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Formation the links between circularity and sustainability in the circular economy

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***Abstract*— Nowadays, many new questions arise regarding the creation and setting of goals for a sustainable circular economy. The study focused on exploring the connections between the concepts of circularity and sustainability in the circular economy. Sustainability aspects integrated into long-term circular economy processes have a clear impact on the environment, the economy and political decisions. The study examines the factors that contribute to and influence the formation of the circular economy and reveals the connection between circularity and sustainability. After reviewing the literature on the links between circularity and sustainability, the theoretical methods that are most often applied to examine aspects of circularity and sustainability have been identified and reviewed. It was also conducted by bibliometric analysis for 2021-2023 which helps to identify current trends and found that the number of studies analysed included five groups which show that the studies are focused on impact, production, end, review and value. The results of the bibliometric analysis show that circularity has links with supply chain, sustainability, material circularity, efficiency and value. The authors have presented research by topic because knowledge is needed to fill existing gaps.**

***Index Terms*—circularity, sustainability, theories, factors, links**

I. INTRODUCTION

Increasing globalization and the growth of the global economy have led to climate change, which is having an increasing impact on our planet. Climate change affects not only nature, but also businesses, corporate activities and global supply chains around the world, and changes all their processes. In order to manage and understand the changes, it is necessary to adapt the new trends towards circularity and sustainability into existing business and supply chain processes.

Increasingly, circularity is being mentioned and associated with politics, economics and science. However, the increasingly common and widely used concept of circularity has some definitional and conceptual uncertainties. There is currently a lot of research and debate on the relationship and contribution of circularity to sustainability and sustainable development (SD), and consequently to a more sustainable and cohesive society.

A review of the circular economy and sustainability literature shows that organizations can work with service providers to improve the efficiency of the circular economy (recycling, reuse, etc.). There is an emerging scientific debate on the relationship and contribution of CE to sustainable development (SD) and more sustainable societies (Schöggl et al., 2020; Schroeder et al., 2019; Ogunmakinde et al. 2022). The circular economy enables companies to develop new business models and thus potential revenues (de Sousa Jabbour et al., 2019). The problem with creating sustainability is that organizations are interconnected. An organization's circular economy goals and strategies depend on other organizations, to provide high-quality materials for recycling and replication as secondary materials. Strategies used to research circular economy focus on an organizational perspective. The organization’s selection and implementation of circular economy objectives lacks the full long-term view. Without the involvement of other organizations, progress on the circular economy will be limited. Therefore, harnessing the efforts of all organizations in the supply chain to address the circular economy offers the second largest opportunity to deploy the circular economy in organizations (De Angelis et al., 2018). We study theories and concepts to identify theoretical solutions helping to implement sustainability. The importance of clear and understandable knowledge plays an important role in improving the sustainability capacity of an organization’s resources in the context of a circular economy (Amui et al., 2017). Using all the clear and understandable knowledge of sustainability, cooperation can be established to overcome the obstacles that

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limit organizations' access to the circular economy. Cooperation can remove obstacles that are often insurmountable, such as rules limiting the potential of the circularity. Encouraging your organization to participate in sustainability coordination means gaining a competitive advantage. The competitive advantage of increasing the efficiency of the circular economy is a unique opportunity for sustainable development (Sánchez-Ortiz et al., 2020; Corona et al., 2019). This is necessary to measure the value that an organization can derive from sustainability metrics. It proposes key indicators for assessing the circular economy. The category "sustainability" includes the challenge and approach needed to overcome the obstacles to the success of the circular economy in the organization. The willingness to cooperate and invest in the circular economy can show which obstacle is most important. By committing to overcoming obstacles through collaboration, you unlock the power of the circular economy in sustainable organizations (Klein et al., 2020).

Sustainability plays an important role in modern organizational strategy, it is a management trend that reflects innovative practices, the application of which in the strategies of real companies in practice does not yet correspond to the theoretical application knowledge (Brusseau, 2019). After analyzing the literature, there is a lack of a systematic overview of dynamic sustainability opportunities integrated with corporate strategies and factors influencing the integration, so this gap must be filled and studied (Schroeder et al., 2019).

There is an overview of the circular economy from articles by different authors. Burinskienė et al. (2022) studied the circularity of materials according to linear and circular models, influencing circular processes by using modern technologies that will ensure sustainable use of natural resources, and according to the concept of closed and open-loop production. Lingaitienė et al. (2021) in their paper identified key elements relevant to circularity, which they grouped into four circularity-relevant categories, and described the work of other researchers in each of these categories in relation to the circularity's overarching goal of waste elimination and sustainable resource use. Vanhamäki et al. (2021) in their research work examined the spatial application of CE through conceptual research and innovation strategies for Smart Specialisation (S3) in Europe, and provided a comparison of how S3 is being implemented in a number of European countries, where CE has been defined as a priority area. Fitch-Roy et al. (2021) analysed the current waste management policies in 60 countries, through the global translation of circular economy principles into public policy and the prevalence of CE policy packages. Velasco-Muñoz et al. (2021) described SE as a strategy for sustainable, regenerative and regenerative agriculture, which is particularly relevant in the current global context of resource scarcity, global climate change, environmental degradation and increasing food demand. The authors have adapted the general CE framework to the specificities of the agricultural sector and have analysed the range of indicators available to assess the circularity performance of agricultural production systems through a decision-making process. Barreiro-Gen & Lozano (2020) argue that an SE that focuses on one of the macro, meso- and micro-levels is one of the solutions to environmental sustainability problems. The authors focus on the micro-level, as at the other levels, enough studies analysing how organisations implement the 4Rs: reduce, repair, reuse and recycle, have found that in order to contribute to CE, not all companies that use the 4Rs are aware of the application of CE principles. Jusel & Burinskiene (2019) also describe the transition to the CE model at three different levels: macrolevel, mezolevel and microlevel. The authors also note that at the microlevel the principle of CE are applied the least. The authors reviewing the factors promoting CE, identified 28 CE obstacles and 22 CE threats and proposed a system of CE promoting and inhibiting factors that replaces the macrolevel environment and promotes the transition to CE at the mezo- and microlevels. Okorie et al. (2018) observed that a recent development in the field of CE included the study of the CE model and its relationship to sustainability. Research has identified the possibility of applying CE methods in a rapidly changing industrial system, including manufacturing processes and Industry 4.0, which allows for the latest advanced in digital technologies. In their paper, the authors explored the integration between CE and digital technologies and proposed a synergetic and integrated framework for CE and digital technologies. Ruiz-Real et al. (2018) examined the role and relationship of CE status and environment.

The authors also analyzeed the stydies of ther scientists in the field of sustainable materials management. Raudeliūnienė & Žukauskas (2022) analyzing the interrelated features of business logistics and sustainable

trasfer processes, idnetified a set of factors influencing the sustainable management of business logistics projects, both externally and internally. It was noted that the external factors affecting sustainability were related to the environment costs, strategy, prject life cycle in order to create effective. Montisci et al. (2022) examined the use of cenventional pesticides in the agricultural industry, highlighted several environmental and sustainability issues related to toxic residues in the soil that pose a risk to the environment and human health, and examined their structure through sustainable solutions and environmental impact reduction. Ulloa-Murillo et al. (2022) analyzed the most important aspects of the management of the organic fraction of municipal solid waste and sustainable and circular production models in Latin America and the Caribbean, found that sustainable and circular production policy strategies prioritize bioenergy and biofuels as the main valorization alternatives of municipal solid waste and reflect the CE and bioeconomy importance as selected regions in essential areas. Stankevičienė & Nikanorova (2020) developed the concept of measuring the developent of eco-innovations in the context of CE, which is based on environmental, economic and social aspects and aims to ensure sustainable development at each stage of product creation, transformation and conversion by creating a closed-loop economy. The study describes models for the concept analysis of CE, the importance of eco-innovation in the context of CE, includin recycling, circular use of material, material efficiency and waste management. Rezk et al. (2019) used the Delphi method to study opportunities, potential areas and challenges in the energy sector. In assessing the expectations of different stakeholders, special attention was paid to the perspectives of reneweble energy and energy efficiency. The authors found that about 50 procent of Egypt‘s energy needs in 2030 will be met from renewble energy source and that all forms of energy not only bring economic and environmental benefits, but also improve living standards.

In this study, we wanted to find out how circularity and sustainability shape the circular economy concept. Previous paper of Schöggl et al. (2020) analysed the evolution of circular economy during two decades of research and identified that usually win-win situation is identified talking about reaching sustainability objectives.

The focus of this paper was on analysing the different theories that explore more precise links between circularity and sustainability. In addition, we wanted to find out how much research identifying current trends and defining priority topics in circularity has been carried out between 2021 and 2023.

The paper consists of several sections. In the next section the review of theories on the sustainability and circularity concept is provided. In the third section the paper analyses the links between sustainability and circularity and names the possibilities to strengthen these links. In the fourth section the methodology is presented. According the provided methodology, the authors formed bibliometric literature sources maps. And finally conclusions and discussions are provided to summarise research delivered in the paper.

II. SUSTAINABILITY AND CIRCULARITY CONCEPT

A. Theories of circularity and sustainability links

There are many concepts, which focused on circularity and sustainability aspects. Some of these concepts directly integrate these two approaches. The authors of this paper highlighted main theories which are important for further analysis.

Theories that need to be analyzed talking about circularity and sustainability links:

- Systems theory: It is very important to understand the process in industry as a complex system with interconnected components and feedback loops. Systems theory helps to understand how the different components of a manufacturing company interact and interact with each other (Tsoukas et al., 2017).
- Circular economy theory: This theory focuses on the sustainable management of resources and the reduction of waste through the principles of reduce, reuse and recycle. How to use it The manufacturing industry can optimize resource consumption and reduce environmental impact (Vidal-Ayuso et al., 2023).

- Operations management theory: It deals with efficient processes and resource allocation within a company. By analyzing the production, distribution and consumption of this system, it is possible to optimize performance and improve overall resource efficiency (Suárez-Eiroa et al., 2021).
- Sustainability theory: By integrating economic, social and environmental goals, this theory helps assess the sustainability of circular processes Ensure long-term profitability (Corona et al., 2019).
- Resource-based Management Theory (RBV): RBV evaluates a company's internal resources and capabilities. When it comes to manufacturing companies, it helps to identify and achieve unique advantages to increase circulation and competitive advantages (Ddiba et al., 2020).
- Institutional theory: It is very important to study how the legal framework, policy and institutional context influence circular processes Industry. Understanding institutional coherence, incentives and dynamics is crucial for effective governance of the circular economy (Agrawal et al., 2023).
- Environmental economic theory: The analysis of external factors such as pollution and resource depletion through the lens of environmental economics provides a basis for understanding the economic impact of the circular economy Industry (Kayal et al., 2019).
- Life cycle assessment: LCA assessment assesses the environmental impacts of products and processes throughout their life cycle and measures the environmental benefits of circular economy methods in the manufacturing sector (Rigamonti et al., 2021).
- In general, the integration of these management theories can provide a holistic view of circular processes in production, allowing informed decisions to be made about sustainable and effective measures.

Systems theory aspects

Systems theory describes a manufacturing company as a complex, interconnected system in which different components, including production, distribution, consumption, and waste management, interact and interact with each other. The theory emphasizes that changes in one part of the system can affect the corresponding parts of the system (Tsoukas et al., 2017). For example, optimizing production from renewable resources can influence distribution strategies and consumer behavior, and thus the entire production system (Hooang & Nguyen, 2021).

By analyzing these relationships and feedback mechanisms, manufacturing companies can develop strategies that increase the circular economy and sustainability (Mies & Gold, 2021). This includes optimizing resource use, reducing waste, and finding synergies between different parts of the production system. In addition, systems theory helps to identify opportunities for improvement and innovation by considering the system as a whole and promoting an integrated and integrated approach to circular processes in the manufacturing sector. Understanding the interdependence and dynamics of a production system enables operators to make informed decisions that are in line with the principles of the circular economy, resulting in greater efficiency, less waste and greater sustainability of production facilities.

Circular economy theory

The theory of the circular economy is an important basis for the management of circular processes in a production company calls for a use-based approach to reduce waste and promote the sustainable use of resources through the development of products and systems that can be reused, repaired and recycledSuárez-Eiroa et al. (2019). This theory emphasizes the transition from the traditional linear model to a circular model, in which resources are extracted, used efficiently and integrated into a closed system (Dominko et al., 2023).

Manufacturing companies can reap the benefits of the circular economy by prioritizing the use of renewable resources, increasing resource efficiency and extending the life of resource-related products and infrastructure. It is the design of production systems. In addition, this theory promotes the involvement of

manufacturing companies in creating a circular economy ecosystem, ensuring the efficient distribution of products and materials, and promoting the sustainable transformation of production (Suárez-Eiroa et al., 2021). It highlights the importance of product life cycle management, eco-design and waste management strategies in promoting the circular economy of manufacturing technologies (Razmjooei et al., 2023).

The circular economy theory enables large manufacturing companies to innovate, develop new business models and drive economic growth while reducing environmental impact (Barreiro-Gen & Lozano, 2020).

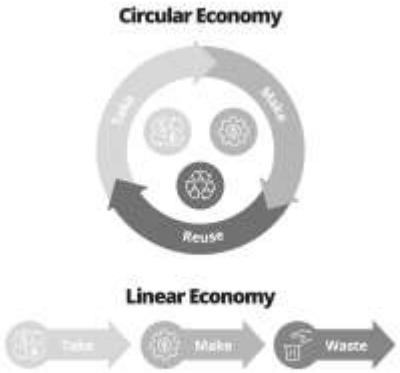

Figure 1. Circular economy versus linear economy

It is in line with the broader Sustainable Development Goals, promotes responsible resource management, a low carbon footprint and contributes to the transition to a circular and more sustainable production environment (Corona et al., 2019).

Operational management theory

Operations management theory plays a key role in controlling circular processes in a production company. This includes the systematic development, implementation and improvement of resource-related processes to ensure efficiency, effectiveness and sustainability. In the context of the circular economy, operations management theory focuses on optimizing resource use, reducing waste, and promoting reuse and recycling of materials in production and distribution processes (Suárez-Eiroa et al., 2021).

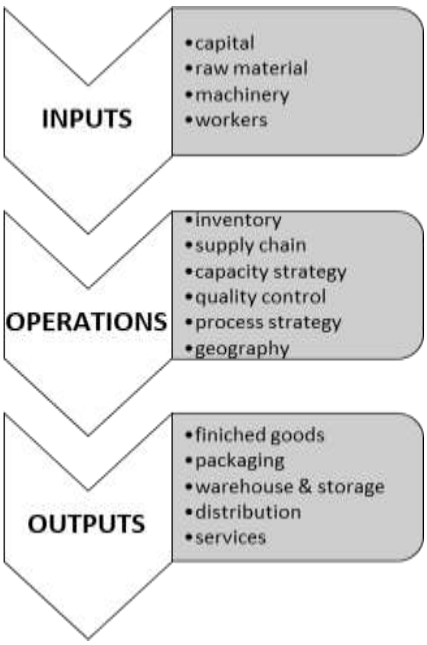

Figure 2. Operational management

In manufacturing, operations management can include streamlining the production of renewable technologies such as solar panels and wind turbines, optimizing production processes, and reducing waste. This includes the efficient management of distribution networks to reduce resource losses during production and transportation. In addition, operations management theory includes strategic planning that ensures that products and materials reach the end of their life in a way that aligns with lifecycle principles, such as product disassembly and recycling planning.

In addition, operations management theory provides tools such as lean and six sigma methods that can be used to identify inefficiencies in processes and simplify operations. Lean principles help eliminate waste, while Six Sigma focuses on reducing the variability and process errors needed to achieve circular economy goals.

By integrating operations management theory, manufacturing leaders can develop strategies to improve processes in the circular economy, reduce resource wastage, and improve overall operational efficiency by promoting a more sustainable and environmentally friendly manufacturing business. This includes implementing sustainable manufacturing practices, optimizing supply chain operations, implementing efficient materials and products storage solutions, and ensuring resource-related products are properly disposed of and recycled (Suárez-Eiroa et al., 2021). Operations management is also becoming an important tool for achieving a circular economy and sustainable practices in the manufacturing sector.

Sustainability theory also stresses the importance of cooperation and partnerships between manufacturing industry actors that promote the integration of the circular economy through collaboration and joint action. We encourage companies to reflect on the long-term consequences of their decisions to achieve a balanced and harmonious relationship between economic prosperity, social well-being and environmental stewardship. Based on this theory, leaders in the manufacturing industry can develop strategies to ensure circular processes, such as recycling and reusing materials, optimizing raw materials consumption and applying sustainable technologies. Integrating sustainability theory into management practices can help create a more sustainable and resilient manufacturing sector, in line with the global goals of a circular and green industry.

Sustainability theory

The theory of sustainability or sustainable development, the management of circularity processes in society in the manufacturing sector, emphasizes an integrated and sustainable approach to the management, social and environmental objectives (Sarkis & Zhu, 2018; Cai et al., 2019). The aim is to ensure that the circular economy not only meets current needs, but also preserves resources and opportunities for future generations (Corona et al., 2019). The manufacturing industry must evaluate and optimize its activities, policies and strategies to promote environmental sustainability. The theory encourages manufacturing companies to adopt circular economy practices that reduce environmental impact, increase resource efficiency, and prioritize renewables.

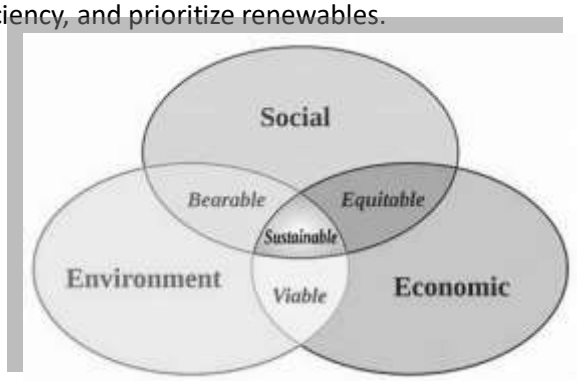

Figure 3. Sustainability theory

Shi et al. (2019) argue that while sustainable development is a key strategy to guide the world's socio-economic transformation, in practice there are still misinterpretations of this theory. The authors sought to elucidate the sequential evolution of the concept and goal of sustainable development and the process of its refinement. Ruggerio (2021) concepts of sustainability and sustainable development were mainly linked to environmental issues, policies related to environmental management, industrial and agricultural production. Schaltegger et al. (2017) argued that business is built by managing ecological, social and economic aspects and analyzed sustainability and the understanding of sustainable business cases that are created in collaboration with stakeholders.

The Resource-Based Approach (RBV) theory

The Resource-Based Approach (RBV) theory, which is used to manage circular processes in a manufacturing company, focuses on leveraging internal resources and skills to gain a competitive advantage in sustainability and movement. In this theoretical context, a company's unique assets, including tangible assets (e.g. technology and infrastructure) and intangible assets (e.g. know-how and patents), are considered essential for achieving circular economy objectives in production (Ddiba et al., 2020).

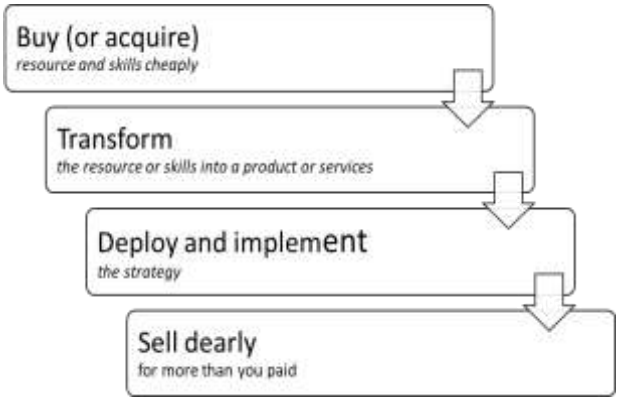

Figure 4. Resource-based approach (RBA)

For power plants, the RBV theory shows that the availability and strategic use of renewable technologies, efficient waste management systems and knowledge of the design and production of the circular economy can provide a clear competitive advantage. Manufacturing companies should focus on developing and using resources that support the circular economy, such as investing in research and development to ensure resource efficiency, integrating renewable solutions and fostering a culture of sustainability and innovation.

RBV theory also emphasizes continuous improvement and adaptation. Manufacturing companies must continuously analyze and update their asset portfolios to remain competitive in dynamic markets while supporting circular economy practices. RBV theory enables market leaders to identify their organization's key competencies and strategically allocate resources to effectively improve circular processes (Ddiba et al. 2020). This includes creating sustainable supply chains, deploying advanced renewable technologies and fostering a culture of the circular economy within the company. Finally, RBV theory provides a strategic basis for manufacturing companies to leverage their resources and capabilities to achieve sustainability and circular economy goals in the manufacturing sector.

Institutional theory

Institutional theory, the management of circular processes in a manufacturing company, focuses on understanding and responding to an organization's work environment. It recognizes that the external

environment, including regulations, norms, and standards, has a significant impact on the organization's conduct and procedures (de Abreu & Ceglia, 2018).

Manufacturing companies should align their policies and actions with existing policies and guidelines to promote the circular economy and sustainable resource management. Compliance with these rules not only ensures compliance with the law, but also contributes to the image of the company. In addition, voluntary compliance with new sustainability and industry standards strengthens the company's commitment to the circular economy and attracts environmentally friendly stakeholders (Agrawal et al., 2023).

Manufacturing companies can participate in sustainable initiatives to influence and shape institutional norms to achieve a circular economy.

It is very important to understand stakeholders and their interests in an institutional context. Working with stakeholders and collaborating with government agencies, environmental organizations and community groups can contribute to circular economy practices (Barreiro-Gen & Lozano, 2020). This collaboration can help develop strategies and systems that promote the circular economy and sustainable production practices.

By integrating institutional theory, production managers can effectively navigate and take advantage of the institutional environment. This includes active participation in decision-making discussions, contributing to the development of legislation to support production processes in the circular economy and working with stakeholders to promote a shared commitment to sustainable practices. Finally, in order to successfully implement circular processes in a manufacturing company, it is necessary to understand and respond to institutional pressures and expectations (Agrawal et al., 2023).

The theory of environmental economics

The theory of environmental economics, which is used to control the circular processes of a manufacturing company, focuses on assessing the economic consequences of environmental measures and policies. This theory emphasizes the efficient allocation of resources and the achievement of the Sustainable Development Goals, taking into account environmental and economic objectives (Murphy & Gouldson, 2020). In the manufacturing sector, environmental performance helps decision-makers assess the costs and benefits of circular economy practices, such as resource recycling, waste reduction and the transition to renewable products (Kayal et al., 2019).

Manufacturing companies that apply this theory take into account external factors such as pollution, carbon dioxide emissions, and resource scarcity in their decision-making processes. For example, they may carry out a cost-benefit analysis to assess the profitability of infrastructure investments in renewable resources compared to traditional fossil fuel-based technologies, taking into account long-term environmental benefits (Ojha et al., 2023).

The theory also examines the development and implementation of market mechanisms, such as carbon pricing or trade restriction schemes, that reflect environmental costs and support circular economy practices in manufacturing. These mechanisms encourage companies to implement greener technologies and processes that determine the cost of external environmental impacts.

In addition, environmental performance promotes the integration of sustainability aspects into investments and financing solutions. Manufacturing companies can assess the financial risks and benefits of circular economy initiatives and make informed decisions that are in line with their environmental objectives.

The theory of environmental economics allows production managers to achieve a balance between business development and environmental protection. This includes exploring green technologies, assessing the feasibility of processes in the circular economy and promoting sustainability policies, while ensuring the long-term profitability and competitiveness of the production unit. Finally, this theory encourages production to adopt environmentally friendly practices that contribute to a more sustainable future.

Life cycle assessment (LCA)

Life cycle assessment (LCA) is a valuable asset lifecycle management tool because it provides a holistic approach to assessing the environmental impact of products and processes throughout their life cycle. For manufacturing, LCA includes an end-of-life environmental footprint assessment for production, distribution, consumption and processing (Rigamonti et al., 2021). Sala et .al (2021) consider LCA and life cycle thinking as the most important concepts an methods for the transition to sustainability, the development and implementation of which have been studied over three decades. Nwodo & Anumba, (2019) conducted a building LCA study that examined the potential environmental impact of buildings and assessed resource use, identified key challenges in developing LCA, such as data intensity and quality, subjective characterization and assessment of environmental impact, lack of system boundary setting procedures, and lack of uncertainty analysis. Corona et al. (2019) says that LCA is a tool to assess the environmental impact of a product or service throughout its life cycle. LCA can analyze different categories of environmental impacts, such as resources, ecosystem services, human health, etc.

Figure 5. Sustainable life cycle

Life cycle assessment helps companies in the manufacturing industry to identify key points of environmental impact and areas where the circular economy can be improved (Rigamonti et al., 2021). For example, the environmental benefits of switching from non-renewable sources to renewable sources can be discovered by comparing the impact of coal-fired electricity on the life cycle of solar or wind energy.

In addition, LCA enables scenario analysis, allowing manufacturing companies to simulate the impact of different life cycle strategies on environmental performance (Hou et al., 2018). To this end, the environmental impact of the linear model of production can be compared with the circular economy model, which includes efficient waste management, recycling of materials and end-of-life products (Rigamonti et al., 2021).

By integrating LCAs into decision-making processes, manufacturing leaders can make informed decisions that minimize the environmental impact of their operations. These include, for example, the development of sustainable and recyclable products, the optimization of production methods and the use of efficient waste management practices. Life cycle assessment offers a holistic approach to the circular economy and guides the manufacturing industry towards greener practices (Rigamonti et al., 2021).

B. *Factors that demonstrate links between circularity and sustainability*

In empirical research, authors may consider factors that demonstrate links between circularity and sustainability shows the Figure 6.

Resource efficiency: a proposal to assess the efficient use of raw materials, and other resources in the production and distribution. Below nine the most important factors are proposed such as:

Waste prevention and recycling: It is proposed to evaluate strategies to reduce waste and increase the recycling of materials used in production.

Integration of renewable resources: It is proposed to examine the use and integration of renewable resources such as solar, wind and hydropower into the power generation portfolio.

Optimized storage and optimization: It is proposed to explore methods for optimizing resource storage systems to increase the efficiency and reliability of distribution.

Circular business models: Explore circular business models such as leasing and product-as-a-service to promote longer life cycles and responsible product consumption.

Quality of regulation and policy coordination: It is proposed to publish compliance with environmental regulations and assess the extent to which a company complies with national and international guidelines to promote mobility in the manufacturing sector.

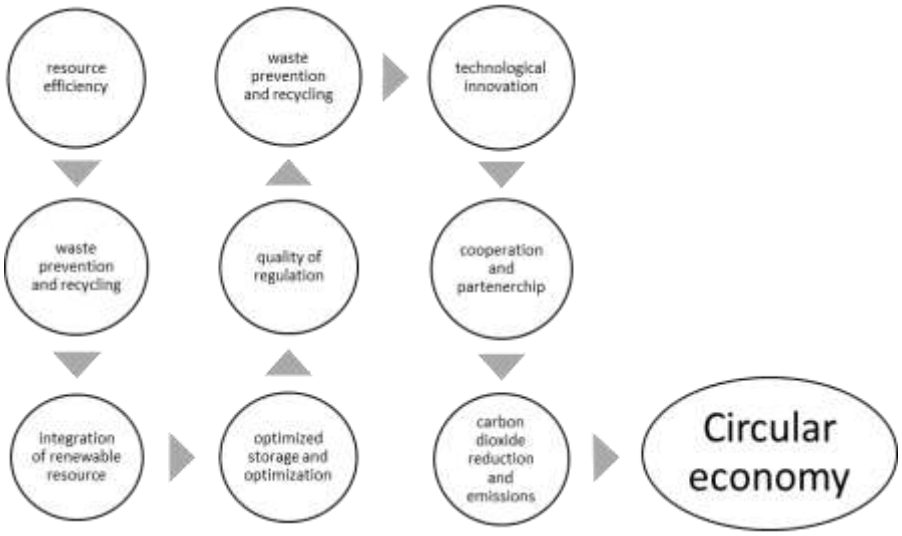

Figure 6. Factors of circular economy

Technological innovation: It is proposed to evaluate the integration of innovative technologies that contribute to the circular economy, such as improved recycling processes and efficient technologies.

Cooperation and partnership: It is proposed to evaluate cooperation with other organizations in order to improve knowledge sharing and understanding of the circular economy in the manufacturing sector.

Carbon dioxide reduction and emissions: It is proposed to evaluate strategies to reduce carbon dioxide and other related pollutants to reduce the carbon footprint.

By analyzing these factors, production management would focus on holistic strategies and action plans to support the adoption of circular economy practices that promote sustainable, efficient and environmentally sound management.

In the transition to CE or in the prioritization of sustainable solutions, business strategies and policy decisions are supported by the quantification of the circularity of products and services (or their contribution to CE) (Peña et al., 2021). Circularity is an economic concept that can be applied to achieve sustainability objectives (Stumpf at al., 2021). It encourages the development of economic models and business strategies that align production and consumption chains so that resources, materials and products are continuously reused and recycled rather than simply consumed and discarded after use (Zolotareva et al., 2023). The Table 1 below shows the four main principles underpinning the circularity.

Table 1. Main principles on circularity

Principles	Description	References
Recycling	Recycling of materials and products is encouraged to maintain the value of materials and products and to reduce waste.	Schöggl et al. (2020); D'Amato et al. (2017); Barros et al. (2021); Antonini et al. (2020); de Pádua Pieroni et al.

		(2018); Stumpf at al. (2021)
Durability of products	Producing quality and durable products that will last longer, reducing the need to keep buying new items.	Barros et al. (2021); Antonini et al. (2020); Koide et al. (2022)
Product rental and sharing	Reducing individual consumption by providing services that allow people to use products without having to buy them outright.	Koide et al. (2022); de Pádua Pieroni et al. (2018)
Product refurbishment	The need to restore old products and components so that they can be used again.	Antonini et al (2020); Koide et al. (2022); de Pádua Pieroni et al. (2018)

Circularity aims to reduce waste, resource consumption and ecological impact, contributing to the sustainability goals (Barros et al. 2021). Circularity can be said to be a means to achieve the sustainability objectives. It is an economic strategy based on a long-term approach to resource use, whereas sustainability is a broader approach that includes a balance between society, the environment and the economy in order to maintain a harmonious and sustainable development of society (Stumpf at al. 2021).

III. LINKS BETWEEN SUSTAINABILITY AND CIRULARITY IN CIRCULAR ECONOMY

The circular economy is one way to achieve sustainability. It seeks to replace the traditional linear economy, where resources are used to produce disposable products and then turned into waste, which often becomes a source of pollution (Ahmad et al., 2019). The circular economy promotes ways to use resources as efficiently as possible, reducing waste and preserving value through recycling, remanufacturing and reuse (Domenech & Bahn-Walkowiak, 2019; Bundgaard et al., 2017).

The circular economy and sustainability are closely linked (Nikolaou et. al., 2021; Schöggl et. al., 2020), as the circular economy is one way to achieve sustainability. This economic model promotes the responsible use of resources by reducing emissions and waste, thereby contributing to environmental protection and resource saving (dos Santos et al., 2022). The circular economy also seeks to create long-term and sustainable economic models that respond to social needs and promote innovation and growth (Geissdoerfer et al., 2018).

The table 2 below shows the ways in which sustainability in the circular economy is achieved.

Table 2. The sustainability ways in the circular economy

Ways	Description	References
Improving resource efficiency	the circular economy aims to use resources as efficiently as possible, while minimizing waste and loss. This is achieved through recycling, remanufacturing, repair and the development of reusable products.	Bennett et al. (2019); Velenturf & Purnell (2021); Daly (2017); Geissdoerfer et at. (2018); Domenech & Bahn-Walkowiak (2019); Bundgaard et al. (2017)
Reducing environmental pollution	The circular economy aims to reduce emissions and the harmful effects on ecosystems through more efficient use of resources, pollution prevention and waste management.	Hoosain et al. (2023); Ahmad et al. (2019); Bundgaard et al. (2017)
Ensuring social responsibility	The principles of sustainability also include ensuring social responsibility, including respect for workers' rights, social inclusion and assessing the social impact of a company's activities.	Geissdoerfer et at. (2018); Upadhyay et al. (2018); Mies & Gold (2021); Fortunati et al. (2020); Ferronato et al. (2022)
Sustainable/circular business model	The circular economy promotes business models that are sustainable and long term, focusing on long-term economic efficiency, customer satisfaction and societal well-being.	Ramirez-Corredores et al. (2023); Jaeger-Erben et al. (2021); Velenturf & Purnell (2021); Geissdoerfer et at. (2018); Fortunati et al. (2020)

The circular economy is a way to achieve sustainability through a systemic and holistic approach to resource use and economic activity. It seeks to create an economic system that contributes to the long-term well-being of humanity and the conservation of the planet’s resources (Mies & Gold, 2021).

The link between circularity and sustainability is that for long-term sustainability, we need to implement circularity principles (Zeng & Li, 2021). Moving towards circularity allows for a more efficient and responsible use of resources, as well as reducing waste and ecological impact (Fortunati et al., 2020). This helps to achieve sustainability objectives by ensuring that natural resources are conserved and can be used in the future without damaging the planet's ecosystems and social well-being.

Creating a sustainable circular economy requires integrated action from the business sector, governments, society and consumers themselves (Velenturf & Purnell, 2021). The circular economy implies the creation of more sustainable processes and is therefore gaining popularity at various levels. Circular economy strategies are being actively pursued in many policy areas around the world, with a clear positive impact on the environment, and with an emphasis on sustainable development, which influences the social aspects of consumption that correlate with economic growth, decoupled from negative environmental impacts. When developing strategies, it is important to include end-of-life actions at the beginning of product design so that the product can be reused, recycled and/or re-manufactured by reducing life-cycle costs, by discounting materials already used in previous cycles and by capturing the energy from previous cycles. This contributes to sustainable economic growth, the development of sustainable supply chains based on international cooperation, the promotion of social responsibility through the provision of relevant consumer information and knowledge on responsible consumption, and opportunities to contribute to a sustainable circularity (Badurdeen et al., 2018).

Here are some of the ways in which we can contribute to a sustainable circular economy.

Table 3. Ways of creating a sustainable circular economy

Ways	Description	References
Design solutions for sustainable products	Businesses should design products to be durable and easy to recycle or repair. Design should focus on saving raw materials, reducing waste and using recycled materials.	Geissdoerfer et at. (2018); Bundgaard et al. (2017); Upadhyay et al. (2018); Mies & Gold (2021); Zeng & Li (2021); Fortunati et al. (2020)
Promote recycling and recovery	Companies can promote recycling programs that make efficient use of waste products and materials. The market for recycled materials can also be expanded and the sale of products made from recycled materials supported.	Bundgaard et al. (2017); Zeng & Li (2021); Fortunati et al. (2020)
Contributing to a sustainable supply chain	Businesses can seek to work with suppliers that apply sustainability principles and strive for the efficient use of raw materials and waste reduction.	Daly (2017); Upadhyay et al. (2018); Mies & Gold (2021); Zeng & Li (2021); Fortunati et al. (2020); Peng & Li (2023)
Promote rental and service models	Instead of single-use products, companies can develop rental or service models that share the use of products among many users, reducing the need for new products	Peng & Li (2023); Gulzari et al. (2022)
Education and information	It is important to educate consumers about the principles of sustainability and responsible consumption. This may include information on recycling options, the importance of product longevity, responsible use of resources, etc.	Zeng & Li (2021); Fortunati et al. (2020); Peng & Li (2023)
Supporting sustainability policies	Public authorities can introduce sustainability policies and legislation to promote a sustainable circular economy. This can include various measures such as taxes on polluting activities, support for sustainability innovations, etc.	Daly (2017); Upadhyay et al. (2018); Mies & Gold (2021); Fortunati et al. (2020); Ferronato et al. (2022)
International cooperation	A sustainable circular economy is a global challenge, and it is important to foster international cooperation, to share best practices and to develop	Ferronato et al. (2022)

	sustainability solutions and standards in all sectors.	

Creating a sustainable circular economy is a complex process that requires a coordinated action plan and commitment from a wide range of stakeholders (Jaeger-Erben et al., 2021; Velenturf & Purnell, 2021). The key is to recognize and implement principles that contribute to resource efficiency, waste reduction and environmental protection in the long term.

In recent times, the term sustainability has become closely linked with the concept of a circular economy. Sustainability represents a comprehensive, systems-level strategy that considers the environmental, social, and economic dimensions of a product, material, process, or technology, evaluating their interactions. While sustainability should underpin the principles of a circular economy, it's crucial to recognize that circularity serves as a means to achieve sustainability. However, not all systems incorporating circular flows are inherently more sustainable.

Circularity, on its own, does not guarantee a sustainable outcome, nor does it serve as a universal remedy for resource efficiency or economic prosperity. Recycling, a pivotal aspect of circularity, can entail significant costs and energy- and resource-intensive processes, sometimes resulting in higher overall life cycle impacts compared to alternative methods. Additionally, not all pathways toward sustainability necessarily contribute to circularity.

In regions lacking recycling infrastructure, advanced technologies, or financial resources, the most environmentally friendly and economically viable option may involve managing waste in secure landfills. In such cases, methane gas generated can be converted into power, heat, or fuel, or waste-to-energy plants can utilize existing co-processing infrastructure. Sustainability transcends a simplistic focus on environmental preservation or a preference for assumed circular and eco-friendly alternatives, including a shift to alternative energies.

To address potential links between sustainability goals and a circular economy, a more holistic approach is essential. This approach forms the foundation for evaluating the diverse impacts of a product, material, service, process, or technology. Adopting systems-level thinking and well-defined life-cycle-based assessments emerges as a crucial tool for measuring the sustainability of circular solutions. These assessments aid in identifying risks, enhancing understanding of trade-offs, preventing unintended externalities currently not factored into pricing, and exploring a range of opportunities.

Formation of links between circularity and sustainability has some potential gaps:

Measurement and Metrics: The authors who conducted research on these topics paid a lot of attention to the search for individual waste recycling solutions, but complex solutions are missing in their works. There are several indexes developed such as (MSCI, 2024):

- Index for Renewables and Energy Efficiency: This index is crafted to mirror the performance of companies actively promoting renewable energy and energy efficiency through the delivery of their products or services.
- Sharing Economy Index: Formulated to reflect the performance of companies engaged in developing innovative products and services poised to substitute resource-intensive alternatives, including those involved in the sharing economy, which is linked with CE using closing loop strategy.
- Sustainable Water Transition Index: Tailored to represent the performance of companies playing pivotal roles in tackling water scarcity, either through their products or services or by effectively managing water-related challenges.
- Natural Resources Stewardship Index: This index is designed to showcase the performance of companies dedicated to safeguarding natural resources, either through the provision of eco-friendly products or services or by adeptly addressing associated issues.
- Plastics Transition Index: Crafted to illustrate the performance of companies serving crucial roles in addressing the challenge of plastic waste, either through their products or services or by adeptly managing issues related to plastic waste.

But has to be oriented to a) companies that provide technologies that enable a circular economy, such as alternatives to single-use plastics; digital technologies that replace traditional resource-intensive ones; and b) companies that reduce their negative operational impact by maximizing resources and/or minimizing waste.

Economic Models: There is the need to develop long-term economic models helping in achieving both circularity and sustainability goals. It is recommended to associate these with different industries and sectors and to measure their efficiency towards reaching higher sustainability.

Policy and Regulatory Frameworks: current regulatory frameworks could better align circular practices with sustainability objectives. It is necessary to promote the integration of circularity and sustainability in the circular economy, which could include taxes on polluting activities, support for sustainability innovations, etc.

IV. METHODOLOGY

The researchers conducted bibliometric analysis in three stages, aiming to identify clusters with interconnected circularity theme. Specific methodological guidelines were used to construct clusters:

- Utilizing the VOSviewer program to analyse articles published in 2021-2023 from open-access databases.
- Employing bibliographical coupling analysis to identify co-linked words and clusters.
- Creating a map for circularity based on revised studies and the co-occurrence of main words in study titles.

To gather articles, the authors searched for keyword "circularity." Using VOSviewer version 1.6.18, bibliographic maps were generated, and clusters were formed. All open-source articles retrieved by VOSviewer in the period 2021-2023 were included, with a limitation of the number of retrieved papers set at this date. The cluster construction ensured that the number of papers did not exceed 50,000 publications per retrieval iteration.

VOSviewer employs VOS mapping technology to explore similarities, as discussed in detail by Van Eck et al. (2010). The technology assigns nodes to cluster networks, where each cluster represents a group of tightly coupled nodes. The number of clusters is determined by the solution parameter, with a higher value resulting in more clusters. Colours in the bibliometric network visualization represent the assigned cluster, and the clustering technique is elaborated by Waltman, Van Eck, and Noyons (2010), using an intelligent local traffic algorithm introduced by Waltman and Van Eck (2013). The resulting bibliographic map depicts papers with distinctive attributes. Colored circles represent different clusters, highlighting closely linked keywords, while lines indicate links among keywords and display the strength of these connections. Distances between words reflect the strength of their associations. The bibliometric research findings are presented below, summarizing the results of words used for cauterization through the demonstration of clusters.

V. RESULTS OF THE BIBLIOMETRIC ANLYSIS STUDY ON CIRCULARITY

The authors of this paper revised researches delivered during 2021-2023 years, trying to find current tendencies and define top priority topics in the area of circularity. By entering keyword "circularity" in the software "VOSviewer," the output was used to create bibliographic map presented in Figures 7.

Figure 7 shows the dominance of words used for research in the field of circularity, which are retrieved from the publications available for the VOSviewer software. The studies on the map are divided into 5 different colors: green, red, blue, yellow and violet. Typically, different colors separate papers into clusters which words are closely combined in publications and what is the popularity of the word.

The authors identified 5 clusters which are figured out during the bibliometric data research. In the Figure 7, all the significant words such as "impact," "production", “end,” “review” and "value" are highlighted and identified by size of the circle. It should also be noted that all keywords are interdependent,

but the distances of the connections are different. In total around 10 significant words were figured out such as "supply chain," "case study," "material circularity," "world," "company," "value," "efficiency," "impact," etc.

The first cluster has words “efficiency” with 329 links and 45 occurrences and “impact” with 587 links and 57 occurrences (on Figure 7 it is mentioned in green color). The second cluster significant word “production” has 366 links and 44 occurrences (on Figure 7 it is mentioned in yellow color). The cluster in red has 2 significant words “building” which has 379 links and 48 occurrences and “end” which prevails by having 433 links and 60 occurrences (on Figure 7 it is mentioned in red color). Centroid of the cluster „review” has 317 links and 80 occurrences (on Figure 1 it is mentioned in violet color). The fifth cluster the most significant word “value” has 436 links and 57 occurrences (on Figure 7 it is mentioned in blue color).

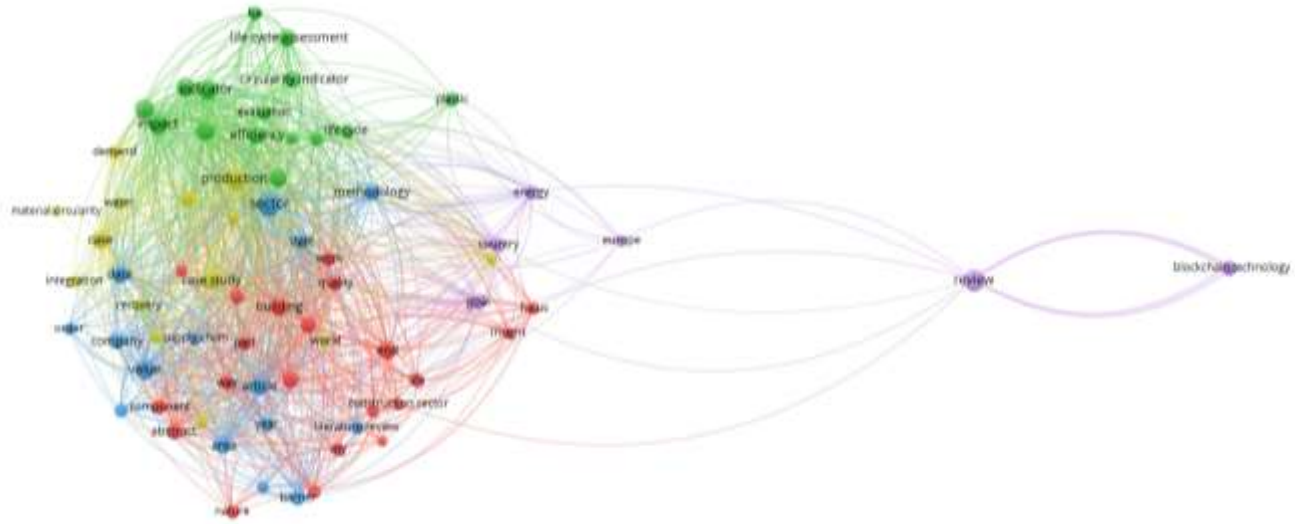

Figure 7. Results on searching of circularity in VOSviewer

The most popular journals are listed in Table 4: waste management, journal of cleaner production, sustainability, sustainable production and consumption, circular economy, science of the total environment, and others. Among the papers Chunbo et al. (2022) paper describing waste hierarchy framework is the most citable paper. The most cited paper is dedicated waste management. The word “sustainable development” has 153 links and 18 occurrences.

From 595 documents which were retrieved during bibliometric literature sources analyse, top 18 most cited papers were mentioned in Tables 4 and 5. All these top cited papers are from the year 2022.

Table 4. Most popular journals publishing papers dedicated to circularity having sustainable approach

Author	Source	Citation	Year
Zhang, Chunbo; Hu, Mingming; Di…	Science of The Total Environment	96	2022
Mao, Jianfeng; Ye, Chao; Zhang, Sh…	Energy & Environmental Science	50	2022
Ding, Ziyi; Chen Zihong; Liu, Jingy…	Journal of Hazardous Materials	40	2022
Chakraborty, Moupali; Kettle, Jeff; …	IEEE Journal on Flexible Electronics	30	2022
van Selm, Benjamin; Fehner, Anita…	Nature Food	28	2022
Kiel, Gavin R.; Lundberg, David J.; P…	Journal of the American Chemical Society	23	2022
Hu, Jinwen; Song, Yueyao; Liu, Jing…	Fuel	21	2022
Khadim, Nouman; Agliata, rosa; M…	Journal of Cleaner Production	16	2022
Klotz, Magdalena; Haupt, Melanie; …	Waste Management	15	2022
Demarteau, Jeremy; Epstein, Alexa…	Science Advances	14	2022
Colasante, Annarita; D’Adamo, Idia…	Environmental Impact Assessment Review	13	2022
Hall, Robert D.; Trevisan, Fabio; de…	Food Research International	13	2022
D’Amico, Gaspare; Arbolino, Rober…	Land Use Policy	13	2022

Tokazhanov, Galym; Galiyev, Olzha…	Journal of Clener Production	13	2022
Antiwi-Afari, Prince; Ng, S. Thomas;...	Journal of Clener Production	12	2022
Contreras-Taica, Anguie; Alvarez-Ri…	Circular Economy	12	2022
Kakwani, Nikita S.; Kalbar, Pradip P…	Sustainable Production and Consumption	11	2022
Varaniūtė, Viktorija; Žičkutė, Ineta;…	Sustainability	11	2022

*595 documents have been retrieved

Identified top 18 most cited authors were not cited in the paper before. However, the authors of these papers highlight waste hierarchy framework, mention artificial intelligence, production of food and chemicals, utilization of plastic, highlights education role and focus on urban water circularity.

Table 5. Citation of articles on the topic of circularity

Author	Source	Citation	Year
An overview of thee waste hierachy framework for analy..	Science of The Total Environment	96	2022
Toward practical lithium-ion battery recycling: adding v…	Energy & Environmental Science	50	2022
Co-combustion, life-cycle circularity, and artificial intelli..	Journal of Hazardous Materials	40	2022
Electronic Wwaste Reduction Through Devices and Printe..	IEEE Journal on Flexible Electronics	30	2022
Circularity in animal production requires a change in the....	Nature Food	28	2022
Cleavable Comonomers for Chemically Recyclable Poly…	Journal of the American Chemical Society	23	2022
Torrefaction-assistef oxy-fuel co-combustion of textile…	Fuel	21	2022
Critical review of nano and micro-level building circular…	Journal of Cleaner Production	16	2022
Limited utilization options for secondary plastics may re…	Waste Management	15	2022
Circularity in mixed-plastic chemical recycling enabled…	Science Advances	14	2022
Assessing the circularity performance in a European cro…	Environmental Impact Assessment Review	13	2022
Digitalisation driven urban metabolism circularity: A rev…	Food Research International	13	2022
Coffee berry and green bean chemistry – Opportunities..	Land Use Policy	13	2022
Circularity assessment tool development for constructio…	Journal of Clener Production	13	2022
Developing and integrative method and design guideline	Journal of Clener Production	12	2022
Virtual Education: Carbon Footprint and Circularity	Circular Economy	12	2022
Measuring urban water circularity: Development and im…	Sustainable Production and Consumption	11	2022
The Changing Role of Management Accounting in Prod…	Sustainability	11	2022

*595 documents have been retrieved

Scientific articles, with valuable theoretical contributions, have become an important source of information on the circularity. The leading researchers in the area of circularity present developments and define future paths to accelerate the micro-transition to a circularity based on the latest knowledge. Our bibliograpic analysis has some limitations.

Firstly, because the published data and citations for bibliometric analysis were collected exclusive papers from the Science website, we could not systematically check for possible selection biases, which meant that there was a risk that relevant items could be not retrieved fully. Secondly, a database has been set up that focuses exclusively on researching circularity. This could be revised again seeking to understand how researches on the circularity topic are extended in the future. The authors may provide more insights on the sustainability and circularity inter-relationship topic.

Further on, the integration of sustainability into circularity related studies may require the development of new paradigm, which could demonstrate the importance of sustainability.

VI. DISCUSSIONS

Currently, plenty of questions takes off regarding the formation for a sustainable circular economy and goals to implement these processes. As the world is entering the era of a circular economy, the governments of the countries of the European Union (EU) play a crucial role in achieving greater resource efficiency and higher circularity of materials. Given the environmental, economic, and social benefits of sustainable use of resources, there is a clear rationale for the EU countries to make further progress in the

transition to a more resource-efficient and circular economy. In the meantime, this requires evaluations relating to the use of resources, the circularity of materials, and the assessment of the macroeconomic benefits associated with increased resource efficiency. Good practices should be identified during research seeking to pursue better policies for implementing the circular economy.

The report focused on exploring the connections between the concepts of circularity and sustainability in the circular economy. Sustainability aspects integrated into long-term circular economy processes have a clear impact on the environment, the economy and political decisions. The study examines the factors that contribute to and influence the formation of the circular economy and reveals the connection between circularity and sustainability.

In addition, a literature study was conducted on the links between circularity and sustainability, the theoretical methods that are most often applied to examine aspects of circularity and sustainability have been identified and reviewed. It was also conducted by biometric analysis for 2021-2023 which helps to identify current trends and found that the number of studies analysed included five groups which show that the studies are focused on impact, production, end, review and value. The results of the bibliometric analysis show that circularity has links with supply chain, sustainability, material circularity, efficiency and value. The authors have presented research by topic because knowledge is needed to fill existing gaps.

VII. CONCLUSIONS

The paper revises the link between circularity and sustainability. With a circular economy approach, companies can reduce their dependence on financial resources and reduce the environmental impact of their activities. Sustainability, on the other hand, refers to our ability to meet the needs of the present without compromising the ability of future generations to meet their needs. It examines social, economic and environmental aspects in order to find a balance between these three pillars. Among the theories dedicated to the research topic, the authors identified main theories such as systems theory, circular economy theory, operations management theory, sustainability theory, resource-based management theory, institutional theory, environmental economic theory, life cycle assessment

The circular economy is closely linked to sustainability, as it promotes resource efficiency and reduces waste, thus contributing to a more sustainable future. By applying the principles of the circular economy, companies can reduce their CO2 footprint and minimize the extraction of raw materials. Circular and sustainable practices can help companies save costs by reducing the need for raw material extraction and waste management. Ultimately, promoting the circular economy and sustainability is key to creating a more sustainable and balanced future for people and the planet.

The authors revised the links between circularity and sustainability. Under the third section the authors identified links which help to reach sustainability objectives, such as indexes, economic models and policy and regulatory frameworks.

The revision of links also includes bibliometric literature review. The authors provided methodology for such revision. The delivered bibliometric analysis highlights company, sector, and factors, also the material circularity approach. The bibliometric analysis shows that there are 5 clusters which represent the most important articles given on circularity topic. The sustainability is not appearing in the research field of circularity, however, some links are found in the field of life-cycle and nature. Further on, other research could be delivered to show mathematical relationships between circularity and sustainability. Herein, the sustainability gets 3-4 times lower attention when other topics highlighted in the area of circularity.

The paper has its limitations, as it includes only bibliometric literature review on circularity topic. Such study could be extended by providing bibliometric study on sustainability topic.

For further bibliometric literature review studies it could be useful to analyze the studies focusing not only on 2021-2023 but also other periods and gathering the changes among different periods.

The further development of circularity and sustainability approaches integrating framework should be oriented into the circularity, since it plays an important role in ensuring the increase of sustainability. Governments have an important role to play in promoting the circular economy and sustainability through regulatory frameworks, incentives and standards.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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Oblikovanje povezav med krožnostjo in trajnostjo v krožnem gospodarstvu

Povzetek - Danes se pojavljajo številna nova vprašanja v zvezi z oblikovanjem in določanjem ciljev za trajnostno krožno gospodarstvo. Študija se je osredotočila na raziskovanje povezav med konceptoma krožnosti in trajnosti v krožnem gospodarstvu. Trajnostni vidiki, vključeni v dolgoročne procese krožnega gospodarstva, jasno vplivajo na okolje, gospodarstvo in politične odločitve. Študija preučuje dejavnike, ki prispevajo k oblikovanju krožnega gospodarstva in vplivajo nanj, ter razkriva povezavo med krožnostjo in trajnostjo. Po pregledu literature o povezavah med krožnostjo in trajnostjo so bile opredeljene in pregledane teoretične metode, ki se najpogosteje uporabljajo za preučevanje vidikov krožnosti in trajnosti. Opravljena je bila tudi bibliometrična analiza za obdobje 2021-2023, ki pomaga opredeliti trenutne trende, in ugotovljeno je bilo, da število analiziranih študij vključuje pet skupin, ki kažejo, da so študije osredotočene na vpliv, proizvodnjo, konec, pregled in vrednost. Rezultati bibliometrične analize kažejo, da je krožnost povezana z dobavno verigo, trajnostjo, krožnostjo materialov, učinkovitostjo in vrednostjo. Avtorji so raziskave predstavili po temah, saj je treba z znanjem zapolniti obstoječe vrzeli.

Ključne besede - krožnost, trajnost, teorije, dejavniki, povezave.