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Sustainability, the Circular Economy, and Digitalization in Libyan Organizations

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Abstract: An economic system that eliminates material and energy loops in systems of production and consumption is known as the circular economy (CE). In this regard, digital technologies (DT) are viewed as answers for the implementation of the Circular Economy. Even though digital technologies are being used more and more in industry, little is known about how they specifically affect the circular economy. Therefore, the purpose of this study is to determine whether and how a limited number of organizations are utilizing digital technologies to support their circular economy and sustainability goals. inductive research approach, which using questionnaires to gather data from IT directors, senior IT professionals, or organization managers in a variety of organizations. The article concluded that where organisations in Libya rely significantly on sustainability initiatives and the objectives of the circular economy, the relation with digital technology deployment is not clear. Digital technologies such as Internet of Things , social media , analytics & big data, and Mobile computing are played a crucial role in supporting sustainability and the circular economy within organizations.

Keywords: Sustainability; Circular Economy; Digitalization; Libyan Organizations.

Introduction

Libya is one of the most populous countries in the southern Mediterranean, which presents it with a great opportunity for modern economic growth focused on wealth and natural resources on the one hand, and manufacturing, trade, free zones, and services on the other, all of which considered crucial components of industrial economic growth. However, the degree of progress in the industrial development process, which in turn depends on adopting the best industrial strategies that take into account the changes occurring in the international are, determines whether the industrial sector develops to become the engine of development and stimulate other sectors. According to some, the circular economy (CE) is a new business philosophy that can assist societies and organizations in achieving sustainable development (McDowall et al, 2017). Restoring the value of depleted resources is the main goal of the CE, which presents a fresh and unique viewpoint on the operational and organizational systems of production and consumption. According to the CE, a circular approach to materials and energy can have positive social,

environmental, and economic effects (Geissdoerfer et al, 2017). Founded in 2010 to hasten the shift to the circular economy, the Ellen McArthur Foundation (Ellen McArthur Foundation, 2022) (paragraphs 2 and 3) contended that the "circular economy is restorative and regenerative by design" and "is based on three principles: design out waste and pollution; keep products and materials in use; regenerate natural systems. According to (Reike et al, 2018), these R-principles also known as end-of-life strategies—are therefore seen as operationalization principles of CE. Because they are enabling and starting the implementation of end-of-life strategies, digital technologies (DTs) like the internet of things, big data analytics, and artificial intelligence are viewed as the primary proponents of the CE shift in this context (Bressanelli et al, 2019).

Enhancing supply chains and procedures, processing information more quickly, making better use of raw resources, and lowering energy use are all possible with the help of digital technology (Chandola, 2016). However, the lack of a clear vision and strategy for the Libyan economy's industrial sector was acceptable in the past, but given the changes that have taken place, both locally and internationally, it is now unacceptable in the modern era. This shows how difficult it is to stick to the same strategy, which has worked for so long. As a result, the poor performance of the industrial sector and the lack of an effective industrial development strategy that helps the Libyan economy grow are the embodiments of the research problem. This paper is distinctive because it fills a major information vacuum on the subject and sheds light on how digital technology might help Libyan organizations with their CE activities. There are four major sections to this article. A review of pertinent literature follows this introduction, followed by a discussion of the research methodology, the main findings, and a discussion of the major themes that emerged. The final section concludes with a research summary and some ideas for potential directions for further study in this area.

Literature review

The Circular Economy and Sustainability:

The Circular Economy and Sustainability Development "that meets the needs of the present without compromising the ability of future generations to meet their own needs" is the most commonly used definition of "sustainability" (Brundtland, 2017). "The organization that creates profit for its shareholders while protecting the environment and improving the lives of those with whom it interacts" is the definition of a sustainable business in the context of business (Savitz and Weber, 2006). The three facets of sustainability are social responsibility, environmental preservation, and economic opportunities (Gimenez et al. 2012). According to Elkington's triple bottom line theory [24], According to the prevailing view, in order for an organization to be fundamentally sustainable over the long term, it must take into account all of the contexts in which it operates, including the three dimensions of sustainability: social, ecological, and economic (Amini & Bienstock, 2014).

The economic dimension takes into account the effective use of both tangible and intangible resources to ensure a company's long-term survival, competitiveness, and

resulting benefits; the ecological dimension focusses on the natural environment and concerns the availability, use, and treatment of natural resources; and the social dimension is concerned with human well-being, society, inter-societal relations, and fairness. As a result, sustainability is a holistic construct that needs to anchor in corporate strategy and the business model, and must be connect to corporate culture, processes, and activities as well as the business model. The Sustainable Development Goals (SDGs), which has introduced by the UN in 2015, consist of 231 performance indicators, 169 specific targets, and 17 primary goals (fig 1). By 2030, the SDGs intended to advance global sustainability. The SDG framework is knowledge as the most all-encompassing endeavor ever created to tackle the primary issues confronting the global society (Kementerian Perencanaan Pembangunan Nasional & Bappenas, 2023).

Figure 1. The 17 UN Sustainable Development Goals (SDGs).

The 17 A worldwide and national agreement to improve the well-being of society is represented by the Sustainable Development Goals (SDGs) (Ni'mah et al., 2024). There are targets linked to each of the SDGs, and each target has one or more "indicators," totaling 241 (Donnelly, 2021). The European Union defines the CE as a "economy where the value of products, materials, and resources is maintained in the economy for as long as possible, and the generation of waste is minimized" (European Commission, 2022). As a result, the CE lessens waste generated by the consumption chain as well as the depletion of natural resources. The "circular economy is restorative and regenerative by design," according to the Ellen McArthur Foundation (paras. 2 and 3), which was founded in 2010 with the goal of hastening the shift to the CE. It "is based on three principles: design out waste and pollution; keep products and materials in use; regenerate natural systems."

The Circular Economy (CE) is a new approach that aims to use natural resources in a sustainable way (McDowall et al., 2017). The CE is based on two main cycles, a biological cycle that regenerates ecosystems by reducing excessive extraction of natural resources, using renewable materials, and reusing energy and organic waste through anaerobic digestion, and a technical cycle that emphasizes the extension of a product's lifespan through a hierarchy of circularity strategies, such as reuse, repair, refurbishment, and remanufacturing (Zhao & Zhu, 2017) and recycling; technical cycles aim to convert what is considered waste into resources for other production systems (Bocken et al., 2017; Murray et al., 2017). According to studies, CE can help organizations achieve balanced, sustainable growth by reducing waste and improving resource utilization (Ghisellini et al. 2016). However, due to the high implementation costs (Wang et al., 2018), rebound effect, and

effectiveness of CE (Pedersen & Hauschild, 2014), few research have questioned whether it is feasible for organizations to use CE (Pedersen & Hauschild, 2016).

Success in moving towards a CE would depend on figuring out how to create a monitoring method for material consumption and its effects on the environment, as well as establishing both short- and long-term target metrics. Policymakers, business executives, and the public should all be involved in creating quantifiable and pertinent monitoring and goals to advance the CE (Oswald, 2013). Since circularity and sustainability are not necessarily interchangeable, these metrics would assess both circularity and the related environmental performance. As an illustration, the energy required for recycling can rise in tandem with recycling rates, thereby offsetting the environmental benefits of secondary material recovery (Haupt et al., 2018). In order to make sure that the economy achieves sustainability rather than just circularity, environmental targets and indicators are also required.

Digital Technologies and the Circular Economy

The most practical way for developing nations to catch up to developed nations' economies and improve the quality of life for their citizens is through industrial development. This is more important than ever for developing nations (Naudé & Szirmai, 2012) (Gehrke et al, 2015). Over the past few decades, a number of industries have struggled with sustainability, which has led to the need for new digital solutions that can handle incoming environmental needs (Cucchiella et al, 2015), (Cavallo et al, 2019). The shift in corporate thinking emphasizes social responsibility (Erol, 2020), society, and its interests in its management (Erol et al, 2020). The social, environmental, and economic domains comprise the Triple Bottom Line, also known as the tripod of sustainability (Deloitte, 2020). From the standpoint of resource reuse, sustainability has been integrated into the circular economy (Trueman, 2019). In order to remain competitive in their industry and add value to DT, businesses integrate sustainability concepts into their operations by considering the next generation (Donnelly, 2021). According to an assessment of the advantages of I4.0 for businesses, one of the primary advantages of using digital technologies is sustainability, since it increases a company's visibility and adds value (Alhawari et al, 2017).

According to (Ucar et al, 2020), DT innovation and technologies including cloud computing, cyber-physical systems, and 3D printers are thought to have an impact on the sustainable business model. It is becoming more and more clear that the adoption of digital technologies and the shift to a CE may be related, and that they may occur simultaneously in various contexts. Understanding what is meant by "digitization" may make it easier to comprehend how the organizations this study looks at are using digital technologies to assist their CE goals. The term "digital transformation" (DT) refers to a company's use of digital technology to improve customer service. It is defined as a shift in business culture and strategy (Matt et al, 2015). The steps of commencement and execution of the DT adoption process should be carefully thought out and proposed, with the goal of fulfilling the company's established proposals (Kane, 2017). The circularity of resources in

supply networks can be unlocked by advanced and digital industrial technology. However, as of yet, no research has been done on the relationship between CE and Industry 4.0 (Lopes de Sousa Jabbour et al, 2018). According to (Kristophersen et al, 2020), there is a lack of research on the application of digital technology "to capture the full potential of circular strategies for improving resource efficiency and productivity." (Okorie et al., 2018). Conducted a comprehensive evaluation of the literature, and the results showed that although studies on the CE had been growing,

There is still a dearth of research on how digital technology can support a CE. According to (Alhawari et al, 2021), "future research studies may investigate the extent to which digital transformation can increase the implementation of CE, and their influence on digital performance management." They also pointed out that while "the development of CE initiatives plays an important role in the growing digital transformation in the value chain," there had been "limited research studies in the interface of circular economy and Industry 4.0. (Pagoropoulos et al, 2017) have similar findings. Stated that "the limited technological perspective" was "the main identified gap" in their review of the existing literature, and that "researchers should focus on this gap, and also create more empirical results, by evaluating the application of digital technologies in actual case studies", going forward. By examining if and how some Libyan organizations are utilizing digital technologies to support their circular economy plans and discussing those tools that they can use to inform sustainable operations management choices, this paper seeks to close this gap. More precisely, the study was conducted to answer the following research questions:

RQ1: How much do organizations pursue circular economy goals and activities?

RQ2: Which digital technologies do organizations use to support their sustainability agenda and the circular economy specifically?

RQ3: What role are digital technologies playing in the transition to sustainability and the CE in the Libyan organizations?.

Research Method

Research design

The research method for this study was qualitative and inductive, based on a review of the available literature and on used an online survey-based methodology a range of libyan organizations selected were approached for their responses using simple random sampling. the organisations were selected to reflect variety in that the organisations were from different sectors.

Population and Sampling

An online survey was circulated to collect the information from IT Directors, senior IT professionals or organisation managers in a range of organisations. The online questionnaire responses reflected the view of just one individual in each organisation, and thus cannot be seen as a fully comprehensive analysis, but rather as a subjective snapshot of the current status quo and future possibilities in each organisation. Participants who were chosen at random received an email with a brief description of the survey and a link to the website that hosted the questionnaire. Participants submitted their responses to the survey monkey website (http://www.surveymonkey.com) using a web browser. Participants were guaranteed total confidentiality in all aspects, with regards to their involvement in this survey. A total of 191questionnaires were distributed, among which I4.0 effective data were received with a 73.29% rate of response. The questionnaire used in this study consisting ten questions relating to use of digital technologies and circular economy activities and their application within the organisations. This allowed an assessment of the technologies and activities currently used (or to be used in the future). The questionnaire was adopt from (Orcid & Jones, 2022) to fit the research context. Upon the collection of I4.0 responses, data was extracted from the survey monkey website, and delivered to the SPSS software package for analysis.

Result and Discussion

Descriptive statistics

The SPSS software were used for analysis the results. The organisations selected in this study covered a variety sectors including Trade, Industries, Energy, Computer and Programming, Contracting, Telecommunications and internet. Table 1 show organisations featured in the research.

Table 1. Distribution of Information About The Organization:

information about the Organization	**Organization (n =140)**	
	No.	%
Main activity or core business of the organization		
Telecommunications and internet	14	10.0
Computer and Programming	6	4.3
Trade	11	7.9
Industries	32	22.9
Energy	34	24.3
Contracting	43	30.7
When the organization founded		
More than 50 years ago	7	5.0
10 to 20 years ago	85	60.7
20 to 30 years ago	29	20.7

information about the Organization	Organization (n =140)	
30 to 40 years ago	17	12.1
More than 50 years ago	7	5.0
Number of employee the organization currently employ		
20 to 50 employees	16	11.4
50 to 100 employees	57	40.7
More than 100 employees	67	47.9
Organization's current annual sales volume		
From $100,000 to $200,000	25	17.9
From $300,000 to $400,000	47	33.6
More than $400,000	68	48.6

Table (1) revealed that the majority of organizations operated in the contracting (30.7%) and energy (24.3%) sectors, while industries accounted for 22.9%. Telecommunications, trade, and programming had a smaller presence. Most organizations were founded between 10 to 20 years ago (60.7%), with only a few having existed for more than 50 years. Regarding workforce size, nearly half (47.9%) employed more than 100 employees, while 40.7% had between50 to 100 employees. In terms of annual sales volume, the highest percentage (48.6%) reported revenues exceeding $400,000, while 33.6% earned between $300,000 and $400,000.

The results are organised below about the research questions.

RQ1: How much do organizations pursue circular economy goals and activities?

Anumber of questions related to CE activities were put forward in the questionnaire. These activities were as indicator of a convertion to a circular economy. based on the leterature review, CE is concerning the concept of recycling, reuse, and remanufacturing thus elimination of waste by keeping them longer in the circle (Trueman, 2019). The activities that put forward in the questionnaire were concerned the waste reduction , more efficient of products recycling , the optimisation of the product reuse of products or packaging by the end consumer (Table 2).

Table 2. Extent of Organizations Pursuing Circular Economy

Extent of organizations pursuing circular economy	Yes		No	
	No	%	No	%
Reduction of waste and/or emissions within the organization.	128	91.4	12	8.6
Production or purchase of readily recyclable products.	112	80.0	28	20.0
Production or purchase of products with a high proportion of recycled material.	99	70.7	41	29.3
Optimization of the product returns processes.	85	60.7	55	39.3

Extent of organizations pursuing circular economy	Yes		No	
	No	%	No	%
Encourage the reuse of product and/or packaging by the end consumer.	107	76.4	33	23.6
Recycling of goods and packaging within the organization.	105	75.0	35	25.0
Adapting the organization's business model (e.g. by using rental/loan agreements instead of purchase/sale either for your products and services, or those you use within the organization); second-hand products; production on demand, reducing inventory and other overheads).	136	97.1	4	2.9
Cooperation and collaboration with partners in the transition to a circular economy.	136	97.1	4	2.9

Table (2) showed that most organizations were actively pursuing circular economy practices. The highest adoption rates were seen in adapting business models (97.1%) and collaborating with partners (97.1%) to support the circular economy. Waste and emissions reduction (91.4%) was also a priority for many organizations. Other common practices included purchasing recyclable products (80.0%), encouraging product/packaging reuse (76.4%), and recycling within the organization (75.0%). However, fewer organizations focused on using products with a high proportion of recycled material (70.7%) or optimizing product return processes (60.7%).

RQ2: Which digital technologies do organizations use to support their sustainability agenda and the circular economy specifically?

Table (3) showed that most organizations widely adopted digital technologies. Internet of Things (98.6%), social media (97.9%), and analytics & big data (96.4%) were the most commonly used. Mobile computing/apps (93.6%) and cloud computing (92.9%) also had high adoption rates. Artificial intelligence and automation of knowledge work were utilized by 85.7% of organizations. However, robotics (66.4%) and digital fabrication technologies such as digital twin and 3D printing (60.0%) had lower adoption rates. The selected organisations in the study reported that a range of digital technologies has increased efficiency, saved time and effort, and improved communication. Digital technologies have contributed to the development of the company and improved the quality of production.

Table 3. Distribution of Digital Technologies Used in The Organization

Digital Technology	Yes		No	
	No	%	No	%
Social Media	137	97.9	3	2.1
Mobile Computing/Apps	131	93.6	9	6.4
Analytics & Big Data	135	96.4	5	3.6
Cloud Computing	130	92.9	10	7.1
Robotics	93	66.4	47	33.6
Artificial Intelligence/Automation of Knowledge Work	120	85.7	20	14.3
Internet of Things	138	98.6	2	1.4
Digital Fabrication/Digital Twin/3-D Printing	84	60.0	56	40.0

Table (4) indicated that digital technologies played a crucial role in supporting sustainability and the circular economy within organizations. The Internet of Things (99.3%) and analytics & big data (97.9%) were the most widely recognized for their contribution to sustainability efforts. Mobile computing/apps (91.4%) and artificial intelligence/automation of knowledge work (85.0%) also had strong support in promoting sustainability. Cloud computing (81.4%) and social media (76.4%) were acknowledged as beneficial, though to a lesser extent. Robotics had the lowest percentage (66.4%) supporting sustainability, with a notable 30.7% considering it not applicable to their operations.

Table 4. Digital Technologies, Sustainability and The Circular Economy

digital technologies, sustainability and the circular economy		Yes		No		not applicable	
		No	%	No	%		
Is this technology supporting the adoption of sustainability principles and practices in the organization, and more specifically the promotion of the circular economy	Social Media	107	76.4	31	22.1	2	1.4
	Mobile Computing/Apps	128	91.4	5	3.6	7	5.0
	Analytics & Big Data	137	97.9	1	0.7	2	1.4
	Cloud Computing	114	81.4	18	12.9	8	5.7
	Robotics	93	66.4	4	2.9	43	30.7
	Artificial Intelligence/Automation of Knowledge Work	119	85.0	20	14.3	1	0.7
	Internet of Things	139	99.3	0	0.0	1	0.7

RQ3: What role are digital technologies playing in the transition to sustainability and the CE in the Libyan organizations?.

As regards the digital technologies deployed, The organisations selected reported that a wide of digital technologies was supporting a more circular economy and the convertion to more sustainability, but this linkage differed between organisations. table 5

reported the role of digital technologies in the transition to sustainability and the Circular Economy (CE) within Libyan organizations. It was found that the most prominent factor was improving efficiency, with 61 responses, accounting for 39.7%. Enhancing communication closely followed, with 58 responses, or 37.8%. Reducing energy consumption was also reported by 55 responses representing 35.7%. Additionally, efforts to reduce production costs, save time, and increase security and protection were highlighted, with 50 (32.5%), 47 (30.6%), and 45 (29.3%) mentions, respectively. Reducing waste and supporting recycling were also important, with 42 (27.3%) and 40 (26.0%) responses. Furthermore, there was a noticeable focus on minimizing the use of available resources, with 37 responses (24.1%). Finally, assisting in circular manufacturing processes.

Table 5. Role of Digital Technologies in The Transition to Sustainability and the CE in The Libyan Organizations

Factor	Frequency	Percentage (%)
Improving efficiency	61	39.7%
Enhancing communication	58	37.8%
Reducing energy consumption	55	35.7%
Reducing production costs	50	32.5%
Saving time	47	30.6%
Increasing security and protection	45	29.3%
Reducing waste	42	27.3%
Supporting recycling	40	26.0%
Minimizing the use of available resources	37	24.1%
Assisting in circular manufacturing processes and improving energy and resource efficiency	35	22.8%

Conclusion

This study examined the role of digital technologies in supporting circular economy (CE) goals and activities in Libyan organizations, highlighting the importance of digital transformation in achieving sustainability. The study found that most organizations were actively pursuing circular economy practices, with high adoption rates of digital technologies such as Internet of Things, social media, and analytics & big data. Digital technologies were reported to have increased efficiency, saved time and effort, and improved communication, contributing to the development of the company and improved quality of production. In addition, the study found that digital technologies such as Internet of Things, social media, analytics & big data, and Mobile computing play a crucial role in supporting sustainability and the circular economy within organizations. However, the study is limited to Libyan organizations and may not be generalizable to other contexts. The study's limitations include the subjective nature of the online survey responses, which may not be fully comprehensive, and the limited scope of the study, which only focused on Libyan organizations.

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