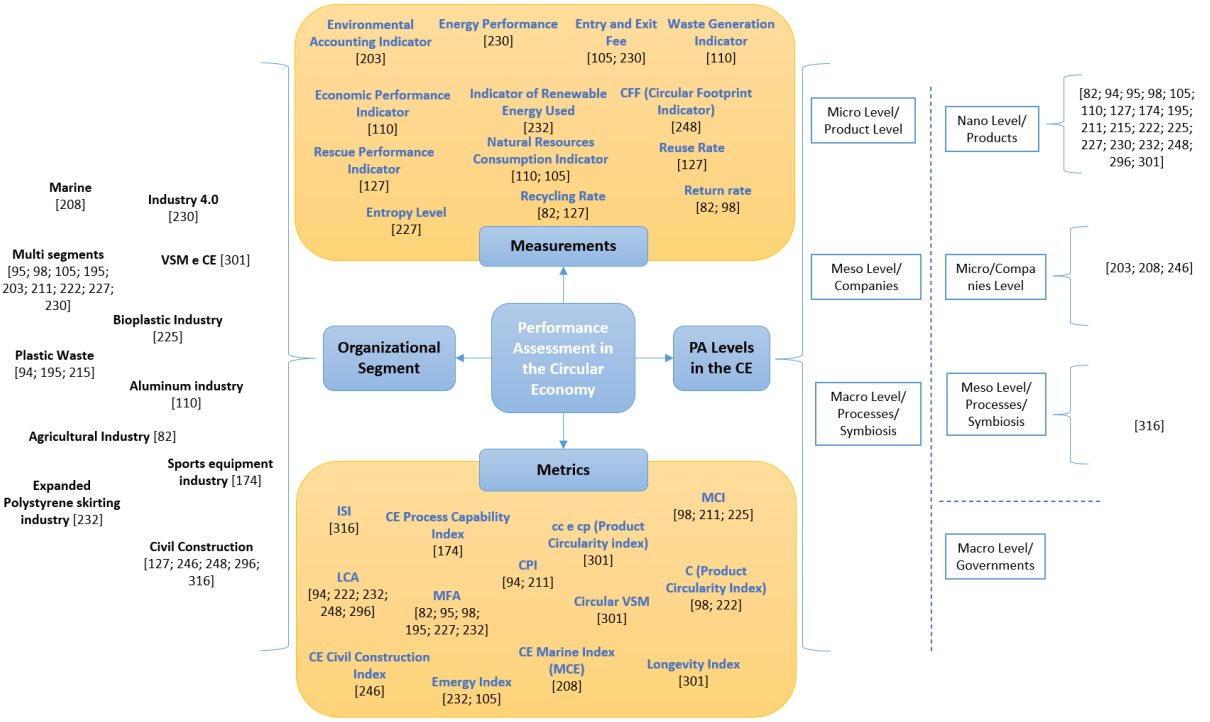
3.3 LITERATURE MAP OF PERFORMANCE EVALUATION IN THE CIRCULAR ECONOMY

For the literature mapping, the articles from the PB can be grouped into four dimensions: (i) levels of performance evaluation system in the circular economy; (ii) organizational segments; (iii) measures for measuring the CE used; and (iv) metrics used, as illustrated in Figure 5.

The performance evaluation system in the circular economy can be classified into 3 levels of the system: micro (product level), meso (industrial area/symbiosis) – process; macro (national or municipal level) – company. The results suggest that few studies compare circularity indicators with environmental performance or link circularity indicators across societal levels (e.g., micro and macro levels) (Harris et al., 2021; Sacco et al., 2021), as illustrated in Figure 5.

Figure 5

Literature map on performance evaluation system



According to Bracquené et al. (2020), the three most commonly cited micro-level indicators are: the Material Circularity Indicator (MCI), proposed by the Ellen MacArthur Foundation (EMF) and Granta Design (GD) (EMF & Granta Design, 2015), the Circular Economy Index (CEI) proposed by Di Maio & Rem (2015) and the Reuse Potential Indicator (RPI) proposed by Park & Chertow (2014).

For some authors, the MCI is one of the most promising and ambitious attempts to develop a circularity metric at the product level (Baratsas et al., 2022; Linder et al., 2017), However, it fails to account for the rigidity of material cycles and ignores the relationship with other product systems, for example, for the use or supply of recycled material. Additionally, the indicator does not consider material losses during manufacturing, thus Bracquené et al. (2020) propose a new product-level indicator, the Product Circularity Indicator (PCI).

The literature presents organizational segments with a higher concentration of studies addressing multi-segments and studies involving construction organizations. It is noteworthy that the study addressing the most SAD characteristics was that of Utrilla et al. (2020).

3.4 FUTURE RESEARCH DIRECTIONS IN CIRCULAR ECONOMY PERFORMANCE EVALUATION

Given the complexities and challenges identified in this context, it becomes imperative to outline directions for future research that deepen and enrich the field. Approaches are proposed that not only address gaps but also enhance performance evaluation in the circular economy, aiming to align it more effectively with the fundamental principles of sustainability (Figure 6).

Figure 6

Future research proposals in Performance Evaluation in Circular Economy

Thus, the aim is to foster a critical and innovative dialogue that leads to more comprehensive and applicable research. The development of integrative SAPs, robust stakeholder engagement, analysis of the interconnection between metrics, longitudinal studies, and international comparison of approaches provides a solid foundation for the continuous evolution of understanding and practice in performance evaluation in the circular economy. These suggestions not only address current knowledge gaps but also pave the way for a more holistic and effective approach in this dynamic and ever-evolving field.

4 FINAL CONSIDERATIONS

Performance evaluation in the circular economy is gaining prominence due to global pressure for sustainability and competitiveness driven by globalization and innovations. While the adoption of CE promises competitive advantages and eco-efficiency, it has not yet fully contributed to sustainability, highlighting the need for improvements. Literature reveals a growing emphasis on metrics for Circular Economy Performance Evaluation (CEPE), particularly at primary levels, yet there remains a gap between metric presentation and the development of comprehensive systems.

Studies on CEPE date back to the 1990s, with increased interest and innovation from 2010 onwards, however, comprehensive and integrative systems are still scarce. Despite the influence of Industrial Ecology, the full extent of CE principles is not fully reflected in research. Metrics are often addressed in isolation with limited stakeholder involvement and external interaction.

The literature emphasizes a simplified approach to CEPE, lacking depth and essential characteristics proposed in performance evaluation systems literature. This study aims to fill these gaps, promoting a broader and enhanced understanding of CEPE. To achieve this, deeper investigation into integrative strategies involving relevant stakeholders and metric interconnection is suggested, aiming to significantly advance circular economy application.

Exploring the growing interest in performance evaluation in the CE is essential, emphasizing the urgency of significant advancements in this area. Directing future research towards integrative and comprehensive strategies can play a crucial role in effectively promoting the circular economy and achieving its sustainable objectives.

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