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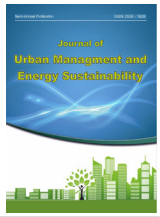

CASE STUDY RESEARCH PAPER

Reinventing the Sustainable Value Chain in Iraq's Oil Industry: The Role of Digital Transformation and Innovation in Creating Competitive Advantage

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ABSTRACT

This study aims to explain the mechanisms of "sustainable value chain reinvention" in Iraq's oil industry and to examine the role of digital transformation and innovation in creating competitive advantage. Given the institutional, operational, and environmental complexity of this industry, a qualitative approach utilizing Grounded Theory was employed to uncover an indigenous model. Data were collected through semi-structured interviews with oil industry experts and analysis of organizational documents and reports, then analyzed using three-stage coding (open, axial, and selective). During open coding, a set of key concepts related to digital technologies (including IoT, artificial intelligence, cloud computing, and blockchain), operational efficiency improvement, data governance, supply chain optimization, and sustainability dimensions (flaring reduction, wastewater management, emissions reduction) were extracted. In axial coding, concepts were organized into main categories: technological infrastructure, digital human capital, business model innovation, institutional alignment, social responsibility, and environmental sustainability. Finally, in selective coding, the central phenomenon of "sustainable value chain reinvention based on digital intelligence" was identified and the paradigmatic research model presented. Findings indicate that sustainable competitive advantage derives not from technology alone, but from the synergy of digital capabilities, innovation culture, and commitment to sustainability principles simultaneously reinforcing triple outcomes: operational, environmental, and social.

Running Title: : The Sustainable Value Chain in Iraq's Oil Industry

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INTRODUCTION

Iraq's oil industry, as one of the main pillars of the country's economy, has constantly faced numerous challenges including global oil price volatility, geopolitical instabilities, and an urgent need to modernize infrastructure and processes. In this environment, maintaining and enhancing sustainability across the value chain of this industry encompassing all stages from exploration and extraction to refining, distribution, and marketing is vital not only for survival but for Iraq's economic growth and prosperity. However, traditional value chain models in this industry often lack the agility and flexibility required to respond to the complex dynamics of global markets and environmental and social sustainability requirements. This gap highlights the essential need for a fundamental review of the structure and performance of Iraq's oil industry value chain, enabling it to be both economically sustainable and fulfil its social and environmental responsibilities. Two key factors digital transformation and innovation emerge as the primary drivers for this reinvention. Digital transformation, leveraging technologies such as artificial intelligence, the Internet of Things (IoT), Big Data analytics, and blockchain, holds the potential to create unprecedented transparency, optimize processes, reduce costs, increase productivity, and enhance safety throughout the value chain. These technologies can help organizations facilitate data-driven decision-making and respond rapidly to market changes. As emphasized in entrepreneurship and business development literature (Eniola, 2020; Ratten, 2020; Yoruk & Jones, 2020), digital transformation creates an appropriate platform for aligning environmental adaptation with opportunity exploitation in the oil industry. Innovation encompassing product, service, process, and business model innovations plays a vital role in creating differentiation and sustainable competitive advantage (Alisher, 2017; Bigné & Decrop, 2019; Jayawardena, 2019; Little et al., 2020). Despite these vast potentials, Iraq's oil industry faces significant obstacles in effectively implementing digital transformation and cultivating an innovation culture. These obstacles may include resistance to change, shortages of skilled human resources, investment limitations, and the absence of an adequate supporting ecosystem. A deeper understanding of how these two factors (digital transformation and innovation) interact with each other and with the components of a sustainable value chain in Iraq's oil industry and how these interactions translate into tangible competitive advantage—is essential. Accordingly, this study seeks to present a comprehensive model for sustainable value chain reinvention in Iraq's oil industry by identifying existing challenges and opportunities, with particular focus on the strategic integration of digital transformation and innovation to achieve long-term sustainable competitive advantage.

MATERIALS AND METHODS

Reinventing the sustainable value chain in Iraq's oil industry requires moving beyond the linear, traditional view of value chains toward a "networked, dynamic, and data-driven" logic of value creation. In turbulent environments, value is built not merely within organizational boundaries but through continuous interaction among actors, technologies, institutions, and markets. From this perspective, markets and their segments are not pre-given and fixed; rather, they are constructed and reconstructed through industrial actions and mechanisms. Consequently, Iraq's oil industry valu e chain must be understood as a "market in formation," continually being redefined as technology, institutional rules, and stakeholder expectations shift (Harrison & Kjellberg, 2010).Within such a framework, sustainability is no longer a decorative goal or merely a reporting exercise; rather, it becomes an indicator of sustained competitiveness, since long-term competitive advantage is achievable only when the value chain simultaneously responds to economic efficiency, social responsibility, and environmental pressures. Experience

from service and marketing domains demonstrates that maintaining attractiveness and competitiveness in changing markets requires innovation in strategy, experience design, and value delivery (Alisher, 2017; Mishra, 2019). The theoretical message for the oil industry is clear: creating competitive advantage without innovating in how value is defined, how stakeholders are engaged, and how new strategies are designed is impossible particularly since today's consumers and stakeholders face a "paradox" of expectations, simultaneously demanding efficiency and fair pricing alongside transparency, accountability, and quality of interaction (Bigné & Decrop, 2019). The primary driver of such reinvention is the synergistic link between "digital transformation" and "innovation." In the literature, innovation is not merely technical ideas but a set of fresh strategies for foresight, value creation, and adaptation to environmental changes (Jayawardena, 2019). In Iraq's oil industry value chain, innovation can range from process innovations (improving operations, maintenance, and waste reduction) and organizational innovations (agility and data governance) to business model innovation and partner interactions. Evidence from experience-centered design studies shows that innovation is most effective when it can increase the "tangibility of value" for stakeholders and uses data and technology to design and deliver value (Little et al., 2020). Beyond technology, entrepreneurship and innovation ecosystem literature emphasizes that innovation and transformation cannot persist without sustainable human and institutional infrastructures. The concept of "entrepreneurial ecosystems" holds that an industry's innovation capacity is the product of a network of actors (universities, government, industry, capital, and society) and mechanisms of knowledge spillover and collective learning (Ratten, 2020). For Iraq, this is particularly important: reinventing the sustainable value chain of the oil industry, without strengthening university-industry linkages, developing research and development capacity, and training data-driven and innovative human capital, risks remaining superficial or creating external dependency (Bedő et al., 2020). Entrepreneurship education literature shows that transferring innovative skills through experiential and problem-based learning methods has higher effectiveness and can strengthen organizational action capacity and learning (Bell & Bell, 2020). Entrepreneurship education throughout an enterprise's lifecycle plays an infrastructural role in institutionalizing innovative behavior (Masurel, 2019). At the individual and organizational level, "entrepreneurial self-efficacy" and "entrepreneurial orientation" can increase enterprises' capacity to pursue opportunities and achieve sustainable development (Eniola, 2020). Strategic fit literature further shows that successfully exploiting opportunities in technology-based businesses is more the result of "configuration" and fit between enterprise capabilities and environmental conditions than of any fixed formula (Yoruk & Jones, 2020). This perspective theoretically supports the proposition that Iraq's oil industry, for creating competitive advantage through digital transformation, must focus on designing an appropriate configuration one that accounts for the level of institutional maturity, infrastructural limitations, environmental risks, and human resource capabilities rather than merely replicating globally successful models.

In summary, the literature demonstrates that an appropriate theoretical framework for this study must regard the sustainable value chain as a "multi-dimensional value creation field" in which digital transformation and innovation are the drivers of activity rearrangement, relationship restructuring, and decision-making logic ultimately enabling sustainable competitive advantage. However, realizing this logic depends on an innovation ecosystem, knowledge spillovers, experiential learning, self-efficacy and entrepreneurial orientation, and above all, organization-environment configuration alignment (Bedő et al., 2020; Bell & Bell, 2020; Eniola,

2020; Ratten, 2020; Yoruk & Jones, 2020).

Methodology

This study is classified as "applied-developmental" in terms of purpose, as it seeks to develop theoretical knowledge in sustainable value chain reinvention while providing a practical, indigenous model for Iraq's oil industry. In terms of data nature and analysis method, the study is qualitative, since the problem under investigation possesses complex, multi-level, and context-dependent dimensions that cannot be explained solely through pre-defined variables and quantitative tools. Given that the primary objective is to discover mechanisms, conceptual relationships, and hidden processes linking digital transformation, innovation, and sustainable competitive advantage in Iraq's oil industry, Grounded Theory was employed as the main strategy. This method enables the final conceptual model to be extracted from within the experiences, perceptions, and interpretations of participants and documentary evidence rather than imposing pre-existing theoretical frameworks onto the data. Grounded Theory is appropriate when the researcher seeks to explain a nascent, context-bound, and less-formulated phenomenon, a condition that aligns well with the complex context of Iraq's oil industry. The study population comprised experts, managers, senior specialists, and professionals active in Iraq's oil industry who were directly or indirectly involved in value chain domains, digital technologies, organizational innovation, environmental sustainability, operations management, supply chain, and energy policy. Participants were selected through purposive and theoretical sampling; initially by identifying individuals with relevant experience, specialized knowledge, and analytical insight, then based on emerging concepts during analysis selecting subsequent participants to enrich conceptual content, expand category dimensions, and resolve analytical ambiguities. Inclusion criteria included meaningful professional experience in the oil industry, familiarity with digital transformation or sustainability dimensions, managerial or specialist experience in operational and strategic domains, and willingness to participate in in-depth interviews. Sampling continued until theoretical saturation was achieved that is, until later interviews yielded no new data capable of meaningfully developing categories or modifying conceptual relationships. Semi-structured in-depth interviews were used as the primary data collection instrument, supplemented by organizational document and report analysis. The interview guide was designed based on theoretical literature, research objectives, and the main study question, addressing topics including the current state of Iraq's oil industry value chain, obstacles and opportunities in digital transformation, applicable innovation types, sustainability requirements, the role of institutional structures, and potential consequences. All interviews were recorded with informed consent, transcribed verbatim, and prepared for analysis. Documentary analysis including strategic reports, policy documents, operational directives, development documents, sustainability reports, and relevant organizational texts was conducted to understand the institutional and industrial research context more precisely and to enable data triangulation. Data analysis followed three-stage Grounded Theory coding: open, axial, and selective. In open coding, interview texts and documents were examined line-by-line and phrase-by-phrase, extracting numerous initial concepts. In axial coding, concepts were grouped by semantic affinity and the relationships among causal conditions, contexts, strategies, intervening factors, and consequences were analyzed. In selective coding, the central phenomenon was identified and the final model centered on "sustainable value chain reinvention based on digital intelligence"was formulated. To enhance validity and reliability, multiple strategies were employed: continuous comparative analysis throughout coding to prevent premature conclusions; member-checking

by sharing analytical interpretations with some experts; data triangulation through combining interviews with documents; maintaining a research audit trail documenting decision-making logic, coding rationale, concept merging, and category formation; and deep engagement with data combined with continuous reflexivity regarding assumptions and theoretical sensitivity to emerging concepts.

DISCUSSION AND FINDINGS

Stage One: Open Coding

At this stage, interview texts were carefully analyzed and semantic units extracted. Fifty initial codes representing key concepts in value chain reinvention, digital transformation, innovation, and sustainability in Iraq's oil industry were identified and classified in the table below. (Tab. 1)

Table 1: Initial Code Extraction

No.	Initial Code (Extracted Concept)	No.	Initial Code (Extracted Concept)
1	Real-time Reservoir Monitoring	26	Reduction of Gas Leakage and Flaring
2	IoT in Drilling Equipment	27	Industrial Oilfield Wastewater Management
3	Blockchain in Supply Contracts	28	Energy Consumption Optimization in Refineries
4	Digital Twins for Operations Simulation	29	Biodiversity Protection in Operational Areas
5	Big Data Analytics in Exploration	30	Transparent Sustainability Reporting (ESG)
6	Automation of Pressure Boost Stations	31	Social Responsibility toward Local Communities in Iraq
7	Cybersecurity of Critical Energy Infrastructure	32	Reducing Carbon Footprint in the Supply Chain
8	ERP Systems Integration in National Companies	33	Renewable Energy Substitution at Sites
9	Predictive Maintenance	34	Physical Asset Lifecycle Management
10	AI Application in Production Estimation	35	Innovation in International Partnership Models
11	Elimination of Paper Bureaucracy in Procurement	36	Localization of New Technologies (Local Content)
12	Satellite Monitoring of Pipelines	37	Development of Oil Service Start-ups in Iraq
13	Cloud Computing for Knowledge Sharing Between Fields	38	University-Industry Collaboration in Basra and Baghdad
14	Smart Leak Detection Sensors	39	Specialized Human Capital in ICT
15	Augmented Reality (AR) for Technician Training	40	Organizational Culture Receptive to Digital Transfor-mation
16	Digital Platforms for Contractor Engagement	41	Geopolitical Risk Management with Smart Tools
17	Reduction of Operational Costs (OPEX)	42	Resilience Against Oil Price Volatility
18	Increased Management Decision-making Speed	43	Transparency in Oil Tender Processes
19	Agility in Responding to Global Market Needs	44	Improvement of Produced Product Quality
20	Value-Added Creation in the Downstream Sector	45	Energy Security and Supply Continuity
21	International Branding of Iraq National Oil Company	46	Reduction of Human Error in Sensitive Operations
22	National Oil and Gas Data Governance	47	Horizontal and Vertical Integration in Value Chain
23	Redesign of Traditional Drilling Processes	48	Enhancement of Domestic Technological Capabilities
24	Data Sharing with Foreign Partners (IOCs)	49	Logistics and Material Transport Optimization
25	Compliance with Global Environmental Standards	50	Workforce Productivity at Remote Sites

Stage Two: Axial Coding

At this stage, open codes were classified into 10 axial categories based on semantic similarities and conceptual linkages. These categories form the core body of the model. (Tab. 2)

Table 2: Classification of Open Codes into Axial Categories

Axial Category	Related Open Codes (Examples)
1. Smart Technological Infrastructure	Internet of Things, Artificial Intelligence, Blockchain, Cloud Computing
2. Data Integration and Governance	Data Governance, ERP Systems, Knowledge Sharing, Cybersecurity
3. Operational Efficiency and Agility	Predictive Maintenance, Cost Reduction, Decision-making Speed
4. Process and Business Model Innovation	Technology Localization, Oil Start-ups, Process Redesign
5. Environmental Sustainability	Flaring Reduction, Wastewater Management, Carbon Footprint Reduction
6. Social Responsibility and Ethics	Tender Transparency, Local Communities, ESG Reporting
7. Digital Human Capital Development	Organizational Culture, AR-based Training, ICT Expertise
8. Strategic and Institutional Alignment	University-Industry Collaboration, National Laws, Geopolitical Risk
9. Supply Chain and Logistics Optimization	Contractor Platform, Pipeline Monitoring, Smart Logistics
10. Value Creation and Competitive Differentiation	International Branding, Downstream Value-Added, Energy Security

Stage Three: Selective Coding and Final Model

At this stage, the "central phenomenon" was identified. The central phenomenon in this study is "Reinvention of the Sustainable Value Chain Based on Business Intelligence," around which all axial categories cohere. (Tab. 3)

Table 3: Final Selective Coding Framework (Paradigmatic Model)

Paradigmatic Model Components	Related Axial Categories
Causal Conditions (Drivers)	Smart Technological Infrastructure, Data Integration and Governance
Central Phenomenon	Reinvention of the Sustainable Value Chain Based on Business Intelligence
Strategies (Actions)	Process and Business Model Innovation, Digital Human Capital Development
Contextual Conditions (Context)	Strategic and Institutional Alignment, Supply Chain and Logistics Optimization
Intervening Conditions (Barriers/Facilitators)	Social Responsibility and Ethics (Institutional Pressures), Environmental Risks
Consequences (Outcomes)	Operational Efficiency and Agility, Environmental Sustainability, Competitive Differentiation

Qualitative Findings Analysis

Qualitative findings analysis reveals that reinventing the value chain in Iraq's oil industry is no longer a strategic choice but an inevitable necessity for survival in the global energy market. Based on the coding conducted, digital transformation as the primary driver (causal conditions) through tools such as IoT and artificial intelligence, transforms the physical and traditional body of the oil industry into an intelligent entity. These technologies, by creating transparency and data governance, provide a context in which "data" as a strategic asset replaces management guesswork. However, interview analysis emphasizes that technology alone is insufficient; business model and process innovation (strategies)

must be designed such that technical knowledge is localized and the link between Iraq's universities and its oil industry is strengthened to ensure the durability of transformation. In terms of consequences, results show that the link between digital transformation and sustainability leads to a form of "green and intelligent competitive advantage." The reinvented value chain enables Iraq's oil industry to not only reduce operational costs and increase agility against oil price fluctuations (economic efficiency), but also to enhance its international standing in the energy transition era through flaring reduction and wastewater management (environmental sustainability). In summary, the model derived from this study indicates that sustainable competitive advantage in Iraq's oil industry is the product of synergy among "digital capabilities," "innovation culture," and "commitment to sustainability principles"transforming the value chain from a linear, rigid structure into a dynamic and value-creating ecosystem. (Fig. 1)

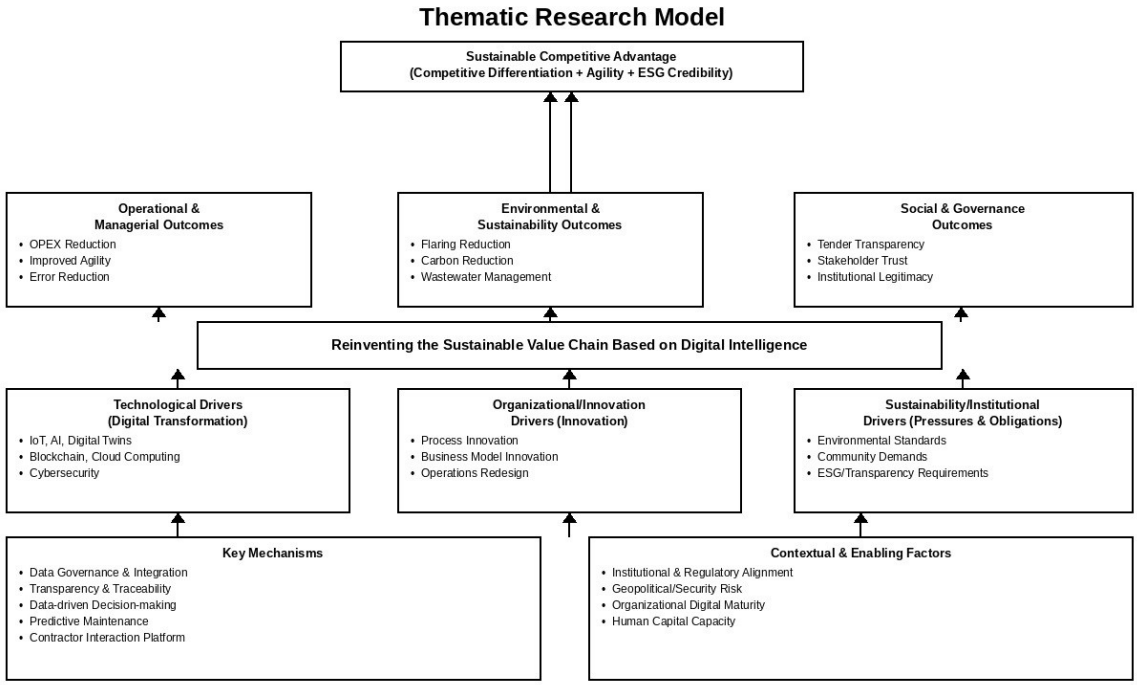

Figure 1: Thematic Research Model: Reinventing the Sustainable Value Chain Based on Digital Intelligence

DISCUSSION AND FINDINGS

The findings of this study demonstrate that reinventing the value chain in Iraq's oil industry is not merely a technological project or minor operational reform, but a structural transformation in the logic of value creation. While Iraq's oil industry faces challenges such as infrastructure aging, data governance limitations, resource waste, environmental instability, and increasing pressure from domestic and international stakeholders, digital transformation emerges as the driving engine of this reinvention. Coding results show that technologies such as IoT, artificial intelligence, blockchain, digital twins, and predictive analytics systems have the greatest impact when deployed within a framework of data governance, information integration, and an innovative organizational culture.

From an analytical perspective, the findings indicate that innovation plays a mediating and facilitating role between digital transforma-

tion and sustainable competitive advantage. Although digital capabilities contribute to operational efficiency improvement, reduced downtime, enhanced traceability, and improved supply chain control, these achievements become competitive advantage only when redefined through process innovation, business model innovation, and inter-organizational interaction innovation. For example, using IoT sensors in oil fields has limited effect if used merely for equipment monitoring; but when the data generated from them is integrated into a decision-support system for predictive maintenance, optimal resource allocation, flaring reduction, and energy consumption optimization, the value chain transforms from a linear, cost-heavy structure into a dynamic and learning one. One of the most important findings of this study is that environmental sustainability and social responsibility in Iraq's oil industry cannot be regarded as marginal or supplementary requirements; rather, they must be embedded in the value chain and at the heart of competitive strategy. The findings show that flaring reduction, wastewater management, emissions reduction, energy optimization, and enhanced transparency in engagement with local communities and regulatory bodies are not merely desirable side effects they themselves become sources of legitimacy creation, risk reduction, and enhancement of organizational credibility. In an environment where the oil industry faces increasing ESG sensitivity, global market pressures, and government and societal expectations, an organization capable of improving its environmental performance through digital tools achieves an advantage that competitors cannot easily replicate.

In summary, the final research model presents a multi-layered picture of how sustainable competitive advantage forms in Iraq's oil industry advantage derived from the simultaneous combination of technological drivers, organizational innovation, sustainability requirements, and contextual conditions. This model shows that investment in technology alone, without reforming decision-making structures, developing digital human capital, establishing institutional alignment, and institutionalizing an innovation culture, cannot lead to real transformation in the value chain. The most important message of this research is therefore that reinventing the sustainable value chain is a gradual, interactive, and multi-level process requiring transformational leadership, data-driven governance, organizational learning, and active stakeholder engagement. Based on model findings, it is recommended that senior managers and policymakers in Iraq's oil industry formulate a comprehensive digital transformation roadmap that accounts for the country's institutional constraints and infrastructural realities. Investment in data infrastructure, particularly data integration across fields and refinery systems, should be prioritized as a prerequisite for any intelligent application. University-industry partnerships, especially in Basra and Baghdad, must be strengthened through joint research programs and internship mechanisms to develop specialized ICT human capital. To overcome organizational resistance, continuous cultural change programs and management incentive alignment with sustainability and innovation goals are essential. Finally, adopting a phased implementation approach through piloting smart applications in selected fields before full-scale deployment minimizes risk while generating knowledge and evidence for systemic change.

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