International Transactions on Education Technology (ITEE)
Vol. 2 No. 1 November 2023

p-ISSN: 2963-6078
e-ISSN: 2963-1947

The Circular Economy's Performance and the Impact of Digitalization

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Author Notification
July, 27 2023
Final Revised
August, 25 2023
Published
September, 05 2023

To cite this document:
Khong, I. (2023). The Circular Economy's Performance and the Impact of Digitalization. International Transactions on Education Technology (ITEE), 3(1) 18-23

Abstract

The acceleration of economic transition towards a more sustainable circular production system is a pressing global concern. This study addresses the scarcity of empirical research on the impact of digitization on circular economy efficiency. It investigates the influence of digitization on the effectiveness of circular economy practices through an empirical analysis of quantitative data obtained from 200 participants within the financial sector of Kozani, Greece. The results, derived from regression analysis, reveal a significant and positive association between digital business practices and circular economy performance. Notably, industrial firms that prioritize digitalization exhibit a notably higher adoption rate of new business innovations for resource efficiency. These findings underscore the strong connection between digitalization and circular economy performance, highlighting the potential for digitalization to catalyze the development of circular business models. This research contributes to our understanding of the pivotal role that digitization plays in advancing sustainable circular economies.
Keywords: circular economy, digitalization, product–service systems, digital business, resource efficiency.

1. Introduction

Manufacturing organizations are presently prioritizing strategies for revenue growth through higher sales volume and cost reduction across supply chain, factory, and operational processes [1]. Within the current linear economic model, characterized by the "take-make-dispose" approach, products are becoming increasingly commoditized, and resource scarcity is impacting various materials [2]. In response, companies are actively exploring alternative approaches to attain sustainable growth and enhance resource efficiency, thus maintaining competitiveness within this economic landscape [3]. Recent years have witnessed a challenge to the traditional growth paradigm rooted in the linear economy, driven by evolving consumer behaviors.

One of the most captivating concepts to emerge in recent times is the Circular Economy. As defined by the Ellen MacArthur Foundation, a circular economy is both healing and sustainable, emphasizing regeneration and the continuous optimization of resources, components, and assets by acknowledging the interplay between technological and biological cycles [4]. The onset of the fourth industrial revolution, which commenced a few years ago, is poised to transform industries. People have reaped the benefits of an array of digital tools and technologies, including information and communication technology (ICT), robotics, machine learning (ML), big data, the Internet of Things (IoT), blockchains, artificial intelligence (AI), cloud computing, 3D technologies, and more [5]. These innovations have proven invaluable in various contexts and have demonstrated their efficacy in addressing global challenges. The circular economy is no exception and has evolved in response to advancements in technological innovation. Through these advancements, digital tool innovation plays a pivotal role in fostering the development of a circular economy [6].

The circular economy, like many other fields, has undergone adaptations influenced by technological advancements [7]. The development of innovative digital tools and methodologies plays a pivotal role in fostering the establishment of a circular economy, aiding businesses and organizations in formulating their circular economy strategies [8]. A fundamental component of circular economy business models is the practice of leasing, renting, or sharing products, as opposed to traditional buying or selling, and digitalization plays a vital role in facilitating and expediting this process [8], [9].

Despite this, numerous organizations in manufacturing and finance sectors have not fully embraced all facets of digitization. Nevertheless, digital technologies are considered potential enablers of the circular economy concept, although the precise mechanisms through which these tools and technologies may drive circular economy principles remain uncertain [10].

2. Research Method

The research adopted a cross-sectional survey research design, utilizing quantitative research methods to investigate various study variables [11]. In this study, the independent variables included digital business innovations and sustainable business practices, while the dependent variable was circular economy performance [12]. The choice of a quantitative methodology was driven by its capacity to gather objective data, which can be effectively conveyed through statistical analysis and numerical representations [13].

The cross-sectional research approach facilitated a focused examination of specific and intriguing digital initiatives, innovations, and attributes within the context of a circular economy. Consequently, it enabled a comprehensive understanding of the instrumental role played by digitization in advancing circular economy principles [14]. Employing the cross-sectional research approach made it convenient to zero in on particular and captivating digital initiatives, innovations, and circular economy characteristics. This approach resulted in a thorough comprehension of how digitalization empowers the circular economy [15].

2.1 Literature Review

Developing a framework for IoT-based product and service platforms represents a key aspect of conceptual research [16]. The authors contend that the integration of IoT solutions to achieve circular economy objectives will exert influence on every facet of a business model. Changes in the value production process, such as heightened individualization, increased customer engagement, the emergence of new costs, and the potential for novel revenue streams, can all impact the performance of the value proposition and its value capture.

IoT and other digital technologies and practices offer significant advantages in various areas, including refurbishment and end-of-life operations, product design, consumer appeal, real-time

product monitoring and tracking, technical support, preventive and predictive maintenance, and product utilization [16].

In contrast, empirical data suggests that a majority of businesses across diverse industries are not adequately positioned to harness the potential benefits offered by digitalization. Numerous challenges associated with the adoption of new business models have been highlighted in existing studies. Among these challenges, businesses face the task of identifying, selecting, and implementing digital innovations that align with their operational needs. Additionally, they must grapple with the pressing necessity of gaining a comprehensive understanding of the development, modification, evaluation, and negotiation of intangible assets.

3. Findings

Leveraging digitalization necessitates a transformation of the business model, entailing the creation of innovative offerings and methodologies to delineate the processes by which value is generated, delivered, and acquired across suppliers, customers, and other elements within the value chain.

3.1 Problem

The circular economy concept has received a lot of attention and acceptance as a long-term paradigm for resource management and waste reduction. However, in the digital age, there are certain challenges that arise when attempting to implement circular economy principles. One of the key issues is the rapid pace of technological advancements and the resulting obsolescence of digital devices and technologies. As new and improved products flood the market, older devices become outdated and are often discarded, contributing to electronic waste.

Additionally, the digital realm poses challenges in terms of the intangible nature of goods and services, making it difficult to trace and monitor their lifecycle. Furthermore, the reliance on complex global supply chains for the production and distribution of digital products makes it challenging to achieve circularity, as there are often barriers to the recovery, recycling, and repurposing of valuable components [17]. To truly realize the potential of a circular economy in the digital realm, innovative solutions are needed to address these issues, including better design for durability and repairability, improved recycling and recovery systems, and the development of sustainable business models that incentivize circular practices. Only by addressing these challenges can we move towards a more sustainable and circular digital economy.

The lack of consumer confidence in second-hand goods and secondary materials may be a hindrance to some circular economy activities. Consumption externalities are more specifically caused by information gaps on the part of consumers regarding the suitability of secondary materials for the manufacture of components and finished goods (i.e., their lack of knowledge regarding the degrees of substitutability between products derived from secondary and virgin materials).

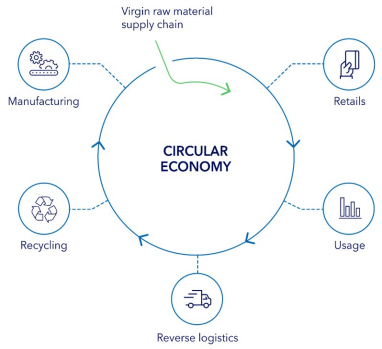
Utilizing a digitally certified quality control system with end-to-end material flow tracking is another option to address customer ignorance, the lack of supply of high-quality recycled materials, and the ambiguity surrounding their quality and availability. This calls for the employment of sensors (to produce data), big data analytics (to offer details on the nature, scope, and timeliness of the supply), and process management (to design procedures for secure reuse) [18].

3.2 Research Implementation

All digital tools have gotten more practical as they have become more widespread and less expensive. This holds true for communications, GPS, mobile devices, and the Internet. The digital economy (DE) is now centered on the Internet. The technology and methods used

by the DE have a lot of potential for increasing productivity and global connectivity among consumers, employees, businesses, and industries in the periphery. Additionally, they provide strong brand-new instruments for promoting creativity in challenging places. Consequently, the DE is built on cutting-edge digital tools, digitized knowledge, and information from the Internet that have an impact on and revolutionize every element of the industrial and social life of the global economy [19].

The study also established a connection between the effectiveness of a circular economy and the progress of digital business practices. Essentially, a digital circular economy framework has the potential to furnish the essential foundations for ecologically and economically sustainable manufacturing processes. The digitalization of the circular economy enhances its functionality and reshapes cognitive models, thereby enabling modifications to the structural framework of the circular economy and an improved understanding of its ramifications. At a structural level, the research promotes critical thinking and equips stakeholders within the circular economy with the tools to effectively utilize their digital infrastructure for processing insights and adapting specific circular economy operations [20]. To address the assumptions that may hinder the complete impact of technological advancements in digitalization on strong sustainability, researchers delve into the layers of mental models to identify the underlying worldviews that drive responses to these impacts.



Picture 1. circular economy

4. Conclusion

The research uncovered a positive correlation between digital initiatives and the success of a circular economy, underscoring the pivotal role of digitization as a potent facilitator of circular economy performance. Furthermore, the analysis unveiled an association between the achievements of a circular economy and advancements in digital commerce. Notably, the study highlighted that enhanced circular economies are intrinsically linked to practices like product reuse and lifespan extension, ultimately resulting in reduced resource consumption through effective material recycling.

Moreover, the study demonstrated that a circular economy offers the opportunity to optimize and safeguard the economic value of various production systems. It is evident that circular economies represent a significant avenue for digitization's potential benefits, with positive implications for society, businesses, and the environment. Digitalization possesses the capability to profoundly enhance circular economies and revolutionize the adoption of circular principles by businesses. Leveraging digitalization can facilitate the implementation of a

circular business strategy that emphasizes strategies like extending, closing, or narrowing the resource loop, delivering substantial cost savings, resource preservation, and the provision of precise and reliable data.

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