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The role of digitalization in innovation: Investigating the environmental sustainability in the context of circular economy in UAE

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Abstract

The study aimed to evaluate the role of digitalization in innovation in terms of circular economy. For the attainment of this goal, the researcher collected data using qualitative methods such as semi-structured interviews with managers and experts from different organizations in the UAE. Further, the qualitatively gathered data was analyzed using thematic analysis to summarize research outcomes. The outcomes disclosed that digitalization such as AI applications, 3D printing, and big data analytics are some of the factors that contribute significantly to bringing innovations and help reduce waste of time, money and other resources. Though digitalization brings multiple benefits some challenges are also there such as skill shortage, lack of infrastructure, waste generation from the disposal of new technologies, and data privacy and security. However, these challenges can be overcome by training and developing employees (T&D), developing equal infrastructure, recycling systems, adopting advanced technologies, and complying with data privacy laws and regulations.

Keywords: Environmental sustainability; Circular economy; Digitalization; Innovation; Digital technologies

1. Introduction

The concept of digitalization has been growing in the globalized economy for many years. This concept is tied to Industry 4.0 and many revolutionary digital technologies are fueling the digital transformation (Hizam-Hanafiah & Soomro, 2021). Digitalization is playing an immense role in innovation and gaining a competitive edge over the competition, companies are taking help from the data which is provided by digitalization. It is found that stressful transformation has taken place in multiple industries and this happens due to increasing competitiveness (Botha, 2018). Companies to gain a competitive edge over their rivals tend to adopt digitalization which is progressively based on the use of Industry 4.0 and encourages the automation of tasks (Kamarul Bahrin et al., 2016). The concept of Industry 4.0 is highly affected by the process of open innovation (Skordoulis et al., 2020).

A growing phenomenon in this modern era is the digitalization of business organizations throughout many industries is made possible by modern digital technologies including IoT, big data analytics, machine learning, and cloud computing (Javaid et al., 2022). For the attainment of significant business benefits like boosting client satisfaction and participation, optimizing operations, and developing new business models, organisations must be successful in adopting change using digital technologies (Bleicher and Stanley, 2017). Moreover, Borouge utilises Borealis' latest exclusive technologies and assists in tackling global challenges like climate change, waste from food and shortages, availability of fresh water, energy shift, healthcare assistance, and waste management (Burke et al., 2021). Borouge is dedicated to offering creative remedies for an array of businesses and consumers within the globe in an efficient and environmentally

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conscious manner. Further, Harteis (2019) found that skill shortage is a challenge for digital implementation and training and development can be a solution to this issue.

Yet, to gain and achieve the maximum benefits from digitalization, it is mandatory for UAE companies they understand the benefits of digitalization and the associated challenges and solutions with their applications. Though there is a wide range of studies, literature discussing the opportunities and challenges is limited specifically within the context of the UAE. Therefore, this research aims to explore the opportunities and challenges of digitalization for a circular economy within the context of the UAE.

1.1. Research Questions

This research aims to build an understanding of the opportunities and challenges associated with the implementation of digitalization for circular economy purposes. For the attainment of this research goal, this study answered three questions.

- Question 1: What are the opportunities associated with the implementation of digitalization for a circular economy?
- Question 2: What are the challenges associated with the implementation of digitalization for the circular economy?
- Question 3: How can the challenges of implementing digitalization for the circular economy be resolved?

In this paper, the researcher used the term digitalization referring to the use of modern technologies such as artificial intelligence (AI), big data, and 3D printing.

2. Literature Review

Antikainen, Uusitali and Kivikyto-Reponen (2018) found digitalization as a booster of transforming the world towards a more sustainable circular economy. The study found that digitalization provides companies with accurate information regarding the location, conditions of the products and their availability, which supports companies in closing the material loops. Digitalization has an important role in making processes efficient within organizations which enables companies to reduce their waste activities and associated costs with them and results in minimizing the transaction cost. Digitalization by enhancing the efficiency of processes ensures the maximization of product life. Hence, it is said that digitalization by reducing the processes and closing loops, boosts the circular economy. It is necessary to note that in the consequences of digitalization, the material loop not only slows but becomes narrow leading companies towards resource efficiency. However, the authors did not adopt a biased view and also reflected on the challenges that companies have to face during the adoption of digitalization and hindering companies from taking complete advantage of digitalization in terms of the circular economy. Some of the challenges that companies face in digitalization include data gathering and its management, competence, and collaboration requirements. It becomes difficult for companies to maintain the collaboration and the competence level that is required to take advantage of digitalization for the circular economy. Further, product visualization and processes, utilizing digital technologies and stakeholder collaboration are some of the major opportunities that companies avail in return for adopting the circular-based business models. Continuing the role of digitalization in the circular economy, Bartekova and Borkey (2022) explained digital transformation as a key that helps unlock the benefits of more sustainable, inclusive growth and enhanced social well-being. Digitalization is beneficial for economic stability as it contributes to the decoupling of economic activity out of the utilization of natural resources and their impact on the environment. Digitalization has become an important source of circular economy and resource efficiency.

According to Climate-KIC (2018), information availability is one of the keys to facilitating a circular economy. Digital transformation allows companies to have circular economy benefits by providing companies with the necessary information and knowledge that helps facilitate the development of new processes. For example, digitalization help companies reduce their transaction cost and also support reducing the risks associated with the sharing model. All these activities are con by digitalization as it helps to facilitate interactions. Taking a slightly different approach, Vilkokari et al. (2019) explained that digitalization imputes and decentralizes the information exchange, it also facilitates the product service system by enabling product materialization, real-time product performance monitoring, and replacing physical content with online one. Xu, She and Liu (2022) claimed that digitalization is a source of environmental sustainability as it enables people to have access to the vast untapped data that contains and potential to help companies plan strategies for the circular economy. Digitalization enables the connection of smart systems to the internet which provides companies with an opportunity to resolve issues relevant to long-term sustainability. Digitalization is a game-changing tool that integrates the benefits of sustainable development of products, environmental sustainability, and

socio-economic development. Digitalization ensures a circular economy within companies and nations by providing better living conditions. The study discussed welfare programs and found that digitalization plays a key role in activating the involvement of the public, enhancing transparency, and ensuring clear governance in welfare programs. Digitalization hastens the transition towards improving people's happiness, health, and sustainable industrial processes (Xu, She and Liu, 2022). Digitalization takes a holistic approach and addresses major challenges such as climate change and biodiversity, but digitalization contains data privacy and security challenges (Paul et al., 2023).

Kalohiannidis et al. (2022) researched to examine the impact of digitalization in supporting the circular economy while considering the case of Greece. The authors claimed that digitalization has the potential to make a transition towards more circular and resource-efficient production systems within organizations. The study found that digitalization has a positive influence on organizational performance and digital business innovations tend to have a positive association with the circular economy of the country. The study outcomes unveiled that when the companies were evaluated for their business innovations, it was found that digital innovations support the strategies that make an efficient use of resources. It was obvious that companies with digitalization tend to perform well in the circular economy compared to the companies that do not have digitalization processes or technologies within their organization. The study outcomes unveiled that there is a correlation between innovations, circular economy, and digital practices. The study outcomes disclosed a clear potential of digital technologies in developing the circular economy processes.

Cagno et al. (2021) highlighted that the significance of digital technologies in facilitating the transition to a Circular Economy is now generally recognized. Nonetheless, operationalization of the discourse is necessary for the transformation. This research executes a comprehensive literature review to better comprehend how digital technologies might facilitate the transition to a Circular Economy. The analysis was informed by the ReSOLVE paradigm, which is widely recognized for its ability to assist industrial enterprises with the transition to the Circular Economy. Despite the extensive focus on the topic by the existing literature, the results of the analysis indicate that only a limited number of Circular Economy aspects and specific technologies are addressed, making it difficult to obtain an inclusive summary of the implementation of DT in the transition to a C and to address it effectively. From an empirical perspective, weaknesses are emphasized, such as the lack of an integrated and integrative study of the linkages, the need to investigate the decision-making process, and the absence of research into specific Circular Economy initiatives. The conclusion of the study suggests prospective future research directions and discusses their theoretical and practical implications. Continuing with the positive aspect of digitalization and its role in innovation, Agrawal et al. (2022) mentioned that digitization contains an ability to change the overall game for companies to create sustainable circular products, according to the findings. Participation from consumers is essential for digitization to successfully foster the development of novel, sustainable, circular products. To expedite the transition toward consumer electronics and digitalization, it was suggested that the researcher employ a product-service model.

Neligan et al. (2023) exerted that at any point during the product lifecycle, a new circular business model may arise. Digitalization may produce new business models, new forms of cooperation, and disruptive innovations by hastening the economy's transition toward more circular production systems and the use of resources in more efficient ways. Nonetheless, there is a paucity of empirical research examining how digitalization may pave the way for a circular economy. This study investigates the impact of digitalization on the promotion of circular business models. It comes out that manufacturers with a strong digital focus are more likely than their German counterparts to rely on innovative business models as part of their resource efficiency strategy. This suggests that digitization may facilitate the introduction of circular business models. Distinctively, Chauhan, Parida and Dhir (2022) found that developing technologies in the domain of digitalization such as artificial intelligence (AI), Internet of Things (IoTs), big data, and blockchain offer opportunities for the circular economy (CE). Many issues, especially those associated with the transition to a circular economy, are believed to have solutions in the combination of digital technology and inventive business models. Due to their growing social and practical significance, there has been an increase in scholarly writing on CE and digitalization in the past decade. This study aims to synthesize the critical discourse at the interface of CE and digital technologies. To shed light on how to implement CE most effectively, the researcher conducted an exhaustive literature review based on emerging themes. The results demonstrate the significance of IoT and AI in the evolution of CE. Numerous studies highlight psychological issues, lack of predictability issues, information fragility, and policy concerns as significant barriers to digitalization-driven CE transformation. In addition, the study found a product service system (PSS) as a significant development in the business model for the digitally enabled CE. A comprehensive analysis of the current literature has resulted in the development of a system-based framework for digitally enabled CE, disclosing connections between various areas of expanding research and offering new perspectives on how to realize CE's benefits.

Further, Okorie et al. (2018) stated that since its introduction in the early 1990s, the concept of CE has acquired traction in academic, governmental, and commercial communities. Recent trends in the field of CE include questioning the

relationship of CE with sustainability and other concepts, questioning it as a paradigm, and the iterative definitions of those concepts. The researcher stated that the sector is a continually evolving industrial system, which includes Industry 4.0 and production processes, with data enabling the most recent advances in DT, and has also been found to present a significant opportunity for the application of circular methods. There has not been extensive research into combining these two disciplines. Through an exhaustive examination of the intertwined domains of CE and I4.0, this study presents an integrative and synergistic CE-DT paradigm with policymaker recommendations and future research suggestions. To achieve this, the researcher attempted to conduct a systematic literature review (SLR; n = 174) of empirically-based studies on digital technologies, I4.0, and circular methods. This systematic literature review was based on the articles that started in 2018. In addition, this article summarizes recent developments in CE research that pertain to manufacturing. While research on CE is on the rise, research into the digital technologies required to realize a CE is still in its infancy, according to the findings. Despite the prevalent belief in the "interdisciplinary" of CE research, the results indicate that a significant portion of it is engineering-focused. In light of these deficiencies, the conclusion of the study proposes a synergistic and integrative CE-DT paradigm for future research.

3. Methodology

The research methodology is aligned with the research aim and the particulars of the study. In this research, the study utilized interpretivism research philosophy. Organizations in the United Arab Emirates were observed about their participation in circular economy activities and the impacts of adopting digital technology on sustainability. Further, to collect qualitative data, the researcher conducted one-on-one interviews with managers and experts from different organizations implementing circular economy principles in the UAE. The qualitative data accumulated here cast light on the challenges, opportunities, and solutions for balancing digitization and sustainability within the circular economy.

The researcher applied thematic analysis on the qualitatively collected data due to which the patterns, trends, and relationships between the UAE's digitization, innovation, environmental sustainability, and circular economy practices became apparent. By transcribing and analyzing the qualitative data obtained from interviews using theme analysis, the study unveiled the role of digitalization in innovation and environmental sustainability within the context of the circular economy. The data analysis assisted in gaining insights into different perspectives and narratives. To thoroughly comprehend the role of digitalization in innovation and its impact on environmental sustainability within the circular economy of the UAE, it was necessary to synthesize qualitative research findings. Analyze the data side-by-side to identify trends, highlight issues, and propose solutions. The research adheres to ethical principles, obtains necessary approvals, and verifies the authenticity and veracity of the data throughout the research.

4. Data Analysis

4.1. Digitalization as a Driver of Circular Economy

The respondents of the research find digitalization as a driver of circular economy as they believe that digitalization can help reduce carbon footprints and is a key enabler of the decarbonization transition. The positive role of the circular economy is not limited to a single sector but it has spread throughout the different industries such as building, transportation, energy and power, and manufacturing sectors. For example, digitalization such as mobile technologies that include AI being used by multiple companies to reduce their use of energy at individual level to reduce cost that automatically contributes to a lower environmental footprint.

Some of the respondents believe that digitalization enables them to have better tracking and monitoring of resources and therefore better management of resources throughout their lifecycle. Using digital technologies such as AI applications, the Internet of Things (IoT) and sensors, and data analytics, companies optimize their resource use which helps reduce waste and improve resource efficiency which is fundamental to a circular economy (Burke et al., 2021; Bartekova and Borkey, 2022; Neligan et al., 2023). The respondents also highlighted the use of blockchain technology as a part of digitalization and found it useful for improving transparency. Transparency facilitates the repurposing of material, recycling, recovery, and effective management of reverse logistics.

A respondent commented,

"The circular economy initiatives are supported by collaborative, sharing activities. Digitalization provides us with platforms for sharing information and collaborative activities. For example, digital platforms enhance coordination between distinctive industry stakeholders such as suppliers, waste management agencies, and production companies. Coordination with these stakeholders enables us to exchange information that results in the product components, materials,

and products". This means digitalization reduces the production of new things by fostering collaboration and resource optimization.

One of the respondents said,

"As per my experience and knowledge, integration of technological advances is beneficial for creating an environment for innovation. Digitalization enhances coordination that results in creating operational efficiency leading firms towards improved services."

Two of the respondents commented that digitalization is a key to success as it enables individuals and firms to necessary coordination between them. Digital technology provides companies with an opportunity to promote equitable and sustainable growth. Digitalization is beneficial for the circular economy as it prominent different ideas that help to reduce the inefficient use of resources and waste of time and resources. Each activity requires some time to complete and the cost is associated with them. Reduction in the repetition of activities means employees are free to invest their time in more creative activities. Hence, digitalization not only helps make the processes efficient but also provides companies with an opportunity to think creatively and bring further innovations. According to the respondents, digitalization is supporting them in meeting the circular economic goals of the country by allowing them to be more effective and efficient in making use of natural resources.

Three of the responses also unveiled that digitalization contributes to the circular economy of companies by providing them with an opportunity to make data-driven decisions. For example, digitalization enables companies to generate and analyze the vast amount of data that can be harnessed to make informed decisions. By assessing the data related to product utilization, production patterns and waste generation, companies can realize the opportunities for developing innovative remanufacturing and recycling processes. Digitalization technologies such as online platforms, mobile apps, and augmented reality play important roles in enhancing the awareness of consumers and keeping them motivated to invest in sustainable products. Further, digitalization allows companies and their consumers to share the used products. For example, some companies sell second-hand watches to their customers reducing the need to make new products.

One respondent communicated that digital innovations are the drivers of making efficient use of resources. Digitalization helped his company to create sustainable products and encouraged the company to make decisions to transform waste into viable products. The use of digitalization provided his company with multiple opportunities in terms of developing a circular economy. For example, digitalization provides companies with an opportunity to promote transparency, enhance resource management, enable, ling data-driven decision-making, foster collaboration, engage customers and support product recycling. Digitalization by leveraging innovations enables companies to meet environmental sustainability targets and make the transition towards a more circular and sustainable economy.

4.2. Digitalization is a Challenge

Some respondents in answer to the questions related to challenges associated with digital technology replied that the digital divide is a challenge in the way of applying digital technologies. All companies in the country do not have equal access to digitalization and this uneven digital infrastructure influences the circular economy negatively. The respondents said that the implementation of digitalization includes the gathering, storage, and assessment of a large amount of data. The privacy and security of the data are major concerns for companies and managing data privacy is a challenge for them.

One respondent commented,

"A lack of trust in data security and privacy can undermine the adoption of digitalization as a solution to the circular economy."

The United Arab Emirates (UAE), like many other nations, is experiencing resource depletion and scarcity. By investigating environmental sustainability within the context of a circular economy, the United Arab Emirates has implemented practices that promote efficient resource utilization, reduce waste generation, and extend the tenure of resources through recycling and reuse. Reduced reliance on finite resources and enhanced resource efficacy contribute to increased environmental sustainability over the long term. The circular economy concept reduces glasshouse gas emissions, which assists the fight against climate change. Circular economy analysis of the UAE's environmental sustainability may reveal opportunities to implement energy-saving technologies, promote renewable energy sources, and improve transportation and logistics systems. This assists the UAE in achieving its goals of reducing carbon emissions and transitioning to a low-carbon economy, both of which are crucial to the struggle against global warming.

One of the respondents voiced,

“Integrating digitalization in business operations was a challenge for us, as we did not have a skilled workforce who could effectively leverage and operate digital technologies.”

Two of the respondents specified interoperability and technical complexity as challenges to the adoption of digitalization. For many companies, the integration of systems and digital technologies can be challenging. The issues related to interoperability issues occur often when companies attempt to exchange and connect across different platforms, stakeholders, and devices. Even, cost and return on investment are also some of the challenges associated with the adoption of digital technologies. For example, the implementation of digital technologies and their maintenance contain significant costs that include the development of infrastructure, training, and software development. Cost can be one of the major barriers in the way of adopting digitalization specifically for small and medium size companies whose profit margin is not so high that they invest heavy finances in technological adoption.

Contrary to other respondents, one respondent claimed,

“Digitalization indeed supports a circular economy, but e-waste generation is associated with digitalization. It is not that digitalization does not cause environmental issues, the disposal of infrastructure and digital devices contribute to environmental issues.”

4.3. Solutions to difficult issues

One of the respondents asserted,

“It is identified that there is a digital divide in the UAE concerning the digital infrastructure and due to this uneven support to some industries and some not in terms of providing finances and infrastructure create problems in adopting digitalization that result in negatively influencing the circular economy. Hence, there is a need for the policymakers in the UAE to make efforts to bridge this gap and ensure that all industries have easy access to digitalization and all stakeholders can benefit from advanced technologies.”

Two of the respondents stated that digitalization enables companies to collect and analyze a larger amount of data that contains threats to privacy and security which are necessary to address. Hence, to overcome the issue of data privacy and security, the response suggested that organizations must comply with the developed data protection regulations. Some respondents favored the implementation of robust measures of cybersecurity that also help safeguard information sensitive. Further, one of them specified that the shortage of skilled workforce is a challenge for companies in adopting digitalization and one of the core solutions to this problem is to train and develop employees by offering them upskilling and reskilling programs. Another respondent stated that it is mandatory for companies that their workforce is equipped with technical skills and digital literacy. Therefore, organizations must adopt culture and work processes to accommodate the changes that digitalization brings. Employees should be trained to adopt changes because digitalization fosters continuous learning and a culture of innovation.

One of the respondents stated,

“Companies should understand that digitalization is not the elimination of waste completely, the technology itself can cause waste generation. Hence, companies integrating digital technologies should be aware of and prepare for recycling and e-waste management practices to mitigate these impacts and assure the digital technologies themselves.”

Some respondents replied that to overcome the integration and interoperability issues, companies can develop standardized protocols. They believe that interoperability systems are critical for seamless collaboration and communication across the circular economy of the ecosystem. Some of the respondents said that as the adoption of digitalization can be an expensive process for some businesses particularly small in nature, they believe the adoption of digitalization should evaluate their return on investment (ROI). Further, from the perspective of government or policymakers, it is pivotal that they develop strategies to provide financial support to such businesses to encourage them to adopt digitalization for the improvement of a circular economy.

5. Discussion

It is assessed that digitalization is a use of digital technologies and also includes the use of AI applications to reduce cost and use of resources to lower the environmental footprint. Further, the data analysis disclosed that the circular economy

is based on the optimization of resource utilization by businesses through the use of digital technology, such as the incorporation of blockchain technology, extolling its potential to increase transparency. Transparency facilitates material reuse, recycling, recovery, and efficient reverse logistics management. These outcomes were supported by Chauhan, Parida and Dhir (2022), as the authors regarded AI as an important component of digitalization and stated that AI applications play a critical role in the circular economy of companies and that blockchain offers opportunities for the circular economy (CE).

The data analysis unveiled that collaboration and information sharing are essential for activities for a circular economy as collaboration enables employees to share their ideas and information and find the best possible innovations to resolve environmental issues and improve the circular economy. Interaction between suppliers and buyers is crucial to reduce waste as it enables companies to order limited amounts of material and prevent them from wrong order delivery and receiving. The outcomes of the research helped assess that coordination is a key to operational efficiency as it helps reduce the number of repeated activities and reduces the process of doing something. Operational efficiency resulting from digitalization just not helps to improve organizational service delivery, and efficient resource utilization as well. Neligan et al. (2023) supported the facts by stating that a new circular business model could evolve at any point during the lifecycle of a product. Digitalization may result in new business models, new forms of cooperation, and disruptive technologies by accelerating the economy's shift towards more circular production systems and the use of resources more efficiently.

There are numerous positive effects of digitization on creative thought. It expedites the decision-making process and the implementation of ideas by accelerating data collection, analysis, and collaboration. Second, digitalization increases output by automating duties, improving workflows, and reducing human error (Kamarul Bahrin et al., 2016). It promotes efficiency by optimizing resource allocation and minimizing operational costs. In addition, technology expands the latitude for exploration and innovation, allowing businesses to investigate forward-thinking options and methods. In addition, it improves customer satisfaction by customizing services, increasing their availability, and expediting interactions. Overall, digitization fosters innovation by providing businesses with the tools and knowledge they need to flourish in the dynamic digital environment (Skordoulis et al., 2020; Neligan et al., 2023).

The responses of different respondents disclosed that digitalization not only presents opportunities for companies to improve their circular economy, but its implementation also brings some challenges that are necessary to address for successful implementation and taking maximum advantage of these technologies. For example, unequal development of infrastructure is one of the major issues that companies face during the implementation of digitalization. Companies are concerned about data privacy and security, and maintaining data privacy is a difficult challenge for companies while implementing digitalization (Paul et al., 2023). Integration of systems and digital technology can be difficult for many businesses. Interoperability challenges arise frequently when businesses seek to share and link data across several platforms, stakeholders, and devices. Cost and return on investment are also some of the issues involved with digital technology adoption. Even, from the responses, it was also perceived that digitalization is not about fostering innovation, it is the development and use of disruptive technologies that support driving circular economies. The responses highlighted the importance of advanced data analytics, AI, and robotic and 3D printing technology for enabling recycling and business processes. It is found that digitalization is not the only way to protect companies from waste generation, but this technology itself is a waste generation. For example, the disposal of digital devices and infrastructure are some of the sources of waste generation.

The study suggested solutions for challenges companies face during the application of digital economies. For example, the outcomes disclosed that all employees within organizations should have equal access to technologies and to protect data and privacy one of the best strategies is to comply with data protection laws. To overcome the challenges of qualified and skilled workers, companies can provide training and development opportunities to their employees (Harteis, 2019). The companies should promote the culture of change adoption to ensure quick and easy implementation of digitalization. Companies should promote the recycling processes for technologies so the waste generated through the disposal of digital systems can be minimized. Further, to overcome the complexities of developing infrastructure and maintenance issues, companies can develop standardized systems that can help reduce digital implementation costs.

6. Conclusion

The research outcomes disclosed that digitalization brings certain opportunities for companies as it helps in the circular economy. For example, it helps reduce the cost associated with materials such as paperwork by automating most of the business functions and enhancing productivity and outcomes. However, it does not come without challenges such as a

shortage of skills, limited knowledge, and unequal access to technologies and infrastructure development. Data privacy and security issues are also critical to digital implementation. However, the unique aspect was that the study highlighted that digitalization also generates waste such as disposal of digital technologies. However, the potential solutions to the problems include training and developing employees, development of equal infrastructure, complying with privacy legislation, and equal access to digitalization.

Compliance with ethical standards

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Disclosure of conflict of interest

We Ibrahim Shouman, who provided the data and contributed to the writing of the research and Tasfiura Dilawer who guided in data collection and equally participated in writing the research paper disclosed that we do not pursue any conflict of interest. We completed this research as a collaborative effort to produce a research paper to contribute to the academic world. We are committed to upholding the highest standards of ethical conduct in research.

References

- [1] Agrawal, R., Wankhede, V. A., Kumar, A., Upadhyay, A., & Garza-Reyes, J. A. (2022). Nexus of circular economy and sustainable business performance in the era of digitalization. *International Journal of Productivity and Performance Management*, 71(3), 748-774. <https://doi.org/10.1108/IJPPM-12-2020-0676>
- [2] Antikainen, M., Uusitalo, T., & Kivikytö-Reponen, P. (2018). Digitalisation as an enabler of circular uop
- [3] Bartekova, E., & Borkey, P. (2022). Digitalisation for the transition to a resource efficient and circular economy. <https://www.oecd-ilibrary.org/docserver/6f6d18e7-en.pdf?expires=1686122085&id=id&accname=guest&checksum=12C125EE073C48A3795D1AFC4B644193>
- [4] Bleicher, J. and Stanley, H., 2017. Digitization as a catalyst for business model innovation a three-step approach to facilitating economic success. *Journal of Business Management*, 12.
- [5] Botha, A. P. (2018). Rapidly arriving futures: Future readiness for industry 4.0. *S. Afr. J. Ind. Eng.* 29, 148–160. doi: 10.7166/29-3-2056
- [6] Burke, R.N., Al Tamimi, A.M.A., Al Shouly, W.S. and Baetsen, D.E., 2021, December. Non-Metallic Technology Deployment for the Next Generation of ADNOC Production Facilities. In Abu Dhabi International Petroleum Exhibition & Conference. OnePetro.
- [7] Cagno, E., Neri, A., Negri, M., Bassani, C. A., & Lampertico, T. (2021). The role of digital technologies in operationalizing the circular economy transition: A systematic literature review. *Applied Sciences*, 11(8), 3328. <https://doi.org/10.3390/app11083328>
- [8] Chauhan, C., Parida, V., & Dhir, A. (2022). Linking circular economy and digitalisation technologies: A systematic literature review of past achievements and future promises. *Technological Forecasting and Social Change*, 177, 121508. <https://doi.org/10.1016/j.techfore.2022.121508>
- [9] Climate-KIC (2018), Digitalisation – Unlocking the potential of the circular economy, https://www.climate-kic.org/wpcontent/uploads/2018/08/ClimateKICWhitepaperFinalDigital_compressed.pdf
- [10] Harteis, C., 2019. Digitalisation of work. *Work-based Learning as a Pathway to Competence-based Education*, 85.
- [11] Hizam-Hanafiah, M., and Soomro, M. A. (2021). The situation of technology companies in Industry 4.0 and the Open Innovation. *J. Open Innov. Technol. Market Complex.* 7:34. doi: 10.3390/joitmc7010034
- [12] Javaid, M., Haleem, A., Singh, R.P., Suman, R. and Gonzalez, E.S., 2022. Understanding the adoption of Industry 4.0 technologies in improving environmental sustainability. *Sustainable Operations and Computers*.
- [13] Kalogiannidis, S., Kalfas, D., Chatzitheodoridis, F., & Kotsas, S. (2022). The Impact of Digitalization in Supporting the Performance of Circular Economy: A Case Study of Greece. *Journal of Risk and Financial Management*, 15(8), 349. ; <https://doi.org/10.3390/jrfm15080349>

- [14] Kamarul Bahrin, M. A., Othman, M. F., Nor Azli, N. H., and Talib, M. F. (2016). Industry 4.0: A review on industrial automation and robotic. *Jurnal Teknologi* 78, 137–143. doi: 10.11113/jt.v78.9285
- [15] Neligan, A., Baumgartner, R. J., Geissdoerfer, M., & Schöggel, J. P. (2023). Circular disruption: Digitalisation as a driver of circular economy business models. *Business Strategy and the Environment*, 32(3), 1175-1188. <https://doi.org/10.1002/bse.3100>
- [16] Okorie, O., Salonitis, K., Charnley, F., Moreno, M., Turner, C., & Tiwari, A. (2018). Digitisation and the circular economy: A review of current research and future trends. *Energies*, 11(11), 3009. <https://www.mdpi.com/1996-1073/11/11/3009>
- [17] Paul, M., Maglaras, L., Ferrag, M.A. and AlMomani, I., 2023. Digitization of healthcare sector: A study on privacy and security concerns. *ICT Express*.
- [18] Skordoulis, M., Ntanos, S., Kyriakopoulos, G. L., Arabatzis, G., Galatsidas, S., and Chalikias, M. (2020). Environmental innovation, open innovation dynamics and competitive advantage of medium and large-sized firms. *J. Open Innovat. Technol. Mark. Complex.* 6:195. doi: 10.3390/joitmc6040195
- [19] Valkokari, P. et al. (2019), “Advancing Circular Business”, Tampere University, https://trepo.tuni.fi/bitstream/handle/10024/128511/Advancing_circular_business.pdf?sequence=1&isAllowed=y
- [20] Xu, J., She, S., & Liu, W. (2022). Role of digitalization in environment, social and governance, and sustainability: Review-based study for implications. *Frontiers in Psychology*, 13. <https://doi.org/10.3389/fpsyg.2022.961057>