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Editorial

Circular Economy and Sustainable Business Performance Management

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Today, more than ever, the world needs to be considered as a finite and limited system, characterized by scarce resources and as a place where restocking is not possible in an infinite way. As such, careful resource management needs to be planned and set by the concurrent actions of heterogeneous stakeholders, from policy makers up to academics and industrialists, in order to effectively implement the Circular Economy (CE) paradigm [1] and to be able to pursue sustainability in time. The different resources involved along the extended product lifecycle need to be adequately managed through innovative business models and design practices, coupled with reverse logistics and digital technology adoption. So far, several methods (e.g., Life Cycle Assessment (LCA) and Life Cycle Costing (LCC), Multi Criteria Decision Methods (MCDM), Material Flow Analysis (MFA), Design for X (DfX)) have been adopted and combined in different ways to measure and assess the circular performance of a system [2]. In addition, indicators able to measure the CE are not directly bonded to the firm's organizational functions involved in CE assessment [3]. With the aim of starting to fill this gap [4], conducted a systematic literature review to map them into 23 categories of CE micro-level metrics and compared them to Porter's Value Chain to detect the metrics' link with archetypal companies' organizational functions. Attempting to bridge methods and metrics in a unique methodology for CE performance assessment [5], proposed a novel methodology, the Circular Economy Performance Assessment (CEPA), mainly based on LCA and LCC and proposing a set of KPIs useful for the quantitative assessment of circular business models.

With the aim of addressing sustainable development, the CE can be adopted in manufacturing companies through the adoption of different Circular Manufacturing (CM) strategies (e.g., recycling, remanufacturing) [6]. Manufacturing companies are attempting to implement these strategies to limit their resource consumption and pollution generation. However, they are still not fully ready and mature enough to employ and deploy CE strategies and related practices in their processes. Indeed, the CE paradigm asks for multiple interventions in the organization (from business models and organizational ones through technological and competence-driven ones, up to data management ones). In this context, some qualitative models and methods have been proposed in the literature to help companies to realize which is their circular level and define roadmaps towards their circular level improvement. In addition, companies could benefit from a set of advantages led by fully embracing the CE paradigm. On the other side, throughout the circular transition, not only several hurdles can be encountered but also a rebound effect could result from the adoption of the CE [7,8]. Related to this, it is still not clear how to systematically measure both the negative and positive impacts occurring throughout the circular transition.

This Editorial refers to the Special Issue "*Circular Economy and Sustainable Business Performance Management*". The Special Issue highlights new opportunities and challenges for advancing the performance assessment of the CE, focusing on technological advancements and management initiatives, and including public–private partnerships between stakeholders.

Twenty-two manuscripts were submitted for consideration for the Special Issue, and all of them were subject to the rigorous *Sustainability* review process. In total, fourteen papers were finally accepted for publication and inclusion in this Special Issue (nine articles and five reviews). The contributions are listed below:

1. Acerbi, F., Sassanelli, C., Terzi, S., Taisch, M., 2021. A Systematic Literature Review on Data and Information Required for Circular Manufacturing Strategies Adoption. Sustainability 13, 1–27. https://doi.org/10.3390/su13042047
2. Negri, M., Neri, A., Cagno, E., Monfardini, G., 2021. Circular Economy Performance Measurement in Manufacturing Firms: A Systematic Literature Review with Insights for Small and Medium Enterprises and New Adopters. Sustain. 13, 1–27. https://doi.org/10.3390/su13169049
3. Tavera Romero, C.A., Castro, D.F., Ortiz, J.H., Khalaf, O.I., Vargas, M.A., 2021. Synergy between Circular Economy and Industry 4.0: A Literature Review Citation. Sustain. 13, 1–18. https://doi.org/10.3390/su13084331
4. Mangenda Tshiaba, S., Wang, N., Ashraf, S.F., Nazir, M., Syed, N., 2021. Measuring the Sustainable Entrepreneurial Performance of Textile-Based Small-Medium Enterprises: A Mediation-Moderation Model. Sustain. 13, 1–19. https://doi.org/10.3390/su131911050
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14. Demko-Rihter, J., Sassanelli, C., Pantelic, M., Anisic, Z., 2023. A Framework to Assess Manufacturers' Circular Economy Readiness Level in Developing Countries: An Application Case in a Serbian Packaging Company. Sustain. 15, 1–25, https://doi.org/10.3390/su15086982

As shown in Table 1, the contributions covered large geographical areas, from specific country cases (e.g., Italy, Serbia, and China) to groups of countries (worldwide). The majority of the contributions (1, 2, 3, 4, 6, 7, 8, 9, 11, 12, 13, 14) relate to the field of business and management in the manufacturing sector. In detail, contributions 4 and 10 also pertain to macro aspects of CE performance assessment; contribution 5 argues about the financial aspects; and contribution 11 is more oriented to the hydrological factors related to the CE adoption (Table 1).

Table 1. Analysis of the published contributions in the Special Issue.

N# of Contribution	Research Area	Focus	Type of Research	Organization/Industry
1	Business and Management	Information and data management and sharing, circular manufacturing, digital technologies, data economy	Systematic Literature Review	Manufacturing
2	Business and Management	Performance indicators, small and medium enterprises	Systematic Literature Review	Manufacturing
3	Business and Management	Sustainability, Industry 4.0	Literature Review	Manufacturing
4	Business and Management, Entrepreneurship	Knowledge Management practices, sustainability entrepreneurship performance, SME, dynamic capabilities	Survey	Textile
5	Finance	Corporate performance; enterprise environmental protection investment; industry competition	Secondary data analysis and Multiple Regression Analysis	Manufacturing
6	Business and Management	Strategic business performance; organizational flexibility; high performance work system; manufacturing organizations	Quantitative research design (Structural Equation Modeling)	Manufacturing
7	Business and Management	Digitalization; small- and medium-sized enterprises (SMEs); Industry 4.0; triple bottom line of sustainability	Systematic literature review through the topic modeling method with a machine learning technique (Latent Dirichlet Allocation)	Manufacturing
8	Business and Management	Lean manufacturing; green manufacturing; competitive priorities; decision areas; sustainability	Systematic Literature Review	Manufacturing
9	Business and Management	Digital servitization; digital technologies; digital supply chain; automotive industry; Industry 4.0	Social Network Analysis (SNA) method	Automotive
10	Business and Management, Entrepreneurship	Circular economy innovation; business model innovation; government incentives; SMEs performance	Survey + Partial Least Squares Structural Equation Modeling (PLS-SEM)	Governments; Manufacturing

Table 1. *Cont.*

N# of Contribution	Research Area	Focus	Type of Research	Organization/Industry
11	Business and Management; Hydrology	Circular economy; circular bioeconomy; floating treatment wetland; phytoremediation; tropical wetlands; Typha latifolia	Model design and lab analysis	Tannery wastewater
12	Business and Management	Circular economy; industry/services strategies; manager/executive/technicians' perceptions	Survey + non-parametrical statistical tests	Manufacturing and service industry
13	Business and Management	Nurture; product-service system; rebound effect; sustainability; dematerialization; system dynamics	Feedback system thinking using system dynamics + case study	Manufacturing and service industry—Car sharing
14	Business and Management	Circular economy; readiness assessment; product lifecycle; manufacturing; KPI; developing country	Framework development and application case	Packaging

It is worth mentioning that contributions 9, 12, and 13 explored the relation between the CE and digital servitization of manufacturing [9] to advance the research on CE performance assessment through a consistent business model transition; in addition, relevance was given to the so-called rebound effect of the CE. Contribution 10 further explored the business model aspect, also evaluating the relationship of the level of business model innovation with the CE and the role of governments (through incentives). At a more micro-level, contribution 14 also raised the need for more support from the governments' side to improve CE performances and to provide a model for companies' CE readiness level assessment. On the other side, multiple researches (1, 4, 7, and 9) investigated the role of I4.0 technologies to support the gathering and evaluation of data and information with the aim of assessing CE performances. Contributions 4 and 8 focused on the adoption of practices (sustainable or lean/green) in manufacturing supporting CE performance improvement, and contribution 2 proposed a framework to ease decision-making processes from a CE perspective.

Finally, the main industry involved in these studies is manufacturing, with specific studies on the service industry (2), textile/tannery wastewater (2), automotive, and packaging.

Contribution 1 identified the pertinent data and information needed to assist the manufacturer's decision-making process in implementing and managing the various CM methods for pursuing the transition to CM using a comprehensive literature study. The research also suggests a theoretical framework based on the findings. It clarifies the four key areas that manufacturers must manage when adopting CM strategies and gives manufacturers an overview of what needs to be updated and enhanced inside the business.

Contribution 2 conducted a systematic literature analysis to better comprehend CE performance-measurement systems for manufacturing organizations from a general standpoint as well as to offer particular guidance for small and medium-sized enterprises and early adopters. The findings reveal a lack of an integrated, comprehensive, and scalable framework for monitoring the success of the circular economy, as well as a dearth of specialized guidance for small- to medium-sized businesses and early adopters.

Contribution 3 reviewed the most recent literature on the circular economy and the notion of Industry 4.0. This work's main goal was to outline the evolution of the CE and I4.0 as well as its multi-step approach of analysis. There have not been any studies up to this point that demonstrate how people are being prepared to deal with the transition from the linear economy, which is prevalent in most countries, towards a CE. It looked at the effects that technology advances have on the human person and on society.

Contribution 4 examined the role of knowledge management practices in sustainable entrepreneurship performance, also analyzing the connections between six concepts—knowledge sharing behavior, innovative capacity, absorptive capacity, dynamic capability, and opportunity recognition. The results demonstrate that knowledge management practices have a favorable and significant influence on the performance of sustainable entrepreneurship and the adaptability of SMEs. Additionally, the link between the dynamic skills of SMEs and sustained entrepreneurial success is strengthened through opportunity awareness. For scholars and practitioners interested in the topic of entrepreneurship, this study provides insightful information and useful recommendations.

Contribution 5 experimentally examined the link between corporate performance (CP) and the size of expenditure made by businesses in environmental protection (EI), starting with micro-enterprises, and looked into the moderating impact of industry rivalry on the relationship between CP and EI. The findings of the study indicate that performance has a significant impact on businesses' decisions about investments in environmental protection, and industry competitiveness can encourage businesses to make such expenditures.

Contribution 6 aimed to illustrate how high-performance work systems (HPWS) offer the foundation for strategic business performance (SBP) through the mediating function of organizational. This research, based on a quantitative approach, acquired information from top, middle, and operational management companies. The findings show that if organizational flexibility does not moderate the link between HPWS and SBP, HPWS will take a very long time to attain SBP. This research, which makes use of real data, shows useful methods for boosting manufacturing organizations' effectiveness in business growth.

Contribution 7 analyzed the literature about Digital Transformation in SMEs, focusing on performance measurement. The tools used by SMEs were analyzed under the triple bottom line perspective of sustainability (i.e., environmental, social, and economic aspects). A systematic literature review (SLR) was performed through the topic modeling method with a machine learning technique (Latent Dirichlet Allocation). The research shown that sustainability is treated as a separate topic in the literature, mostly neglecting the social and environmental aspects. This paper proposed a framework and research directions contributing to sustainable development goals (SDGs) 1, 5, 8, 9, 10, and 12 and able to guide policymakers and SMEs transitioning their production paradigm toward sustainability and digitalization.

Contribution 8 aimed to understand the relationships between Lean–Green practices from the point of view of the Operations Strategy. Synergies and potential trade-offs between competitive priorities and changes in decision areas were apparent when Lean–Green practices were investigated through a systematic literature review. The results found that Lean and Green are synergistic in most practices but must be managed according to the Operations Strategy.

Contribution 9 explored digital services in supply chains of the automotive industry. The research results indicated how suppliers affect car manufacturers to deliver digital services to their customers. Finally, this study shows that a closer interaction between manufacturers and suppliers in the manufacturing ecosystem is made possible by the integration of digital technology with product-related services. These connections let the production ecosystem withstand the impact of various conditions.

Contribution 10 investigated the impacts of the CE and business model innovation (BMI) on the economic, environmental, and social performance of Small and Medium Enterprises (SMEs) in Pakistan, Malaysia, and China, as well as the mediating function of governmental incentives. According to the findings, BMI and CE innovation have positive, noteworthy effects on the economic, environmental, and social performance of SMEs. The study also discovered that the link between CE innovation, BMI, and the economic, environmental, and social performance of SMEs can be mediated by government incentives.

Contribution 11 created a floating treatment wetland (FTW) to treat the effluent utilizing local plant species through phytoremediation in order to provide a cost-effective method for the treatment of tannery wastewater. Three distinct plant species were used to assess the FTW's effectiveness. The pilot model shows that FTWs are a cost-effective option in the installation of a costly treatment plant with high related running costs for treating effluent from tanneries. FTWs can assist in moving traditional wastewater treatment plans towards more sustainable ones in order to achieve the CE paradigm. Moreover, it is essential that the materials used for a wetland foundation have the ability to be recycled, are affordable, inexpensive, and available locally in order to adhere to the principles of the CE and ecologically friendly development.

Contribution 12 evaluated the integration of CE practices in both public and private organizations in the Iberian Peninsula's northwest. The perception of CE firms was evaluated through an online survey, containing information about the area(s) it was integrated in, why, the challenges it faced, or what was required to complete it, and how the effect of the adopted CE practices was quantified. According to the findings, businesses usually relate the CE to "resource optimisation". The primary strategic area where the CE was applied was the "Entity's vision and mission". "Environmental reasons" were the primary driving force behind entities' and organizations' adoption of the CE, while "lack of information and guidance" and "lack of financial resources" served as the primary hurdles.

Contribution 13 looked at whether nurturing should be a major concern in the product-service system, given that some features might have a rebound effect that has a big impact on meeting goals. This study showed that the business model system is intricate, with related problems and solutions. The results of this study show that the factor of nurture is a strong predictor of profit growth, but it also causes a decline in the environmental and social performance of the implementation of the product-service system, which has the impact of causing the system to rebound.

Contribution 14 developed a framework split on two levels (product and business model) for evaluating a company's CE readiness operating in underdeveloped nations. The framework helps businesses monitor a path for progress by defining subsequent activities and KPIs. Application of the methodology revealed areas for improvement, particularly in the policy environment, to encourage CE adoption in underdeveloped countries. In fact, the circular transformation process in businesses would be greatly aided by legislative incentives and tools of public authorities.

Several research gaps were detected by the set of contributions gathered in this Special Issue.

It is significant to note that, in relation to the usage of digital technologies, relatively few researchers have examined how moving to a CE backed by I4.0 might affect both people and society. The potential costs to society of the CE transition and the tools these players will have to prevent societal failure are also unknown. Adopting the many I4.0 technologies in developing economies may provide significant difficulties in addition to those relating to the system dynamics. In I4.0, the CE model enables the assessment of the revenue from chain production waste in a way that can boost ROI while lowering the environmental effects.

In addition, studies demonstrating the positive benefits of eco-conceptions, industrial and territorial ecology, the functional economy, second use, reuse, repair, recycling, and valuation from a social and political standpoint are still lacking in the field of CE performance assessment research.

Concerning data-driven circular manufacturing, to evaluate the potential effects that each piece of data and information could have on the pursuit of not only the specific circular manufacturing strategy to which it is connected but also the other strategies not theoretically intended to be bonded, a quantitative model might be created. Tracking and managing data and information might serve as the foundation for calculating the advantages of using circular manufacturing and gauging how well manufacturers use it. Long-term, this would lay the groundwork for the creation of a model that evaluates the amount of circular maturity in manufacturing firms through the formulation, computation, and monitoring of particular key performance metrics.

Additionally, a more thorough analysis of the discovered data and information should be carried out to better define their own qualities (such as accessibility and timeliness). The degree of granularity of the data might be one of the matters that receives special attention.

Future research should also focus on determining who is in charge of the collection and administration of the various types of data and information since the actors responsible for collecting them are connected to how those data and information are used. The manufacturing firm should be broken down into its individual functions as the unit of analysis, with relationships between internal managers and staff and external stakeholders from other organizations also being taken into account.

From an empirical standpoint, it could be possible to further explore the managerial and technological challenges that firms encounter when attempting to use data in circular manufacturing. In-depth research should be carried out to specifically identify and suggest to manufacturers the new processes required to capture the majority of the data and information that have emerged as being pertinent in circular manufacturing.

The integration of CE levels, theoretical development and empirical application, characteristics of the proposed indicators, considerations of sustainability, comprehensive perspectives on industrial systems, and scalability to adapt to firms' various characteristics are all areas where the current literature falls short.

An integrated, comprehensive, and scalable performance-measurement system for manufacturing enterprises is still lacking, according to the studied literature [10]. All of these qualities should be included in a successful performance-measuring system in order to decrease the measurement process' complexity.

Regarding integration, a successful performance-measurement system for the CE should give unmistakable instructions on how other paradigms inside manufacturing organizations, such as sustainability, would be covered concurrently. As a result, the CE should cover all CE levels while also comprehending how they relate to one another. Again, it is preferable to have a single, distinct method rather than many ones for gauging success at various levels and it is advised to take into account the viewpoints of various industrial decision-makers.

Concerning scalability, an efficient performance-measurement system for the CE should be adapted to various businesses, particularly SMEs and new adopters, in accordance with their unique characteristics and changing needs, in terms of the scope and depth of analysis, while also enabling internal performance measurement and benchmarking activities.

In particular, a scalable framework would permit the availability of many levels of analysis and, consequently, sets of indicators.

Grounded on the previous gaps reported above, there are several potential directions of study that could be implemented to establish a proficient performance assessment of the CE. This Special Issue, "*Circular Economy and Sustainable Business Performance Management*", identifies the following directions:

- The exploration of how new digital technologies, gathered under the umbrella of Industry 4.0, can support the measurement and analysis of lifecycle data according to the industrial symbiosis level of the system. Since not only single companies but also industrial parks, global supply chains, urban territories, and municipal solid wastes can be taken into account as referring systems of a circular economy performance assessment, the analysis of data coming from an extended and circular supply chain gives the chance to approach very different scenarios in which circular business models have been adopted. This opens the way to also consider, in the measurement of the performance, specific building blocks such as reverse logistics and particular systems' conditions;
- The use of design practices to specifically empower product design and development according to specific measurement performances, such as DfX guidelines and checklists, and to give strategic directions to shift the linear lifecycle into a circular one;
- The development of methods and practices able to systematically and practically measure and assess the circularity degree of a given system and to take into account all the heterogeneous resources involved in its lifecycle;
- The development and adoption of methods and approaches, and of a set of related KPIs, suitable for the assessment of the circularity performance in different fields of application. These KPIs can deal with the circularity degree of the resources occurring

within the product life cycle and can also support the quantification of those that are the economic, environmental, and, most of all, social benefits of the CE. These KPIs, from a regulations and reporting perspective, can support the creation of a product certification system related to the circularity of resource flows, internal reporting and benchmarking in companies or support in the creation/enrichment of databases useful for LCA, etc. From a companies' portfolio circular innovation perspective, they can support not only the decision-making process along the design of new products but also the comparison of different versions of the same product based on their degree of circularity;

- The development of a CE maturity model, based on the definition of a set of KPIs for CE performance assessment, aimed at both defining companies' level of readiness in terms of circularity and proposing a roadmap to better address the CE.

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