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INVESTIGATING THE IMPACT OF TECHNOLOGICAL CHARACTERISTICS AND ABSORPTIVE CAPACITY ON SUSTAINABLE PERFORMANCE: THE MEDIATING ROLES OF SMART CONTRACT ADOPTION INTENTION IN EGYPT'S OIL AND GAS SECTOR

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ABSTRACT

This study examines the relationship between some technological components (perceived compatibility, non-complexity, relative advantage), absorptive capacity, and sustainable performance in the oil and gas industry in Egypt, focusing on the intention to adopt smart contracts as a case study. Research Design/Methodology: To test our hypotheses, we conducted a quantitative cross-sectional survey, and obtained a sample comprising 434 managers and professionals of the oil and gas industry in Egypt (62% response rate). We employed Structural Equation Modelling (SEM) using AMOS to analyze the collected data, alongside Confirmatory Factor Analysis (CFA) and bootstrap mediation analysis. Findings: All hypothesized paths were statistically significant ($p < 0.001$). Non-complexity of technology perceived to be the most sustainable performance yielding direct effect of ($\beta = 0.682$), followed by perceived technology compatibility ($\beta = 0.618$). Intention to adopt smart contracts was found to be a partial mediator, and in the context of technological components, absorptive capacity, and sustainable performance, ($p = 0.002–0.003$). The model explained 26.3% of adoption intention variance ($R^2 = 0.263$) and 50.2% of sustainable performance variance ($R^2 = 0.502$). Originality: This study provides the first energy sector initiative in a developing country to suggests digital transformation pathway for oil and gas industry in Egypt, and other similar resource-based sectors.

KEYWORDS: Smart Contracts, Blockchain Adoption, Technological Characteristics, Absorptive Capacity, Sustainability Performance, Oil and Gas Sector.

1. INTRODUCTION

It is expected of Egypt's oil and gas sector to continuously optimize its operations, on the grounds of profitability, adherence to regulations, and accountability to climate change (Wang et al., 2022). Considering the importance of the sector to the economy, Egypt's Ministry of Petroleum and Mineral Resources has begun to use digitally based (by the means of AI and blockchain technologies) integrated means of production improvement, and production sustainability (Kongdachudomkul et al., 2025).

Blockchain, and smart contracts used in conjunction, substantially change how things are done in the sector (Khan et al., 2021). Such contracts are self-executing. There is no need for a middle man, and payment disputes and cash flow management become automated; the flow of transactions (Martins et al., 2022). Therefore, smart contracts improve the management of joint ventures and contracts in the services sector of the value chain, and they augment the practice of emissions reporting and sustainability (Martins et al., 2022).

Contracts based on these technologies can improve efficiency, transparency, and accountability, thus they can be the tools for the management of sustainability and value of joint ventures in oil and gas. Yet, the developing countries like Egypt are the poorest in the use of smart contracts (Almaher, 2024). There are still many unexplored areas when it comes to the potential drivers of the adoption of resource intensive industries (Groschopf et al., 2021). The literature has addressed the potential of blockchain, but the impact of technological dimensions and the capacity for organizational learning on the sustainable impact of smart contracts remain understudied (Mohamed et al., 2023; Adel et al., 2025).

This study investigates perceived ease of use, relative advantage, compatibility, and absorptive capacity, and how they influence the sustainable adoption of smart contracts (Kaminski, 2011; Zhang, 2008). Using the Technology Acceptance Model and the Diffusion of Innovations model, this research is the first to apply TAM-IDT to smart contracts in the energy sector (Rogers, 2003; Venkatesh & Davis, 2000; Zhang, 2008; Rahimi et al., 2018). This study substantiates the mediation of adoption intention and the technology-sustainability nexus (Mohamed et al., 2023; Igartua & Hayes, 2021; Leth-Steensen & Gallitto, 2015), and provides smart contracts recommendations to the developing world (Adel et al., 2025).

1.1. Research Problem and Research Questions

Mubarak et al. (2024) and Society of Petroleum Engineers (2025) state that developing countries such as Egypt have limited research regarding the factors that contribute to the adoption of smart contracts in the oil and gas industry. Blockchain technology could improve the operational efficiency and sustainability of the oil and gas sector. Egypt has an emerging oil and gas industry and barriers to a $5.6 billion industry in oil and gas exploration. Egypt Forward (2025) states that there is a lack of knowledge regarding how perceptions of technology and an organization's ability to absorb and utilize knowledge impact the adoption of smart contracts and the impact on sustainable development.

The potential of blockchain in developing markets is hindered by adoption challenges related to technology, organization, and the environment (Yaqoob et al., 2022). In the petroleum industry, literature is scarce on the intention to adopt smart contracts and the role of the said intention on the technological, absorptive and sustainability performance factors (Cohen & Levinthal, 1990; Moore & Benbasat, 1991; Zahra & George, 2002).

The research problem prompts the following research questions:

- **RQ1:** What is the relationship between absorptive capacity and sustainability performance in the Egyptian oil and gas sector?
- **RQ2:** How do technological characteristics (perceived compatibility, perceived non-complexity, and perceived relative advantage) relate to sustainability performance in Egypt's oil and gas sector?
- **RQ3:** To what extent does absorptive capacity influence smart contract adoption intention among oil and gas organizations in Egypt?
- **RQ4:** How do technological characteristics affect smart contract adoption intention in the Egyptian oil and gas sector?
- **RQ5:** What is the relationship between smart contract adoption intention and sustainability performance?
- **RQ6:** Does smart contract adoption intention mediate the relationship between absorptive capacity and sustainability performance in Egypt's oil and gas sector?
- **RQ7:** Does smart contract adoption intention mediate the relationships between technological characteristics dimensions and sustainability performance?

2. LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

2.1. Understanding Technology Adoption and

Organizational Performance

Organizations face a persistent challenge: how to successfully adopt new technologies and translate that adoption into lasting performance gains (Mubarak et al., 2024). Different technological features—like compatibility and simplicity—work through distinct organizational mechanisms. When systems integrate seamlessly with existing infrastructure, implementation friction decreases. When technologies are simple to learn, people adopt them faster and more enthusiastically. Organizations that perceive technology as both valuable and practically feasible commit more genuine resources to implementation (Lin & Wu, 2025). Together, these features shape decision-making quality, operational efficiency, and successful execution (Mubarak et al., 2024).

A review of 127 studies found that technological characteristics explain 45–58% of adoption variance, driving improvements in operational efficiency, resource optimization, and regulatory compliance (Lau & Lo, 2019; Ni & Abdullah, 2025). In IoT adoption specifically, perceived advantage strengthens adoption ($\beta=0.52$), while complexity creates barriers ($\beta=-0.43$), both significantly affecting economic and environmental outcomes (Legesse et al., 2024). Notably, small businesses in Bali perceiving greater IoT advantages achieved 32% higher sustainability performance (Amaranti et al., 2024).

H1: Absorptive Capacity Drives Sustainability Performance in Egyptian Oil and Gas Sector.

2.2. Technological Attributes as Performance Drivers

Technology characteristics directly influence performance through multiple routes (Mubarak et al., 2024). Compatible systems minimize friction by avoiding extensive modifications. Simpler technologies accelerate skill development, while perceived advantages strengthen investment commitment (Qu & Kim, 2025). These features promote sustainability both directly—enhancing decision quality—and indirectly by improving adoption and implementation quality (Begnini et al., 2025). Blockchain supply chain studies illustrate this vividly: compatible systems achieved 74% adoption rates with 22% efficiency gains, while incompatible systems reached only 48% adoption with 8% efficiency gains (Okoh & Odorikpe, 2025).

H2: Technological Characteristics Positively Affect Sustainability Performance in Egyptian Oil and Gas Sector.

2.3. Absorptive Capacity and Smart Contract Intentions

Organizational absorptive capacity—the ability to recognize, assimilate, and exploit new knowledge—fundamentally enables blockchain and smart contract adoption (Rauniar et al., 2014). Organizations integrating technological sophistication, digital experience, and emerging technology learning develop substantially stronger adoption intentions (Almher et al., 2024). Among 400 small businesses in Bali, absorptive capacity most strongly influenced adoption intentions ($\beta=0.52$, $p<0.001$), with capacity-possessing organizations showing 48% greater digital technology adoption intent (Damai & Tricahyono, 2026). Iraqi oil and gas research analyzing 250 managers confirmed this: organizational readiness and technological capability together predicted adoption ($\beta=0.51$, $p<0.001$) (Almher et al., 2024).

H3: Absorptive Capacity Positively Affects Smart Contract Adoption Intention in Egyptian Oil and Gas Sector.

2.4. Technological Attributes and Smart Contract Adoption Intentions

The adoption of technology is determined by the perception of stakeholders (Singh & Gupta, 2025). Technological attributes account for 52%–64% of the variance of adoption intention based on a meta-analysis of 127 studies (Or, 2024; Ma et al., 2024). In a study of 388 SME managers in Jordan, relative advantage ($\beta=0.51$, $p<0.001$), compatibility ($\beta=0.47$, $p<0.001$), and low complexity ($\beta=-0.39$, $p<0.001$) were the greatest predictors (Ma et al., 2024). The research on Iraqi oil and gas confirmed that functional benefits ($\beta=0.42$, $p<0.001$) and security benefits ($\beta=0.38$, $p<0.001$) explained 58% of the variance in adoption intention (Almher et al., 2024).

H4: Technological Characteristics Positively Affect Smart Contract Adoption Intention in Egyptian Oil and Gas Sector.

2.5. Adoption Intentions Driving Sustainability Performance

Adoption intention functions as a psychological catalyst transforming technology's theoretical potential into tangible organizational gains (Or, 2024; Linh & Huyen, 2025). Across 127 studies, adoption intention strongly predicted organizational use and sustainability ($\beta=0.65$, $p<0.001$) (Or, 2024). Blockchain supply chain implementations revealed dramatic gains: 18 oil and gas installations with strong adoption intentions achieved \$4.6 million annual savings, 65% dispute reduction, and 80% invoicing cost cuts (Okoh & Odorikpe, 2025). Egyptian oil and gas organizations demonstrated 15–22% efficiency improvements with strong adoption intentions (Ahmed & Adeel, 2025).

H5: Smart Contract Adoption Intention Positively Affects Sustainability Performance in Egyptian Oil and Gas Sector.

2.6. Mediating Pathways: Adoption Intention as Bridge

Absorptive capacity drives performance improvements substantially through adoption intention (Rauniar et al., 2014). Among 400 Bali businesses, adoption intention mediated 48% of absorptive capacity's sustainability effect (β=0.31, $p<0.001$) (Damai & Tricahyono, 2026). Iraqi oil and gas research confirmed this mechanism: absorptive capacity predicted adoption intention (β=0.51, $p<0.001$), which strengthened performance (β=0.48, $p<0.001$), with intention transferring 41% of total effects (Almher et al., 2024).

H6: Smart Contract Adoption Intention Mediates Absorptive Capacity's Effect on Sustainability Performance in Egyptian Oil and Gas Sector.

In a meta-analysis of 127 studies, Ma et al. (2024) found that adoption intention significantly mediates the impacts of technological characteristics with an average of 0.38 mediation. Relative advantage predicted adoption intention (β=0.62, $p<0.001$) in 18 oil and gas blockchain implementations and also positively affected sustainability performance (β=0.65, $p<0.001$) (Okoh & Odorikpe, 2025).

H7: Smart Contract Adoption Intention Mediates Technological Characteristics' Effect on Sustainability Performance in Egyptian Oil and Gas Sector.

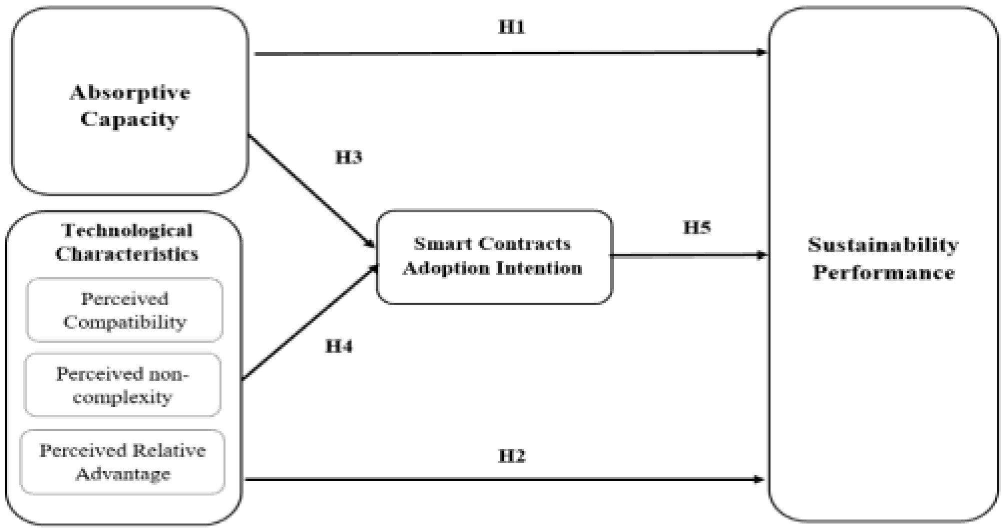

Figure 1: Conceptual Framework

3. METHODOLOGY

3.1. Research Design and Sample

A cross-sectional quantitative survey approach was utilized to assess the impacts of the specific technology characteristics and absorptive capacity on sustainability performance, mediated by smart contracts adoption intention, within the oil and gas industry in Egypt (Adel et al., 2025; Bakry et al., 2024). Egypt's oil and gas industry, which is undergoing a digital and transitional evolution, has high sustainability and economic relevance.

The target population was composed of managers and professionals in the oil and gas industry in Egypt, especially in Alexandria (the petroleum capital of the country). Using stratified random sampling in a multisampling technique, 700 questionnaires were distributed across different organizational levels and functions. From the 471 questionnaires (67.3%) received, 37 (5.3%) were incomplete or ineligible. Following extensive data screening, 434 questionnaires were valid, representing a 62% response rate—more than adequate for structural equation modeling. Department Managers represented 35.3%, General Managers 19.6%, Assistant General Managers 17.7%, Head of Sections 13.8%, and Senior Professionals 13.6%. In terms of geography, 74% were located in Alexandria and 26% in other locations.

3.2. Measurement And Analysis

All constructs applied established, modified scales with five-point Likert responses (Adel et al., 2025). Technological Characteristics included three dimensions: Perceived Compatibility, Perceived Non-Complexity, and Perceived Relative Advantage (Rogers, 2003; Kaminski, 2011; Rahimi et al., 2018; Wang et al., 2011). Absorptive Capacity applied three items measuring the recognition and application of knowledge (Cohen & Levinthal, 1990; Zahra & George, 2002). Smart Contracts Adoption Intention used four items measuring the likelihood of adoption (Almaher et al., 2024; Venkatesh & Davis, 2000), whereas Sustainability Performance applied seven items on the economic, environmental, and social dimensions (Aljanadi & Alazzani, 2023; Adel et al., 2025).

AMOS (Byrne, 2010; Bakry et al., 2024) was used for two-stage structural equation modeling. The first stage was Confirmatory Factor Analysis (CFA), which evaluated the measurement model by checking Composite Reliability, Average Variance Extracted, and discriminant validity (Fornell & Larcker, 1981; Rönkkö & Cho, 2020; Kassem, 2022; Goretzko et al., 2023). The second stage involved testing structural relationships via path coefficients, critical ratios, and mediation effects obtained through bootstrap methods (Mohamed et al., 2023; Hayes, 2013, 2022; Kenny, 2023).

4. RESULTS

4.1. Measurement Model Evaluation

The measurement model analysis proved highly reliable and valid. Composite Reliability (CR) values for all constructs exceeded the benchmark of 0.70: Perceived Compatibility (CR = 0.842), Perceived Non-Complexity (CR = 0.870), Perceived Relative Advantage (CR = 0.912), Absorptive Capacity (CR = 0.807), Smart Contracts Adoption Intention (CR = 0.906), and Sustainability Performance (CR = 0.947). Convergent validity was confirmed with AVE values above 0.50: Perceived Compatibility (AVE = 0.640), Perceived Non-Complexity (AVE = 0.690), Perceived Relative Advantage (AVE = 0.777), Absorptive Capacity (AVE = 0.526), Smart Contracts Adoption Intention (AVE = 0.708), and Sustainability Performance (AVE = 0.718) (Fornell & Larcker, 1981; Rönkkö & Cho, 2020).

Table 1: Model Validity Measures.

Construct	CR	AVE	MaxR(H)	PNC	SP	SCAI	AC	PC	PRA
Perceived Non-Complexity (PNC)	0.870	0.691	0.888	0.831					
Sustainability Performance (SP)	0.947	0.718	0.951	0.779***	0.848				
Smart Contracts Adoption Intention (SCAI)	0.906	0.708	0.913	0.594***	0.683***	0.842			
Absorptive Capacity (AC)	0.807	0.526	0.723	0.669***	0.702***	0.677***	0.725		
Perceived Compatibility (PC)	0.842	0.640	0.846	0.567***	0.422***	0.344***	0.662***	0.800	
Perceived Relative Advantage (PRA)	0.912	0.777	0.922	0.772***	0.634***	0.593***	0.716***	0.543***	0.881

Note: Diagonal values in bold represent the square root of AVE. Source: Authors' analysis (2026).

4.2. Assessment Of Multicollinearity

Tolerance and Variance Inflation Factor (VIF) values were examined to identify multicollinearity. Hair et al. (2011) recommend that multicollinearity is a concern if VIF > 5 and tolerance < 0.20. All VIF values were below 5 and tolerance values exceeded 0.20, confirming that multicollinearity is not an issue in the present study (see Table 2).

Table 2: Assessment Of Multicollinearity.

Variable	Tolerance	VIF
Perceived Compatibility	.683	1.465
Perceived non-complexity	.509	1.965
Perceived Relative Advantage	.512	1.953
Absorptive Capacity	.906	1.104

Source: Authors' analysis using primary survey data (2026); analysis performed in AMOS (v25).

4.3. Model Fit Indices

The CFA measurement model demonstrated excellent fit: $\chi^2/df = 2.627$ (≤ 3.0), RMSEA = 0.058 (< 0.08), TLI = 0.952 (≥ 0.90), and CFI = 0.960 (≥ 0.90). The structural model also showed excellent fit: χ^2/df = 2.662, RMSEA = 0.059, TLI = 0.951, and CFI = 0.959. All fit indices confirm the structural model accurately depicts the relationships among constructs (Mohamed et al., 2023; Byrne, 2010; Goretzko et al., 2023).

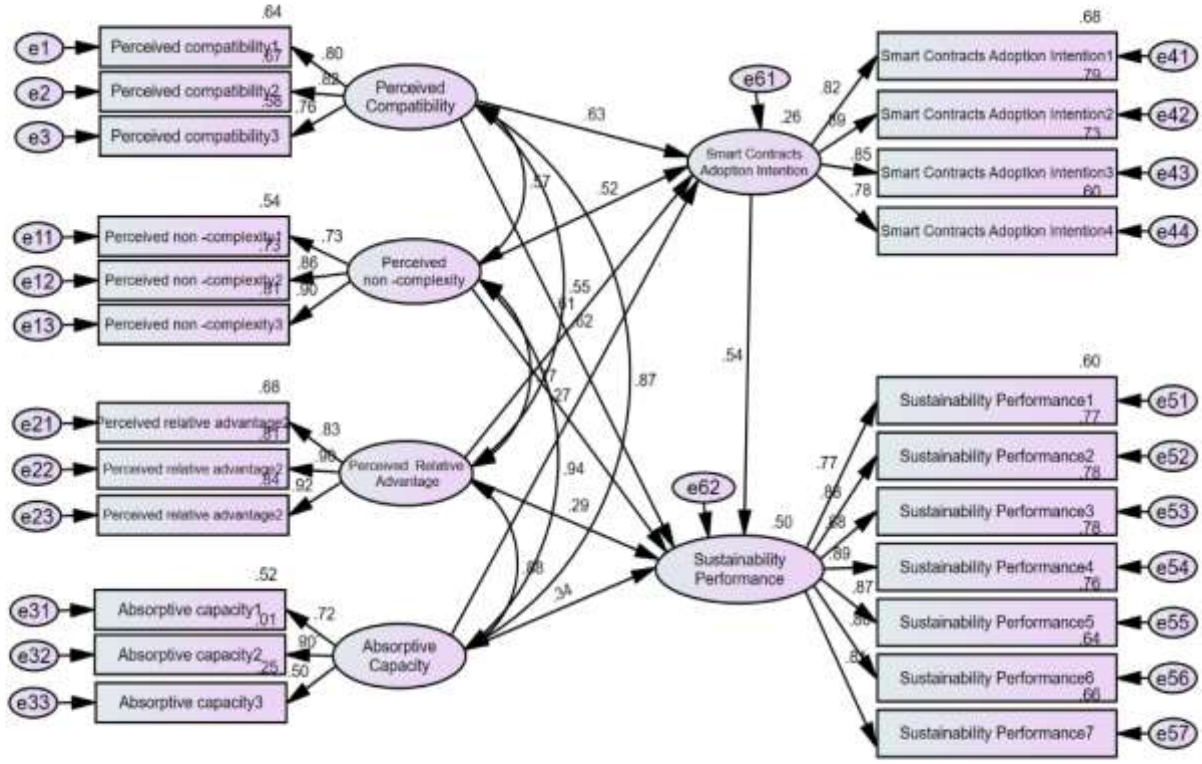

Figure 2: Structural Model.

4.4. Direct Effects Testing

All hypothesized relationships provided strong statistical evidence (p < 0.001). Non-complexity (β = 0.682) had the strongest direct impact on sustainability performance, followed by perceived compatibility (β = 0.618) and perceived relative advantage (β = 0.290). Absorptive capacity also predicted sustainability performance substantially (β = 0.342). For adoption intention, perceived compatibility had the strongest impact (β = 0.627), followed by perceived relative advantage (β = 0.613) and perceived non-complexity (β = 0.521). Absorptive capacity also predicted adoption intention (β = 0.269). Adoption intention had a considerable impact on sustainability performance (β = 0.542) (Mohamed et al., 2023; Adel et al., 2025).

Table 3: Standardized Direct Effects.

Hypothesized Path	Standardized Beta (β)	P-Value
Smart Contracts Adoption Intention ← Perceived Compatibility	.627	.000
Smart Contracts Adoption Intention ← Perceived Non-Complexity	.521	.000
Smart Contracts Adoption Intention ← Perceived Relative Advantage	.613	.000
Smart Contracts Adoption Intention ← Absorptive Capacity	.269	.000
Sustainability Performance ← Perceived Compatibility	.618	.000
Sustainability Performance ← Perceived Non-Complexity	.682	.000
Sustainability Performance ← Perceived Relative Advantage	.290	.000
Sustainability Performance ← Absorptive Capacity	.342	.000
Sustainability Performance ← Smart Contracts Adoption Intention	.542	.000

Source: Authors' analysis based on SEM Results (2026).

4.5. Indirect Effects and Mediation Testing

Bootstrap methods confirmed the indirect effects of hypotheses H6 and H7 (Hayes, 2013, 2022). Absorptive capacity, perceived compatibility (p = 0.003), perceived non-complexity (p = 0.003), perceived relative advantage (p = 0.002), and adoption intention all demonstrate partial mediation effects (Baron & Kenny, 1986). This partial mediation shows that adoption intention is an important mediating mechanism alongside direct effects (see Table 4).

Table 4: Indirect (Mediating) Effects.

Indirect Path	P-Value	Mediation Type
Perceived Compatibility → SCAI → Sustainability Performance	.003	Partial Mediation
Perceived non-complexity → SCAI → Sustainability Performance	.003	Partial Mediation
Perceived Relative Advantage → SCAI → Sustainability Performance	.002	Partial Mediation
Absorptive Capacity → SCAI → Sustainability Performance	.003	Partial Mediation

Source: Authors' analysis based on SEM Results (2026). SCAI = Smart Contracts Adoption Intention.

4.6. Variance Explained

The structural model has strong explanatory power. Technological characteristics and absorptive capacity explained 26.3% of the variance in Smart Contracts Adoption Intention ($R^2 = 0.263$). The full model accounted for 50.2% of the variance in Sustainability Performance ($R^2 = 0.502$), signifying that the combined direct and indirect effects explain more than half of the variation in sustainability performance results (Mohamed et al., 2023; Adel et al., 2025).

5. DISCUSSION

This study provides robust empirical evidence linking technological characteristics, absorptive capacity, smart contract adoption intention, and sustainability performance in Egypt's oil and gas sector (Adel et al., 2025; Bakry et al., 2024). These findings extend the literature on blockchain adoption and sustainability in resource-intensive industries (Mohamed et al., 2023; Groschopf et al., 2021).

Interestingly, perceived non-complexity outperformed all others predicting sustainability performance ($\beta = 0.682$), while perceived relative advantage lagged ($\beta = 0.290$)—yet both remained statistically significant (Jain et al., 2025; Wang et al., 2022). This stark contrast from studies from the Western world illustrates the infrastructure deficiencies in the study location, where the value of simplicity overshadows other potential gains (Tairu et al., 2025).

Organizations with absorptive capacity show a strong predictive relationship to sustainability performance ($\beta = 0.342$) (Ali et al., 2025; Chen et al., 2024). This is consistent with foundational theory demonstrating that learning capacity amplifies technology-facilitated sustainability improvement (Karagiannopoulou et al., 2022; Li et al., 2024).

Perceived compatibility dominated adoption intention ($\beta = 0.627$), followed by relative advantage ($\beta = 0.613$) and non-complexity ($\beta = 0.521$)—consistent with TAM and UTAUT frameworks (Davis et al., 2023; Tarhini et al., 2017). The intention for adopting smart contracts has a significant mediating role between absorptive capacity and sustainability performance, and between technological characteristics and sustainability outcomes (p = 0.002–0.003), confirming hypotheses H6 and H7.

The integrated model explained 50.2% of sustainability performance variance, validating technology adoption and organizational learning as sustainability drivers. Yet 49.8% remains unexplained, influenced by sustainability strategies, stakeholder engagement, regulatory compliance, and organizational culture (Egbumokei et al., 2024). These findings reveal a crucial insight: digital transformation alone does not achieve sustainability—technological solutions prove most effective when integrated with comprehensive organizational approaches.

5.1. Research Contributions

This research develops technology adoption, organizational learning, and sustainable performance through an integrated framework that advances the Technology-Organization-Environment (TOE) framework, Technology Acceptance Model (TAM), and absorptive capacity theory (Taherdoost et al., 2024). This research has five distinct contributions: (1) absorptive capacity impacts the extent to which consumers in developing countries factor technological features into adoption anticipations (Shahadat et al., 2023); (2) organizations must invest in adequate human and knowledge resource systems as technology alone is insufficient (Faiz et al., 2024); (3) smart contracts enhance organizational sustainability via automated compliance and transparency (Almher et al., 2024; Taseen et al., 2025); (4) TAM constructs function differently in oil and gas settings where security and regulatory compliance outweigh interface simplicity (Okoh & Odorikpe, 2025); and (5) SEM is particularly suitable for complex mediation in developing economies research contexts (Kastelli et al., 2022).

5.2. Limitations And Future Research Directions

The cross-sectional nature of this research does not allow understanding of causality or the evolution of relational adoptions over time (Kurniasari et al., 2025). Longitudinal studies would elucidate the dynamic interplay of perceptions of technology, organizational readiness, and intentionality (Gu et al., 2025; Li et al., 2024).

This research is focused on Egypt's oil and gas sector and may not be applicable elsewhere (Kurniasari et al., 2025; Bakry et al., 2024). Future studies should analyze regulatory frameworks in both developing and developed countries (Joshi et al., 2024). Additionally, examining actual operative behaviors rather than adoption intentions alone would deepen understanding of technology-sustainability connections (Venkatesh & Davis, 2000; Saleem et al., 2024).

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