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Digital Transformation is Driving the Economy Towards Sustainable Economic Growth

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Abstract:

Digital transformation impacts every industry by adding significant value along entire supply chains. It is affecting them with different degrees and speeds. The use of digital technologies in production chains increases the ease of interaction in supply and distribution. In most developing countries, most of the economic sectors and industries still use traditional tools and methods in their supply chain, especially for producing and marketing their products. For this reason, they are suffering from a decrease in sales volume. This pushes employees to not advance in their career in these industries because they can't earn enough money to cover their main daily needs for life**.** Furthermore, the adverse effects of environmentally unsustainable consumption and production patterns are becoming unmanageable. It is therefore necessary to explore a meaningful improvement in resource performance in the world economy. To fill these gaps, there is a need to exploit the Digital Revolution and its contribution to sustainable economic growth, and to manage the natural resources consumed and produced by these industries. This paper conducts a conceptual literature review and uses Documentary methodology focusing on the analysis of how digital transformation improves the economy, and how it contributes to sustainable economic growth. In order to achieve sustainable economic growth, as a result, it is essential to leverage technological innovations. This study provides insights into how Industry 4.0, Circular Economy, and Digitalization can facilitate this process.

Keywords: Circular Economy (CE), Digital Economy (DE), Industry 4.0, Digital Revolution, Economy
JEL classification: H12.
Paper type: Theoretical Research.

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1. Introduction

Worldwide industries have followed a linear economy model since the Industrial Revolution (P. Intasian et al., 2021). As the world confronts a severe menace related to the climate change crisis, a more durable solution for manufacturing is needed, i.e., a circular economy in which waste can be used as raw materials or resources for production of other products (P. Intasian et al., 2021).

The fundamental philosophy of circular economy (CE) is the concept of "cradle-to-cradle" in production and consumption systems through the application of reuse, recovery, and recycling of materials and energy (M. Mannan and S. Al-Ghamdi, 2022). This concept is gaining popularity worldwide as it aims to increase resource efficiency through closed-loop technologies (M. Mannan and S. Al-Ghamdi, 2022). The products and materials in a circular economy retain their value for the longest period possible (M. Pellegrini, And al, 2018). The amount of waste and use of resources is significantly reduced, and at the end of a product's life, it is reused to create additional value (M. Pellegrini, et al, 2018). CE offers economic and business opportunities and produces social and environmental benefits (M. Pellegrini, et al, 2018).

Despite the importance of the circular economy, its involvement in the industry is still too weak, implying the need for data-based systems for more advanced implementation (L. de Morais, et al, 2021). This data is the main element in the CE. It will be captured and used for making automated decisions that can improve the service quality and then improve the product`s process and citizen's life. However, data quality plays a key role in this project, because poor data quality may turn out to hurt productivity, outcomes, decision-making, and development (Z. korachi and B. Bounabat, 2018).

In general, only a small number of the reviewed approaches explicitly address Circular Economy, and the advice given to enterprises is very generic and incoherent (K. Opferkuch, et al, 2021). The literature review indicates that little attention is given to social and circularity measures, but instead focus on traditional economic and environmental aspects (T. Calzolari, et al, 2022). Moreover, despite the clear benefits of big data-driven industrial symbiosis, there are still weaknesses in recycling, reduction and reuse solutions based on operational data (M. Tseng, et al, 2017). On the other hand, the industry 4.0 revolution is a new way of managing production and the supply chain along the whole lifecycle of the product (E. Markova, et al, 2022). It is based on the use of robotics and digital technologies on a large scale, leading to a significant improvement in the efficiency of the production process (E. Markova, et al, 2022).

Industry 4.0 and digital transformation are closely related concepts that are transforming the way businesses operate. The digital transformation has become an increasingly important topic in economics and has had a significant impact on economic growth and sustainability. Many studies have explored the relationship between digital transformation and the economy, with some focusing on the impact of digital technologies on productivity, innovation, and employment.

For instance, a study by (Brynjolfsson and McAfee, 2014) found that the adoption of digital technologies led to an increase in productivity, as well as a shift in the types of jobs available, with a greater emphasis on higher-skilled jobs. Meanwhile, a study by (Akerman et al. 2017) highlighted the role of digital technologies in promoting innovation, with firms that adopted digital technologies more likely to introduce new products and services.

Moreover, digital transformation has also been found to have a positive impact on sustainability, as it enables more efficient use of resources, reduction of waste, and the development of new sustainable products and services. In a study by (Gualandris and Kalchschmidt, 2018), digital transformation was found to be a key factor in enabling digital

economy and circular economy practices, which can help reduce waste and promote sustainability.
Overall, digital transformation has the potential to contribute significantly to sustainable economic growth. However, there are also challenges associated with digital transformation, including issues related to privacy, security, and the digital divide. Therefore, policymakers need to take a proactive approach to ensure that the benefits of the digital transformation are maximized while minimizing its negative impacts.
The purpose of this paper is to examine the ways in which digital transformation is being utilized to drive the Circular Economy, Industry 4.0, and Digital Economy, with the aim of achieving sustainable economic growth.
The present paper is structured as follows: Literature Review, Methodology, Result, and Conclusion.

2. Literature review

The purpose of this conceptual literature review is to provide a conceptual overview of the concepts of digital transformation, sustainable economy, circular economy, digital economy, industry 4.0 and economic growth theory. These concepts are linked together to provide a better understanding of the problem and to provide a foundation for the research study.
On the one hand, digital transformation refers to the integration of digital technology into all areas of an organization, which fundamentally changes the way it operates and delivers value to customers. According to (Berman and Marshall, 2019), digital transformation involves the use of technologies such as cloud computing, big data analytics, and artificial intelligence to transform business models, operations, and customer experiences. Digital transformation has been identified as a driver of sustainable economic growth, as it enables companies to operate more efficiently and sustainably (Schwab, 2016). Moreover, digital transformation is a key factor in enabling digital economy, industry 4.0 and circular economy.
The digital economy is a term used to describe the economic activities that are enabled by digital technologies such as the internet, mobile devices, cloud computing, and big data analytics (Rehman et al., 2019).
Industry 4.0 is a term that refers to the current trend of automation and data exchange in manufacturing processes. It is characterized by the integration of advanced technologies such as the Internet of Things (IoT), artificial intelligence (AI), robotics, and big data analytics into the production process, leading to increased efficiency, productivity, and customization (Kagermann, et al. 2013).
The Circular Economy is an economic model that aims to eliminate waste and promote the continuous use of resources through reuse, repair, refurbishment, and recycling (Ellen MacArthur Foundation, 2013). It emphasizes the importance of designing products and materials with a focus on durability, recoverability, and recyclability, and seeks to create a closed-loop system where waste becomes a valuable resource (Ellen MacArthur Foundation, 2013).
On the other hand, a sustainable economy is an economy that is based on sustainable development principles, which means that economic growth is achieved without compromising the ability of future generations to meet their own needs. According to (Vaze et al, 2021), a sustainable economy is characterized by the efficient use of resources, the protection of natural ecosystems, and the equitable distribution of wealth. Sustainable economic growth is essential to address environmental challenges such as climate change and resource depletion.
Moreover, economic growth theory is concerned with explaining the factors that contribute to economic growth. According to (Barro and Sala-I-Martin, 2004), economic growth can be attributed to a variety of factors, including investments in physical and human capital,

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technological progress, and institutional reforms. Economic growth theory is important because it provides insights into how economic growth can be sustained over the long term, and how it can contribute to social welfare.

The concepts of digital transformation, sustainable economy, digital economy, Industry 4.0, circular economy and economic growth theory are closely linked. Digital transformation can enable companies to operate in a more sustainable and efficient manner, which can contribute to sustainable economic growth. According to (Mishra et al., 2021), the use of digital technologies such as blockchain can help to reduce waste and improve the efficiency of supply chains. Sustainable economic growth, in turn, can contribute to the adoption of digital technologies, as companies seek to remain competitive in a rapidly changing economic landscape.

These concepts should also be employed to address the adverse impacts of environmentally unsustainable production and consumption practices that are becoming increasingly unmanageable in today's fiercely competitive business environment.

To achieve this, there is a need to identify significant enhancements in the overall performance of global economic resources (S. Rajput and S. Singh, 2019). Consequently, numerous companies have endeavored to identify ways to reuse product materials or components and extend their value over an extended period (S. Rajput and S. Singh, 2019).

To this end, CE helps industries eliminating toxic materials and reusing waste (S. Rajput and S. Singh, 2019). The goal of CE is to improve resources efficiency at multiple supply chain levels (S. Rajput and S. Singh, 2019). In fact, the intensification of global consumption requires the adoption of circular economy and sustainable manufacturing for efficient production and for limited resource management (B. Hapuwatte and I. Jawahir, 2021).

A circular approach to managing consumed and produced resources enables a significant reduction in global finite resource consumption. At the same time, it will enable urban problems to be addressed (G. Bressanelli, et al, 2018). Circular economy is widely regarded as an approach that holds promise for promoting sustainable business development. However, the paradigm of the circular economy is not yet widely adopted by businesses, as they confront many different challenges (G. Bressanelli, et al, 2018). Human pressure on the natural resource is globally increasing, and the need for a circular economy is becoming more and more important to manage natural resources consumption (Velenturf and P. Purnell, 2021).

On the one hand, digital technologies are considered as a means for implementing the circular economy (E. Uçar, M. Dain and I. Joly, 2020). On the other hand, Industry 4.0 also advances the traditional linear economy to a sustainable supply chain based on CE. An integrated supply chain based on Industry 4.0 and CE is argued to be more agile, durable, self-organized, secured, and highly integrated with ICT (Y.Geng, et al, 2008).

To facilitate the circular economy implementation there is a need to develop digital tools and strategies that can provide comprehensive and useful data to enhance repairs, remanufacturing, and reuse (L. Peiró et al., 2021). A literature review has indicated that digital technology has significant potential to promote CE development (L. Peiró et al., 2021). DE and CE are attracting policymakers, and academics attention globally, particularly in the context of the COVID-19 crisis that has gravely affected the world' s environment, economy, and society (Z. Liu, J. Liu and M. Osmani, 2021).

The circular economy (CE) has the potential to take advantage of newly emergent digital technologies, including the Internet of Things (IoT), artificial intelligence (AI) big data..., etc. Together with business model innovation, these digital technologies are said to bring solutions to a multitude of problems around the world (C. Chauhan, et al, 2022). Though there is a considerable number of research on the fields of DE and CE, few studies are focusing on these two concepts integration (Z. Liu, et al, 2021). In addition, the main obstacle to the implementation of CE is the lack of technological, financial, and human resources, as well as

management unwillingness and end user indifference to sustainability (K. Saha, et al, 2021).
Lastly, findings indicate that collaboration, shared knowledge of value chain sustainable management, and commercialization of recycling of waste, amongst other activities, are some of the actions that industries need to successfully implement CE (K. Saha, et al, 2021).
In conclusion, digital transformation, sustainable economy, digital economy, Industry 4.0, circular economy and economic growth theory are all important concepts that are closely linked. Digital transformation can enable companies to operate more sustainably and efficiently, which can contribute to sustainable economic growth. Economic growth theory provides insights into how economic growth can be sustained over the long term, and how it can contribute to social welfare. Understanding the relationship between these concepts is essential for policymakers and business leaders who are seeking to promote sustainable economic growth in the digital age.

3. Research Methodology

The purpose of this section is to present the methodology used to understand the relationship between digital economy (DE), circular economy (CE), and Industry 4.0, and how they can contribute to sustainable economic growth. The paper focuses on the documentary methodology used to search, filter, and interpret findings from previous papers.
The Documentary methodology has been used in this study to search, filter, and interpret findings about DE, CE, and Industry 4.0 obtained from previous papers to understand how these 3 concepts can contribute together to enable sustainable economic growth.

3.1 Documentary Methodology

The Documentary methodology is a research approach that is used to perform systematic investigation and analysis of existing documents and sources to gather information and knowledge on a specific topic. It involves searching, collecting, and critically examining various types of documents such as books, articles, reports, publications, archives, and online resources. The purpose of documentary research is to obtain relevant and reliable information, data, or evidence to support research objectives, explore a particular subject, or contribute to knowledge in a specific field (Ahmed, 2010).

3.2 Data Collection

The data collection process began with a comprehensive search of academic literature databases, including Google Scholar, Web of Science, and Scopus (Creswell, 2014). The search was conducted using a combination of keywords such as "digital transformation," "circular economy," "Industry 4.0," and "sustainable economic growth." The search was limited to papers published between 2015 and 2021 to ensure the relevance and timeliness of the findings.

3.3 Data Filtering

The search resulted in many papers, which were filtered based on their relevance and quality (Creswell, 2014). The filtering process involved reading the abstracts and titles of the papers to determine their relevance to the research question (Creswell, 2014). The papers were then further filtered based on their quality, as assessed by their research design, methodology, and the rigor of their analysis. Only papers that met the inclusion criteria were selected for further analysis.

3.4 Data Interpretation

The selected papers were analyzed using a thematic analysis approach (Creswell, 2014). This involved reading and re-reading the papers to identify themes and patterns related to DE, CE, and Industry 4.0, and how they can contribute to sustainable economic growth. The themes and

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patterns were then organized into a conceptual framework to provide a better understanding of the relationship between these concepts.
The Documentary methodology was used in this study to search, filter, and interpret findings about DE, CE, and Industry 4.0 obtained from previous papers. The data collection process involved a comprehensive search of academic literature databases, while the data filtering process involved reading the abstracts and titles of the papers to determine their relevance and quality. The data interpretation process involved a thematic analysis approach, which involved identifying themes and patterns related to DE, CE, and Industry 4.0, and how they can contribute to sustainable economic growth. The findings of this study provide insights into the potential of DT, CE, and Industry 4.0 to promote sustainable economic growth and inform policymakers and business leaders about the opportunities and challenges associated with these concepts.

4. Results

The current world has made the initial transition to a radically new technological reality. To this end, the use of technologies is an indispensable factor for the development of the economy. For this reason, the current paper aims to illustrate the use industry 4.0, CE, and DE in enabling sustainable economic growth.

4.1 Circular Economy and Digital Economy

Industry can no longer proceed with legacy ways that are threatening the planet's finite resources (D. Atalay Onur, 2020). Hence the need for a model to create societal changes, boost collaborative manufacturing, and develop the novelty concept (D. Atalay Onur, 2020). Moreover, the growth of environmental awareness has led to the emergence of the 7Rs (Reduce, Reuse, Recycle, Redesign, Renew, Repair, and Recover), referring to the actions needed to implement circular economy, in order to extend resource life by using them efficiently and effectively (J. Araujo-Morera, and al, 2021).
The circular economy is among the best ways to improve systems sustainability, since it focuses particularly on reducing, reusing and recycling its components (J. Stanković, and al, 2021).
On the other hand, digitization can stimulate the change to a more sustainable circular economy (M. Antikainen, and al., 2018). It has the potential to close manufacturing cycles by delivering precise information about product location, availability, and condition. Digitization can also improve process efficiency in companies, reduce waste, extend the life of products, and reduce costs (M. Antikainen, and al., 2018).

4.2 Circular Economy and Industry 4.0

The concept of Industry 4.0 is closely related to cyber-physical systems (CPS), cloud computing (CC), internet of things (IoT), and big data. Its main objective is to achieve precision, accuracy, and the highest level of automation in industrial processes (L. Thames and D. Schaefer, 2022). By leveraging these technologies, Industry 4.0 can help to boost the circular economy, creating more value for consumers and generating environmental, economic, and social benefits. In turn, the circular economy can also help to enhance the effectiveness and sustainability of Industry 4.0 (A. Abdul-Hamid, and al., 2020).
The synergy between Industry 4.0 and the circular economy is particularly significant. Industry 4.0 can help to optimize resource efficiency and reduce waste in the production process, which are key principles of the circular economy. On the other hand, the circular economy can help to ensure the sustainable use of resources, which is crucial for the long-term success of Industry 4.0. Together, Industry 4.0 and the circular economy can enable businesses to generate more value from fewer resources, while also creating a more sustainable future for all.

4.3 Industry 4.0 and Digital Economy

Industry 4.0 is not only work process automation and human resources substitution with digital software (E. Markova, and al., 2021). It is a change in the principles of activity of the state and a transformation of the business construction, mentality and consciousness (E. Markova, and al., 2021). Indeed, the key main directions of the fourth industrial revolution are the digital economy, the application of robotics in production and consumption, the Internet of things, etc. (E. Manavalan, K. Jayakrishna, 2019).

Digitization is not just a product or technology but instead represents an approach leveraging digitization resources to successfully change the way organizational work is done [9]. It entails the redefinition of business processes and technologies to enhance the employees' working environment as well as interaction with clients (E. Markova, and al., 2021). Industries are slowly moving towards Industry 4.0 because of rising costs (S. Rajput and S. Singh, 2020).

4.4 Connection of CE, DE, and Industry 4.0 for sustainable economic growth

The fast growth of the industry has provided important opportunities for economic development and growth; however, its operations have caused impulsive degradation of the environment (R. Singh, and al., 2020). To this end, the circular economy can support industries optimizing resource use and reducing waste (R. Singh, and al., 2020). In addition, this could surmount the negative threats posed by the traditional linear and promoting environmental sustainability by emphasizing the concept of innovative products (F. Jia, and al., 2020).

The circular economy may help in changing the company culture in order to assure the simultaneous improvement of the social, economic and environmental dimensions (D. Salvioni and A. Almici, 2020). Research studies highlight the contributory role played by stakeholder engagement in establishing values and principles consistent with the protection of the environment and the well-being of the community (D. Salvioni and A. Almici, 2020). The findings show that human resources, project management, green design, executive leadership, collaborative relationships, and information technology are essential to the success of the circular economy (S. Bag,and al., 2020). In addition, Industry 4.0 has a strong connection with sustainability and the latter has a significant relationship with the circular economy (S. Bag,and al., 2020).

Digital transformation has redesigned industries and opens the gateway towards data driven, smart, connected, and agile industries. Within this background, Industry 4.0 is growing rapidly and offering innovative and cleaner outcomes (S. Rajput and S. Singh, 2020). Therefore, there is a strong need to re-engineer traditional manufacturing configurations into intelligent industries to achieve reliability, agility, and flexibility (S. Rajput and S. Singh, 2020).

Consequently, CE, DE, and Industry 4.0 can be used together to develop developing countries industries, and enhance its economic, social, and environmental dimensions, as illustrated in Table 1. However, the use of these three concepts to achieve present and future generations' requirements needs a holistic strategy guiding their implementation (Z. Korachi and B. Bounabat, 2019).

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Table 1: Comparative table of CE, DE, and Industry 4.0 and their impacts on the Economy, Environment and Social

Developing countries industries dimensions	Circular Economy	Digital Economy	Industry 4.0
Economy	• Reuse of materials and products (S. Rajput and S. Singh, 2019). • Extend resource life by using resources rationally and efficiently to repeatedly create value, reducing expenses and wastes (J. Araujo-Morera, and al., 2021).	• Drive transition to a sustainable circular economy (M. Antikainen, 2018). • Reduce waste, extend product life and decrease costs.	• Redesigning business processes and technologies in order to create a better working environment (E. Markova, and al., 2021). • Providing a circular economy and cleaner outputs that achieve ethical trade. • Revampinglegacy fabrication systems to intelligent ones to achieve greater flexibility, reliability, and self-adaptability (S. Rajput and S. Singh, 2020).
Environment	• Allow industry to adapt the end-of-life concept to recovery. • Eliminate waste through explicit implementation of sustainable methods (S. Rajput and S. Singh, 2019). • Improve environmental performance and resource efficiency.	• Implementation of innovative processes, inventive solutions to solve environmental problems. • Using sensors, data analysis, and blockchain technologies to solve environmental problems.	• Enabling conscious use of natural resources. • Reducing in environmentally harmful emissions.
Social	• Address urban and social problems. • Quality life improvement.	• Create societal changes, boost collaborative manufacturing, and develop a sense of novelty (D. Atalay Onur, 2020). • Generation of innovative learning and design methods by recycling, crafting and collaborating in developing countries (D. Atalay Onur, 2020).	• Development of mentalities, consciousness and activity of the state (E. Markova, and al., 2021).

Source: Authors

5. Conclusion

The present paper aims to provide a comprehensive examination of the current state of research on Circular Economy (CE), Digital Economy (DE), and Industry 4.0 concepts. It delves into the progress made, emerging trends, challenges faced, and the potential integration of these concepts, with a particular focus on their applicability in developing countries. The objective is to explore how these concepts can contribute to meeting the social, economic, and environmental requirements of these countries.

CE, DE, and Industry 4.0 are proving to be crucial drivers of sustainable economic growth due

to their ability to minimize waste, promote recycling and reusing of materials, and generate overall social, environmental, and economic benefits. The reduction of waste and the efficient use of resources are fundamental aspects of CE, aligning with the principles of sustainability and environmental preservation. Likewise, DE and Industry 4.0 utilize digital technologies and automation to optimize processes, enhance productivity, and create new economic opportunities.

To fully capitalize on the potential of information technologies and these three concepts for sustainable economic growth, it is essential to establish a clear strategy (O. Ogunmakinde, et al., 2021). Recognizing this need, future research efforts will be dedicated to the development of a comprehensive strategy that effectively incorporates CE, DE, and Industry 4.0 (Korachi and Bounabat, 2020). This strategy will serve as a roadmap for developing countries, enabling them to harness the power of these concepts and leverage their benefits to promote sustainable development.

By embracing CE, DE, and Industry 4.0, developing countries can unlock new avenues for economic growth while simultaneously addressing social and environmental challenges. These concepts offer opportunities to enhance resource efficiency, foster innovation, and improve overall social well-being. The integration of these concepts in developing countries can lead to improved living standards, reduced environmental impact, and increased economic prosperity.

In conclusion, this paper provides valuable insights into the integration and utilization of CE, DE, and Industry 4.0 in developing countries. It emphasizes the need for a well-defined strategy to fully exploit the potential of these concepts and maximize their positive impacts. By implementing such a strategy, developing countries can embark on a path towards sustainable development, robust economic growth, and enhanced social and environmental outcomes. The findings presented in this paper serve as a foundation for future research and policy-making in the context of sustainable economic development in developing countries.

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