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A New Key to a Sustainable Future: Promoting Sustainability Performance Through Digital Technologies, ESG Activities, and Circular Economy in Jordanian Energy Companies

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ABSTRACT

The purpose of the study was to ascertain how environmental, social, and governance (ESG) practices and digital technologies (DTs) affected the sustainability performance of Jordanian energy corporations, in addition to researching the circular economy's mediating effects. A mixed-stage partial least squares structural equation model (PLS-SEM) was used to examine the hypotheses' outcomes in order to accomplish the study's goal. 278 Jordanian energy businesses received surveys via the Internet. The outcomes demonstrated how DTs and ESG initiatives directly benefit the circular economy. The performance of sustainability has improved as a result of the circular economy. Furthermore, the findings demonstrate that the circular economy effectively intermediates DTs, ESG principles, and sustainability. The study makes an original contribution by employing the circular economy as a successful medium to support sustainability performance. This research provides valuable insights to policymakers, regulators and government on the degree to which Jordanian energy companies adhere to circular economy principles and how this relates to sustainability performance.

1. INTRODUCTION

Moving forward, organizations' strategies to mitigate climate change prioritize the circular economy [1]. Circularity has been the focus of a reorientation of views about sustainable practices due to the significant breakthroughs in science and technology. Redesigning the design while keeping materials, parts, and goods operating at their best is the foundation of the circularity idea [2]. The circular economy is built on restorative and regenerative manufacturing processes. These kinds of systems preserve the long-term worth of materials and goods. A circular economy eliminates weather-related events that cause greenhouse gas emissions to rise, creates value, and lessens the negative effects of consumption [3]. Environmental efficiency is promoted via circular economies, which shut the loops of slow and narrow materials.

Using technology advancements in service and industrial organizations to execute both radical and incremental changes is more likely when a circular economy is adopted [4]. Scholars and professionals have acknowledged that dangers related to government, society, and the environment impede the advancement of the circular economy and sustainable development. Thus, implementing green technology has an impact on how many organizations—like the energy industry, for instance—activate their sustainability and governance processes [5]. Long-term acquisition of finite resources and a rise in continuous improvement efforts are facilitated by the deployment of environmental technologies that support environmental, social, and governance activities in the energy sector [6]. The literature has given governance, environmental, and social concerns a lot of attention. However, prior research efforts have only focused on enhancing market value, raising financial performance, and boosting financial efficiency [7, 8]. Resources like oil and electricity are produced, explored, and managed by the energy sector, setting it apart from other industries. Since the energy industry produces around 70% of environmental pollution, many governments find it difficult to establish stringent regulations for energy corporations to limit greenhouse gas emissions [9]. The circular economy has a lower likelihood of success and works less sustainably in the energy sector because of the heavy fuel usage. As a result, several scholars have investigated circular economy-related topics utilizing the causal linkages and reviews method. There is currently little research on leveraging the circular economy to integrate governance, social, and environmental practices with long-term performance [7, 8, 10]. There is insufficient evidence to draw firm conclusions on the relationship between ESG ratings and the circular economy in the energy industry. The study's major purpose is to evaluate and filter the causal linkages between sustainability performance and ESG rating while taking the circular economy's mediation function into consideration.

Furthermore, the idea of the "circular economy" represents the change from the traditional linear model of production and consumption to a circular model that closes the material loop to reduce material extraction and waste disposal [11, 12]. It also replaces the idea of "end-of-life" through material recovery, recycling, and reduction within the manufacturing, distribution, and consumption stages. Circular economy concepts may be used at three levels: macro (a community or country), meso (industrial systems and networks), and micro (one enterprise) [13]. Organizations may accelerate the shift to a circular economy by questioning the ways in which they create, deliver, and collect value within their business models by putting a range of circular economy approaches into practice at the micro level [14]. A number of factors impact the adoption of these practices, either serving as facilitators or obstacles [15]. In light of this, Industry 4.0 is focused on developing smart factories and products, which implies that opportunities exist to enhance the effectiveness of business models, organizational performance, organizational strategies, and skill sets [16]. Facilitating communication between many stakeholders is another aspect of it [17]. In this industry, digital technologies that facilitate automation, networking, and communication include cloud computing and the Internet of Things [18]. With the help of these innovative and cutting-edge technologies, companies can now adopt data-driven strategies to collect data on a product's life cycle, from material properties and process parameters to improve the manufacturing system's vertical and horizontal integration [19, 20]. This is particularly useful in digitally driven manufacturing systems.

While formerly examined independently, the domains of digital technology and circular economy have lately begun to be explored in tandem [21]. Due to this, there has been a push to implement circular economy principles and get a deeper understanding of how digital technologies may facilitate the circular transition [22, 23]. More precisely, everyone acknowledges that the industry cannot embrace circular economy methods unless digital technologies are used [24]. To take use of the range of digital technologies available for the industrial circular transition, practitioners do not yet have clear recommendations to follow [16]. As a result, it is unclear how digital technologies and the circular economy relate to sound environmental management [17, 25]. According to Centobelli et al. [15], further advice is thus required to comprehend how digital technologies might assist industrial enterprises in their circular transformation by encouraging the adoption of circular economy practices. Consequently, the study's second goal is to look at how digital technologies, such as a circular economy, affect sustainability performance.

2. LITERATURE REVIEW

2.1 Digital technologies

According to Schöggl et al. [26], digital transformation is a broad term for the transformation process characterized by the increased use of digital solutions. According to Hanelt et al. [27], digital technologies are broadly characterized as a combination of communications, computing, networks, and many individual dispersed information. Managing these digital transformation initiatives affects the benefits even if digital transformation plans are recognized as essential prerequisites for using digital technology [28]. Companies may use digital technology to construct global, cross-functional, distributed, modular, and cross-functional business processes that enable work to be completed across time, geography, and function [29]. Digital technologies are rapidly being incorporated into products (for example, IoT sensors) in order to make advantage of digital resources and build new capabilities. The term "Industry 4.0," coined in Germany in 2011 to characterize the application of numerous digital technologies in the industrial sector, is also widely used [25]. Companies require adequate digital strategies since using digital technology demands and promotes organizational changes [25, 30]. Such tactics require intensive information exchange between external and internal companies on digital channels. They must integrate IT capabilities across organizations more closely and support cross-functional processes [13]. Neligan [31] found that having a corporate digital plan is positively associated with improved material efficiency and a higher rate of digital technology deployment. Neligan [31] surveyed 589 German manufacturing companies and found that companies with “highly developed” digital strategies implemented six out of seven material efficiency measures - such as using new materials or streamlining manufacturing processes - more frequently and with higher adoption rates. When using digital technology, operational efficiency is the goal that supply chain managers prioritize the most, according to data collected from 405 participants [32]. According to Rodrigo et al. [33], the application of digital technologies like big data analytics, blockchain, IoT, and AI is also viewed as a crucial component of circular and sustainable product management in addition to traditional operations and supply chains. Digital technology use may improve supply chain transparency, enable real-time monitoring, and maximize resource usage [34]. Additionally, it can improve the caliber of data required for making decisions about sustainability at the process and product levels. To be more precise, AI and big data have the ability to automate and alter data, which has enormous promise for product evaluation and creation. IoT may also create new information flows by improving the efficiency and quality of internal and external data collecting processes on operations and goods [35, 36]. These technologies will probably completely change how businesses create goods, allocate resources, and assess sustainability. Conversely, businesses may lower waste and improve resource efficiency by incorporating digital technology into several facets of the circular economy [37]. Digital technology can monitor product life cycles, advance sustainable practices, and evaluate a product's environmental effects from its inception until its disposal [36]. In this sense, precise, up-to-date data is made available for product life cycle analysis using digital technology, which promotes more accurate decision-making and environmentally friendly product designs [34]. According to Rodrigo et al. [33], digital technology may foster innovation in product design and thereby advance circularity. Programs for computer-aided design may produce designs for products that take recyclability, durability, and repairability into account. Therefore, companies can integrate digital technologies into their product design processes to reduce environmental impacts and improve their functionality and lifespan.

2.2 Environmental, social, and governance rating

Recently, the ESG rating system has gained significant public attention. According to Dorfleitner et al. [24], investors who invest in sustainability use ESG ratings to find opportunities that fit their goals. Sustainable development, or ESG, aims to create a harmonious coexistence between humans and the natural world. In view of the rise of sustainable development, all societal levels concur that businesses must increase their social duties [38]. Alnoor et al. [7] state that environmental, social, and governance practices are a vital component of sustainability performance assessment and that all capital stakeholders may utilize them to evaluate the environmental, social, and governance performance of a business. According to Zhang et al. [39], a firm's environmental, social, and governance policies enable investors to assess its performance completely and disclose non-financial information about the company to the public. Investors are given an understanding of a company's duties in these areas by evaluating non-financial market data, which is used to evaluate an organization's environment and social and governance practices. To help investors make more informed judgments about all of a company's investments, ESG activities have become increasingly common in economics, management, and financial reporting. Professionals in finance typically assess this kind of information. In order to project the future status of the market, financial analysts usually review and assess market data and trends. Companies have been perceived as a possible burden on financial performance because of their link with cost rises, in addition to the notion that ESG duties impact the latter. The increasing frequency of catastrophic environmental disasters that have disrupted global markets and destroyed infrastructure has led to the development of this strategy. It has drawn public attention to social responsibility and emphasized the value of strong governance frameworks [40]. Company stocks are ranked according to ESG concerns using ESG scoring. Nowadays, most investment strategies that promote responsible investing include environmental, social, and governance aspects as a core component [41]. Performance is key to obtaining an ESG score [42]. Previous research has found that ESG initiatives improve corporate performance [43]. According to Lazareva et al. [44], scholars have looked at how ESG impacts performance from an economic perspective. According to several studies, ESG ratings have reduced a company's financing costs and reduced risk. Consequently, companies with significant investments in ESG are more resilient in their operations, finances, performance, and sustainability [45].

Additionally, ESG ratings have classified activities that enhance a company's strategy's environmental and societal aspects [46, 47]. This supports circular economy strategies, which recycle or reuse waste generated during production in the downstream manufacturing processor supply chain [48, 49]. Moreover, increasing the use of renewable energy sources is the first step in business involvement in ESG [49, 50]. One of the basic tenets of the circular economy is closely aligned with this element [51, 52]. Specifically, in order for the system to be resilient to outside shocks, resource dependency needs to be decreased [53]. However, many businesses and manufacturers have begun to place a high value on the sustainability and environmental impact of their products as investors' attention has shifted from solely financial performance to non-financial indicators of sustainable development, such as environmental, sustainability, and governance (ESG) ratings [54]. As a result, businesses that want to receive excellent ESG ratings may include the circular economy in their procedures and policies.

2.3 Circular economy

The circular economy, as a novel paradigm and idea in economics, has drawn a lot of interest lately. Because it may reduce energy usage, environmental impact, resource prices, and trash generation, reusing and recycling materials is a crucial part of the circular economy. The circular economy aims to maintain items and their components at their greatest value throughout the duration of their usage. It also offers an image of a sustainable future due to the circular economy. Ecosystems and the circular economy are connected [55]. The effective use of resources and numerous chances to advance renewable energy sources, lower greenhouse gas emissions and waste production, enhance energy efficiency, and produce non-toxic bioproducts are together referred to as the "circular economy". The circular economy is a new economic model and idea that has attracted much attention recently. Reusing and recycling materials is an aspect of the circular economy that can reduce resource prices, energy costs, environmental costs, and waste input costs. The goal of the circular economy is to extend the useful life of goods and their components. It offers an insight into how the circular economy might contribute to a sustainable future as well. Khatami et al. [51] assert that there is a relationship between circular and ecological economies. The phrase "circular economy" describes a resource-efficient economy that presents a number of chances to optimize energy efficiency, lower greenhouse gas emissions and waste generation, boost renewable energy sources, and create non-toxic bioproducts. Organizations need to be very explicit about how they use closed material cycles to generate, transmit, and recover value [7, 56]. According to Shen et al. [57], there is a connection between the economic system and the circular economy. The circular economy is an economic structure that seeks to displace the traditional economy. It can serve as a spark for long-term growth. Raw resources are taken, processed, consumed, and finally wasted within the economic exchange system. Due to the continuous depletion of resources, this end-of-life process exacerbates environmental degradation [44]. The industrial system is designed with recovery or recovery in mind. By taking on the function of the end-of-life concept, restoration transforms the flow of goods and materials from conception to death into a cradle-to-cradle process. Because of this, the circular economy sees discarded goods and parts as resources and commodities that can be incorporated into entirely new manufacturing processes. As a result, several previous studies have used a criticality-related approach to this idea. Neri et al. [58] argue that the industrial system is a key issue for the circular economy. Thus, the effects of industrial features and incentive factors on the influential manufacturing industries were studied, using the circular economy as a framework. One of the key components of the circular economy is sustainability [1, 24]. Putting sustainability first in circular economy strategies helps reduce pollution and energy waste while enhancing social, economic, and environmental outcomes. These strategies include reducing, recycling, and reusing [59]. Firms may achieve corporate sustainability by leveraging the circular economy to save costs on materials, increase revenue, and enhance brand image [48]. Firms can now sustainably create safe and high-quality products thanks to the circular economy. This underscores the importance of the energy sector adopting circular economy principles and sustainable practices [60].

2.4 Sustainability performance

Sustainability has become a major focus for practically all organizations as it is essential to their expansion, profitability, and survival in the twenty-first century [61]. By implementing sustainable practices, businesses may increase profits while maintaining their long-term survival. Performance and sustainability have been linked [62]. A company's goal is to generate long-term performance via efficient and successful management. The success of businesses and the assessment of their performance depend on critical performance indicators. Performance indicators might be a useful tool for assessing the current state of a business and choosing fresh approaches to meet long-term objectives [63]. According to Elkington and Rowlands [64], three main dimensions—social, environmental, and economic—can be used to achieve sustainable performance. According to this strategy, businesses should prioritize social, environmental, and economic issues equally. Environmental factors are critical for sustainable performance [7, 65]. Environmental performance was described [66] as an organization's degree of greening its operations to satisfy the environmental expectations of society [67]. One of the most essential aspects of sustainability performance is evaluating how an organization affects natural ecosystems, which comprise living and nonliving components. A company's financial performance may be assessed using metrics such as labor productivity, cost containment, inventory investment reduction, earnings, and value of goods recapturing [68]. The economic sustainability performance component assesses an organization's ability to allocate resources efficiently in order to provide stable growth and a good return on investment. Regarding social responsibility issues, such as those pertaining to equal rights policies, health and safety, labor for children, forced labor, freedom of association, training and education, human rights and services, and management effectiveness, the term "social performance" describes an organization's position. Social performance is a crucial component of sustainable performance [69]. A company's ability to effectively use its best management practices to cultivate a culture of loyalty and trust among customers, employees, and the community is assessed by the prior studies as part of the social sustainability performance pillar in order to generate long-term shareholder value [31, 70].

2.5 Hypotheses development

2.5.1 Digital technologies and circular economy

The circular economy is defined as a renewable system that minimizes the use of natural resources and generates waste in order to maintain natural capital [16, 58, 71]. The adoption of a circular economy necessitates the cooperation of all governmental and non-governmental organizations as private manufacturing enterprises mostly rely on raw commodities like oil and precious metals. Future managers of industrial businesses may have difficulties as a result of this. Notwithstanding the dangers connected to mineral shortages, societies place a high value on these minerals since they support economic growth [23]. Schöggl et al. [26] assert that manufacturing firms are essential to the shift to a circular economy because of the combination of these factors and the negative social and environmental effects of unsustainable production. In order to lower emissions and use resources, manufacturing enterprises must adopt sustainable and circular strategies and take into account the long-term effects of their actions on society and the environment. Consequently, industrial organizations may create long-term financial sustainability as well as socially and ecologically responsible plans by considering the requirements and interests of all stakeholders [72]. The prior perspective is in line with the recommendations of stakeholder theory, which holds that an organization is made up of people and groups that have an interest in the business, including suppliers, consumers, shareholders, and workers [33]. This idea highlights that the corporation must take into account the needs of all parties involved and not only put the interests of shareholders first by increasing profits. Additionally, it implies that businesses that successfully manage their relationships with stakeholders would be more long-term profitable and sustainable [73]. Digital technologies have the potential to ease the shift towards a circular economy, as per earlier studies conducted [74, 75]. This is especially true for the gathering, arranging, combining, and supplying of product data. Digital technology may be utilized to monitor products and parts at the industrial level throughout their various life cycles. According to Alnoor et al. [7], they may also assist with the quality and availability of data needed to make decisions about sustainability at the process and product levels, such as how much energy machines are using in real time. Digital technologies have numerous direct applications in the context of the circular economy, but they can also indirectly promote economic transformation by improving knowledge sharing and collaboration between and within organizations and by raising the level of digitalization along the value chain [25]. Digital technologies thus play a crucial role in the circular economy transformation process, which is based on recycling resources to protect natural resources and, consequently, natural capital. Our hypothesis is therefore:

H1: *Digital technologies have a positive effect on the circular economy.*

2.5.2 ESG rating and circular economy

Stakeholder theory-wise, ESG reconstructs the objective of maximizing company value by including CSR factors. There are two major effects of this change. In terms of CSR, businesses may build networks of corporate collaboration and social capital by embracing the social responsibility ethos espoused by ESG initiatives. In their manufacturing processes, this lessens the impact of resource restrictions [76]. In addition, the increasing recognition of corporate social responsibility motivates businesses to embrace technological innovation and implement resource-efficient methods in order to tackle resource limitations [58, 65]. In addition to ESG concerns, the circular economy falls under the umbrella of sustainability. Thus, the requirement for companies to make judgments about how to protect two areas: the environment and people - is addressed through the circular economy and ESG efforts [50]. An organization’s entire business plan can be improved by categorizing actions related to ESG concerns [77]. This is in favor of circular economy schemes that recycle or repurpose trash from production in a different line of business or supply chain [48]. Enterprises adhering to ESG principles consume more renewable energy, claim [50]. One fundamental tenet of the circular economy is to lessen reliance on outside resources so that the system may become robust to shocks from the outside world [51]. Since investors are turning their attention away from financial performance and toward non-financial indicators of sustainable development, like environmental, sustainability, and governance (ESG) ratings, many businesses and manufacturers have begun to prioritize the sustainability and environmental impact of their products [54, 78]. Consequently, organizations that include the circular economy in their policies and practices ought to score well on ESG. ESG, according to Leandro and Paixao [59], offers a framework for business management strategies and concepts that more effectively describe sustainability. These concepts are implemented by the circular economy in order to meet sustainable development objectives and promote sustainable behavior in people, communities, and businesses [51]. Thus,

H2: *ESG activities will positively affect the circular economy*.

2.5.3 Circular economy and sustainability performance

The advantages of the circular economy for sustainability-related outcomes have been the subject of some research. Sica et al. [79] assert that while the scholarly discourse around circular economies has mostly concentrated on technological transfers of materials and energy, along with restructuring for environmental enhancement, social justice has been overlooked. Moreover, conceptual analysis rather than a thorough evaluation has usually been used to study the connection between the circular economy and sustainability performance. Conventional organizations use circular economy techniques to improve their social, economic, and environmental performance [26, 80, 81]. Since efforts to protect the environment coincide with the objectives of future generations, a circular economy embraces sustainability [57]. Korhonen [56] argues that in the circular economy, corporate operations have an influence on the economy, the environment, and society. The financial benefits include lower energy and raw material costs, cheaper environmental taxes, decreased emissions, and the utilization of waste management systems. Additionally, putting money into circular economy initiatives may raise a company's market worth. Therefore, a number of investigations have supported and again demonstrated this opinion. Foundation [32], for example, claims that the circular economy forces businesses to conserve money and provide yearly net benefits, encouraging economic sustainability. Based on the new business models and operations connected to completing the loop, Jansson et al. [49] claim that there are additional social advantages, including enhanced community spirit, equal access to goods and services, and the development of job opportunities. The benefits circular economy business models offer for sustainability are further covered by Senadheera et al. [80]. These benefits include more profits, less harm to the biosphere, and improved social well-being. By lowering emissions, waste production, and the consumption of virgin resources, the circular economy improves environmental performance. Furthermore, the recovery or reuse of renewable waste boosts the effectiveness of resource usage [82].

H3: *The sustainability performance will be positively impacted by the circular economy*.

2.5.4 Mediating role of circular economy

According to Chauhan et al. [16] and Schöggl et al. [26], digital technologies have become a useful or even crucial instrument for facilitating the circular economy in industrial enterprises. According to Aldegis et al. [6], Ivanov and Webster [48], Zaidan et al. [83], and others, digital technologies enhance data collecting, transparency, and resource efficiency, all of which contribute to better circular design and services. Electric motors, electronic equipment, construction, and waste management are just a few industries that have demonstrated the value of digital technology in facilitating the shift to a circular economy [17, 35, 84]. Digital technology can offer practical solutions for minimizing the use of natural resources throughout the life cycle of a product, developing environmentally friendly goods, production methods, and services, as well as cutting down on harmful emissions [69]. According to Li et al. [61], the creation of green goods and the invention of optimal environmental design are made possible by improved information flow management made possible by the Internet of Things, cloud-based design, and big data analysis. Through automatically enhanced manufacturing processes, digital technology may also aid in the improvement of information gathering and processing to better regulate air pollution, water quality, energy efficiency, and heavy metals [85]. In an Internet-connected production line or piece of equipment, businesses integrate sensors and RFID technology to create a digitally enabled manufacturing system that can remotely monitor and manage production parameters. Laskurain-Iturbe et al. [86], who discovered that advanced manufacturing technologies have the ability to help green manufacturing processes, adopted a similar strategy. According to Rodrigo et al. [33], digital technologies like data-driven carbon footprint studies help lower greenhouse gas emissions. Every point previously made affects sustainability, either directly or indirectly. Numerous research have demonstrated this impact. Evidence of the beneficial effects of digital technology on sustainability has been shown in earlier research [13, 74]. Therefore, by assisting businesses in making the shift to a circular economy—which attempts to lessen negative environmental effects, protect natural resources, and minimize waste through recycling—digital technology may enhance sustainability performance. Hence:

H4a: *Digital technologies will positively affect sustainability performance through the circular economy.*

The fundamental ideas of the circular economy are strongly related to the ESG rating. As per Alnoor et al. [7], ESG categorizes operations that bolster the business strategies of the company with respect to the environment and society, along with those that encourage the circular economy approaches, like recycling or repurposing waste from production processes in other manufacturing processes [51]. In order to promote sustainability, the circular economy is an economic system that is applied at the micro, or companies and consumers, meso, or eco-industrial parks, and macro, or cities, regions, and governments, according to Rodrigo et al. [33]. Additionally, it closes the energy and material cycles and prevents the depletion of resources. Businesses interested in environmental, social, and governance classifications can integrate the circular economy's principles into their policies and business plans, as it is a morally significant matter aimed at protecting the environment and humans while also improving the use of natural resources. As a result, investors who value moral benefits above everything else can choose to use an ESG-based investment approach. ESG is defined by

Leandro and Paixao [59] as business management strategies and ideas that most effectively frame sustainability. In order to achieve sustainable development goals and promote sustainable behavior among people, communities, and enterprises, the circular economy puts these principles into practice [48, 51]. Therefore,

H4b: *ESG activities will positively affect sustainability performance through the circular economy.*

3. METHODOLOGY

The Jordanian Ministry of Energy and Mineral Resources (JMEMR) has been leading developments in investments related to energy production and distribution. Four operational, technical, financial, and training criteria were used in a methodical program to refurbish the energy production, transmission, and distribution stations. This allowed Jordan to identify the qualified energy sector that could function there. As a result, the JMEMR chose seven businesses that specialise in the design, production, distribution, maintenance, operation, and repair of power plants as well as the extraction, refining, purification, and distribution of petroleum derivatives. For the Jordan Economic Monitor 2022/2024, the research examined data from previous World Bank publications and reviewed the Iraqi JMEMR website to get information about these businesses. This study employed a non-probability technique. This term describes selecting a senior manager or human manager to gain further insight into the business. The non-probability approach may be used as the study's sample includes senior managers or department heads in energy corporations. Managers and department heads of Jordanian energy companies provided questionnaires from which the study's findings were gathered. As a result, an online survey was implemented. Calls, texts, and emails reminded respondents of the response rate. Two hundred forty-five questionnaires (88% response rate) out of 278 sent to managers and department heads of Jordanian energy enterprises operating in the country were returned and utilized for additional analysis. 88% of the data's responses were still valuable. The survey included two sections. The first section described the demographic profile and aimed to provide information, background, and descriptions of the survey participants. The second section measured the constructs using a five-point scale of strongly agree to strongly disagree. The scale was subjected to content validity by sending it to six digital technologies and sustainability experts. Minor modifications occurred in some items of the scale. Males make up 65% of the population, and females make up 35%. The nature of labour in the energy industry, where men predominate in the workforce, makes this disparity commonplace.

When it comes to age, most of the respondents (42%) are in the age group of 118 (41-50 years), which is followed by the second age group of 69 (51-60 years), which is represented by (24.9%), the third age group of 53 (31-40 years), which is represented by (18.7%) of the respondents, and the last age group of 38 (21-30 years), which is represented by (14.4%) of the respondents. In terms of job experience, 76 (27.3%) of respondents had work experience ranging from 11 to 20 years, while 127 (45.7%) respondents had more than 21 to 30 years of experience. According to the present survey, 55 (20%) of the respondents had between 31 and 40 years of experience in their field of work; 20 (0.07%) of the respondents fell into the final group and had fewer than 10 years of work experience. There are around 112 (40.3%) people with bachelor's degrees, followed by those with master's degrees, 78 (28%) and 55 (19.7%) with diplomas, and 33 (12%) with PhDs.

Digital technologies have been measured using four items according to Li et al. [60]. Uçar et al. [85] have devised a three-item scale for measuring the circular economy. Sharma et al. [81] provided 20 elements that were used to quantify sustainability. Sultana et al. [82] used 24 elements for the ESG rating in order to gauge ESG activities. By using Harman's methodology to solve the typical bias issue, this study was able to determine that the overall variance did not surpass 50%. The common bias method's results verify that this issue is not cause for alarm. Furthermore, the data did not raise any concerns about the normal distribution problem. However, in order to investigate linear and causal correlations between the research variables, this study used PLS-SEM.

4. DATA ANALYSIS

4.1 PLS-SEM analysis

In this study, PLS-SEM was utilized to look at the circular economy's mediating function as well as the causal linkages between variables. The PLS-SEM approach includes assessing both the measurement and structural models. The measurement model's validity is evaluated using both discriminant and convergent approaches. Convergent validity is made up of the load factor, Construct Reliability (CA), Average Variance Extracted (AVE), and composite reliability (CR). AVE must exceed 0.50, while CR and load factor must exceed 0.70. Table 1 shows the measurement model's convergent validity.

There are three techniques for measuring discriminant validity: cross loading, heterotrait-monotrait correlation ratio (HTMT), and Fornell-Larker. The discriminative validity of this study was tested using the Fornell-Larker technique. According to Fornell and Larcker, the load of any construct should be greater than the variance caused by the construction and other structures. Discriminant validity is shown when a concept's AVE is greater than the variance shared by that construct and all other constructs. As indicated in Table 2, the square roots of the AVE should be greater than the correlations between the latent components.

This study produced four hypotheses to answer the research issues. To test hypotheses, parameter estimations for statistical significance and coefficient values were assessed using a bootstrapping method based on PLS-SEM. The path coefficient (β) represents the strength of the links between the components and is a fundamental step in hypothesis testing. The above statement may be understood as standardised beta coefficients derived using ordinary least squares regressions. These coefficients range from -1, indicating a negative link, to +1, indicating a positive relationship [87]. One may use a bootstrapping approach to ascertain their significance and obtain t-values for each route. If the sign of the route is opposite to the hypothesised direction, it is considered insignificant. On the other hand, a significant path in the hypothesised direction provides empirical evidence for the claimed link. The PLS algorithm was executed with 5,000 bootstrap samples using the bootstrap method. One-tailed t-tests were given since all hypotheses were unidirectional. The statistical significance of the path coefficients at a 5% error probability was determined using the t and p values. A statistical significance threshold of 5% implies that to accept the hypothesis, the t-value must be greater than 1.65, and the p-value must be 0.05. Table 3 presents the findings from the structural model assessment.

Table 1. Convergent validity of the measurement model

Variables	Items	Loading Factor	CR	AVE	Variables	Items	Loading Factor	CR	AVE
Digital Technologies (DTs)	DTs1	0.827	0.933	0.736					
	DTs2	0.868							
	DTs3	0.810							
	DTs4	0.875							
ESG Activities	ESGA1	0.735	0.784	0.738	Circular Economy CE	CCE1	0.823	0.772	0.731
	ESGA2	0.725				CCE2	0.814		
	ESGA3	0.784				CCE3	0.783		
	ESGA4	0.723			Sustainability Performance SP	SP1	0.763	0.801	0.788
	ESGA5	0.824				SP2	0.709		
	ESGA6	0.763				SP3	0.758		
	ESGA7	0.755				SP4	0.722		
	ESGA8	0.854				SP5	0.830		
	ESGA9	0.787				SP6	0.757		
	ESGA10	0.795				SP7	0.785		
	ESGA11	0.841				SP8	0.848		
	ESGA12	0.924				SP9	0.862		
	ESGA13	0.754				SP10	0.852		
	ESGA14	0.839				SP11	0.899		
	ESGA15	0.803				SP12	0.827		
	ESGA16	0.784				SP13	0.908		
	ESGA17	0.726				SP14	0.847		
	ESGA18	0.897				SP15	0.812		
	ESGA19	0.761				SP16	0.881		
	ESGA20	0.818				SP17	0.764		
	ESGA21	0.792				SP18	0.815		
	ESGA22	0.872				SP19	0.822		
	ESGA23	0.810				SP20	0.846		
	ESGA24	0.718							

Table 2. Discriminant validity of the constructs based on Fornell-Larcker criterion

Variables	1	2	3	4
1. ESG Activities	0.863			
2. DTs	0.422	0.858		
3. SP	0.473	0.689	0.797	
4. CE	0.260	0.204	0.187	0.858

The DTs and ESG rating are expected to improve sustainability. The DTs and ESG rating are expected to benefit the circular economy, according to hypotheses 1 and 2. A noteworthy positive correlation ($\beta = 0.641$, $p < 0.05$) and ($\beta = 0.115$, $p < 0.05$) has been found between DTs, ESG activities, and circular economy. Hypotheses 1 and 2 are therefore validated. Sustainability performance is expected to benefit from the circular economy, according to Hypothesis 3. The findings indicate a significant association ($\beta = 0.106$, $p < 0.05$) between the circular economy and sustainability performance. Therefore, hypothesis 3 is supported. H4 and H5 are also supported because the association between DTs, ESG activities, and sustainability performance was mediated by the circular economy.

Table 3. Path coefficients and hypotheses testing

Direct Path	O	M	SD	T	P Values	Label
ESG activities-> SP	0.117	0.175	0.053	1.038	0.016	Accepted
DTs-> SP	0.641	0.645	0.053	12.013	0.000	Accepted
ESG activities-> CE	0.115	0.109	0.031	2.822	0.000	Accepted
DTs-> CE	0.204	0.21	0.042	4.804	0.000	Accepted
CE -> SP	0.106	0.113	0.048	2.267	0.000	Accepted
Indirect path						
ESG activities-> CE-> SP	0.298	0.110	0.027	16.048	0.000	Accepted
DTs-> CE-> SP	0.021	0.021	0.008	2.822	0.002	Accepted

5. DISCUSSION

The present study endeavors to investigate how digital technologies and ESG ratings in Jordanian energy businesses influence their sustainability performance by means of a circular economy. Thus, in order to achieve sustainable performance and a circular economy, the system that has been discovered offers public enterprises practical techniques for adopting digital technologies and ESG grading in addition to important scientific knowledge. The study's finding that digital technologies benefit the circular economy lends credence to Hypothesis 1, which maintains that digital technologies do, in fact, benefit the circular economy. Product data collection, organization, and exchange may be made easier by digital technology [74, 75]. Furthermore, because products and components have many life cycles, digital technology allows for their monitoring. According to Neligan et al. [71], it provides the high-quality data needed for sustainable decision-making at the process and product levels. The outcomes also showed a favorable correlation between ESG initiatives and the circular economy. This finding is in line with Hypothesis 2, which postulated that the circular economy would benefit from ESG categorization, and is thus endorsed. The findings are in line with research showing that business management strategies and concepts that more successfully attain sustainability may be framed by the ESG categorization. These methods and concepts are applied by the circular economy to meet sustainable development objectives and promote sustainable behavior in people, communities, and businesses [51, 88]. Stakeholder theory suggests that ESG activities help businesses build cooperative networks and social capital, which reduces resource restrictions in their production processes. Companies are encouraged to implement technical innovation and resource-efficient techniques by the growing awareness of corporate social responsibility [76]. Furthermore, sustainability is the broad category that includes the circular economy. According to Esken et al. [30], the circular economy and ESG initiatives help businesses meet their obligation to make decisions about how to safeguard people and the environment. For this reason, classifying activities pertaining to ESG issues can enhance businesses' overall business strategy [45, 77], supporting circular economy strategies that recycle or reuse production waste in a later business line or supply chain.

The outcome demonstrates a favorable correlation between ESG rating and performance sustainability. In order to give a more thorough and effective evaluation of sustainability performance, ESG ratings have incorporated additional criteria into their assessment models, most of which relate to environmental and governance problems. The study's findings are consistent with previous studies [83]. Given the concerns expressed over potential resource shortages and the increase in the world's energy supply, this contribution is crucial. Furthermore, companies are under pressure to innovate in sustainability because of pollution and environmental damage. Sustainability performance in this sense refers to combining specialized resources to increase group productivity, cutting energy use, and turning waste into inputs for production. Given this, the circular economy promotes raising the added value that consumers receive by enhancing products and resources, recycling waste, and obtaining raw materials from the market as opposed to natural resources. Additionally, the concept might be more appealing to policymakers and energy companies than competing strategies because many conceptualizations of the circular economy [13, 77] seem to place more emphasis on the environmental perspective and less emphasis on the social and economic dimensions. This can hinder the transition to a more sustainable economic performance by diverting resources and attention from more comprehensive and holistic methods. Accordingly, the study concludes that sustainability performance will be enhanced by a circular economy, which includes the recovery, recycling, reuse, and regeneration of resources used in the processes of production, distribution, and consumption. When putting circular economy plans into practice, it's important to consider the social and political climate. New technologies are required for the circular economy in order to promote resilience, renewability, reuse, repair, upgrading, refurbishing, recycling, and recovery through management engagement. The result shows a positive correlation between the circular economy and performance sustainability. The term "circular economy" also mainly refers to the financial advantages businesses have as a result of reducing inputs, increasing efficiency, and avoiding waste, with comparatively quick results in terms of performance sustainability. The results of this investigation support those of other investigations [58, 80, 81].

In terms of the circular economy's mediating role, the research discovered that it had a favorable influence on the correlation between sustainability performance and the predictors (digital technologies and ESG activities). Thus, Hypothesis 4 (4a and 4b) is deemed to be valid. Digital technology has affected the performance of sustainability by helping industrial companies transition to a circular economy. According to the previous study [39], digital technologies provide improved data collection and processing to improve productivity and better control air pollution, water quality, energy efficiency, and heavy resource usage. This conclusion is consistent with that research. Li et al. [61] claim that cloud-based design, significant data analysis, and enhanced information flow management enabled by the Internet of Things are what enable the development of green products and creative environmental design. Additionally, as the circular economy is a morally significant problem that seeks to protect people and the environment while also maximizing the use of natural resources, businesses with an emphasis on environmental, social, and governance issues may incorporate its principles into their policies and strategies. Consequently, an ESG-based investment strategy may be used by investors who place a higher priority on ethical profits than any other factor. ESG is defined [88] as business management strategies and concepts that most effectively frame sustainability. In order to achieve sustainable development goals and promote sustainable behavior among individuals, communities, and companies, the circular economy brings these concepts to life [48, 51].

6. IMPLICATIONS

Theoretically, the study's conclusions have a significant impact on the body of work that has improved our understanding of sustainability and the circular economy. To start with, this study adds to the body of information already available on digital technologies and ESG operations by offering a road map of procedures that can help businesses make the switch to more sustainable production and consumption. This includes the power of the circular economy to operate as a mediator between sustainability, ESG initiatives, and digital technologies. The results of this study confirm that the ESG rating, digital technologies, and the circular economy are the main pillars of sustainable performance development. This study demonstrates how ESG actions have a greater impact on sustainability performance in the context of the circular economy. According to stakeholder theory, businesses should see their pursuit of business prospects that align with circular economy principles and sustainability performance as an obligation to many stakeholders. This research makes a valuable contribution to the fields of environmental, social, and governance studies, circular economy practices, and sustainability performance. It offers companies new environmental and technological options that can help them become more competitive and improve their sustainability performance. Our work contributes to the body of knowledge on sustainability performance in the energy sector by building a bridge between four critical study areas: the circular economy, digital technologies, sustainability performance, and ESG rating. Most previous studies have only sometimes looked at the aforementioned elements, paying little attention to how these concepts interact, especially when considering Jordan's energy sector [7, 43, 58]. Examining the theoretical foundations of the previously described ideas as well as the direct and indirect consequences of these initiatives on sustainability performance through the circular economy and the ESG rating are therefore relevant to the topic of the research. The current study demonstrates how quickly improving the circular economy and sustainability performance can be achieved through digital technologies and environmental, social, and governance initiatives.

Practically, the study looked at how digital technologies, ESG practices, and sustainability performance are mediated by the circular economy. Therefore, determining what makes something conceivable is one of the main issues facing academics, decision-makers, and practitioners. Building organizational, financial, and strategic skills for sustainable practices is essential if the energy sector is to transition to a circular economy and sustainable development. In this sense, our viewpoint expands on the current knowledge of circular economy business models in the energy sector by looking at one of the critical components that practitioners and policymakers identified. In practical terms, this research opens up the possibility for managers and business owners to collaborate with organizations to help create business strategies that incorporate elements of the circular economy model. One major obstacle to the adoption of circular economy practices is the dearth of technological tools. The present discourse is being shaped by the increasing recognition of the detrimental effects of human endeavors on commercial organizations. As a result, decision-makers decided to implement an integrated strategy toward sustainable development and rethink their previous approaches. The study's findings aid in the understanding of how to assist the implementation of circular economy applications and sustainability practices by practitioners and policymakers. These activities include recycling, remanufacturing, circular procurement, and circular design, all of which are critical to sustainable performance. Businesses and management should offer more security and transparency to follow the life cycle of a product. Furthermore, to attain sustainability, this research suggests that managers, legislators, and governments should push for the operationalization of ESG initiatives and the adoption of circular economy initiatives. It is believed that financial and non-financial information disclosure is insufficient to implement circular economy initiatives. However, using technology to support a greener world significantly impacts many nations' and businesses' environmental problems. Green technology is a product and management solution that lowers greenhouse gas emissions and environmental burdens. Jordanian energy companies must also continue to adopt digital technologies because of their impact on the design and development of green products and the innovation of environmental designs capable of reducing and limiting pollution. It has been shown that companies that adopt digital technologies, such as the Internet of Things, extensive data analysis, and cloud-based design, make companies more industrially efficient, less polluting, and more quality in dealing with natural resources.

Managers must thus understand how important it is to activate seminars and training programs in order to foster self-efficacy and use green technology that encourages sustainable operations. In addition to promoting the disclosure of non-financial data, such as social, political, and environmental data, these administrative courses and workshops also help businesses become more financially efficient and improve their reputation. Managers need to understand that sharing knowledge should not be disproportionate or outdated, but rather integrative. Modified information disclosure reduces costs while increasing the efficiency of reusing goods, components, and resources. Furthermore, governments should establish guidelines regarding how green technology and information exchange should work as a crucial first step in implementing circular economy applications. Businesses are under intense societal and political pressure to include environmental issues in their entire business strategy. As a result, it is believed that emphasizing environmental issues like climate change at the expense of other topics like challenges with governance and green technology will impede the growth of the circular economy and achieve sustainability. As their main solution, companies should concentrate on applying the concurrent engineering technique. Therefore, organizing training sessions, seminars, and workshops for various stakeholders and incorporating them into organizational procedures will lessen the problems associated with environmental pollution and advance sustainability. Sustainability and financial efficiency are increased via green technology and ESG indices.

7. CONCLUSIONS

Through the circular economy's mediating role, the current study aims to quantify the effects of digital technologies and environmental, social, and governance (ESG) activities on sustainability performance. To get the findings, SmartPls was used to evaluate the data. The findings demonstrated that digital technology and the circular economy are positively correlated. Consequently, our first hypothesis is validated. According to Di Maria et al. [23] and Nara et al. [70], among others, digital technologies make it easier to gather, organize, and share product data. Our findings support this theory. Digital technologies have the capability to monitor products and furnish superior quality data to enable sustainable decision-making at both process and product levels. This is particularly useful as product components and elements undergo several life cycle stages and require constant observation [80]. By raising the degree of digitalization, digital technologies may further strengthen the circular economy by fostering more cooperation and the sharing of information and experience both inside and across enterprises [25]. As a result, businesses may lower waste and improve resource efficiency by incorporating digital technology into various circular economy components. Digital technology can monitor product life cycles, advance sustainable practices, and evaluate a product's environmental effects from inception to disposal.

On the other side, businesses that exhibit a lack of circular and sustainable processes must be subject to stringent policies and supervision. Because the energy business, particularly the oil and power industries, requires large amounts of land and significant financial resources. The primary source of the atmosphere's carbon dioxide gas production is also the oil and electrical industries. Therefore, by assisting and entering into contracts with more sustainable energy supply firms, our research of oil and power companies is a good answer to the most economical method of mitigating environmental deterioration.

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