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AN OVERVIEW OF CIRCULAR ECONOMY-BASED PERFORMANCE MEASUREMENT SYSTEM FOR SMES

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Abstract. Nowadays, as the topic of environmental sustainability has become more relevant due to growing global challenges, the role of the circular economy has gained immense popularity in business. The essence of the concept of circularity, proposed in the 1960s by the American economist Kenneth E. Boulding (Boulding, 1966), is to turn end-of-life goods into resources for others by closing the cycles in industrial ecosystems and minimizing waste. Even though many studies have been carried out, there is still a rather fragmented, unclear basis for measuring and assessing circular economy performance when applying it in the business field. Therefore, the purpose of this article is, after examining a procedure for assessing circular economy in business field, to systemise sustainability assessment methods and measurement indicators in SMEs. The results of the study demonstrate how management methods such as the Plan-Do-Check-Act cycle are linked to the effectiveness of using circular economy-based measurement via clearly set procedures and indicators.

Keywords: circular economy, sustainable development, circularity indicators, circularity metrics, analytical tools, company performance, evaluation.

JEL Classification: L25, M10, Q01, Q50, Q56.

Introduction

The growing demand for goods and the self-centred "make, use, dispose" approach have increased rapidly over the last century. The 1950s brought the wonders of internationalization and mass production focused on quantity over quality, bringing global warming closer than we think. A great tool for avoiding negative impacts on the environment, circular economy, turns end-of-life goods into resources for others, closing loops in industrial ecosystems and minimizing waste. It substitutes sufficiency for production by reusing what is possible, recycling what cannot be reused, repairing what is broken, and remanufacturing what cannot be repaired (Stahel, 2016).

Kirchherr et al. (2017), by analysing 114 definitions, proposed a single answer on circular economy: *"[CE is] an economic system that replaces the "end-of-life" concept with reducing, alternatively reusing, recycling, and recovering materials in production/distribution and consumption processes, [...] with the aim to accomplish sustainable development, thus simultaneously creating environmental quality, economic prosperity, and social equity, to the benefit of current and future generations"*. According to Prieto-Sandoval et al. (2018), the definition of circular economy must include four key elements: 1) resource and energy recycling, reducing resource demand, and recovering value from waste; 2) a multi-level approach; 3) a means of achieving sustainable development; and 4) its close connection to social innovation.

The significance of circular economy comes from its inevitable link with sustainable development, as both share common evidence of resource exploitation and environmental degradation. The Ellen MacArthur Foundation (2013) also refers to sustainable design strategies (SDS) as the "official" circular economy principles in publications and reports. Economic, social, and environmental sustainability are the three dimensions most often associated with the concept (Ekins et al., 2019).

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Kravchenko et al. (2020) in relation to several other authors stated that it is critical to recognize the complexity of the transition from a linear to a circular economy and realize its importance for achieving sustainable development goals. The authors stated that "*To ensure a circular economy solution can contribute positively to sustainability, it needs to be planned with sustainability considerations and intentions in mind and assessed on its sustainability performance prior, during and after implementation*" (Kravchenko et al., 2020). As Negri et al. (2021) put it: "*The measurement of performance is paramount to track progress and foster the implementation of the circular economy paradigm*". Janik and Ryszko (2019) stated that with numerous indicators and procedures developed "*it is possible to measure the level of application of circularity principles and to justify the actions aiming to ensure the transition from linear to circular economy. The micro level activities and relevant metrics are of particular importance*". While choosing appropriate techniques, it is relevant to define sustainability concerns for the project as well as critically analyse and prioritize information to make informed decisions (Kravchenko et al., 2020). The proper implementation of a particular performance-measurement system may, however, conflict with some firm characteristics, such as a lack of resources and a muddled strategy, resource and capability constraints, a lack of operative instruments, organizational settings, and awareness levels, all of which are present in small-medium enterprises (SMEs) (Negri et al., 2021). European Union (2003) defined SMEs as "*Firms that employ fewer than 250 persons and which have an annual turnover not exceeding EUR 50 million, and/or an annual balance sheet total not exceeding EUR 43 million*". Implementing circularity would give these businesses, which frequently lack the necessary expertise, resources, and support, and which also are less prone to undertake transformational changes, a competitive advantage (Negri et al., 2021).

A firm's process performance must be measured to evaluate how circular the overall system is. The evaluation is conducted in the phases of the material input, design, production, consumption, end-of-life (EoL) resource management (Elia et al., 2017). Actions involved have been proposed and categorized by Ellen MacArthur Foundation (2013): circular product design and production, business models, cascade/reverse skills, cross cycle and cross sector collaboration. There are also five categories of requirements to be measured: reducing input and use of natural resources, reducing emission levels, reducing valuable materials losses, increasing share of renewable and recyclable resources, increasing the value durability of products (Elia et al., 2017 referring to EEA, 2016).

This article aims at identifying the circularity measures in the business field and at systemising sustainability assessment methods and measurement indicators in SMEs. The sections of this article focus on the findings of the literature review on the peculiarities of circular metrics and indicators (Section 1), instruments for measuring the circular economy (Section 2), and procedure for evaluating the performance of the circular economy (Section 3).

1. Circular economy metrics and indicators

Panchal et al. (2021) following the ideas of Lebas, 1995, Thomas and Birat, 2013 stated: "*We cannot manage what we do not measure; thus, to effectively manage the circular economy implementation, its performance measurement is essential*". Saidani et al. (2019), using EEA (2003), mentioned that performance indicators have the same variables as descriptive indicators but are linked to target values, evaluating the gap between the actual and desired state of the situation. It also became abundantly evident from our examination of the literature that there is currently no single, widely used definition or evaluation metric or indicator, especially on the topic of circular economy. Each one was founded on a distinct sector, level of observation (micro, meso, macro), and with a focused intention (Ekins et al., 2019). Therefore, it is essential to define and distinguish between several metrics and indicators to proceed with the assessment. With the same form and content, indicators give an idea on certain phenomena, while metrics show the success of achieving corporate objectives. In the circular economy context, indicators essentially focus on how services and goods grasp the concept and are hence calculable measures made up of several metrics. As shareholders have not properly defined the concept of circularity, it turned to be an abundance in the matter of indicators and metrics (Corona et al., 2019 referring to Pauliuk, 2018). Moreover, these two have been criticized by scientific community for not considering characteristics of the circular loops, the multi-dimensional sustainability performance (environmental, social, and economic aspects), and not integrating the great number of new frameworks from the past five years (Corona et al., 2019). According to these authors in Corona et al. (2019), evaluating metrics and indicators with specific requirements revealed that none of them correspond to them, only partially do so, or are not appropriate for measuring the sustainability and circular strategy of the company. As a result, it is necessary to introduce adequate, up to date, and almost universal measurements.

In the broad sense, Rao et al. (2009) explained that metrics are used to assess and manage resource performance, convey performance to internal and external stakeholders, and recommend improvements by pointing out gaps between an actual performance and industry standards. Requirements for metrics, in the view of Corona et al. (2019), refer to the reliability (consistency and robustness of the metric), validity (degree of the measurement) and the utility (practicalities). The difficulties with the current circularity metrics, however, have to do with measuring the circularity goals across all aspects of sustainability, assessing the scarcity of used materials, and underestimating the complexity of multiple cycles (multifunctionality) and the effects of material downcycling (Corona et al., 2019).

Generally, since the transition process for sustainable business is challenging and costly, before choosing the tool or a combination of tools for measuring circularity, setting indicators is required. Similarly, choosing the right indicators is important not only for businesses, but also for the relevant government agencies, as they stimulate economic growth at the macro level (Hysa et al., 2020). Rao et al. (2009) noted that environmental indicators reflect the environmental performance to a large extent, hence this conclusion can be attributed to circularity indicators as well. To proceed with them, Ekins et al. (2019) suggested that it would be necessary to specify the "desired" end state's goals. Second, how strategies and policies can be used to implement change in the current situation. Finally, how the process can be monitored, evaluated, and improved to gauge goal-related progress. The author also pointed out two purposes for indicators: ones to provide guidance, others to provide feedback and review performance (Ekins et al., 2019). To give a more practical example, in their case study on post-industrial plastic waste, Huysman et al. (2017) calculated the Circular Economy Performance Indicator (CPI), which they defined as the ratio of the actual environmental benefit obtained over the ideal environmental benefit according to quality. If the CPI value is less than 1, the actual environmental benefit is lower than the ideal environmental benefit according to quality.

Moraga et al. (2019) differentiated indicators by the circularity concept definition, these are sensu stricto (narrow focus on technological cycle of resources) and sensu latu (broader focus on sustainablility). Futhermore, Moraga et al. (2019) specified indicators to such categories: direct with specific strategies, direct with non-specific strategies, indirect (contains circularity information but is not direct to its definition). In a circular economy strategy, differences arise in the following areas in which performance is measured: functions, products, components, materials, embodied energy, and reference (Moraga et al., 2019). United Nations Environment Programme (UNEP, 2005) pointed out another limitation of indicators by specifying the scope of measurement using the Life Cycle Thinking (LCT) approach. The concept arose from the need to achieve more sustainable consumption and production patterns through full life cycle management of products (UNEP, 2005). On this idea, Moraga et al. (2019) identified three scopes of indicators: one that measure physical properties from technological cycles without the use of the LCT approach in scope 0; full or partial LCT approach in scope 1; and cause-and-effect chain modelling in scope 2 to measure the effects (burdens/benefits) from technological cycles regarding environmental, economic, and/or social concerns. Additionally, they identified indicators by implementation scale (attributing to the level of observation): product or service, corporate, inter-corporate, city, region, nation, world; as well as specified types of them: parameter, ratio, index, and composite (Moraga et al., 2019). Nonetheless, Hysa et al. (2020) segregated indicators into four group areas: production and consumption; waste management; secondary raw materials; and competitiveness and innovation. On the other hand, Saidani et al. (2019) proposed a taxonomy along ten key criteria presented in Table 1.

Table 1. Categories for the proposed taxonomy of circularity indicators (Saidani et al., 2019)

Categories of indicators (criteria)
#1 – Levels *(micro, meso, macro)*
#2 – Loops *(maintain, reuse/remain, recycle)*
#3 – Performance *(intrinsic, impacts)*
#4 – Perspective *(actual, potential)*
#5 – Usages *(e.g., improvement, benchmarking, communication)*
#6 – Transversality *(generic, sector-specific)*
#7 – Dimension *(single, multiple)*
#8 – Units *(quantitative, qualitative)*
#9 – Format *(e.g., web-based tool, Excel, formulas)*
#10 – Sources *(academics, companies, agencies)*

Corona et al. (2019) provided a summary of the examined circularity metrics (or "indices") and indicators, including their measuring basis and case studies. These authors provide a list of environment focused circularity indices which includes the following groups: Circ(T) or Cumulative Service Index, Material Circularity Indicator, Global Circularity Index; Circularity Index, Circular Economy Indictor Prototype, Circular Economic Value; and New Product-level Value Circularity Metric, which is, additionally to environment, economy focused. Within the group of circularity indicators, Corona et al. (2019) distinguish Sustainable circular index that covers all three sustainability views of environment, economy, and society, as well as five more indicators that represent environment and economy, i.e., Reuse Potential Indicator, Value-based Resource Efficiency, Longevity Indicator, Eco-efficiency index, and Eco-efficient Value Ratio, and additionally economy focused indicators such as Circular Performance Indicator, Global Resource Indicator, and Circularity degree.

2. An overview of frameworks for circular economy performance measurement

As a starting point, Wang (2018) defined evaluation methods for judging circulation at each level presented in Table 2. All tools and related frameworks are built around these concepts.

Altogether, there are two types of tools: assessment indicators – an assessment through one indicator (which were described in the section above) and assessment frameworks which combine several indicators which evaluate different aspects of circularity of a system (Corona et al., 2019).

Table 2. The evaluation methods of circular economy cycle (Wang, 2018)

Evaluation method	Concept
Life cycle method	Evaluate the environmental impact of each phase of the product life cycle
Cleaner Production Audit method	In accordance with certain procedures and standards, to investigate and diagnose the service and production process, find out the reasons of high pollution, high consumption, and low efficiency, put forward plans to reduce consumption and efficiency, and then choose a set of improved production technology to promote corporate clean production
Material flow analysis method	Quantitatively estimate material flows in society

One of the most used tools is Life Cycle Assessment (LCA) framework (ISO 14040 – ISO 14044 standards) that systematically evaluates environmental aspects of a product through all stages of its life cycle (UNEP, 2005), This approach considers climate change impacts (fossil fuels emissions, usage of minerals, land, and water), ecosystem services (e.g., eutrophication, acidification and ecotoxicities), and human health (human toxicities, particulate matters) (Corona et al., 2019). To better align the LCA with the circularity goals, a global resource indicator has been added to consider recycling and the relative importance of resource indicators (Panchal et al., 2021 referring to Adibi et al., 2017). Another problem associated with LCA is the accumulated experience on end-of-life (EoL) assessments. However, without detailed information on open-loop recycling processes, the ISO standards recommend a hierarchy procedure to account for this multifunctionality (Corona et al., 2019). There is another disadvantage to using LCA in evaluating product service systems, namely the definition and delimitation of reference systems, the establishment of functional units and system boundaries (Chen et al., 2020).

Often used as an adjunct to LCA to address its shortcomings, the Input-Output Analysis (IOA) describes the interdependence of sustainability across many sectors of a regional, national, or global economy (Corona et al., 2019). According to Rocca et al. (2021), who cited Motevali Haghighi et al. (2016), the hybrid Balanced Score Card (BSC) for assessing performances in sustainable supply chains was developed using this methodology. By computing the input-output balance sheet for the complete product life cycle, this tool enables quantifying the circularity of the product or service. The assessment takes into account the life-cycle circularity of the resources used, the utilization of renewable energy and materials, recycled materials, the frequency of reuse, and the sharing of products and materials meant for recycling, reuse, or landfill (Janik and Ryszko, 2019 referring to Capellini, 2017).

The Material Flow Analysis (MFA) tool calculates mass balances over time within a specified space to evaluate flows and stocks in a system using material flow indicators (Corona et al., 2019). Flows are measured in terms of their mass to determine the amount of materials used, but nothing about quality or the scarcity of the material (Corona et al., 2019). According to Panchal et al. (2019), the limitation of this approach, despite its flexibility and simplicity, is the unavailability and unpredictability of the data, as well as the fact that it can only be applied at the macro-level (national and city) to assess the performance of the circular economy. Chen et al. (2020) mentioned that at the business level, this method is time-consuming and costs manpower. Furthermore, Rocca et al. (2021) noted that the MFA approach has not been thoroughly studied and is therefore not one that professionals frequently use to evaluate circularity performances.

Other frameworks were discussed by Rocca et al. (2021). These frameworks included Multi-Criteria approaches (MCDM) and Fuzzy Logic, DfX and Guidelines, Emergy- and Exergy-based approaches, adopted simulation approaches like Discrete Event Simulation (DES), and other industry-specific methods for measuring performances. In general, DfX and Guidelines are the best way to go, if you want to empower product design and development or change from a linear lifetime to a circular one. Other approaches such as LCA, MFA, DEA/IeO, MCDM and DES are designed to consider and evaluate all potential system factors over nearly the whole lifecycle (Rocca et al., 2021).

Additionally, some sustainable practices are appropriate for assessing performance on the circular economy. In some cases, these practices have adopted the Analytical Hierarchy Process (AHP) or Analytic Network Process (ANP) developed by Saaty in 1980 and 1996, respectively; the Balanced Scorecard (BSC) developed by Kaplan and Norton in 1992, which integrates three dimensions of sustainability; and the Composite Index developed by Puolamaa et al. in 1996, and Cherchye and Khuosmanen in 2002, that summarizes data related to sustainability issues (Kamali et al., 2018).

3. Procedure for circular economy performance evaluation

In general, Klerman (2005) identified the steps to implement a performance measurement system that includes: 1) start somewhere – define goals and possible outcomes, record and distribute results; 2) evaluate the measurements – compliance with requirements, measure consistency and properties of the system; 3) put in place auditing program – establishing the auditing team and observe selected cases; 4) use the measurements (more) – monitoring organizational performance, remediation decisions; 5) repeat – review and re-evaluate previous steps.

Following the idea, the Plan-Do-Check-Act (PDCA) cycle, commonly referred to as the Deming cycle or the Shewhart cycle, is one of the most well-known methods

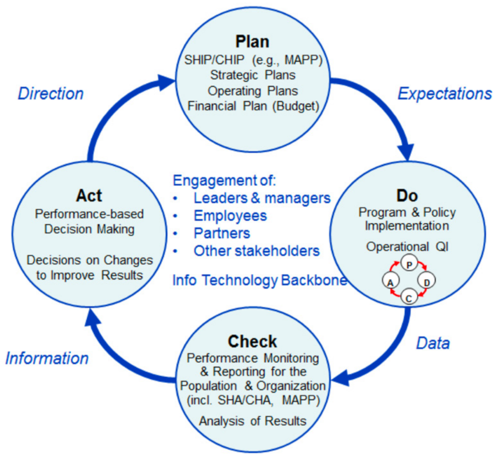

Figure 1. A PDCA-based performance management system (Moran et al., 2013)

for continuous process improvement of management practices (Johnson, 2002). In the first step "Plan" it is relevant to recognize opportunities and plan the change; for the "Do" step is to test the change; the "Check" refers to review the test, analyze the results, and identify learnings; and finally, "Act" means application of the implemented solutions based on what was identified from the "Check" step (Johnson, 2002). However, Qing-Ling et al. (2008) state that the basic PDCA model in the performance measurement system consists of four phases including performance plan, performance implement, performance appraisal, and result disposal. Jagusiak-Kocik (2017) stated that *"PDCA cycle is contained in a circle and never ends, as the knowledge gained from the last stage becomes the basis for the next cycle; improvement is not seen as the end and does not bring satisfaction with the current situation"*. The author also mentions that this methodology is simple to implement, it can be successfully used by any SME, and it helps to overcome internal barriers and minimize the impact of external ones (Jagusiak-Kocik, 2017). As a result, the SME can greatly construct an efficient and dynamic PDCA cycle strategy to suit their needs across all departments (Chakraborty, 2016). With this methodology, a company can achieve competitiveness and sustainable development by proposing more practical and specific measures and looking for the best performance measurement models based on its actual performance measurement situations (Qing-Ling et al., 2008). In addition, Perera et al. (2013) mentioned the ISO14031 international standard, which outlines a procedure for evaluating whether an organization's environmental performance satisfies the standards it has set for itself using the PDCA business process improvement model.

Despite working on the performance management system in public health, Moran et al. (2013) developed their own PDCA cycle (Figure 1). These authors explain everything in the cycle starts with the formulation of goals and objectives for performance assessment in the "Plan" phase, which are derived from annual operating plans for all programs, services, and projects. To ensure that the plans lead to real results, they are transferred to "Expectations" for execution in the "Do" phase. Then, "Expectations" are expressed in program performance indicators and targets, and new or updated policies that support efforts to improve quality. Implementation in accordance with goals and budgets, as well as improvements in operational quality, produce "Data" that will be used in the "Check" phase. The "Check" stage tracks and examines organizational data from operations, including information on population and community changes, translating it into "Information" that influences decisions during the "Act" stage. Lastly, in "Act" it is crucial to decide on changes and think on how to improve results while creating or revising the cycle back at the "Plan" phase.

Addison et al. (2020) developed a performance management system with regards to biodiversity indicators using PDCA methodology (Figure 2). In the "Plan" phase, Step 1 of the framework involves defining a decision context with specific questions to ensure that the indicators will match the business's decision-making needs. Step 2 involves developing goals, which are a vision of what the business wants to achieve. Addison et al. (2020) also suggested dividing goals into objectives using Doran's (1981) SMART methodology. Step 3 entails exploring potential actions that can manage or mitigate impacts and help achieve the goals and objectives that have been decided upon. In the "Do" phase, we select

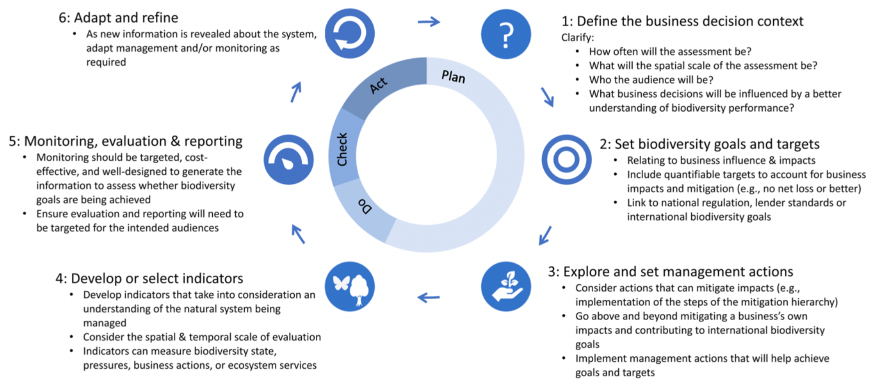

Figure 2. A PDCA framework to guide the development and use of biodiversity indicators by business (Addison et al., 2020)

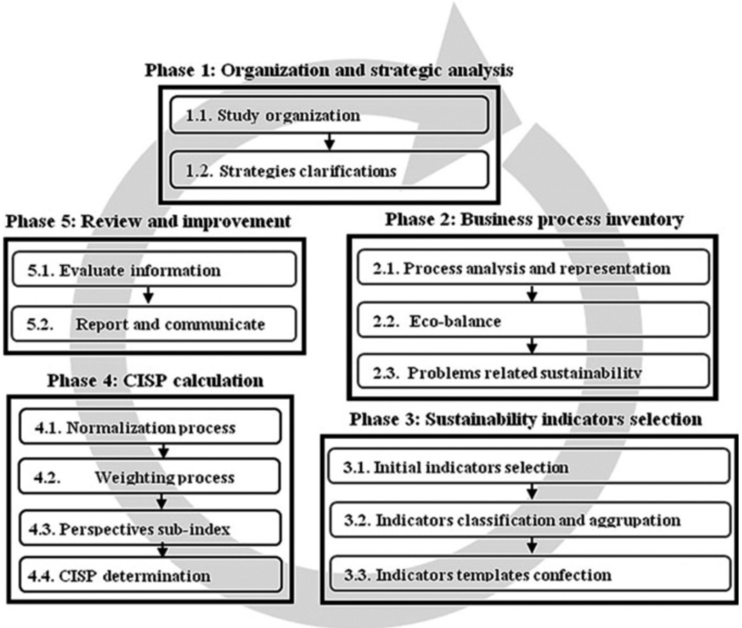

Figure 3. Procedure for sustainability performance evaluation (Medel-González et al., 2013)

relevant indicators that are best suited for business decision purposes. To provide the relevant information, the "Check" phase should comprise monitoring (i.e., data collection), evaluating, and reporting in a focused, cost-effective, and well-designed manner. The "Act" uses the information from the "Check" to adapt and improve performance, involves reviewing past performance, making necessary adjustments to indicators and data collection techniques, and occasionally goals.

Another example is on performance measurement in sustainability context done by Medel-González et al. (2013) (Figure 3). Although consisting of five steps, its context lies within the PDCA cycle: 1) organizing and clarifying the principal's strategies of the organization; 2) identifying main aspects and associated impacts; 3) initial selection of different indicators based on sustainability impacts, defining and documenting with the right attributes; 4) conducting a calculation of Corporate Index of Sustainability Performance (CISP); 5) comparing the value of the CISP versus the scale of sustainability performance evaluation, that is to provide qualitative meaning to the numerical results of the CISP (Medel-González et al., 2013). Then the report is prepared to provide information on sustainability performance to managers and stakeholders (Medel-González et al., 2013).

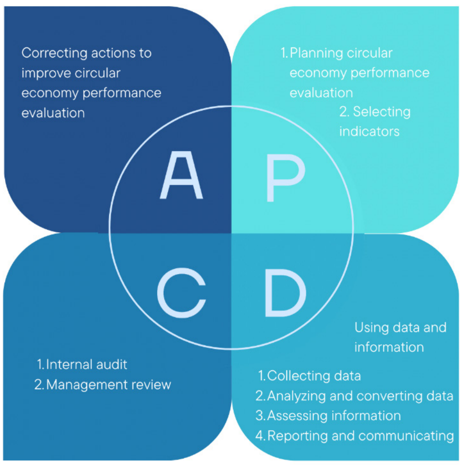

Figure 4. The PDCA cycle for circular economy performance measurement

Summarizing these procedures for circular economy performance measurement we interpreted a PDCA cycle for SME as presented in Figure 4. In the "Plan" phase, all relevant planning procedures for the circular performance evaluation should be carried out. Predictions (i.e., potential outcomes) should be stated along with goals, targets, resources, and vision. Then, based on the objectives of the evaluation, indicators and pertinent frameworks should be chosen. During the "Do" phase, we carry out the planned activities and collect results, which we then analyse and distribute to various shareholders (leadership, management, employees, partners). The "Check" means gathering the feedback and revision of the step "Do" with management. It is important to compare current results with initial predictions and ensure that the practice is aligned with the plan. Finally, we document the newly created practice in the "Act" phase and take corrective action (returning to the "Plan" phase).

Conclusions

Currently, the circular economy is a widespread topic in academia due to its close relationship with sustainability and is inherently a potential solution for more efficient use of resources. In this study, we took a closer look at this concept, identified key circular indicators and performance management frameworks for SMEs, and redesigned the PDCA cycle to suit our topic.

We evaluated the existing methodologies and concluded that there is no such thing as "unified measurement" yet. However, several frameworks suggest, rather focusing only on sustainability or the environment, a way to achieve similar results in relation to a particular sector. In this work, an attempt was made to develop a general procedure for assessing the performance of a company in relation to circularity, which would have common features with the observed methods. Its essence lies in the original idea of continuous monitoring of the results of the assessment with planning, analysis, revision, and performance activities.

According to the layout of this paper, when using the PDCA cycle to measure the performance of the circular economy, it is recommended to be aware of the topic of circularity in general, decide on the purpose of the assessment, and think ahead about desired outcomes, describe actions and select indicators related to the business sector, and finally put them into practice, constantly monitoring and improving the process.

Future research may develop such a process for large enterprises, as well as test the proposed method in practice, distinguishing between SMEs on products and services, and by sector. Ultimately, further work is needed to clarify the validity of the PDCA concept and its impact on the growing businesses of Industry 4.0. Finally, more research is needed to point out the importance on undertaking appropriate steps in mitigating negative effects of climate change with implementation of circularity, rather than introducing corporate social responsibility initiatives and failing to address the root of the problem.

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