Article

The Impact of Digitalization in Supporting the Performance of Circular Economy: A Case Study of Greece

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Abstract: Digitalization has the potential to hasten the economic transition towards a more resource-efficient as well as robust circular production system. However, there is a paucity of empirical research on the influence that digitalization has on the ability of a circular economy to function effectively. The objective of this study was to investigate the effect that digitalization has on the performance of the circular economy. The research was based on an empirical analysis of quantitative data obtained from a sample size of 200 investors and entrepreneurs in the financial sector of Kozani, Greece. Regression results showed that there is a positive relationship between digital practices and performance of a circular economy, and that digital business innovations have a positive effect on performance of a circular economy. Even while a sizeable proportion of Greek companies apply new business innovations to support the strategy of resource efficiency, it is abundantly obvious that this percentage is far higher among industrial organizations that place a heavy focus on digitalization. According to the findings of the research, there is a favorable correlation between the adoption of digital business practices and innovations and the success of circular economies. This demonstrates very clearly that digitalization has the potential to function as a driving force behind the development of circular business models.

Keywords: circular economy; digitalization; product–service systems; digital innovations; resource efficiency

1. Introduction

People are polluting the environment and using up scarce resources faster than the planet can keep up (Larsson and Lindfred 2019). The world has set a new record for how much material the global economy uses. It has passed the 100 billion tonne mark (Larsson and Lindfred 2019; Rizos et al. 2021). Even though fertility rates may go down in the future, the UN predicts that the world population will keep growing and reach 9.8 billion people by 2050. If people keep using plastic at the rate they do now, the seas will be full of plastic by 2050, and there will be more plastic than fish. For a long time, the global economy has been based on the "take, make, throw away" model of consumption and material use. On the other hand, there has been a considerable shift toward a more circular model during the last several years away from this linear one. The idea of a circular economy has drawn a lot of interest as a possible remedy for some of the most pressing and difficult problems related to sustainable development. (Berg and Wilts 2019).

The COVID-19 epidemic has had a significant impact on global financial markets, resulting in a global economic calamity. Many individuals have lost their jobs, and many firms have seen revenue declines. According to researchers, the best method for reviving the world's economy following COVID-19 is to execute and embrace circular economy tactics while abandoning linear economy practices (Khan et al. 2021; Liu et al. 2021). Although the circular economy may provide enterprises with possibilities and generate

value and development, the shift to a circular model is difficult and time-consuming, and it necessitates adjustments in business models, strategies, and regulations.

We are now on the cusp of the fourth industrial revolution, which began a few years ago. Information and communication technology (ICT), robots, machine learning (ML), big data, the Internet of Things (IoT), blockchains, artificial intelligence (AI), cloud computing, 3D technologies, and a large range of other digital tools and technologies have all benefitted people. These innovations have aided individuals in many different circumstances and have emerged as solutions for many of the world's issues. People have benefited greatly from a variety of digital tools and technology (Arthur et al. 2022). The circular economy is not an exception; in addition, adjustments to it have been made as a result of advancements in technological innovation (Agrawal et al. 2022). The development of novel digital tools and methods is assisting in the preparation of the groundwork for a circular economy. They support companies and organizations as they establish business models for the circular economy. By making efficient use of resources, these models have the ability to shut the material loop, slow it down, and narrow it. The practice of leasing, renting, or sharing items rather than purchasing or selling them is one of the most crucial elements of business models that are based on circular economies. One of the primary enablers of this procedure and one of its core facilitators is digitalization (Lawrenz et al. 2021). In addition, in order to foster growth, the CE has to make use of a greater number of fresh talents as a direct consequence of the digital revolution and the growing need for sustainability. According to the most recent study, digital technology has a great deal of potential as an instrument for fostering CE development. The integration of consumer electronics and digital technologies, on the other hand, is a relatively unexplored but rapidly expanding field of research that is just in its infancy at this point. There is a lot of research that has been carried out in the fields of CEs and DEs, but there are not many studies that look at how these two subjects may be merged together. Therefore, the purpose of this article was to investigate the role that digitization plays in enabling a circular economy.

It is important to note that majority of studies, such as Barteková and Börkey (2022), Bressanelli et al. (2018), and Rizos and Bryhn (2022) concentrate on industries and product manufacturing enterprises. However, some organizations in the manufacturing and finance sectors have not fully embraced the different aspects of digitalization On the other hand, despite the fact that very little is known about the precise ways in which these tools and technology may support the circular economy, digital technologies are considered as possible facilitators of the concept. This research aimed to fill in these gaps and illustrate how digitalization may aid in boosting the performance of a circular economy. This goal would be achieved by responding to the research questions as well as testing the hypotheses listed below.

1.1. Research Questions

1. What are the different digital business innovations in a circular economy?
2. What are the different digitalization practices in a circular economy?
3. What is the enabler role of digitalization in the performance of circular systems?

1.2. Significance of the Study

This study on digitalization and circular economy provided unique knowledge on the role played by the different aspects of digitalization in enhancing the performance of a circular economy.

2. Literature Review

Bressanelli et al. (2022b) provide a framework for Internet of Things-based product service systems. This study is one of the conceptual studies. The authors argue that using IoT solutions to achieve circular economy objectives will almost certainly have an effect on all components of a business's model. Changes to the value creation process, such as increased individualization and interaction with customers, as well as new expenses

and possible new value income streams that have an impact on value capture, can all have an effect on the value proposition's performance and cause it to shift in a different direction (Antikainen et al. 2018). According to Bressanelli et al. (2022b), the IoT and other digital technologies and practices increase renovation and end-of-life operations, product design, consumer attraction, monitoring and tracking product activity, technical assistance, preventative and predictive maintenance, and product utilization. Noman et al. (2022) developed a relational matrix that connects the six business model strategies that are included in the ReSOLVE framework to the relevant big-data-enabling properties of each strategy. The authors emphasize that new CBMs are required to address the complexity of using big data for a circular economy and that there should be a focus on understanding the demands of key stakeholders. They also emphasize the importance of prioritizing a focus on understanding the demands of key stakeholders. Roséen (2019) highlights the need to incorporate blockchain applications into a value-driven company strategy as a means of mitigating the consequences of sub-optimization and environmental rebound to the greatest extent possible. Simply focusing on blockchain technology as a means of improving environmental efficiency may promote corporate practices that are not sustainable.

To transform their business models and evolve across digital technologies, such as big data analytics, artificial intelligence, and digital platforms, companies are in a better position to reap the benefits gathered (Parida et al. 2019; Visnjic et al. 2018). The innovation of business models could be described as some proposed, innovative, non-trivial changes to the fundamental aspects of the existing business model as well as the architecture that combines these elements (Foss and Saebi 2016; Ritter and Lettl 2018). Thus, it is suggested that business model innovation focus on introducing new components into individual business model elements as well as into multiple elements, forming alignment in a value creation architecture. In particular, this means that a change in the business model could aim at introducing new components into the individual elements of the company's business model. Conversely, according to evidence, most companies from various sectors are not well-placed to take advantage of the opportunities offered by digitization. Published research names numerous difficulties associated with the introduction of new business models. A special challenge for many companies is to find, select, and implement individual digital advances applicable to their operations. Another challenge is the fact that there is an urgent need for an in-depth understanding of how intangible products are built, modified, analyzed, and sold or purchased. This is well-illustrated by the example of digitally activated advanced service business models, where the offer is not a service or a product, but a guarantee of achieving a particular result for its consumers (Ziaee Bigdeli et al. 2017; Parida et al. 2019). A major result of digital technology and innovative business models is the need for continuous improvement in order to remain competitive and provide long-term value to consumers. Therefore, leveraging digitalization goes hand in hand with business model transformation processes, which require the development of new offerings and processes that determine the way value is created, delivered, and acquired among suppliers, customers, and other parts of the value chain. (Parida et al. 2019; Sjödin et al. 2017; Story et al. 2017).

2.1. Circular Economy

The origin or creator of the circular economy (CE) is unknown, but it seems to have been created in the 1990s based on two academic works: Boulding's "The Economics of the Coming Spaceship Earth" (Boulding 1966) and Mulvey's "Closed-loop Economy" (1976) (Murray et al. 2017). The first model of the circular economy was described by Pearce and Turner (1990, p. 40). In 2014, the term "circular economy" was used for the first time in policy from the European Union. The Circular Economy Package, which the European Commission approved, changed several waste rules and included a message about the transition to a circular economy. However, President Jean-Claude Juncker, who assumed office later that year, examined the suggestion from the new commission. In 2014, the European Commission gave up on its plans to reduce waste, but it promised to come up

with a new, more aggressive plan in 2015. This was because people had wrong ideas about the circular economy, so it was only seen as a way to protect the environment (Ranta et al. 2021). The goal was to get everyone involved together and build better partnerships so that the circular economy could grow across Europe, be put into place faster, and allow problems to be solved in creative ways. In 2018, the European Commission put in place a way to track the progress and success of circular economy projects. This framework uses a set of indicators to cover all the different parts of the circular economy (European Commission—Environment 2015).

Larsson and Lindfred (2019) say that the linear economy and business models may help companies for a short time, but only for a short time. Over a longer period of time, linear models may expose businesses to operational, market, legal, and business risks. Businesses and organizations could take steps to reduce these risks and change their business strategies to be more circular. By 2030, changing from a linear to a circular model of the economy is expected to bring in USD 4.5 trillion, create more jobs, and make the economy stronger (Liu et al. 2021).

Pearce and Turner (1990), in their book "*Economics of Natural Resources and the Environment*", describe the circular economic model based on the idea that there is a strong relationship between the economy and the environment. Pearce and Turner (1990) claim that there are four distinct economic roles for the environment: amenity values include the availability of resources, a place to put waste and emissions, and a system for maintaining life.

Switching to renewable energy and making energy use more efficient are becoming more and more important. So, switching to renewable energy is now part of their plan to change their circular economy (European Commission—Environment 2015). This will be accomplished by making the best use of the resources that have already been used and by avoiding actions that cause pollution and emissions/discharges (European Commission—Environment 2015; Phung 2019).

A summary of definitions for "Economic Opportunities in Relation to a Circular Economy" is provided in Table 1 below.

Table 1. Economic opportunities of a CE.

Author	Economic Opportunities in Relation to a CE
(Antikainen et al. 2018)	CE is a concept that aims to alter the economy's resource allocation. Instead of being thrown away, factory waste might be repurposed to benefit another operation, and products could be repaired, reused, or enhanced.
(Rizos et al. 2021)	CE stands for "restorative" or "regenerative" industry. The emphasis in this approach is on restoration, the use of greener energy, the elimination of dangerous substances, and, most importantly, the elimination of waste. It also aims to reconstruct the ecological and social elements of society by utilizing available resources.
(European Commission—Environment 2015)	One of the EU's objectives to create a sustainable, resilient, and competitive environment is the shift to a more circular economy.
(Khan et al. 2021)	Important components of CE include recycling, reducing, and reusing the many physical inputs to the economy as well as using garbage as a resource to help reduce the use of basic resources.
(Aloini et al. 2020)	CE has the potential to create jobs and promote growth and well-being, while also reducing environmental impacts.
(Böhmecke-Schwafert et al. 2022)	CE is associated with the use of closed-loop materials, which helps to reduce material extraction as well as waste and pollution generation during the investment and consumption process.
(Murray et al. 2017)	By effectively planning and managing the whole procurement, design, and production processes, the CE economic model aims to maximize the utilization of the environment while also enhancing well-being.

Pearce and Turner's book "*Economics of Natural Resources and the Environment*" also details the shift from the traditional linear or open-ended economic system to the circular economic system (Pearce and Turner 1990). The authors examined the conventional linear economic system critically and created a new economic model called the circular economy that uses the

first and second laws of thermodynamics. This model is based on the idea that "everything is an input to everything else". This model, which integrates three economic roles of the environment, resource provider, waste assimilator, and source of utility, emphasizes the connection between the economy and the environment (Pearce and Turner 1990).

The core concepts of the circular economy are encapsulated in many "R" frameworks. 3R, 4R, 6R, and 9R are the most prominent R frameworks for circular economies. The 3R structure is linked to the terms "Reduce", "Reuse", and "Recycle", which are often used interchangeably. It indicates that recycling a product or its valuable components and materials may reduce the amount of raw resources used (Liu et al. 2022a).

The fourth R, "Recover", is added to the preceding R in the 4R framework to stress the necessity of energy recovery from waste. The 6R framework was later expanded with the addition of two additional Rs: "Redesign" and "Remanufacture".

Finally, the 9R framework included "Rethink", "Repair", "Refurbish", "Remanufacture" (such as in the 6R framework), and "repurpose" in the 4R model. Each of these frameworks follows a hierarchy, with each R preceding the next (Barteková and Börkey 2022; Liu et al. 2022a). The 9R CE framework devised by Potting et al. (2017) gives a holistic view of digital functions for a circular economy and hence justifies the effects of digitalization and circular economy performance.

Figure 1 below presents the 9R model by Potting et al. (2017) that explains the process of transiting from a linear economy to a circular economy.

Circular economy			
Increasing circularity — Rule of thumb: more circularity — fewer natural resources and less environmental pressure	Smarter creation and use of products	R0 Refuse	Making a product obsolete by eliminating its purpose or by completely replacing it with another one.
		R1 Rethink	Increased product usage (e.g., via product sharing or multi-functional products).
		R2 Reduce	Less raw materials and natural resources are used in the production of goods in a more efficient manner.
	Extending the lifespan of products and parts	R3 Reuse	Reuse of a product that has been rejected but is still useable by a different user for the same purpose.
		R4 Repair	In order for a product to continue performing as intended, it must be repaired or maintained if it is damaged or malfunctioning.
		R5 Refurbish	An older product is being renovated and/or modernized so that the upgraded version can perform the product's original purpose.
		R6 Remanufacture	Using components from a discontinued product to create a new one that performs the same purpose.
		R7 Repurpose	Incorporating leftover items or their components into new products that serve a different purpose.
	Useful application of materials	R8 Recycle	Processing materials to return them to their original high quality or to lower them.
		R9 Recover	The process of incinerating waste and recovering the energy it contained.
Linear economy			

Figure 1. The 9R model, adapted from (Liu et al. 2022a).

The circular economy has emerged as a potential strategy for decoupling economic development from resource use and waste creation. Bodies of the circular economy might potentially approach sustainability by decoupling economic development from resource consumption and waste creation, but not ignoring the issues that arise as a result of this transformation (Bressanelli et al. 2019, 2022a; Lieder and Rashid 2016).

It should be mentioned that developing a circular economy is a tough and time-consuming process in which the primary aim is to alter the mindset of economic players and organizations in order to create ecological goods that employ cleaner manufacturing processes. Entrepreneurs are change agents who adapt to changing situations and may contribute to this transformation (Khan et al. 2021; Neumeyer et al. 2020; Bag et al. 2020).

As a method for achieving the circular economy, digitization is used. The digital data stored using the binary system are utilized for product digital representation (Mulhall et al. 2022; Liu et al. 2022b; Wang et al. 2022). They primarily give information on the technical qualities and performance of the items. They may also include environmental parameters and can be decoded by software, such as Building Integrated Management (Mulhall et al. 2022; O'Grady et al. 2021). Furthermore, the harmonic collaboration of digital devices and agriculture leads to the development of farm management and practices. An agricultural data-collecting approach would establish the circumstances for integrated monitoring of sustainable agriculture and aid those engaged in long-term development practice planning choices (Crovella et al. 2021; Chehri et al. 2020; Della Chiesa et al. 2019; Kontogeorgos et al. 2017).

2.2. Digitalization

Technology has an impact on several aspects of people's lives nowadays. In the previous three centuries, the industrial revolution had an impact on the environment and social traits. This revolution had a huge impact on economic systems. A significant change in people's lives occurred about 10,000 years ago. Human and animal activities were combined as a consequence of this revolution, resulting in improved communication, transportation, and manufacturing. This advancement aided urbanization and population increase as well. Between 1760 and 1840, the first industrial revolution took place.

On Figure 2 above, Allen and Sarkis (2021) say that mass production became possible with the help of assembly lines and electricity. The third revolution began in the 1960s. This was the era of the creation of computers and the internet. As a result, the third revolution is often referred to as the computer or digital revolution. The fourth revolution, which is now underway, is the most recent. Big data, the Internet of Things (IoT), and artificial intelligence are examples of emerging technologies that fall under the category of "digital technology". (Phung 2019; Ranta et al. 2021; Noman et al. 2022). "Industry 4.0" in manufacturing was made possible by these technologies. Digital technologies such as cloud computing, blockchains, and cyber–physical systems are all linked to the idea of digitalization (Liu et al. 2022a; Ramesohl et al. 2022).
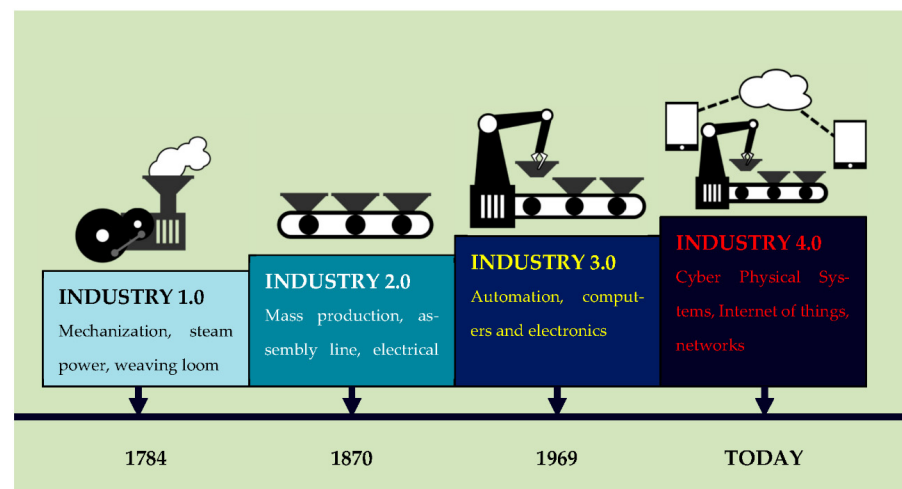

Figure 2. The four industrial revolutions adapted from (Allen and Sarkis 2021).

Bressanelli et al. (2018) say that the Internet of Things (IoT) and other digital innovations or practices are the backbone of the fourth industrial revolution. These have

recently been thought to have disruptive effects. Digitization is mostly caused by computerization, which began in the 1960s with the first commercial mainframe computers. As personal computers became more popular in the 1980s, digital design tools and automated manufacturing improved (Khan et al. 2021).

As digital tools have become more common and their prices have gone down, they have all become more useful. This is true for portable computers, communications, global positioning, and the Internet. The Internet has become the hub of the digital economy (DE) (Arthur et al. 2022; Pagoropoulos et al. 2017). The DE's technologies and practices show a lot of promise for making consumers, workers, companies, and industries in the periphery more productive and better connected to the rest of the world. They also provide strong new tools for driving innovation in places that are hard to reach. So, the DE is built on new kinds of digital tools, digitized knowledge, and Internet-related information that affect and change all parts of the global economy's industrial and social life (Aloini et al. 2020; Lawrenz et al. 2021).

Additionally, digital technology could help companies sell the CE. The IoT, for example, lets businesses track the use, status, and location of items in real time, keep track of materials using the best IoT technology, and recycle items that have been used up. All of these things help with the transition to a CE (Bressanelli et al. 2018). Research also shows that by using the results of process analysis and big data processing in the DE to improve the storage and delivery of economic activities in many sectors, digital data could make a big difference in how well they work (Barteková and Börkey 2022). When COVID-19 showed up, all social and economic activity stopped, which messed up the world economy in a big way. The DE has been seen as a key factor in economic growth, including the rise of new models and businesses such as online education, telemedicine, and telecommuting, as well as the speeding up of traditional firms' digital transformation (Liu et al. 2022a; Rizos et al. 2021).

Digitization principles provide improved information management and transparency in real time for information connected to the circulation of materials and goods under consideration (Preut et al. 2021; Pagoropoulos et al. 2017; Yang et al. 2018). New digital technologies, on the other hand, may help with the adoption of the circular economy by allowing the redesign of business models, consumption habits, and goods (Bressanelli et al. 2021, 2022a; Cagno et al. 2021).

Through the capitalization of digitization, industry is moving toward the fourth industrial revolution (Industry 4.0), which is changing the way we do business in industrial value chains. Some of the industries are already benefiting from Industry 4.0. A new era has dawned in which business has become "smarter" through the use of IoT-related technologies, predictive analytics, and mass data exchange. Process automation and optimization can improve both profitability and productivity by minimizing errors, accelerating production, and saving costs (Parida et al. 2019; Grubic and Jennions 2018). A number of benefits could be mentioned. Automating and optimizing processes can increase profitability and productivity. Recent forecasts from BCG and PwC show that Industry 4.0 will increase efficiency by 15–20 percent over the next five years and will also contribute more than 20 percent to revenue generation. Most professionals in the field discern this change through an affirmative perspective. This information shows that the use of digital technology offers great potential for transforming business models into business-to-business (B2B) scenarios while providing new opportunities for revenue and value. Companies that succeed in leveraging the capabilities of big data and analytics outperform their competitors in relation to revenue growth and efficiency in the way they operate (Parida et al. 2019; Baines et al. 2017).

A large number of industrial companies are motivated to experiment with new business models based on digital technology because of the potential and benefits that are believed to exist. Such models can create and maintain value throughout the product lifecycle based on the solution provided (for example, a service-based, performance-based unit) (Parida et al. 2019; Visnjic et al. 2018). Antikainen et al. (2018) indicate that businesses already employ digital tools to streamline operations. Artificial intelligence (AI) and other

digital tools are being used by businesses to enhance product design and manufacturing in general. Additionally, 3D printing may streamline manufacturing by only utilizing the precise quantity of material required; this technique, which involves building up layers of a product as it is printed, can reduce waste and the usage of extra resources. Additionally, it may be utilized to locally manufacture replacement components, promoting recycling and remanufacturing. Predictive maintenance is a function of the Internet of Things (IoT), which may assist prolonging product lifespans. Additionally, sensors or robots may be used to improve trash management and recycling.

Hedberg and Šipka (2021) indicate that online platforms and digital solutions such as the Internet of Things (IoT) are also allowing service-based business models such as products as a service, where customers buy the desired services, such illumination, mobility, or nutritious food, rather than simply necessary tools or goods. Customers may utilize things more wisely when they are able to pay for their use. Sharing and renting minimize the need for people to possess things, which lowers the requirement for ongoing manufacturing.

A study by Hedberg et al. (2020) revealed that a digitalized circular economy removes obstacles to more efficient resource usage throughout a product's lifecycle, leading to a digital circular economy. Greater links between essential stakeholders throughout the value chain and improved access to better information might be very beneficial for the transition to a circular economy. For safer and more effective reuse and recycling, this entails monitoring and tracing priceless materials, goods, and components as well as hazardous substances along the value chain.

Based on the above literature, the following hypotheses were formulated for this study:

H1. *There is a positive relationship between digital practices and the performance of a circular economy.*

H2. *Digital business innovations have a positive effect on the performance of a circular economy.*

3. Methodology

3.1. Research Type, Design, Study Area, Target Population, and Data Collection

The study employed a quantitative research methodology based on a cross-sectional survey research design, and it was this design that was used in order to assess the many study variables. The study variables included digital practices for sustainability and digital business innovations as the independent variables and performance of the circular economy as the dependent variable. The reason for using the quantitative methodology is that it allows for the collection of objective data that can be clearly communicated through statistics and numbers (Queirós et al. 2017). The cross-sectional research design is dependent on conducting an in-depth investigation of a group or event in order to investigate the causes of a variety of underlying principles that are associated with the research problem or subject matter that is being studied. Because the design of the research was cross-sectional, it was simple to concentrate on particular and compelling digital practices or innovations and aspects of a circular economy. As a result, a thorough comprehension of the enabling role that digitalization plays in a circular economy was achieved.

The research design was chosen so that the researcher could extrapolate the findings to a larger group of community investors and entrepreneurs in the financial sector in Kozani. The financial sector is a segment of the economy that is made up of businesses and organizations that provide financial services to wholesale and retail clients. This industry group includes a wide variety of businesses, such as banks, investment organizations, insurance providers, and real estate companies (Kalogiannidis et al. 2021; Chatzitheodoridis and Kontogeorgos 2020). Therefore, different investors and entrepreneurs are involved in the financial sector, and we found it ideal to utilize them in generating data to understand the enabling role of digitalization in a circular economy. Kozani, in particular, is a little Greek city in the country's north. Additionally, it is one of the four regional subdivisions that comprise the Western Macedonia region (Kalfas et al. 2022; Chatzitheodoridis et al. 2013, 2017). Grevena, Florina, and Kastoria are the other three cities in this region. The Municipality of Kozani, which is

located in the Western Macedonia region of Northern Greece, has a total area of 366,018 square kilometers and a total population of 71,388 as per the census completed in 2011 (ELSTAT 2022). Kozani is approximately 470 km from Athens, Greece's capital, and approximately 120 km from Thessaloniki, the country's second-largest city.

3.2. Sample Size and Sampling Technique

A sample of 200 entrepreneurs and investors from Kozani, Greece, made up the main sample for the study. In the Kozani regional unit, there were 10,198 local businessmen, investors, and entrepreneurs as a whole in 2021. After evaluating the survey's accuracy (km = 114.71) and reliability (P = 99.7%), the sample size was chosen. The variance of the weekly distance they drive by automobile, just for work and business, was calculated using a preliminary sample (or pilot sampling) of 50 persons. S^2 = 74,698.98 and s = 273.31 were the results. The degree of dependability (P) required determines the value of z; when utilizing the sample size calculation, a value of $z = 3$ is often utilized, which equates to a level of dependability of P = 99.7%. Equation (1) calculates that the minimal sample size should be 200.36, or 200 people, using our values of N = 10,198 (population of respondents), s = 273.31 (standard deviation of the sample), z = 3 (value which equates to a level of dependability P = 99.7%), and d = 57.35 (the needed precision d was arbitrarily selected and represents half the confidence interval) (Kalogiannidis et al. 2022a, 2022b, 2022c; Kalfas et al. 2013, 2020).

$$n = \frac{N(zs)^2}{Nd^2 + (zs)^2} \tag{1}$$

whereby:

n is the minimum sample of respondents;
d is the needed precision;
N is the total population;
s is the population proportion;
z is the critical value.

Calculation of the minimum sample of respondents is given as below:

$$n = \frac{10,198(3*273.31)^2}{10,198*57.35^2 + (3*273.31)^2} \Leftrightarrow n = 200.36$$

A purposive sampling technique was used to select the representative sample for the study.

3.3. Data Collection and Data Analysis

To collect data from the chosen entrepreneurs and investors situated in Kozani, Greece, the research used an online survey questionnaire. Data from the chosen citizens of Kozani, Greece, were gathered via an online survey questionnaire. Only after receiving participants' informed permission and verifying that they were willing to take part in the research was data collected. The data collected were helpful in identifying links between the study variables and providing answers to the research questions. Investigative questions on digitalization and circular economies were included in the questionnaire.

The quantitative data were coded, and the SPSS (Statistical Package for the Social Sciences) was used to analyze it. The results are presented in tables, and their interpretation was based on frequencies and percentages. Regression analysis was used to calculate the combined predictive power of the numerous independent variables on the study's dependent variable. In this case, a multiple regression model was needed to calculate different predictive values.

$$\Upsilon = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \varepsilon \tag{2}$$

where:

Y = performance of a circular economy;
β_0 = constant (coefficient of intercept);
X_1 = digital practices;
X_2 = digital business innovations;
ε = represents the error term in the multiple regression model;
$\beta 1 \ldots \beta 3$ = is the regression coefficient for the different aspects of collaborative communication, which helped establish the level of influence that the independent variables (information sharing, decision synchronization, incentive alignment) on the dependent variable (physical distribution service quality) in soft drink manufacturing companies. The hypotheses of the study were tested at the 5% (0.05) level of significance.

3.4. Ethical Considerations

In Kozani, Greece, the researcher made it a point to guarantee that permission had been sought from local company owners and investors as well as leaders in local government at the study's conclusion in accordance with ethical principles. This was carried out to verify the intent of the investors and local government officials to take part in the study.

The researcher ensured that informed consent was obtained to confirm the willingness of entrepreneurs and investors from Kozani, Greece to participate in the study. This was in addition to maintaining a high degree of secrecy and privacy while working with respondents' data. Finally, the respondents were given the freedom to answer questions based on their interpretation of the different opinion questions. This helped in obtaining broad answers to certain questions.

Respondents were given the chance to answer follow-up questions depending on how they understood the various kinds of opinion questions before drawing conclusions about their responses. This was beneficial as it allowed us to collect responses to different questions from a larger group of individuals.

4. Results

The various findings from the SPSS analysis are presented in this section.

4.1. Univariate Analysis

The demographic characteristics of study participants are shown in Table 2 of the research.

Table 2. Demographic characteristics of study participants.

Characteristic	Frequency	Percentage (%)
Gender		
Male	123	61.5
Female	77	38.5
Education level		
Certificate	9	4.5
Diploma	22	11.0
Bachelor's	65	32.5
Master's	97	48.5
PhD	7	3.5
Years spent in financial sector		
Under 5 years	51	25.5
5–10 years	60	30.0
Over 10 years	89	44.5
Total	200	100

Source: primary data (2022).

The majority of the participants (61.5%) were male, and the females only accounted for 38.5%.The majority of the study participants (48.5%) had a master's degree, and only 4.5% had a certificate. The majority of the participants (44.5%) had spent over 10 years in the finance sector followed by 30.0% who had been in the sector for 5–10 years, and only 25.5% had spent less than 5 years in the finance sector.

4.2. Descriptive Statistics

The study sought to establish the different digital practices for sustainability, and the findings on this variable are presented in Table 3.

Table 3. Results on digital practices for sustainability.

	SD	D	U	A	SA
	%	%	%	%	%
1. Information sharing					
Digitalization involves stimulating the development of current small enterprises as well as major firms' circular business methods.	7.0	11.3	2.6	73.7	5.4
CE sustainability is improved by a wider adoption of the Internet of Things, big data, and data analytics.	3.0	2.7	5.8	62.8	25.6
Since digitalization is largely technologically driven and turnover-driven, it can lead to exploitative practices.	11.8	20.2	4.4	53.9	1.6
The digital sector has a big environmental impact and consumes a lot of energy.	10.3	4.7	11.5	28.2	45.3

Key: SD = strongly disagree, D = disagree, U = undecided, A = agree, SA = strongly agree. Source: primary data (2022).

The results in Table 3 indicate that 73.7% of respondents agreed digitalization involves stimulating the development of current small enterprises as well as major firms' circular business methods. A total of 62.8% of respondents also agreed that CE sustainability is improved by a wider adoption of the Internet of Things, big data, and data analytics. A total of 53.9% agreed that since digitalisation is largely technologically driven and turnover-driven, it can lead to exploitative practices. In addition, 45.3% of respondents strongly agreed that the digital industry uses a lot of energy and has a significant negative influence on the environment.

The study also sought to explore the different digital business innovations in a circular economy, and the findings are presented in Table 4.

The results in Table 4 reveal that 49.2% of respondents agreed that digital technologies allow for greater efficiency and circularity in material processing and product manufacturing. A total of 57.5 % of respondents disagreed that the majority of Greek businesses operate on the cloud. Moreover, 43.2% of respondents agreed that digital advancements make materials more durable, repairable, reusable, and recyclable, and trash is converted into a resource. In addition, 47.9% of the respondents agreed that the individual/isolated segments of the value chain may benefit from digital technologies that link data, partners, devices, and customers.

Table 5 presents the findings concerning circular economy business models.

Table 4. Results on digital business innovations.

	SD	D	U	A	SA
	%	%	%	%	%
Digital technologies allow for greater efficiency and circularity in material processing and product manufacturing.	3.6	8.4	4.7	49.2	34.1
The majority of Greek businesses operate on the cloud.	57.5	12.6	9.4	11.9	8.6
Digital advancements make materials more durable, repairable, reusable, and recyclable, and trash is converted into a resource.	5.9	7.7	10.2	43.2	33.1
Individual/isolated segments of the value chain may benefit from digital technologies that link data, partners, devices, and customers.	3.8	4.3	20.2	47.9	23.9

Key: SD = strongly disagree, D = disagree, U = undecided, A = agree, SA = strongly agree. Source: primary data (2022).

Table 5. Results on circular economy business models.

	SD	D	U	A	SA
	%	%	%	%	%
The circular economy allows for the reduction in resource use by recycling materials.	5.2	3.5	6.6	38.4	46.3
Improved circular economies are associated with reusing products as well as extending their lifespan.	2.6	6.8	17.1	47.0	26.5
A circular economy allows for maximizing and maintaining the economic value of different product systems.	4.0	6.0	7.7	30.8	51.5
Creating a highly performing circular economy necessitates significant changes across the value chain.	1.9	4.7	6.3	31.6	55.6

Key: SD = strongly disagree, D = disagree, U = undecided, A = agree, SA = strongly agree. Source: primary data (2022).

The results in Table 5 indicate that 46.3% of respondents strongly agreed that the circular economy allows for a reduction in resource use by recycling materials. A total of 47.0% of respondents agreed that improved circular economies are associated with reusing products as well as extending their lifespan. The respondents (51.5%) strongly agreed that a circular economy allows for maximizing and maintaining the economic value of different product systems. Finally, 55.6% of the respondents strongly agreed that creating a high-performing circular economy necessitates significant changes across the value chain.

4.3. Regression Analysis

The relationship between digitalization and an improved circular economy was established using regression analysis as presented in Tables 6–8.

Table 6. Model Summary.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.798 [a]	0.673	0.484	0.60214

a. Predictors: (constant), digital practices, digital business innovations.

Table 7. ANOVA.

	S	Sum of Squares	Df	Mean Square	F	Sig.
	Regression	76.204	2	28.031	73.201	0.014
1	Residual	71.051	198	0.413		
	Total	147.255	200			

a. Dependent variable: performance of a circular economy. b. Predictors: (constant), digital practices, digital business innovations.

Table 8. Coefficients.

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
	(Constant)	0.588	0.126		1.941	0.210
1	Digital practices	0.168	0.054	0.371	1.124	0.024
	Digital business innovations	0.042	0.072	0.062	0.817	0.011

a. Dependent variable: performance of a circular economy.

The dependent variable was a circular economy. The independent variable was regressed against the dependent variable, obtaining an R^2 value of 0.673. This indicates that

the independent variables jointly explain 67.3% of the variation in the dependent variable (circular economy). The regression results also confirm that the study's independent variables did not influence 32.7% of the changes.

The F statistic of 73.201 at prob. (Sig) = 0.014 conducted at a 5% level of significance means that there was a statistically significant linear relationship between the independent variables and the dependent variable (performance of a circular economy) as a whole.

The results in the table above confirm a relationship between digitalization and performance of a circular economy since $p < 0.05$.

Hypothesis Testing

Since the significance level of 0.024 was less than 0.05%, we confirm that digitalization is a positive enabler in regard to the performance of a circular economy. Therefore, we accept hypothesis H1 and conclude that there is a positive relationship between digital practices and the performance of a circular economy.

Additionally, there was a relationship between digital business innovation and the performance of a circular economy since the significance level of 0.011 is less than 0.05%, and we therefore accept H2 and conclude that digital business innovations have a positive effect on the performance of a circular economy.

5. Discussion

The study showed that digitalization is a positive enabler of the performance of a circular economy. This indicates that digitalization opens up new opportunities by providing data on product location, condition, and availability. They emphasized the need for open, accurate, and massive data in decision making. The study findings show that digitalization allows for the creation of new digital platforms and marketplaces based on the virtualization of goods and processes.

The study showed that there is a positive relationship between digital practices and performance of a circular economy. In this case, digitalization also makes networking, cooperation, and cocreation with stakeholders, including consumers, simpler and more efficient (Böhmecke-Schwafert et al. 2022). Digitalization, according to the respondents, encourages user engagement in product and service creation processes while also assisting firms in reaching and interacting with consumers more effectively than previously. The switch from a linear to a CE structure is made possible by the implementation of a digital infrastructure upgrade (Neligan 2018). A digitalized CE infrastructure will be more responsive to changes in policy and market settings if certain dynamic data patterns are identified. The structural layer might perhaps benefit from such pattern-layer thinking by better identifying critical challenges (Larsson and Lindfred 2019; Liu et al. 2021).

The study also showed that there is a relationship between digital business innovation and the performance of a circular economy. In principle, a digitalized CE infrastructure could be able to provide the structural requirements for manufacturing systems that are both ecologically and economically sustainable. Better performance and mental models are the result of digitalizing the CE, which makes it possible to adjust the structure of the CE and learn about its impacts (Barteková and Börkey 2022; Khan et al. 2021). Even though it is highly unlikely that research that improves knowledge on the pattern layers will completely resolve the debate over the technological solution, it may help to clarify the roles of various technologies in the developing CE practices' information architecture and accelerate the adoption of best practices (Bressanelli et al. 2022b). At the structural level, research encourages the expansion of one's thinking and allows CE stakeholders to utilize their CE digital infrastructure to absorb outcomes and alter particular CE operations in an appropriate manner. Going into the mental models' layers is the only way for researchers to both identify the worldviews that drive impact reactions and correct the assumptions that prevent the technical breakthroughs brought about by digitalization from having a full influence on strong sustainability (Khan et al. 2021; Berg and Wilts 2019; Cesari 1967). According to the paper, CEs combine hard, measurable scientific progress with more

abstract, nebulous forms of societal improvement. In order to develop and implement theory in CEs, research on digitalization has to move beyond the approaches that are traditionally accepted and which are conceptually confined. In spite of the significance of the existing theory, it is essential to develop a brand-new theory in order to accomplish paradigmatic breakthroughs and ensure long-term sustainability (Allen and Sarkis 2021; Antikainen et al. 2018).

One of the most important enablers of customer engagement and interactive interactions is social media. Furthermore, as a result of digitization, marketing is becoming more interactive and intelligent. Finally, the study showed that digitization aids in cost reduction and increased efficiency, especially resource efficiency. Despite the great potential for advancing CE digitalization research and knowledge, we recognize that there are restrictions to completing studies on this new issue (Barteková and Börkey 2022; Rizos and Bryhn 2022). The activities carried out and the capacity to monitor effects may be restricted in the early deployment, in addition to the usual implementation problems. It is important to use theory to evaluate potentials and recommendations when there has been minimal implementation, and also to exploit CE digitization experiences to increase theoretical knowledge when more has been accomplished.

6. Conclusions

The study showed that digitalization is a positive enabler in regard to the performance of a circular economy; hence, there is a positive relationship between digital practices and the performance of a circular economy. The study also showed that there is a relationship between digital business innovation and the performance of a circular economy. The study revealed that a circular economy allows for reduction in resource use by recycling materials, and the improved circular economies are associated with reusing products as well as extending their lifespan. Additionally, it was revealed that a circular economy allows for maximizing and maintaining the economic value of different product systems. It is clear that CEs are largely connected to different digitalization opportunities that benefit people, businesses, and the environment. It is possible that digitalization will be of tremendous assistance to CEs, and it also has the potential to be a game-changer for the transition of a large number of businesses to a CE. The adoption of a circular business model that focuses on delaying, closing, or narrowing the loop may greatly benefit from the use of digitalization. This can assist in the reduction in costs, the preservation of resources, and the provision of data that are reliable and correct. The many business models that underpin a circular economy are predicated on the idea that the ecosystem, rather than a single company, is responsible for closing the loop. In order to make circular business models a reality, it is necessary to network and coordinate with many stakeholders, in addition to finding new business partners. While brand-new products and services are essential, the advent of digitalization has opened the door to chances for cocreation with many stakeholders and individual customers. Platforms for online collaboration that make use of virtual technology are becoming an increasingly significant part of the networking and cocreation processes. In addition, we are aware that consumers, particularly those who are early adopters of new products and services, play an important part in the transition to the CE. The respondents believed that the ability to contact consumers and connect with them is essential for the development of innovative circular business models and that digitalization makes both of these things possible.

6.1. Theoretical Contributions

This study also clearly showed that a circular economy can be relied upon to eliminate the different limitations of a traditional linear economy and hence could be used as a suitable framework to make national economies more sustainable and resource-efficient. Furthermore, business entities can utilize the different aspects of a critical consideration of digitalization, such as innovations to enhance the performance of a circular economy.

6.2. Practical Implications

This study provided evidence for how different business models can be incorporated digitally to enhance the performance of a circular economy. Business can therefore achieve greater profitability by utilizing different models that emphasize sharing, reusing, repairing, and remanufacturing to provide substantial prospects for innovation. The study also explained a circular economy as a paradigm based on three design-driven principles: reducing waste and pollution, extending the useful life of goods and materials, and regenerating natural systems. Therefore, governments can utilize this paradigm to eradicate environmental pollution and achieve sustainability of resources in the economy.

6.3. Future Research Perspectives

To allow for effective cooperation, challenges linked to data sharing must be handled. Gaining trust and security in data exchange are major difficulties that may be overcome with creative technical solutions, such as blockchain technology. This research was a first step in determining the role of digitalization in the implementation of CE-based business models. As a result, further research on real-world business scenarios using both qualitative and quantitative data is required.

7. Limitations

The challenges with the study design and execution are the primary factors contributing to the limits of this body of work. The COVID-19 pandemic was a serious limitation to all of the efforts that have been made. Even if there was an attempt made to steer clear of bias, it is possible that it still exists. The sample and the methodological problem were also limitations of this study. The unwillingness of the respondents to finish and return the questionnaire in its whole and on time was an additional restriction that should be taken into consideration. In a subsequent study that is analogous to this one, it may be possible to investigate the perspectives of a sample that represents the whole of the area or the entirety of the nation. Nevertheless, an appropriate purposive sampling technique was utilised to select a suitable sample for the study so as to enhance the generalizability of the study findings.

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