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# Investigating the Impact of E-Procurement on Sustainability through Digitalization Technologies of Blockchain and Robotics Process Automation: An Applied Study on the Oil and Gas Industry in the Egyptian Context

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**Abstract**
E-procurement describes the automation and simplification of procurement procedures, such as ordering, payment, and purchase, through the use of digital platforms and technology. With the help of this technology, businesses can efficiently track orders, manage suppliers, and keep expenditure under control. E-procurement is the workhorse of digital purchasing. It is a software solution for automating spend purchasing from requisition to purchase order processing and, in some cases, implementing integration with identified companies' back-office applications. E-procurement in the oil and gas industry contributes to cost savings and improved adherence to safety and environmental regulations by lowering procurement cycle times, improving supplier selection, increasing transparency, and lowering the risks connected with manual procurement methods. Therefore, this study examines the relationship between e-procurement and sustainability, particularly focusing on the mediating role of digitalization technologies in Egypt's oil and gas sector.

The study adopted a deductive quantitative approach, focusing on employees within the oil and gas sector. Primary data were collected via a questionnaire, where respondents were asked to indicate their level of agreement with various statements using a Likert scale.

The study found that the relationship between e-procurement and digitalization technologies was partially supported. In addition, the relationship between digitalization technologies and sustainability was partially supported. Also, the relationship between e-procurement and sustainability is partially supported. The findings revealed that there was a mediation role of digitalization technologies between e-procurement and sustainability.

**Keywords**: E-Procurement, Digitalization Technologies & Sustainability

## 1. Introduction

Currently, in a knowledge economy where knowledge and information are abundant and digitalization is a necessity, the digitalization of a country has become the key determinant for competitiveness (Boikova et al., 2021). Digitalization significantly impacts the procurement sector, a crucial sector for sustainability on a global scale. In addition, with the dawn of the digital age and the breakneck pace of change, being good at procurement now means being able to embrace and integrate new technologies quickly and efficiently (Simionescu et al., 2021).

Oil and gas companies, facing the pressure of both competitive markets and government regulations, need state-of-the-art software solutions that can keep pace (Hunt et al., 2022).

E-procurement is the workhorse of digital purchasing. It is a software solution for automating spend purchasing from requisition to purchase order processing and, in some cases, implementing integration with identified companies' back-office applications (Albinkalil et al., 2021). Generally, it refers to a supply chain management process that integrates electronic technology. It is an important application of e-commerce technology in business-to-business transactions, and its development has broad prospects. However, it is necessary to consider the possible negative effects of e-procurement systems to balance use with benefits at all levels of society sensibly. E-procurement use, rather than its mere presence, plays a strategic role due to several positive effects (Ilhan and Rahim, 2020). On the other hand, the negative influence of costs and risks can have different reactions leading to ineffective outcomes. Besides, it has already been observed that large companies have more capabilities to adopt e-procurement; they also have more resources to manage greater pressure on negative aspects (Marei, 2022).

Digitalization technologies, including advanced analytics, cloud computing, the Internet of Things (IoT), and blockchain, offer transformative potential by enhancing data visibility, automating processes, and facilitating decision-making (Akter et al., 2022). These technologies can play a crucial mediating role in strengthening the link between e-procurement practices and sustainability outcomes by enabling more transparent, efficient, and responsible supply chain management. However, existing research has primarily focused on the direct impact of e-procurement on organizational performance, often neglecting the mediating effect of digitalization technologies in achieving sustainability goals (Singh and Chan, 2022).

The research problem addressed in this study stems from the limited understanding of how digitalization technologies influence the effectiveness of e-procurement practices in achieving sustainability outcomes within the oil and gas industry. While digitalization is widely recognized for its potential to drive sustainability, the specific mechanisms through which it mediates the relationship between e-procurement and sustainability outcomes remain underexplored. This gap in the literature calls for a deeper investigation into the mediating effect of digitalization technologies to provide actionable insights for industry practitioners and policymakers.

This study offers valuable insights into the relationship between e-procurement and sustainability, particularly focusing on the mediating role of digitalization technologies. By addressing specific objectives, this research contributes significantly to scientific knowledge and the broader community. It equips organizations with the necessary scientific knowledge to develop and implement procurement policies effectively. Moreover, it guides industry practitioners and policymakers in promoting the adoption of EPTs and GPP in ISO industries, thereby fostering sustainable development. Through this study, companies can establish benchmarks for enhancing their procurement capabilities, gaining insights that may confer a competitive advantage in the long term.

## 2. Literature Review

### E-Procurement

E-procurement involves the application of information and communication technology (ICT) by governmental entities to oversee their procurement procedures with suppliers. It encompasses the utilization of digital platforms and electronic systems to streamline the acquisition of goods, services, and works needed by the public sector. In essence, e-procurement streamlines and enhances the efficiency of procurement processes through the integration of ICT tools and platforms. It offers benefits such as improved transparency, reduced transaction costs, faster processing times, and increased accessibility to a broader supplier base. Ultimately, e-procurement aims to enhance the effectiveness of government procurement while fostering transparency, competition, and accountability in the procurement ecosystem (Asare and Prempeh, 2017).

Moreover, e-procurement refers to the use of digital platforms and technologies to automate and streamline procurement processes, including purchasing, ordering, and payment, in the oil and gas industry. This system allows companies to manage suppliers, track orders, and control spending efficiently. In the oil and gas sector, e-procurement helps reduce procurement cycle times, improve supplier selection, enhance transparency, and minimize the risks associated with traditional manual procurement methods, ultimately contributing to cost savings and better compliance with environmental and safety standards (Isoghom and Worgu, 2024).

***E-Ordering***

E-Ordering is a digital replacement for the conventional physical Delivery Order used in logistics and goods delivery? It serves as an instruction for delivering goods or cargo, typically created electronically by shipping or expedition firms. E-O includes crucial details like the type and quantity of goods, their source and destination, and any specific delivery instructions. The goal of implementing E-Os is to streamline administrative tasks, minimize paper usage, and accelerate goods delivery by offering swift access to shipping information via digital platforms. By eliminating the need for physical paperwork, E-O facilitates quicker and more efficient administrative processes, fostering improved coordination among involved parties. Moreover, E-O enhances overall logistics efficiency by furnishing valuable data for planning and monitoring goods delivery, resulting in faster, smoother processes, reduced administrative expenses, and enhanced customer service (Kristiyantia et al., 2024).

In addition, e-ordering involves the electronic generation and management of purchase orders through an online system. In the oil and gas industry, e-ordering enables companies to quickly place orders for essential materials, equipment, and services needed for exploration, drilling, production, and maintenance operations. This system improves accuracy, reduces paperwork, and facilitates real-time tracking of order status, which is crucial for maintaining the tight schedules often required in oil and gas projects (Isoghom and Worgu, 2024).

***E-Sourcing***

E-sourcing refers to the utilization of digital technologies to streamline and enhance the initial stages of the procurement process before the formal tendering or requesting of quotes from suppliers. This involves leveraging online platforms and tools to perform tasks such as searching supplier databases, discovering new suppliers for specific spending categories, securely exchanging procurement documents with potential suppliers, and digitally prequalifying vendors. The primary objectives of e-sourcing are to broaden market access, decrease search costs for both buyers and suppliers, generate benchmark pricing information, and facilitate the optimization of the supplier base (Oniyangi and Ibrahim, 2024).

Also, e-sourcing is the use of internet-based tools to identify, evaluate, and engage suppliers for goods and services. In the oil and gas industry, e-sourcing enables companies to access a broader pool of potential suppliers, assess their capabilities, and negotiate contracts more effectively. It helps streamline supplier selection processes, ensures competitive pricing, and supports compliance with sustainability and quality standards critical for managing supply chains in the complex and highly regulated oil and gas environment (Chukwuemeka and Poi, 2023).

***E-Tendering***

E-tendering refers to the electronic management of all aspects of the tender process, including the publication, communication, access, receipt, and submission of tender-related information and documents via the Internet. This digital approach replaces traditional paper-based tender processes, offering a more efficient and streamlined experience for all parties involved. E-tendering practices are utilized across various business sectors, including procurement of goods, sourcing service providers, hiring business consultants, and selecting contractors for construction projects. By leveraging digital platforms and technologies, e-tendering enhances transparency, accessibility, and speed in the tendering process (Sarkar et al., 2023).

Furthermore, e-tendering refers to the electronic submission and evaluation of bids for contracts. In the oil and gas industry, e-tendering is used to invite suppliers and contractors to submit proposals for projects such as drilling operations, pipeline construction, and facility maintenance. The digital process enhances transparency, reduces bid evaluation time, and ensures fair competition among bidders, which is essential in managing large-scale projects with stringent regulatory and safety requirements (Isoghom and Worgu, 2024).

### *E-Informing*

*E-informing* is predominantly being used in the partial implementation of e-procurement by some public sector organizations. E-informing denotes the electronic dissemination of procurement-related details. Utilizing channels such as emails, web portals, or digital notifications, these organizations communicate procurement procedures to suppliers, contractors, and internal personnel (Gbonda et al., 2024). Moreover, e-informing involves the electronic dissemination and sharing of information between an organization and its suppliers or stakeholders. In the oil and gas sector, e-informing platforms provide real-time access to critical information such as market trends, safety updates, technical specifications, and regulatory changes. This timely and accurate information flow supports better decision-making, improves collaboration with suppliers, and enhances the overall efficiency and safety of operations (Isoghom and Worgu, 2024).

### *E-Reverse Auctioning*

E-actioning, referred to as e-reverse auctioning, involves customers and sellers competing against one another for products or services via an electronic platform. In e-actioning, vendors use a website or online marketplace to present their goods or services to prospective customers, and purchasers bid against one another to get the best deal on the goods they want to buy (NOGO, 2017). In addition, e-reverse auctioning is a type of e-auction where suppliers compete to offer the lowest price for goods or services rather than the highest bid. In the oil and gas industry, e-reverse auctions are commonly used for purchasing high-cost items, such as machinery, drilling equipment, or bulk raw materials, where cost savings are critical. The competitive nature of reverse auctions helps drive down prices, providing substantial financial benefits while ensuring suppliers meet the necessary quality and delivery standards (Kandpal, 2023).

### *E-Auctioning*

It, known as online bidding, involves a digital auction where a buying organization interacts with two or more invited suppliers. In this dynamic process, suppliers can submit multiple bids, and they possess some degree of insight into the activities of their competitors. E-auctions can produce some conflicting action as a commodity; they should produce better results and are thus an appropriate technique for organizations to acquire their purchase (Dey and Bhattacharya, 2021). E-auctioning refers to the online process where buyers invite suppliers to compete in a bidding process for contracts or orders. In the oil and gas industry, e-auctioning can be used to secure services, equipment, or commodities at competitive prices. This method fosters price transparency and cost efficiency, allowing companies to leverage competitive bidding to reduce procurement costs while maintaining quality standards (Onumajuru et al., 2024).

### *E-Invoicing*

It is described as the electronic transfer of billing and payment information between business partners and plays a crucial role in streamlining financial supply chains and connecting internal enterprise processes with payment systems. While e-invoicing is not a novel concept and has been successfully implemented in various countries, there is a need to further develop the process to increase its adoption rate. One significant advantage of e-invoicing is its ability to eliminate multiple steps involved in traditional paper invoicing, as depicted in the figure below, simplifying the invoicing process for both buyers and suppliers by removing tasks such as printing, posting, sorting, and registration (Ali, 2016).

E-invoicing refers to the electronic generation, submission, and processing of invoices between buyers and suppliers. In the oil and gas industry, e-invoicing helps streamline the complex billing and payment processes associated with large-scale projects, including equipment rentals, service contracts, and material purchases. By automating invoicing, oil and gas companies can reduce errors, accelerate payment cycles, and improve cash flow management. Additionally, e-invoicing enhances compliance with regulatory and tax requirements, ensuring accurate financial reporting and audit trails, which are essential in this highly regulated industry (Onumajuru et al., 2024).

### *E-Contract Management*

E-contract management known as a smart contract, delineates obligations among parties in a computationally interpretable format, dictating how they're fulfilled, refused, or waived based on future events. It enables the seamless organization of processes in distributed systems, facilitating contract creation, execution, and communication without human intervention. Initially introduced in information systems research, electronic contracts encode obligation definitions electronically, allowing for efficient monitoring and oversight (GUO et al., 2021).

Moreover, e-contract management involves the digital creation, negotiation, approval, execution, and monitoring of contracts through an online platform. In the oil and gas industry, e-contract management is crucial for managing the extensive array of contracts that govern operations, including supplier agreements, service contracts, joint ventures, and compliance with regulatory standards. This system enhances contract visibility, reduces administrative burdens, and ensures timely renewals and compliance. E-contract management also provides a secure and accessible repository for contract documentation, facilitating efficient risk management and dispute resolution, which are vital for maintaining smooth operations in a complex and high-stakes environment (Warburton, 2023).

## Sustainability

In a business context, sustainability involves incorporating environmental, social, and economic factors into operational practices to ensure longevity while mitigating adverse effects on the planet and society. It encompasses adopting strategies that fulfill current requirements without jeopardizing the ability of future generations to meet their own needs (Peláez et al., 2023). Sustainability refers to the ability to meet present needs without compromising the ability of future generations to meet their own needs. In the oil and gas industry, sustainability encompasses practices that balance economic growth, environmental protection, and social equity. It involves adopting technologies and strategies that ensure the long-term viability of resources while minimizing negative impacts on the environment and communities (Bathrinath et al., 2021).

### *Economic Sustainability*

Economic sustainability involves maintaining capital over time, which necessitates the adoption of sustainable business practices. Preserving assets and ensuring that current economic activities don't significantly diminish the living standards of future generations requires different decision-making regarding environmental asset preservation. (Kaur and Kander, 2023). Economic sustainability in the oil and gas industry involves practices that support long-term financial viability and profitability without depleting resources or harming the economy of local communities. This includes efficient resource management, investment in innovative technologies, and the establishment of robust supply chains that reduce costs and enhance competitiveness. It also considers the economic impacts on communities, such as job creation and local development, ensuring that economic benefits extend beyond the industry itself (Dmitrieva and Romasheva, 2020).

### *Environmental Sustainability*

Environmental sustainability is a crucial aspect, aiming to optimize resource efficiency. In today's interconnected world, stakeholders' relationships are reshaped by the sustainability-driven sharing economy. This principle ensures that meeting present needs doesn't compromise the environment's quality or the ability to sustain future generations. Integrating environmental sustainability into operations enhances organizational value and amplifies the benefits of digitalization (Feroz et al., 2021). Environmental sustainability in the oil and gas industry pertains to the responsible use of natural resources and the implementation of practices that minimize ecological damage. This includes reducing greenhouse gas emissions, managing waste effectively, and protecting biodiversity during exploration, extraction, and production processes. Environmental sustainability aims to ensure that the operations of the oil and gas sector do not compromise the health of ecosystems, thus preserving them for future generations while also addressing climate change challenges (Obeidat et al., 2020).

***Social Sustainability***

Social sustainability entails tackling various social concerns such as labor conditions, well-being, quality of life, equality, diversity, and community cohesion. Organizations must prioritize labor rights, guaranteeing job stability, equitable wages, and social protection measures to uphold social sustainability. During crises like the present one, organizations may prioritize financial survival, potentially resulting in decreased investment in corporate social responsibility (CSR) endeavors. This could lead to layoffs, salary cuts, health and safety issues, hygiene and social distancing measures, adherence to government regulations, and the creation of local job opportunities becoming critical considerations. These factors are vital for maintaining social sustainability during times of crisis (Rai et al., 2023). Social sustainability refers to the maintenance and improvement of social quality, which includes factors such as community engagement, labor rights, and equitable distribution of resources. In the oil and gas sector, social sustainability involves ensuring that operations respect human rights, engage with local communities, and contribute to their well-being. This includes fostering transparent communication, providing fair labor conditions, and investing in community development initiatives, thereby enhancing the social fabric of regions impacted by oil and gas activities (Rentizelas et al., 2020).

**Digitalization Technologies**

Digitalization technologies are a broad spectrum of digital tools and systems facilitating the conversion of conventional manufacturing processes into systems that are not only more efficient and flexible but also sustainable. Several pivotal digitalization technologies have the potential to lower costs and enhance the adaptability and sustainability of manufacturing systems (Demartini et al., 2019). Digitalization technologies refer to the integration of digital tools and systems that enhance operations, decision-making, and efficiency across various sectors. In the oil and gas industry, these technologies encompass a wide range of solutions, including data analytics, Internet of Things (IoT) devices, and cloud computing. Digitalization enables oil and gas companies to improve operational efficiencies, optimize supply chains, enhance safety measures, and drive sustainability initiatives by leveraging real-time data and advanced analytics for informed decision-making (Al-Rbeawi, 2023).

***Block Chain***

It is a form of Distributed Ledger Technology (DLT) that safeguards and registers transactions within a peer-to-peer (P2P) network rather than relying on a single server or multiple servers. In this system, data is stored across interconnected systems, all of which maintain identical information. If updates made by a computer are not verified, the network will reject them. In the blockchain, multiple transactions involving the exchange of value are grouped (Namasudra et al., 2021). Blockchain is a decentralized digital ledger technology that securely records transactions across multiple computers, ensuring that the recorded data cannot be altered retroactively. In the oil and gas industry, blockchain can enhance transparency and trust in supply chain management by providing a secure and tamper-proof record of transactions, from exploration and extraction to distribution and sales. It can also streamline contract management and e-procurement processes, reduce fraud, and improve regulatory compliance by offering real-time tracking of assets and transactions, ultimately fostering greater accountability and efficiency (Ahmad et al., 2022).

***Robotic Process Automation***

RPA is designed to automate repetitive tasks and remove the necessity for human involvement by utilizing software robots. These robots manage administrative responsibilities, enabling employees to concentrate on more intricate cognitive tasks. Additionally, RPA software robots utilize the same interfaces as humans, ensuring that their processes closely resemble those executed by humans (Farinha et al., 2024). Robotic Process Automation (RPA) refers to the use of software robots or "bots" to automate repetitive and rule-based tasks, thereby enhancing operational efficiency and accuracy. In the oil and gas sector, RPA can be employed to streamline various processes, such as data entry, invoice processing, and compliance reporting. By automating these routine tasks, oil and gas companies can reduce operational costs, minimize human error, and free up valuable human resources for more strategic and analytical work, leading to increased productivity and improved overall performance (Fernandez and Aman, 2021).

***Artificial Intelligence***

AI involves machines interacting with humans via electronic output devices without revealing their non-human identity, usually evaluated through binary judgment criteria. Marvin Minsky, a prominent figure in AI, characterized AI as empowering machines to execute tasks typically associated with human intelligence. The symbolic school perceives AI as the manipulation of symbols, where basic symbols represent physical entities. Despite diverse interpretations, the core of AI revolves around theories, techniques, technologies, and practical applications geared toward imitating, improving, and expanding human intelligence (Jiang et al., 2022). In the oil and gas industry, AI is utilized to enhance operational efficiency, improve safety, and drive innovation. Applications of AI include predictive maintenance, where algorithms analyze data from equipment sensors to forecast failures before they occur, thereby minimizing downtime and maintenance costs. AI is also used for optimizing drilling processes, enhancing reservoir management through data analysis, and improving decision-making in supply chain management by analyzing market trends and operational data. By harnessing AI, the oil and gas sector can achieve greater efficiency, reduce environmental impact, and adapt to the rapidly changing energy landscape (Choubey and Karmakar, 2021).

**Hypotheses Development**

Hidayanti et al. (2022) aimed to investigate the implementation of robotic process automation (RPA) in auditing the e-procurement of goods and services in Indonesia. The study employed qualitative research methods for analysis and descriptive examination. The methodology involved exploring the potential of RPA as a tool to facilitate audit processes by extracting and processing large amounts of data efficiently. The results revealed that RPA implementation demonstrated promising capabilities in streamlining audit activities and generating usable data for audit purposes, thereby offering a potential solution to the challenges associated with manual audit processes in the public procurement sector.

AlQubaisi et al. (2022) aimed to investigate the mediation role of sustainable supply chain practices in the e-procurement processes of ADNOC, the largest energy company in the UAE. The study utilized a quantitative approach, collecting data through surveys administered to procurement and sustainability professionals within ADNOC. The results revealed that integrating sustainable practices into e-procurement processes positively influenced supply chain efficiency and environmental sustainability metrics. The study concluded that sustainable supply chain initiatives play a crucial role in enhancing the overall effectiveness and sustainability of e-procurement practices at ADNOC.

Addy et al. (2024) sought to identify the factors influencing the adoption of e-procurement in Ghana by applying an extended Unified Theory of Acceptance and Use of Technology (UTAUT2) and employing a mixed-method approach. Initially, semi-structured interviews were conducted to refine the UTAUT2 model, followed by a questionnaire survey using the modified model. Structural Equation Modeling (SEM) was then utilized to analyze the survey data. The findings revealed that five independent constructs from the UTAUT2 model significantly influenced practitioners' intention to accept and utilize e-procurement within Ghana's construction sector.

Gurgun et al. (2024) investigated the correlation between e-procurement implementation and construction supply chains. Their study involved a thorough literature review, a focus group discussion to identify 28 barriers, a questionnaire survey of 131 construction practitioners to assess these barriers, and the application of the fuzzy technique for order preference by similarity to the ideal solution (fuzzy TOPSIS) for prioritization. Additionally, 15 semi-structured interviews were conducted to delve deeper into the shift from traditional procurement to e-procurement. The research findings underscored that issues such as unexpected order cancellations and significant fluctuations in material costs were identified as the most significant barriers. Addressing these obstacles has the potential to enhance supply chain efficiency.

Omorodion and Joseph (2024) aimed to identify critical success factors and assess the management implementation of electronic procurement initiatives in the upstream sector of Nigerian oil and gas firms. The study employed a mixed-methods approach, combining qualitative interviews and quantitative surveys with key stakeholders such as procurement managers, IT specialists, and executive management. The results underscored the significance of factors such as strong leadership commitment, robust IT infrastructure, comprehensive staff training, and effective change management strategies in successful electronic procurement implementation.

The existing literature on the relationship between e-procurement and digitalization technologies in the oil and gas sector has significant gaps, particularly in understanding how these technologies specifically impact sustainability and operational efficiency in this unique and complex industry. Most studies focus on general industries and lack detailed analysis of how specific digital tools, like AI or blockchain, mediate e-procurement outcomes in the oil and gas sector. Additionally, the predominance of qualitative approaches limits the quantitative evidence needed to establish causal relationships.

***H1: The Relationship between E-Procurement and Digitalization Technologies.***

Xiao and Su (2022) aimed to investigate the influence of technological innovation on achieving social and environmental sustainability, particularly focusing on small and medium enterprises (SMEs). It addressed the urgent need for transitioning to environmental and social sustainability by harnessing innovation, especially in the context of digital evolution. By collecting data from SMEs in both developed and developing countries. The findings revealed that attitudes toward technological innovation significantly influenced organizational innovation, which in turn played a crucial role in promoting environmental and social sustainability. However, digital entrepreneurship did not emerge as a significant mediator in this relationship.

Abid et al. (2022) aimed to investigate the dynamic interplay among technological progress, institutional quality, and environmental and social sustainability across Italian cities spanning from 2010 to 2019. They categorized cities into three economic tiers and utilized a generalized least squares (GLS) model to analyze data encompassing various indicators related to these factors. The findings suggested that the rate of economic development within a city significantly influenced the relationship between technological advancement, institutional quality, and environmental and social sustainability. Notably, technological progress exhibited a positive correlation with sustainability outcomes over the long term, while institutional quality did not emerge as a significant determinant in the Italian context.

Khalaf et al. (2023) aimed to comprehensively review emerging AI technologies for corrosion monitoring in the oil and gas industry. The study employed a systematic approach, synthesizing existing literature to explore how AI technologies, including machine learning and advanced sensors, are being utilized to monitor and predict corrosion in oil and gas infrastructure. The results highlighted that AI-based corrosion monitoring systems can effectively detect and predict corrosion, leading to improved maintenance strategies, reduced operational risks, and enhanced asset integrity in the oil and gas sector to sustainably.

Using firm-level data from the People's Republic of China's (PRC) oil and gas industry, Liu et al. (2023) investigated the relationship between digitalization, sustainability, and competitiveness. The purpose of the study was to investigate how digitization affects sustainability promotion. To test the proposed association, they used partial least squares structural equation modeling. The businesses' competitiveness and sustainability were shown to have been significantly enhanced by digitization, as supported by their empirical findings. Furthermore, the outcomes validated the intermediary function of sustainability in the correlation between digitization and competitiveness. These results showed that in China's oil and gas industry, digitization may play a key role in achieving sustainability-led competitiveness. According to the detailed investigation, digitization helped businesses stay sustainable by enhancing process visibility and establishing higher-level integration.

Waqar et al. (2023) conducted a systematic literature review to explore the applications of artificial intelligence (AI) in oil and gas projects toward sustainable development. The study utilized a qualitative approach, systematically analyzing a wide range of literature to synthesize findings on how AI technologies are being applied in various facets of oil and gas projects to promote sustainability. The results indicated that AI is increasingly utilized for predictive maintenance, optimizing operations, and enhancing decision-making processes in the oil and gas sector, thereby contributing to improved efficiency, reduced environmental impact, and overall sustainable development goals.

Böttcher et al. (2024) aimed to investigate strategies for integrating ecological sustainability into business models without compromising economic viability. Their research involved developing a taxonomy of digital sustainable business models and providing recommendations for achieving both ecological and economic sustainability. By examining 31 start-ups, they constructed a taxonomy outlining these models. The methodology likely combined qualitative and quantitative approaches such as case studies, interviews, and data analysis to identify common traits among the start-ups. The researchers detailed how digital technology plays a crucial role in creating these ecological business models and how they contribute to sustainable value across ecological, economic, and technological dimensions. The findings suggest that companies can move beyond merely using digital technology for optimization and instead incorporate sustainability as a fundamental aspect of their organizational identity.

Oyewole et al. (2024) aimed to explore the transformative integration of artificial intelligence (AI) into sustainable finance, with a focus on redefining financial practices in alignment with environmental, social, and governance (ESG) criteria. The methodology involved a systematic review of current practices and an analysis of AI's applications, challenges, and strategic frameworks. Findings indicated that AI technologies, such as the Financial Maximally Filtered Graph (FMFG) algorithm, significantly improved the processing and analysis of vast datasets, facilitating sustainable investment decisions.

Hasan et al. (2024) aimed to investigate sustainable supply chain practices within the oil and gas industry through a case study approach. The researchers utilized a qualitative methodology, conducting in-depth interviews and analyzing company documents to understand how oil and gas companies integrate sustainability principles into their supply chain operations. The results indicated that adopting sustainable practices such as reducing carbon emissions, implementing green procurement strategies, and promoting supplier diversity not only enhanced environmental stewardship but also contributed to cost savings and improved corporate reputation. The study concluded that sustainable supply chain practices are crucial for fostering long-term resilience and competitiveness in the oil and gas industry.

***H2: The Relationship between Digitalization Technologies and Sustainability.***

Omoregbe et al. (2022) examine the impact of electronic procurement practices on the sustainable competitive advantage of the upstream sector of oil and gas firms in Nigeria, specifically focusing on electronic tendering, invoicing, payment, and auctioning. Employing an ex-post facto and survey research design, the study targeted employees and management staff of procurement departments in the Niger Delta region. A total of 224 questionnaires were distributed, with 220 successfully retrieved through convenience sampling. Statistical analysis was conducted using the ordinary least squares (OLS) technique with SPSS Version 22. The findings revealed that electronic tendering, invoicing, and payment had a positive and significant relationship with sustainable competitive advantage in the upstream oil and gas industry. Although electronic auctioning did not demonstrate significant influence, it still showed a positive correlation with sustainable competitive advantage. Consequently, the study recommended that organizations should encourage electronic procurement practices to enhance their sustainable competitive advantage.

Maina (2023) aimed to assess the impact of e-procurement adoption on sustainable procurement performance in Kenyan telecommunication firms. It evaluated implemented e-procurement strategies and their effects on sustainability and identified implementation challenges. Primary data was collected through questionnaires from procurement, ICT, and accounting officers, with an 85% response rate. The analysis included descriptive statistics and regression, showing positive outcomes like cost reduction and competitive advantage. Challenges included high implementation costs and resistance to change. The study concluded that e-procurement adoption is crucial for enhancing sustainability in Kenyan telecommunication companies.

Singh et al. (2023) researched to examine the increasing use of e-procurement in sustainable procurement practices. Their study focused on a sample of 55 organizations and 162 respondents, including procurement managers and staff. It aimed to investigate how the implementation of e-procurement technologies influenced sustainable procurement practices. Utilizing a quantitative approach and deductive sampling, the study employed questionnaire surveys as the primary method to assess the proposed framework. The results indicated a positive correlation between the adoption of e-procurement technology and sustainable procurement practices. The study aimed to contribute to the development of a consistent and dependable framework for sustainable procurement in Malaysia.

Onumajuru et al. (2024) investigated the relationship between e-procurement and supply chain sustainability in the oil and gas industry in Rivers State, Nigeria, using a quantitative and explanatory research design grounded in stakeholder theory. The study focused on a target population of 25 oil and gas firms, employing a census approach to select five respondents from each company based on their managerial roles, resulting in 125 targeted respondents with 103 usable questionnaires. Data were collected using a validated self-administered survey and analyzed through descriptive and inferential statistics, including Pearson Product Moment Correlation and Partial Correlation, using SPSS version 22. The results indicated a significant, strong, and positive relationship between e-procurement and various dimensions of supply chain sustainability, such as environmental, financial, and social responsibilities. The study concluded that e-procurement positively influences supply chain sustainability, with competitive pressure also playing a significant role in this relationship.

The existing literature on the relationship between e-procurement and sustainability in the oil and gas sector reveals significant gaps, particularly regarding how e-procurement practices contribute to sustainability outcomes in this context. Most studies have focused on broader sectors and theoretical frameworks without providing empirical evidence specific to the unique challenges of the oil and gas industry. Additionally, the multifaceted nature of sustainability, which includes environmental, social, and economic dimensions, remains underexplored. Many prior studies have also relied on qualitative methodologies, limiting the understanding of quantitative relationships needed to establish causality. This research aims to fill these gaps by providing a quantitative examination of the impact of e-procurement on sustainability outcomes in the oil and gas sector, thereby enriching academic literature and offering practical insights for industry practitioners seeking to leverage e-procurement for achieving sustainability goals.

***H3: The Relationship between E-Procurement and Sustainability.***

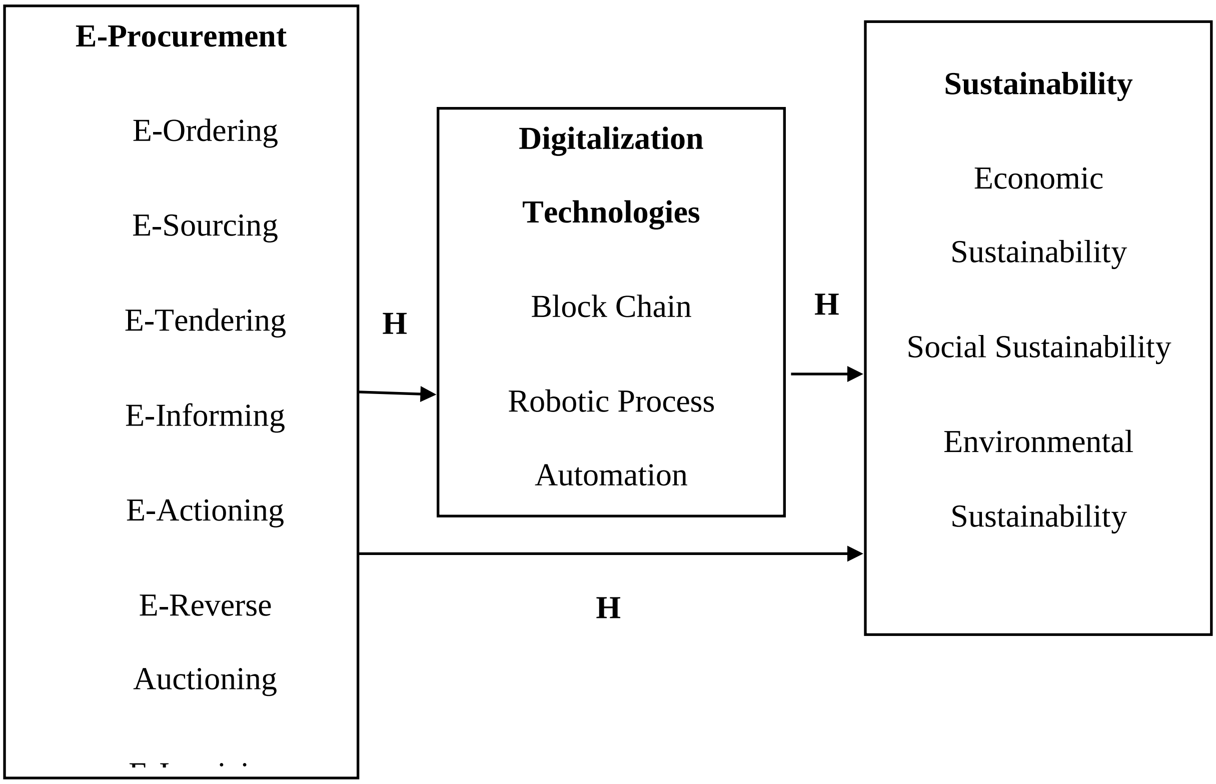
## 3. Research Methodology

The research methodology seeks to empirically examine the proposed mediation effect of digitalization technologies on the correlation between e-procurement practices and sustainability outcomes, specifically within the oil and gas industry in Egypt. It adopts a deductive quantitative approach, focusing on employees within this industry. Through a convenience sampling technique, a sample size of 512 employees was chosen to participate in the study. Primary data were collected via a questionnaire, where respondents were asked to indicate their level of agreement with various statements using a Likert scale ranging from 1 to 5. Given the absence of a predefined sampling frame and the substantial number of companies in Egypt, the sample size was determined using the formula for a 95% confidence level as outlined by Saunders and Townsend (2016). Structured questionnaires tailored to assess perceptions and experiences regarding e-procurement, digitalization technologies, and sustainability initiatives were distributed among the targeted employees. Statistical methods are employed to analyze the responses and explore the relationships between the variables.

- **Independent Variable:** E-Procurement (E-Ordering- E-Sourcing- E-Tendering- E-Informing- E-Actioning- E-Reverse Auctioning- E-Invoicing- E-Contract Management).
- **Mediator Variable:** Digitalization Technologies **(**Block Chain- Robotic Process Automation- Artificial Intelligence).
- **Dependent Variables:** Sustainability (Economic Sustainability- Social Sustainability- Environmental Sustainability).

**Therefore, the current research framework could) be expressed using the following figure:**

***Figure 1: Research Model***




Accordingly, from the framework, these could be the research hypothesis expressed:

**H1 There is a Significant Relationship between E-Procurement and Digitalization Technologies**

*$H_{1.1}$ There is a Significant Relationship between E-Ordering and Digitalization Technologies*
*$H_{1.2}$ There is a Significant Relationship between E-Sourcing and Digitalization Technologies*
*$H_{1.3}$ There is a Significant Relationship between E-Tendering and Digitalization Technologies*
*$H_{1.4}$ There is a Significant Relationship between E-Informing and Digitalization Technologies*
*$H_{1.5}$ There is a Significant Relationship between E-Actioning and Digitalization Technologies*
*$H_{1.6}$ There is a Significant Relationship between E-Reverse Auctioning and Digitalization Technologies*
*$H_{1.7}$ There is a Significant Relationship between E-Invoicing and Digitalization Technologies*
*$H_{1.8}$ There is a Significant Relationship between E-Contract Management and Digitalization Technologies*
**H2 There is a Significant Relationship between Digitalization Technologies and Sustainability**
*$H_{2.1}$ There is a Significant Relationship between Block Chain and Sustainability*
*$H_{2.2}$ There is a Significant Relationship between Robotic Process Automation and Sustainability*
*$H_{2.3}$ There is a Significant Relationship between Artificial Intelligence and Sustainability*
**H3 There is a Significant Relationship between E-Procurement and Sustainability**
*$H_{3.1}$ There is a Significant Relationship between E-Ordering and Sustainability*
*$H_{3.2}$ There is a Significant Relationship between E-Sourcing and Sustainability*
*$H_{3.3}$ There is a Significant Relationship between E-Tendering and Sustainability*
*$H_{3.4}$ There is a Significant Relationship between E-Informing and Sustainability*
*$H_{3.5}$ There is a Significant Relationship between E-Actioning and Sustainability*
*$H_{3.6}$ There is a Significant Relationship between E-Reverse Auctioning and Sustainability*
*$H_{3.7}$ There is a Significant Relationship between E-Invoicing and Sustainability*
*$H_{3.8}$ There is a Significant Relationship between E-Contract Management and Sustainability*

In this research, data collection involved administering a questionnaire to employees within Egypt's oil and gas sector. The questionnaire employed a five-point Likert scale to assess the impact of various E-Procurement technologies (E-Ordering, E-Sourcing, E-Tendering, E-Informing, E-Actioning, E-Reverse Auctioning, E-Invoicing, E-Contract Management) on Digitalization Technologies (Blockchain, Robotic Process Automation, Artificial Intelligence). Additionally, the questionnaire aimed to examine the mediating role of sustainability factors (economic, social, and environmental). Respondents rated their opinions on a scale ranging from 1 denoting "strongly disagree" to 5 representing "strongly agree." Initially, 600 survey questionnaires were distributed, and 555 participants voluntarily responded. However, 43 surveys were excluded due to inaccuracies. Consequently, the researcher analyzed 512 fully completed and accurate questionnaires for further investigation.

***Table 1: Statement Variable***

| Variables | Statements | References |
|---|---|---|
| **E-Procurement** (E-order) | 1. The company employs an internet-based order management system (OMS).<br>2. Customized order forms are utilized online by the company.<br>3. An online platform for warehouse integration has been developed by the company. | Kiusya. (2018) |
| **E-Procurement** (E-sourcing) | 1. The company receives digital quotations from various suppliers through online channels.<br>2. It conducts digital bidding processes to identify the most qualified supplier offering the lowest bid.<br>3. Utilizing e-sourcing software, the company manages its procurement procedures.<br>4. Standardized and regular online communication | Kiusya. (2018) |

| Variables | Statements | References |
|---|---|---|
| | with suppliers is facilitated by the company | |
| **E-Procurement** (E-tending) | 1. The company creates and posts tender documents on the internet.<br>2. It conducts online screening and evaluation of potential suppliers.<br>3. Regular assessments of supplier performance are carried out online by the company.<br>4. The company utilizes an internet-based system to manage historical bid submissions. | Kiusya. (2018) |
| **E-Procurement** (E-informing) | 1. The commission collects supplier data from previous clients electronically.<br>2. They electronically share our information with relevant suppliers.<br>3. Information regarding pricing and other relevant details is distributed electronically by the commission. | Mwangi. (2020) |
| **E-Procurement** (E-Actioning) | 1. Managerial policies are inclined towards promoting the adoption of e-procurement.<br>2. Staff receive training in e-procurement techniques.<br>3. Management provides backing for e-procurement initiatives. | Asare and Prempeh. (2017) |
| **E-Procurement** **(**E-Reverse Auctioning) | 1. E-reverse auctioning is primarily utilized to ensure lower prices, even when dealing with "key partners."<br>2. In reverse auctions, the determining factor is consistently the lowest price available.<br>3. We view reverse e-auctions as the initial phase of negotiations, during which sellers propose their highest price discounts before delving into detailed specification discussions.<br>4. A crucial aspect of the e-auction process involves assessing various supplier capabilities before the auction, allowing us to prioritize factors beyond just price and select the most suitable supplier. | Tassabehji. (2010) |
| **E-Procurement** (E-Invoicing) | 1. Utilizing e-invoicing rather than manual methods offers both time and cost savings.<br>2. E-invoicing provides a secure method for storing documents.<br>3. Serenic proves to be an efficient platform for managing e-invoicing. | Ndei and Mutuku. (2021) |

| Variables | Statements | References |
|---|---|---|
| | 4. I am proficient in creating e-invoices and submitting them through Serenic. | |
| **E-Procurement** (E-Contract Management) | 1. Employees responsible for contracts possess expertise in procurement contract management.<br>2. Staff members understand how to decipher contract documents.<br>3. The educational background of Ministry staff impacts the efficacy of contract management.<br>4. Competent staff members proficiently handle contract management through their experience. | Lifard. (2020) |
| **Digitalization Technologies** (Block Chain) | 1. I have confidence in blockchain technology's ability to securely transmit data.<br>2. I am knowledgeable about the safety mechanisms inherent in blockchain technology. | Kim et al. (2022) |
| **Digitalization Technologies** (Robotic Automation) | 1- Enhance security protocols within swarm robotics applications to bolster resilience against potential threats.<br>2- Empower swarm robotics systems to efficiently coordinate, reach consensus, and effectively carry out mission objectives.<br>3- Streamline the integration of additional functionalities into swarm robotics frameworks.<br>4- Simplify the process of documenting and validating the actions performed by robots. | Al-Jaroodi and Mohamed. (2019) |
| **Digitalization Technologies** (Artificial Intelligence) | 1- The AI technology keeps me absorbed in what I am doing.<br>2- The AI technology holds my attention.<br>3- The AI technology is fun.<br>4- AI technology is interesting.<br>5- The AI technology is engaging. | Wang et al. (2023) |
| **Sustainability** (Sustainability Economic**)** | 1. The company adheres to all legal requirements concerning salary and benefit payments for its local workforce.<br>2. Its employees receive competitive compensation compared to industry standards,<br>3. the company also provides a range of employee benefits.<br>4. the company demonstrates a favorable outlook toward economic considerations. | Lalangui et al. (2018) |
| **Sustainability (**Social | 1. The company fosters dialogue and engagement with | Lalangui et al. |

| Variables | Statements | References |
|---|---|---|
| Sustainability) | both internal and external stakeholders to shape its sustainability vision.<br>2. Implement initiatives that enable employees to voice their concerns and ideas.<br>3. the company advocates for societal involvement in shaping public policies to advance common interests | (2018) |
| **Sustainability** **(**Environmental Sustainability) | 1. The company prioritizes environmental conservation and sustainability.<br>2. It actively assesses the potential impacts of its operations on climate change.<br>3. Additionally, the company is acknowledged for its outstanding practices in cleaner production and pollution prevention management.<br>4. It also implements targeted efforts to minimize material usage. | Lalangui et al. (2018) |

## 4. Results and Findings

To examine the research hypotheses comprehensively, the data were subjected to structural equation modeling (SEM) analysis, employing AMOS version 24. Initially, a measurement model was established to validate the underlying structure of the research model. Confirmatory factor analysis (CFA) was employed to evaluate the appropriateness of the measurement model for the dataset. Subsequently, assessments were made to confirm the normality and multicollinearity assumptions. Additionally, descriptive analyses, encompassing the study variables and respondent profiles, were conducted using SPSS version 25.

### Data Testing using Validity and Reliability

To assess the quality of the data utilized in this study, an examination of validity and reliability was conducted, as detailed in Table 2. Kaiser-Meyer-Olkin (KMO) measures and Average Variance Extracted (AVE%) values indicate the appropriateness of the data for factor analysis and the extent to which the variables explain the constructs, respectively. Acceptable KMO values, ranging from 0.500 to 0.917, suggest that the variables are suitable for factor analysis. Moreover, high AVE values, ranging from 80.758% to 87.772%, indicate that the variables explain a substantial proportion of the variance in their respective constructs. Additionally, reliability, assessed through Cronbach's alpha coefficients, measures the internal consistency of the items comprising each construct. With Cronbach's alpha values ranging from 0.860 to 0.948, exceeding the commonly accepted threshold of 0.7, the constructs demonstrate high internal consistency. Furthermore, factor loadings above 0.8 for most items signify strong relationships between the items and their respective constructs, further supporting the reliability of the measurement model. Overall, these results indicate high levels of validity and reliability in the measurement of the research variables, ensuring confidence in the study's findings and conclusions.

***Table 2: Validity and Reliability Test***

| Variables | KMO | Cronbach's α | AVE % | Items | Factor Loadings |
|---|---|---|---|---|---|
| E-Order | .760 | .917 | 85.777 | EO1 | .853 |
| | | | | EO2 | .868 |
| | | | | EO3 | .853 |
| E-Sourcing | .867 | .934 | 83.462 | ES1 | .835 |
| | | | | ES2 | .832 |
| | | | | ES3 | .831 |

| Variables | KMO | Cronbach's α | AVE % | Items | Factor Loadings |
|---|---|---|---|---|---|
| | | | | ES4 | .840 |
| E-Tending | .862 | .926 | 82.055 | ET1 | .829 |
| | | | | ET2 | .792 |
| | | | | ET3 | .820 |
| | | | | ET4 | .842 |
| E-Informing | .758 | .910 | 84.801 | EIF1 | .849 |
| | | | | EIF2 | .846 |
| | | | | EIF3 | .849 |
| E-Actioning | .760 | .915 | 85.452 | EA1 | .862 |
| | | | | EA2 | .849 |
| | | | | EA3 | .853 |
| E-Reverse Auctioning | .870 | .941 | 85.015 | ERA1 | .859 |
| | | | | ERA2 | .862 |
| | | | | ERA3 | .843 |
| | | | | ERA4 | .837 |
| E-Invoicing | .860 | .920 | 80.758 | EIN1 | .798 |
| | | | | EIN2 | .815 |
| | | | | EIN3 | .817 |
| | | | | EIN4 | .800 |
| E-Contract Management | .864 | .927 | 82.000 | EMC1 | .814 |
| | | | | EMC2 | .821 |
| | | | | EMC3 | .826 |
| | | | | EMC4 | .818 |
| Block Chain | .500 | .860 | 87.772 | BC1 | .878 |
| | | | | BC2 | .878 |
| Robotic Automation | .867 | .934 | 83.501 | RA1 | .832 |
| | | | | RA2 | .833 |
| | | | | RA3 | .829 |
| | | | | RA4 | .846 |
| Artificial Intelligence | .917 | .948 | 82.715 | AI1 | .831 |
| | | | | AI2 | .834 |
| | | | | AI3 | .828 |
| | | | | AI4 | .815 |
| | | | | AI5 | .829 |
| Sustainability Economic | .864 | .929 | 82.352 | SE1 | .821 |
| | | | | SE2 | .831 |
| | | | | SE3 | .820 |
| | | | | SE4 | .823 |
| Social Sustainability | .758 | .910 | 84.738 | SS1 | .853 |
| | | | | SS2 | .850 |
| | | | | SS3 | .839 |
| Environmental Sustainability | .863 | .928 | 82.318 | ENS1 | .835 |
| | | | | ENS2 | .819 |
| | | | | ENS3 | .816 |
| | | | | ENS4 | .822 |

**Measurement Model using the Confirmatory Factor Analysis**

The measurement model was rigorously assessed through confirmatory factor analysis, and the model fit indices collectively indicate a well-fitting model. Specifically, the minimum discrepancy, represented as the chi-square divided by the degrees of freedom (CMIN/DF), yielded a value of 1.073, well below the recommended threshold of 2.00. The associated p-value, denoting the probability of obtaining a discrepancy as large as observed with the sample, was 0.000, significantly below the 0.05 threshold, further affirming the model's adequacy. Additionally, the goodness of fit (GFI) reached 0.931, surpassing the desirable threshold of 0.80, and the adjusted goodness of fit index (AGFI) was 0.920, reinforcing the model's goodness of fit. The Bentler-Bonett normed fit index (NFI) and the Tucker-Lewis index (TLI) both exceeded 0.90, with values of 0.966 and 0.997, respectively, while the comparative fit index (CFI) achieved 0.998, all indicative of a well-fitting model. Furthermore, the assessment of model fit includes the root mean square residual (RMR) and the root mean square of approximation (RMSEA), with values of 0.015 and 0.011, respectively, both falling below the recommended threshold of 0.1. These results collectively underscore the robustness and appropriateness of the confirmatory factor analysis model. Figure 2 visually represents the confirmatory analysis, where factor loadings are depicted on arrows, indicating strong factor loadings, thereby validating the efficacy of the confirmatory factor analysis.

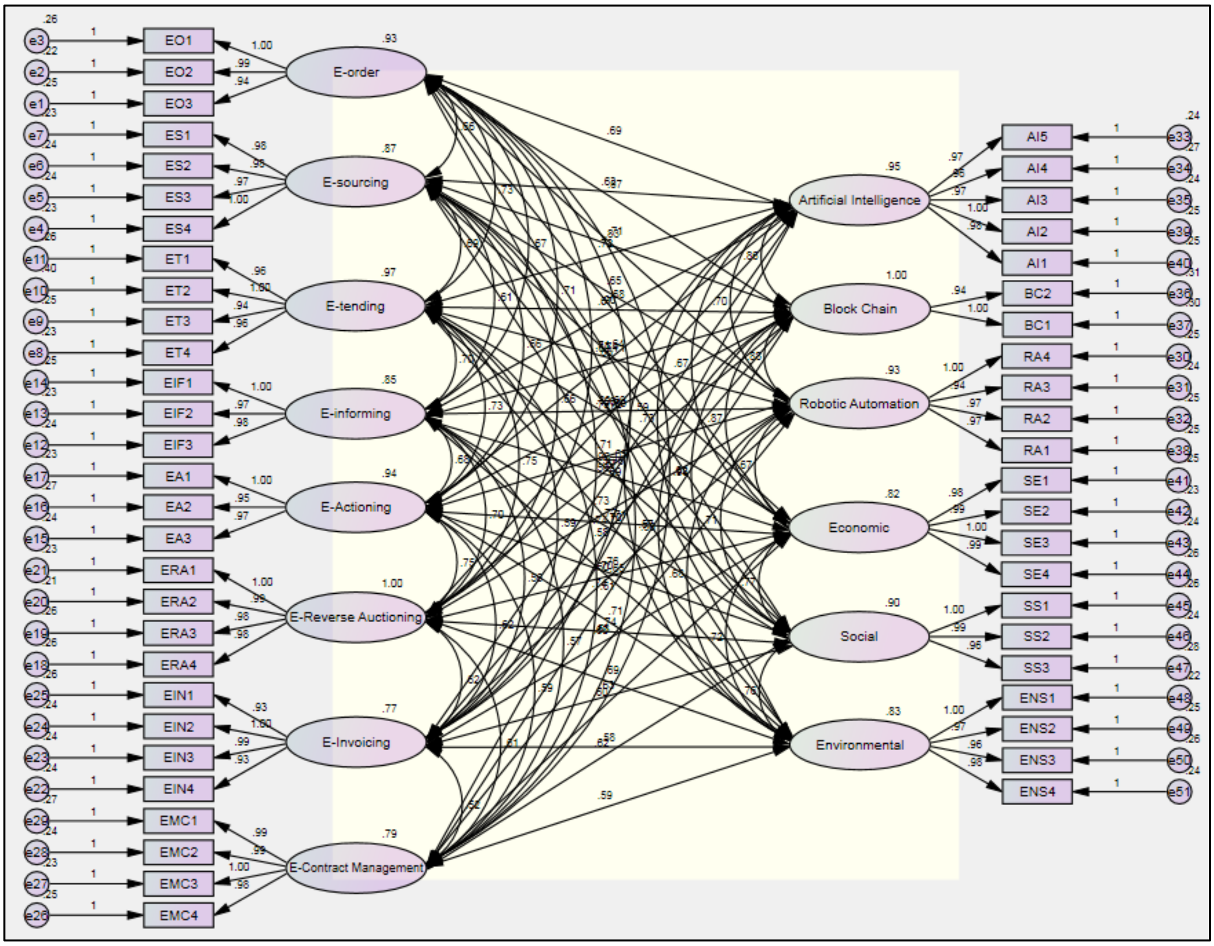



*Figure 2: CFA for the Measurement Model*

After confirming that the model fit indices are acceptable, the measurement model was examined. Table 3 shows the factor loadings for the statements assigned to each construct. All factor loadings ranged from 0.930 to 1.000, and all P-values were less than 0.05. This indicates that all factor loadings were greater than 0.4, demonstrating good validity and a well-fitting model.

*Table 3: Item Loading after Confirmatory Factor Analysis*

| | | | Estimate | S.E. | C.R. | P |
|---|---|---|---|---|---|---|
| EO3 | <--- | E-order | .943 | .030 | 30.989 | *** |
| EO2 | <--- | E-order | .994 | .031 | 32.390 | *** |
| EO1 | <--- | E-order | 1.000 | | | |
| ES4 | <--- | E-sourcing | 1.000 | | | |
| ES3 | <--- | E-sourcing | .969 | .030 | 31.787 | *** |

| | | | Estimate | S.E. | C.R. | P |
|---|---|---|---|---|---|---|
| ES2 | <--- | E-sourcing | .978 | .031 | 31.958 | *** |
| ES1 | <--- | E-sourcing | .984 | .030 | 32.309 | *** |
| ET4 | <--- | E-tending | .957 | .033 | 29.033 | *** |
| ET3 | <--- | E-tending | .941 | .033 | 28.383 | *** |
| ET2 | <--- | E-tending | 1.000 | | | |
| ET1 | <--- | E-tending | .956 | .034 | 28.448 | *** |
| EIF3 | <--- | E-informing | .984 | .033 | 30.251 | *** |
| EIF2 | <--- | E-informing | .967 | .032 | 30.296 | *** |
| EIF1 | <--- | E-informing | 1.000 | | | |
| EA3 | <--- | E-Actioning | .971 | .030 | 32.376 | *** |
| EA2 | <--- | E-Actioning | .946 | .030 | 31.162 | *** |
| EA1 | <--- | E-Actioning | 1.000 | | | |
| ERA4 | <--- | E-Reverse Auctioning | .978 | .029 | 33.630 | *** |
| ERA3 | <--- | E-Reverse Auctioning | .977 | .029 | 33.728 | *** |
| ERA2 | <--- | E-Reverse Auctioning | .990 | .028 | 35.610 | *** |
| ERA1 | <--- | E-Reverse Auctioning | 1.000 | | | |
| EIN4 | <--- | E-Invoicing | .930 | .032 | 28.721 | *** |
| EIN3 | <--- | E-Invoicing | .985 | .033 | 29.439 | *** |
| EIN2 | <--- | E-Invoicing | 1.000 | | | |
| EIN1 | <--- | E-Invoicing | .931 | .033 | 28.201 | *** |
| EMC4 | <--- | E-Contract Management | .979 | .032 | 30.155 | *** |
| EMC3 | <--- | E-Contract Management | 1.000 | | | |
| EMC2 | <--- | E-Contract Management | .993 | .033 | 30.499 | *** |
| EMC1 | <--- | E-Contract Management | .995 | .033 | 29.769 | *** |
| RA4 | <--- | Robotic Automation | 1.000 | | | |
| RA3 | <--- | Robotic Automation | .940 | .029 | 32.070 | *** |
| RA2 | <--- | Robotic Automation | .966 | .030 | 32.131 | *** |
| RA1 | <--- | Robotic Automation | .969 | .030 | 32.058 | *** |
| AI5 | <--- | Artificial Intelligence | .973 | .029 | 33.165 | *** |
| AI4 | <--- | Artificial Intelligence | .962 | .030 | 31.866 | *** |
| AI3 | <--- | Artificial Intelligence | .974 | .029 | 33.122 | *** |
| AI2 | <--- | Artificial Intelligence | 1.000 | | | |
| AI1 | <--- | Artificial Intelligence | .980 | .030 | 33.077 | *** |
| BC2 | <--- | Block Chain | .939 | .029 | 32.097 | *** |
| BC1 | <--- | Block Chain | 1.000 | | | |
| SE1 | <--- | Economic | .979 | .032 | 30.736 | *** |
| SE2 | <--- | Economic | .989 | .031 | 31.487 | *** |
| SE3 | <--- | Economic | 1.000 | | | |
| SE4 | <--- | Economic | .987 | .032 | 30.627 | *** |
| SS1 | <--- | Social | 1.000 | | | |
| SS2 | <--- | Social | .992 | .031 | 32.088 | *** |
| SS3 | <--- | Social | .955 | .031 | 30.397 | *** |
| ENS1 | <--- | Environmental | 1.000 | | | |
| ENS2 | <--- | Environmental | .974 | .031 | 31.383 | *** |
| ENS3 | <--- | Environmental | .959 | .031 | 30.656 | *** |
| ENS4 | <--- | Environmental | .982 | .031 | 31.728 | *** |

## Descriptive Analysis

Table 4 provides insights into the demographic characteristics of the sample population, consisting of 630 individuals. Regarding gender, the majority are female, accounting for 50.6% (319 individuals), while males constitute 49.4% (311 individuals) of the sample. In terms of age distribution, the highest proportion falls within the range of 30 to less than 40 years, representing 36.5% (230 individuals) of the sample. The next largest age group is 22 to less than 30 years, comprising 27.9% (176 individuals), followed by 50 to less than 60 years with 18.3% (115 individuals), and 40 to less than 50 years with 17.3% (109 individuals). When considering education level, the distribution shows that the highest percentage of individuals hold a bachelor's degree, accounting for 46.3% (292 individuals), followed by those with a master's degree at 41.7% (263 individuals), while 11.9% (75 individuals) have a doctorate.

***Table 4: Descriptive Statistics of Respondents Profile***

| | **Frequency (n=630)** | **Percent** |
|---|---|---|
| **Gender** | | |
| Male | 311 | 49.4 |
| Female | 319 | 50.6 |
| **Age** | | |
| 22-Less than 30 | 176 | 27.9 |
| 30- Less than 40 | 230 | 36.5 |
| 40- Less than 50 | 109 | 17.3 |
| 50- Less than 60 | 115 | 18.3 |
| **Education level** | | |
| Bachelor's degree | 292 | 46.3 |
| Master's degree | 263 | 41.7 |
| Doctorate degree | 75 | 11.9 |

The table provides detailed descriptive statistics for various e-procurement and sustainability variables. E-order has a mean of 2.5206 with a standard deviation of 1.01908, indicating moderate usage with some variability. E-sourcing shows a mean of 2.5000 and a standard deviation of 1.00199, reflecting similar levels of implementation. E-tending presents a mean of 2.5048 and a standard deviation of 1.02550, suggesting consistent application across the sample. E-informing has a mean of 2.5286 and a lower standard deviation of 0.97910, indicating slightly less variability. E-actioning is characterized by a mean of 2.4508 and a standard deviation of 1.03206, reflecting moderate engagement with slightly higher variability. E-Reverse Auctioning shows a mean of 2.5492 with a standard deviation of 1.07432, suggesting a somewhat higher focus in this area.

For e-invoicing, the mean is 2.4730 with a standard deviation of 0.94444, indicating relatively consistent usage. E-Contract Management has a mean of 2.4937 and a standard deviation of 0.97135, reflecting moderate implementation with limited variability. Block Chain stands out with a higher mean of 2.8619 and a standard deviation of 1.13128, suggesting a stronger emphasis on this technology. Robotic automation shows a mean of 2.5365 with a standard deviation of 1.02641, indicating moderate adoption. Artificial intelligence has a mean of 2.5333 and a standard deviation of 1.03115, highlighting similar engagement levels.

In the context of sustainability, Sustainability Economic has a mean of 2.7683 and a standard deviation of 1.01825, suggesting moderate importance with some variability. Social sustainability presents a mean of 2.7508 with a standard deviation of 1.03198, indicating consistent focus across the sample. Lastly, environmental sustainability shows a mean of 2.7587 with a standard deviation of 1.00185, reflecting a similar level of emphasis with slightly less variability. These statistics provide a comprehensive overview of the implementation and focus on both e-procurement technologies and sustainability initiatives within the sample.

***Table 5: Descriptive Analysis for the Research Variables***

| Variables | Mean | Std. Deviation | Frequency | | | | |
|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | 5 |
| E-order | 2.5206 | 1.01908 | 101 | 228 | 192 | 90 | 19 |
| E-sourcing | 2.5000 | 1.00199 | 101 | 229 | 204 | 76 | 20 |
| E-tending | 2.5048 | 1.02550 | 106 | 222 | 204 | 74 | 24 |
| E-informing | 2.5286 | .97910 | 81 | 254 | 199 | 73 | 23 |
| E-Actioning | 2.4508 | 1.03206 | 120 | 222 | 193 | 74 | 21 |
| E-Reverse Auctioning | 2.5492 | 1.07432 | 95 | 240 | 193 | 58 | 44 |
| E-Invoicing | 2.4730 | .94444 | 95 | 234 | 224 | 62 | 15 |
| E-Contract Management | 2.4937 | .97135 | 94 | 239 | 205 | 76 | 16 |
| Block Chain | 2.8619 | 1.13128 | 103 | 88 | 287 | 97 | 55 |
| Robotic Automation | 2.5365 | 1.02641 | 88 | 253 | 180 | 81 | 28 |
| Artificial Intelligence | 2.5333 | 1.03115 | 94 | 239 | 193 | 75 | 29 |
| Sustainability Economic | 2.7683 | 1.01825 | 93 | 98 | 340 | 60 | 39 |
| Social Sustainability | 2.7508 | 1.03198 | 104 | 87 | 335 | 70 | 34 |
| Environmental Sustainability | 2.7587 | 1.00185 | 92 | 99 | 343 | 61 | 35 |

**Normality Testing for the Research Variables**

Table 6 presents the outcomes of the Kolmogorov-Smirnov test of normality, which constitutes a formal evaluation of the normality assumption for the variables under investigation in this study. The results indicate a departure from normal distribution, as evidenced by the statistical significance of the associated P-values, all of which fall below the conventional alpha level of 0.05. This implies that the data deviates from a normal distribution, and this departure should be taken into account when conducting subsequent statistical analyses and interpreting the findings.

***Table 6: Formal Testing of Normality***

| | Kolmogorov-Smirnov[a] | | |
|---|---|---|---|
| | Statistic | Df | Sig. |
| **E-order** | .218 | 630 | .000 |
| **E-sourcing** | .215 | 630 | .000 |
| **E-tending** | .209 | 630 | .000 |
| **E-informing** | .237 | 630 | .000 |
| **E-Actioning** | .212 | 630 | .000 |
| **E-Reverse Auctioning** | .227 | 630 | .000 |
| **E-Invoicing** | .214 | 630 | .000 |
| **E-Contract Management** | .223 | 630 | .000 |
| **Block Chain** | .245 | 630 | .000 |
| **Robotic Automation** | .241 | 630 | .000 |
| **Artificial Intelligence** | .226 | 630 | .000 |
| **Sustainability Economic** | .287 | 630 | .000 |
| **Social Sustainability** | .292 | 630 | .000 |
| **Environmental Sustainability** | .292 | 630 | .000 |

In cases where formal normality tests reveal non-normal distributions in the data, researchers may resort to informal normality tests to gauge the extent of departure from normality. The results of these informal tests are presented in Table 7, indicating that both skewness and kurtosis values fall at the acceptable range of ±1. This divergence implies that the data conform to a normal distribution pattern.

***Table 7: Informal Testing of Normality***

| | Skewness | | Kurtosis | |
|---|---|---|---|---|
| | Statistic | Std. Error | Statistic | Std. Error |
| **E-order** | .324 | .097 | -.461 | .194 |
| **E-sourcing** | .357 | .097 | -.300 | .194 |
| **E-tending** | .378 | .097 | -.300 | .194 |
| **E-informing** | .465 | .097 | -.094 | .194 |
| **E-Actioning** | .389 | .097 | -.367 | .194 |
| **E-Reverse Auctioning** | .578 | .097 | -.097 | .194 |
| **E-Invoicing** | .317 | .097 | -.140 | .194 |
| **E-Contract Management** | .342 | .097 | -.277 | .194 |
| **Block Chain** | -.044 | .097 | -.468 | .194 |
| **Robotic Automation** | .490 | .097 | -.234 | .194 |
| **Artificial Intelligence** | .460 | .097 | -.219 | .194 |
| **Sustainability Economic** | -.013 | .097 | .046 | .194 |
| **Social Sustainability** | -.096 | .097 | -.118 | .194 |
| **Environmental Sustainability** | -.045 | .097 | .080 | .194 |

**Testing Multicollinearity Assumption**

This section investigates and verifies the assumption of multicollinearity between the independent variables for the conducted model. It is one of the important assumptions required to avoid redundancy of information in the model under study. It occurs when two or more predictors in a model are highly correlated with each other. This leads to problems with understanding which predictors contribute to the variance explained in the criterion, as well as technical issues in calculating a multiple regression model. Therefore, redundant information about the criterion is provided. By testing VIFs as shown in Table 8 for the independent variables for the research model, it could be observed that the VIFs of the research variables are all less than 5, implying that there is no problem of multicollinearity between the independent variables.

***Table 8: VIF values for Research Variables***

| Independent Variables | VIF |
|---|---|
| E-order | 3.624 |
| E-sourcing | 3.532 |
| E-tending | 3.691 |
| E-informing | 3.368 |
| E-Actioning | 3.775 |
| E-Reverse Auctioning | 3.768 |
| E-Invoicing | 2.825 |
| E-Contract Management | 3.041 |

**Testing the Research Hypotheses**

This section presents the findings concerning the influence of independent variables on dependent variables. Within Table 9, the correlation has been derived, revealing notable observations:

From the table below we find that E-Procurement (E-Ordering, E-Sourcing, E-Tendering, E-Informing, E-Actioning, E-Reverse Auctioning, E-Invoicing, E-Contract Management), Digitalization Technologies (Block Chain, Robotic Process Automation, Artificial Intelligence), and Sustainability (Economic Sustainability, Social Sustainability, Environmental Sustainability) have correlation values that are positive and high values, which means that all the variables in this model have positive and strong correlation.

***Table 9: Correlation Matrix for the Research Variables***

| | | 1. | 2. | 3. | 4. | 5. | 6. | 7. | 8. | 9. | 10. | 11. | 12. | 13. | 14. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. E-order | r | 1 | | | | | | | | | | | | | |

| | | 1. | 2. | 3. | 4. | 5. | 6. | 7. | 8. | 9. | 10. | 11. | 12. | 13. | 14. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sig. | | | | | | | | | | | | | | |
| | N | 630 | | | | | | | | | | | | | |
| 2. E-sourcing | r | .752** | 1 | | | | | | | | | | | | |
| | Sig. | .000 | | | | | | | | | | | | | |
| | N | 630 | 630 | | | | | | | | | | | | |
| 3. E-tending | r | .761** | .764** | 1 | | | | | | | | | | | |
| | Sig. | .000 | .000 | | | | | | | | | | | | |
| | N | 630 | 630 | 630 | | | | | | | | | | | |
| 4. E-informing | r | .744** | .724** | .763** | 1 | | | | | | | | | | |
| | Sig. | .000 | .000 | .000 | | | | | | | | | | | |
| | N | 630 | 630 | 630 | 630 | | | | | | | | | | |
| 5. E-Actioning | r | .756** | .753** | .766** | .749** | 1 | | | | | | | | | |
| | Sig. | .000 | .000 | .000 | .000 | | | | | | | | | | |
| | N | 630 | 630 | 630 | 630 | 630 | | | | | | | | | |
| 6. E-Reverse Auctioning | r | .756** | .749** | .760** | .762** | .784** | 1 | | | | | | | | |
| | Sig. | .000 | .000 | .000 | .000 | .000 | | | | | | | | | |
| | N | 630 | 630 | 630 | 630 | 630 | 630 | | | | | | | | |
| 7. E-Invoicing | r | .715** | .734** | .700** | .671** | .725** | .717** | 1 | | | | | | | |
| | Sig. | .000 | .000 | .000 | .000 | .000 | .000 | | | | | | | | |
| | N | 630 | 630 | 630 | 630 | 630 | 630 | 630 | | | | | | | |
| 8. E-Contract Management | r | .747** | .724** | .718** | .723** | .726** | .727** | .686** | 1 | | | | | | |
| | Sig. | .000 | .000 | .000 | .000 | .000 | .000 | .000 | | | | | | | |
| | N | 630 | 630 | 630 | 630 | 630 | 630 | 630 | 630 | | | | | | |
| 9. Block Chain | r | .842** | .851** | .836** | .824** | .854** | .851** | .798** | .800** | 1 | | | | | |
| | Sig. | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | | | | | | |
| | N | 630 | 630 | 630 | 630 | 630 | 630 | 630 | 630 | 630 | | | | | |
| 10. Robotic Automation | r | .763** | .751** | .777** | .765** | .763** | .770** | .723** | .710** | .848** | 1 | | | | |
| | Sig. | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | | | | | |
| | N | 630 | 630 | 630 | 630 | 630 | 630 | 630 | 630 | 630 | 630 | | | | |
| 11. Artificial Intelligence | r | .758** | .734** | .761** | .747** | .770** | .779** | .714** | .721** | .837** | .775** | 1 | | | |
| | Sig. | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | | | | |

| | | 1. | 2. | 3. | 4. | 5. | 6. | 7. | 8. | 9. | 10. | 11. | 12. | 13. | 14. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | 630 | 630 | 630 | 630 | 630 | 630 | 630 | 630 | 630 | 630 | 630 | | | |
| 12. Sustainability Economic | r | .774** | .790** | .799** | .786** | .803** | .789** | .746** | .751** | .895** | .775** | .795** | 1 | | |
| | Sig. | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | | | |
| | N | 630 | 630 | 630 | 630 | 630 | 630 | 630 | 630 | 630 | 630 | 630 | 630 | | |
| 13. Social Sustainability | r | .775** | .794** | .791** | .774** | .812** | .786** | .749** | .743** | .894** | .788** | .782** | .874** | 1 | |
| | Sig. | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | | |
| | N | 630 | 630 | 630 | 630 | 630 | 630 | 630 | 630 | 630 | 630 | 630 | 630 | 630 | |
| 14. Environmental Sustainability | r | .787** | .786** | .784** | .772** | .793** | .781** | .744** | .756** | .892** | .771** | .796** | .868** | .867** | 1 |
| | Sig. | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | .000 | |
| | N | 630 | 630 | 630 | 630 | 630 | 630 | 630 | 630 | 630 | 630 | 630 | 630 | 630 | 630 |
| **. Correlation is significant at the 0.01 level (2-tailed). | | | | | | | | | | | | | | | |

Table 10 shows the SEM analysis for the impact of the research variables.

The study examines the relationship between e-procurement and digitalization technologies, revealing a positive effect on blockchain adoption. Key E-Procurement dimensions include E-Order, E-Sourcing, E-Tending, E-Informing, E-Actioning, E-Reverse Auctioning, E-Invoicing, and E-Contract Management. These findings highlight the significant positive impact of e-procurement on the adoption of blockchain technology.

The analysis reveals a significant positive relationship between E-Procurement and Robotic Automation, with E-Order, E-Tending, E-Informing, E-Actioning, and E-Reverse Auctioning showing significant effects. However, E-Sourcing, E-Invoicing, and E-Contract Management do not show significant effects on robotic automation, as their p-values are greater than 0.05.

The study examines the relationship between E-Procurement and Artificial Intelligence, finding strong positive effects such as E-Tending, E-Informing, E-Actioning, and E-Reverse Auctioning. However, E-order, E-sourcing, E-invoicing, and E-contract management do not significantly affect artificial intelligence, as their p-values are greater than 0.05.

The second hypothesis examines the significant relationship between digitalization technologies and sustainability, and the first sub-hypothesis of the fourth hypothesis focuses on economic sustainability. The analysis reveals an insignificant effect of blockchain, robotic automation, and artificial intelligence, as their p-values are greater than 0.05.

The analysis shows a significant positive effect of artificial intelligence on social sustainability, a negative effect of blockchain on social sustainability, and an insignificant effect of robotic automation on social sustainability, as their p-values are greater than 0.05.

The analysis shows a significant positive effect of artificial intelligence on environmental sustainability, a negative effect on blockchain, and an insignificant effect of robotic automation on it, as the p-value is greater than 0.05.

The third hypothesis explores the relationship between e-procurement and sustainability, focusing on economic sustainability. The analysis shows the positive effects of E-Sourcing, E-Tending, E-Informing, E-Actioning, and E-Contract management on sustainability. However, e-ordering, e-reverse auctioning, and e-invoicing do not significantly impact sustainability, as their p-values are greater than 0.05.

The analysis reveals significant positive effects on social sustainability, with e-sourcing, e-tending, e-informing, e-actioning, e-invoicing, and e-contract management having a significant impact. However, E-Order and E-Reverse Auctioning do not show significant effects, as their p-values are greater than 0.05.
The analysis reveals significant positive effects of E-Order, E-Sourcing, E-Tending, E-Informing, E-Actioning, E-Invoicing, and E-Contract management on environmental sustainability. E-order has a strong effect, while E-sourcing, E-tending, E-informing, A-actioning, and E-invoicing have a substantial relationship. E-contract management has a significant relationship, while E-reverse auctioning does not show a significant effect.
The fourth hypothesis explores the role of digitalization technologies in promoting sustainability. Results show no significant effect of digitalization on economic sustainability, but significant effects of blockchain and artificial intelligence on social and environmental sustainability, indicating direct effects.
Moreover, for the first sub-hypothesis of the fourth hypothesis. There is a significant effect of E-Procurement dimensions on the blockchain, which means that BlockChain could mediate the relationship between E-Procurement dimensions and both social and environmental sustainability.
Moreover, it could be observed that BlockChain fully mediates the relationship between E-order, E-reverse auctioning, and social sustainability, as the effect turned out to be insignificant in the presence of Block Chain, while partially mediating the relationship between E-sourcing, E-tending, E-informing, E-actioning, E-reverse auctioning, and social sustainability, as the effect remains significant in the presence of Block Chain.
Furthermore, it could be observed that Block Chain fully mediates the relationship between E-Reverse Auctioning and Environmental Sustainability as the effect turned out to be insignificant in the presence of Block Chain, while partially mediating the relationship between E-order, E-sourcing, E-tending, E-informing, E-Actioning, E-Reverse Auctioning, and Environmental Sustainability as the effect remains significant in the presence of Block Chain.
Furthermore, for the third subhypothesis of the fourth hypothesis. There is a significant effect of E-tending, E-informing, E-Actioning, and E-Reverse Auctioning on Artificial Intelligence, which means that Artificial Intelligence could mediate the relationship between E-tending, E-informing, E-Actioning, and E-Reverse Auctioning and both social and environmental sustainability.
Moreover, it could be observed that artificial intelligence fully mediates the relationship between e-reverse auctioning and social sustainability, as the effect turned out to be insignificant in the presence of artificial intelligence, while partially mediating the relationship between e-tending, e-informing, e-actioning, and social sustainability, as the effect remains significant in the presence of artificial intelligence.
Furthermore, it could be observed that artificial intelligence fully mediates the relationship between e-reverse auctioning and environmental sustainability, as the effect turned out to be insignificant in the presence of artificial intelligence, while partially mediating the relationship between e-tending, e-informing, e-actioning, and environmental sustainability, as the effect remains significant in the presence of artificial intelligence.

***Table 10: SEM Analysis for the Research Variables***

| | | | Estimate | P | |
|---|---|---|---|---|---|
| Block Chain | <--- | E-order | .144 | *** | .990 |
| Block Chain | <--- | E-sourcing | .184 | *** | |
| Block Chain | <--- | E-tending | .152 | *** | |
| Block Chain | <--- | E-informing | .212 | *** | |
| Block Chain | <--- | E-Actioning | .243 | *** | |
| Block Chain | <--- | E-Reverse Auctioning | .118 | *** | |
| Block Chain | <--- | E-Invoicing | .111 | *** | |
| Block Chain | <--- | E-Contract Management | .076 | .006 | |

| | | | Estimate | P | |
|---|---|---|---|---|---|
| Robotic Automation | <--- | E-order | .142 | .006 | .750 |
| Robotic Automation | <--- | E-sourcing | .074 | .118 | |
| Robotic Automation | <--- | E-tending | .193 | *** | |
| Robotic Automation | <--- | E-informing | .201 | *** | |
| Robotic Automation | <--- | E-Actioning | .146 | .007 | |
| Robotic Automation | <--- | E-Reverse Auctioning | .096 | .040 | |
| Robotic Automation | <--- | E-Invoicing | .087 | .064 | |
| Robotic Automation | <--- | E-Contract Management | .063 | .166 | |
| Artificial Intelligence | <--- | E-order | .104 | .055 | .700 |
| Artificial Intelligence | <--- | E-sourcing | .070 | .161 | |
| Artificial Intelligence | <--- | E-tending | .156 | .004 | |
| Artificial Intelligence | <--- | E-informing | .227 | *** | |
| Artificial Intelligence | <--- | E-Actioning | .120 | .035 | |
| Artificial Intelligence | <--- | E-Reverse Auctioning | .158 | .002 | |
| Artificial Intelligence | <--- | E-Invoicing | .078 | .114 | |
| Artificial Intelligence | <--- | E-Contract Management | .060 | .213 | |
| Economic | <--- | E-order | .056 | .210 | .832 |
| Economic | <--- | E-sourcing | .092 | .027 | |
| Economic | <--- | E-tending | .181 | *** | |
| Economic | <--- | E-informing | .240 | *** | |
| Economic | <--- | E-Actioning | .273 | *** | |
| Economic | <--- | E-Reverse Auctioning | .044 | .279 | |
| Economic | <--- | E-Invoicing | .067 | .094 | |
| Economic | <--- | E-Contract Management | .111 | .004 | |
| Economic | <--- | Block Chain | -.038 | .602 | |
| Economic | <--- | Robotic Automation | -.056 | .200 | |
| Economic | <--- | Artificial Intelligence | .027 | .483 | |
| Social | <--- | E-order | .071 | .175 | .837 |
| Social | <--- | E-sourcing | .212 | *** | |
| Social | <--- | E-tending | .233 | *** | |
| Social | <--- | E-informing | .267 | *** | |
| Social | <--- | E-Actioning | .379 | *** | |
| Social | <--- | E-Reverse Auctioning | .062 | .195 | |
| Social | <--- | E-Invoicing | .165 | *** | |
| Social | <--- | E-Contract Management | .113 | .013 | |
| Social | <--- | Block Chain | -.386 | *** | |
| Social | <--- | Robotic Automation | -.069 | .122 | |
| Social | <--- | Artificial Intelligence | .096 | .014 | |
| Environmental | <--- | E-order | .140 | .004 | .803 |
| Environmental | <--- | E-sourcing | .174 | *** | |
| Environmental | <--- | E-tending | .186 | *** | |
| Environmental | <--- | E-informing | .214 | *** | |
| Environmental | <--- | E-Actioning | .306 | *** | |
| Environmental | <--- | E-Reverse Auctioning | .037 | .409 | |
| Environmental | <--- | E-Invoicing | .102 | .022 | |
| Environmental | <--- | E-Contract Management | .099 | .020 | |

| | | | Estimate | P | |
|---|---|---|---|---|---|
| Environmental | <--- | Block Chain | -.273 | .004 | |
| Environmental | <--- | Robotic Automation | -.020 | .662 | |
| Environmental | <--- | Artificial Intelligence | .086 | .028 | |

The model fit indices (CMIN/DF = 1.241, GFI = 0.919, CFI = 0.992, AGFI = 0.905, and RMSEA = 0.020) are all within their acceptable levels. The SEM model conducted for the effect of the research model is illustrated in Figure 3.

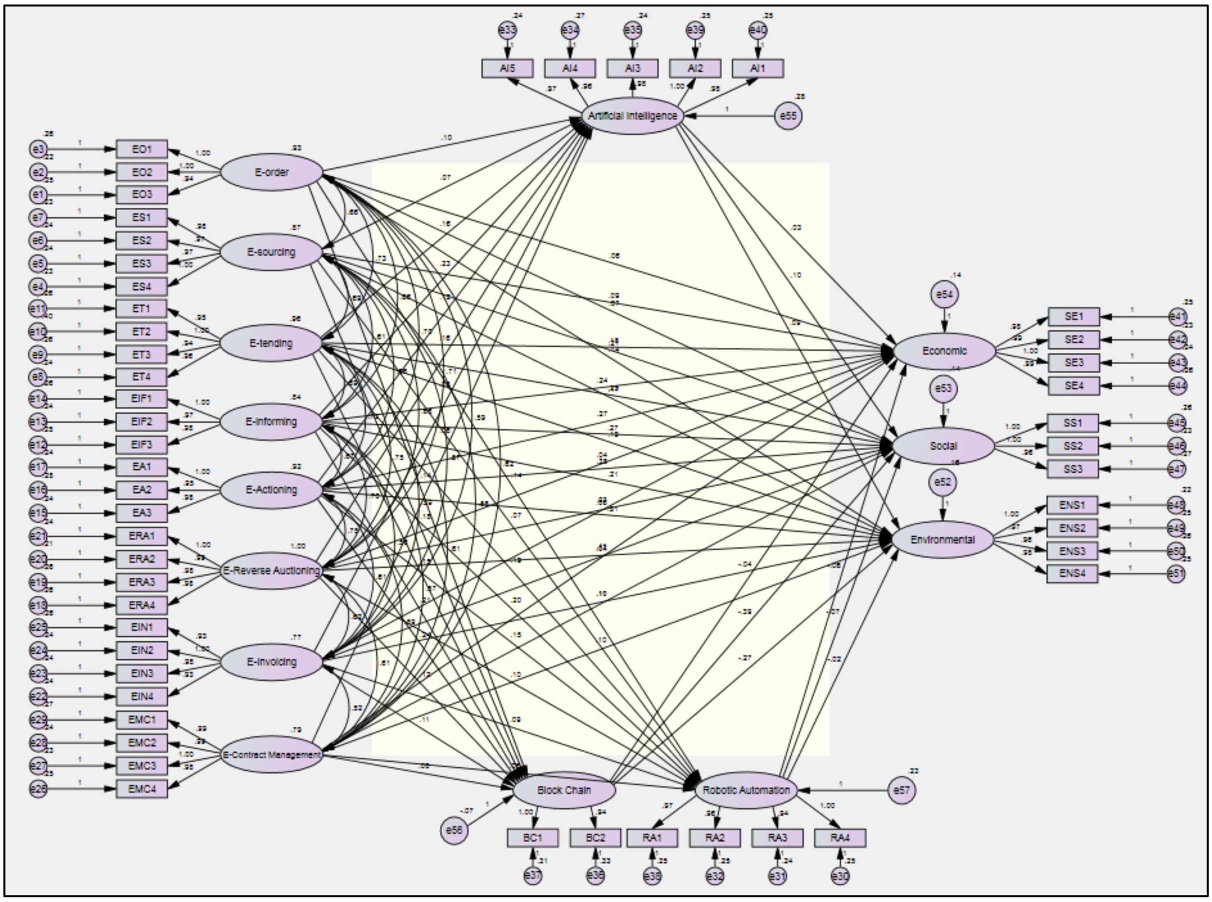



***Figure 3: SEM for the Research Variables***

**Summary of Testing Research Hypotheses**

The study reveals significant relationships between e-procurement dimensions and digitalization technologies across three key areas. Blockchain adoption is influenced by all dimensions, while robotic automation is influenced by e-sourcing, e-invoicing, and e-contract management. Artificial intelligence is influenced by E-Tending, E-Informing, E-Actioning, and E-Reverse Auctioning.

The study reveals that digitalization technologies have different impacts on various sustainability dimensions. Economic sustainability is not significantly influenced by blockchain, robotic automation, or artificial intelligence. Social sustainability is positively impacted by artificial intelligence, while blockchain has a significant negative effect.

The study reveals that e-procurement dimensions have significant positive effects on various sustainability dimensions. Economic sustainability, social sustainability, and environmental sustainability all show positive effects. However, E-Order, E-Reverse Auctioning, and E-Invoicing do not show significant relationships. The findings highlight the varied influence of e-procurement on sustainability outcomes.

The study reveals that digitalization technologies do not significantly impact economic sustainability, but blockchain and artificial intelligence significantly influence social and environmental sustainability, acting as a mediator between e-procurement dimensions and these sustainability dimensions.
Blockchain mediates the relationship between certain E-Procurement dimensions and social sustainability, while artificial intelligence significantly mediates the relationship between E-Reverse Auctioning and social sustainability. Blockchain partially mediates the relationship with sustainability aspects, while artificial intelligence maintains a significant effect in the presence of AI.

***Table 11: Summary of Research Hypotheses***

| Hypothesis | Description | Results |
|---|---|---|
| **$H_1$** | ***There is a Significant Relationship between E-Procurement and Digitalization Technologies*** | Partially Supported |
| **$H_2$** | ***There is a Significant Relationship between Digitalization Technologies and Sustainability*** | Partially Supported |
| **$H_3$** | ***There is a Significant Relationship between E-Procurement and Sustainability*** | Partially Supported |
| **H4** | ***There is a mediation role of Digitalization Technologies between E-Procurement and Sustainability*** | Partially Supported |

## 5. Research Discussion

The study aimed to investigate the potential mediation effect of digitalization technologies on the relationship between e-procurement practices and sustainability outcomes within the oil and gas industry in Egypt.

The study, involving 512 employees in the oil and gas industry in Egypt, found that digitalization technologies significantly enhance the correlation between e-procurement practices and sustainability outcomes. The adoption of these technologies could potentially amplify the positive impact of e-procurement practices on sustainability in the industry.

The studies conducted by Hidayanti et al. (2022), AlQubaisi et al. (2022), Addy et al. (2024), Gurgun et al. (2024), and Omorodion and Joseph (2024) provide valuable insights into various aspects of e-procurement and its implementation in different sectors. Hidayanti et al. (2022) focused on the potential of robotic process automation (RPA) in streamlining audit activities in e-procurement, while AlQubaisi et al. (2022) highlighted the positive influence of sustainable supply chain practices on e-procurement processes. Addy et al. (2024) identified factors influencing the adoption of e-procurement in the construction sector; Gurgun et al. (2024) delved into the correlation between e-procurement implementation and construction supply chains; and Omorodion and Joseph (2024) emphasized critical success factors for electronic procurement initiatives in the Nigerian oil and gas sector. These studies collectively contribute to a comprehensive understanding of the challenges, opportunities, and best practices in e-procurement across different industries, thereby offering valuable insights for future research and practical implementation in the field.

The studies by Xiao and Su (2022), Abid et al. (2022), Böttcher et al. (2023), Khalaf et al. (2023), Waqar et al., and Mansoor (2023), Oyewole et al. (2024), and Hasan et al. (2024) collectively contribute to the understanding of the relationship between technological innovation and sustainability across various sectors. Xiao and Su's findings underscore the influence of attitudes toward technological innovation on organizational innovation, which in turn promotes environmental and social sustainability in SMEs.

Conversely, Abid et al.'s study emphasizes the positive correlation between technological progress and sustainability outcomes in Italian cities, with economic development playing a significant role. Böttcher et al.'s research highlights the integration of ecological sustainability into business models through digital technology, emphasizing the potential for sustainable value creation.

Khalaf et al., Waqar et al., and Mansoor's studies both demonstrate the increasing utilization of AI technologies in the oil and gas sector to enhance sustainability through corrosion monitoring, predictive maintenance, and operational optimization. Oyewole et al.'s work delves into AI's transformative impact on sustainable finance, particularly in aligning financial practices with ESG criteria. Finally, Hasan et al.'s case study approach elucidates how sustainable supply chain practices in the oil and gas industry contribute to environmental stewardship, cost savings, and improved corporate reputation. These studies collectively highlight the multifaceted impacts of technological innovation on sustainability across different industries, providing valuable insights for future research and practical applications.

The studies by Omoregbe and Olufolahna (2022), Maina (2023), and Singh et al. (2023) all focus on the impact of e-procurement on sustainable procurement practices in different contexts. Omoregbe and Olufolahna's study specifically examines the Nigerian oil and gas industry, highlighting the positive relationship between electronic tendering, invoicing, and payment with sustainable competitive advantage. Maina's research in Kenyan telecommunication firms also demonstrates the positive outcomes of e-procurement adoption, such as cost reduction and competitive advantage, despite challenges like high implementation costs.

On the other hand, Singh et al.'s study in Malaysia emphasizes the positive correlation between e-procurement technology adoption and sustainable procurement practices, aiming to contribute to the development of a consistent framework for sustainable procurement. While all three studies support the importance of e-procurement in enhancing sustainability, they differ in their specific industry focus and geographical context. These findings provide valuable insights for organizations seeking to leverage e-procurement for sustainable procurement, albeit within different industry and regional settings.

## 6. Research Implications

The study highlights the significant role of digitalization technologies in enhancing the relationship between e-procurement practices and sustainability outcomes in the Egyptian oil and gas industry. This research explains the relationship between e-procurement and sustainability in Egypt's oil and gas industry, examining economic, social, and environmental dimensions.

The study investigates the mediating role of digital technologies like blockchain, robotic process automation, and artificial intelligence in enhancing sustainability efforts within organizations.

This study provides practical insights for practitioners, policymakers, and players in the Egyptian oil and gas industry. It enables better decision-making on e-procurement systems, focuses on sustainability impacts, and determines investment levels.

Digitalization technologies like blockchain, robotic processing automation, and unsupervised machine learning can enhance sustainability outcomes in the oil and gas sector, guiding strategic investments for greening and greening actions.

This study examines the policy and regulatory implications of e-procurement in Egypt, aiming to equip policy authorities with the necessary programs and laws for improved sustainability.

## 7. Research Recommendations

Based on the findings of the study, there are many recommendations proposed for organizations within the oil and gas industry in Egypt.

Invest in digitalization technologies like cloud-based platforms, blockchain, and AI-driven analytics in e-procurement processes for improved efficiency, transparency, and accountability. Implement training programs for procurement professionals.

Organizations should conduct a thorough needs assessment to identify skill gaps in e-procurement platforms, develop comprehensive training programs incorporating hands-on workshops, online courses, and simulations, and establish ongoing support for continuous skill development.

Strategic partnerships with technology providers can enhance the oil and gas industry's digital solutions, improving operational efficiency and sustainability. Collaboration with industry peers and associations can also enhance digitalization.

Continuously assess digitalization technologies' impact on sustainability outcomes in e-procurement practices, using KPIs and data analytics to improve efficiency, cost-effectiveness, and environmental benefits. Engage stakeholders for feedback and ensure tools adhere to industry norms.

The text advocates for the adoption of digitalization policies in the oil and gas industry, citing benefits such as increased efficiency and reduced environmental impact, and promoting partnerships between the public and private sectors.

## 8. Limitations and Suggestions for Future Research

This study offers valuable insights into the mediation effect of digitalization technologies on the relationship between e-procurement practices and sustainability outcomes in the oil and gas industry. However, several limitations should be acknowledged. The study employed a convenience sampling technique, which may limit the generalizability of the findings. Since the sample may not accurately represent the broader population of employees in the oil and gas industry, the results could reflect specific characteristics of the selected sample rather than the entire industry. Additionally, the research adopts a cross-sectional design, collecting data at a single point in time. While this approach allows for the examination of relationships between variables, it does not capture the dynamic nature of e-procurement practices, digitalization technologies, and sustainability outcomes over time. Relying on self-reported data through questionnaires also presents challenges, as responses may be influenced by biases such as social desirability or recall bias, potentially leading to inaccuracies. Furthermore, the study's focus on broad categories of digitalization technologies may overlook the specific impacts of individual technologies, and its industry-specific focus may limit the broader applicability of the findings.

Future research could address these limitations in several ways. Expanding the sampling techniques to include more robust approaches, such as stratified or random sampling, would enhance the representativeness of the sample and improve the generalizability of the findings. Employing longitudinal studies could also provide a deeper understanding of how the relationships between e-procurement practices, digitalization technologies, and sustainability outcomes evolve. Comparative analyses with other industries could reveal how different contexts affect the adoption and impact of these technologies, enhancing the broader applicability of the research. Additionally, future studies could delve into specific digital technologies like artificial intelligence, blockchain, or the Internet of Things to identify which tools are most effective in enhancing sustainability. Combining quantitative methods with qualitative approaches, such as interviews or case studies, could provide richer insights into the mechanisms at play, uncovering contextual factors and challenges that are not easily captured through surveys. Finally, exploring other mediating or moderating factors, such as organizational culture or regulatory compliance, could offer a more comprehensive understanding of what drives successful sustainability initiatives in the oil and gas industry.

By addressing these limitations and exploring suggested areas for further research, future studies can deepen the understanding of how digitalization technologies transform procurement processes and enhance sustainability outcomes in the oil and gas industry. This expanded research agenda will contribute to more targeted strategies for leveraging digital tools to achieve environmental, social, and governance objectives, ultimately supporting the industry's ongoing sustainability efforts.

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