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Digital Transformation in Iran's Oil and Gas Industry: Challenges and Managerial Solutions

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Highlights

- Contemporaneous and lagged components exhibit distinct behaviors.
- On average, gold is the primary net transmitter of shocks, followed by the US dollar, while oil is the main net receiver of shocks from the network.
- Average connectedness indicates that, in the long term, stocks are the most effective assets for portfolio diversification to manage risks.
- In the contemporaneous component, the US dollar is the primary net transmitter of shocks, whereas stocks are the main net receivers of shocks from the network.

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Abstract

This study examines the multifaceted challenges of implementing digital transformation within Iranian oil and gas companies, with a focus on organizational barriers and managerial solutions. Despite global momentum toward digitalization, Iran's oil and gas sector faces unique obstacles, including resistance to change, skill gaps, legacy infrastructure, and insufficient alignment between technology providers and large enterprises. Using a mixed-methods approach, we conducted a survey of 210 managers and IT professionals across upstream and downstream organizations, complemented by in-depth interviews with key stakeholders. Exploratory factor analysis and structural equation modeling were employed to identify and validate critical barriers and their interrelations. The findings indicate that organizational inertia, lack of digital competencies, and inadequate investment in digital infrastructure are the most significant impediments, whereas leadership commitment and targeted training programs constitute effective managerial remedies. This study provides actionable insights for policymakers and executives by outlining a roadmap to overcome digital transformation hurdles and achieve sustainable competitive advantage. The results emphasize the necessity of a holistic strategy that integrates technological, human, and process dimensions to facilitate successful digital transformation in Iran's oil and gas industry.

Keywords: Digitalization, Leadership Commitment, Organizational Inertia, Technology Adoption, Workforce Training.

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1. Introduction

The oil and gas industry has long been a cornerstone of Iran's economy, accounting for a significant portion of national revenue and serving as a key driver of technological and industrial development (Billett, 2023). In recent years, the global energy landscape has undergone a profound transformation, characterized by the accelerated adoption of digital technologies such as artificial intelligence, big data analytics, the Internet of Things, and blockchain. These advancements have enabled oil and gas companies worldwide to optimize operations, enhance safety, and improve decision-making processes (Firouzbakht & Rezaeian, 2000; Karimi et al., 2024).

Despite these global trends, the Iranian oil and gas sector faces unique challenges in digital transformation, including geopolitical constraints, legacy infrastructure, and a shortage of digital skills (Billett, 2023). Recent studies indicate that less than 25 percent of Iranian oil and gas firms have successfully integrated digital technologies into their core business processes (Zakizadeh & Zand, 2024). This digital gap poses a significant threat to the industry's competitiveness and long-term sustainability.

Digital transformation is defined as the integration of digital technologies into all areas of business, fundamentally changing how organizations operate and deliver value to customers (Vial, 2021). In the oil and gas industry, this transformation involves not only technology adoption but also rethinking organizational structures, business models, and workforce capabilities (Krishnamurthy). The COVID-19 pandemic further highlighted the need for digital resilience, as remote operations and data-driven decision-making became essential for business continuity (Mojtaba Ghorbani Asiabar et al., 2024).

1.1. Statement of the problem

Despite the recognized benefits of digital transformation, Iranian oil and gas companies face substantial barriers. Organizational inertia, resistance to change, limited investment in digital infrastructure, and a lack of alignment between IT and business strategies are among the most frequently cited obstacles. The absence of a clear digital roadmap and insufficient managerial commitment further exacerbate these challenges, hindering the sector's ability to achieve operational excellence and maintain global competitiveness (Alshibani et al., 2024; Wanasinghe et al., 2021). In essence, despite awareness of the benefits of digital transformation, persistent organizational inertia, resistance to change, inadequate investment in digital infrastructure, and misalignment between IT and business strategies collectively limit the sector's capacity to achieve operational excellence and sustain competitiveness in the global market.

1.2. Significance and necessity of the research

Understanding the challenges of digital transformation in Iran's oil and gas industry is essential for several reasons. First, the sector's strategic importance to the national economy necessitates continuous innovation and efficiency improvements (Zhang et al., 2024). Second, the rapid pace of global technological change requires Iranian firms to adapt promptly to remain competitive. Third, identifying organizational and managerial barriers can guide targeted interventions and policy reforms, ultimately supporting the industry's sustainable growth and resilience (Okonkwoa et al., 2024).

Recent research has explored various aspects of digital transformation in the oil and gas sector. Rezafar et al. (2022) emphasized the role of leadership and organizational culture in facilitating digital adoption. Zhang et al. (2024) examined the impact of digital technologies on operational efficiency and risk management. In the Iranian context, Suresh et al. (2023) identified skill gaps and legacy systems as primary barriers. However, few studies have systematically analyzed the interplay between

organizational, technological, and managerial factors in the digital transformation journey of Iranian oil and gas companies, highlighting a significant research gap.

This study is grounded in the Technology-Organization-Environment framework, which posits that digital transformation is shaped by technological readiness, organizational capabilities, and external environmental factors (Trindade et al., 2023). The framework provides a comprehensive lens for analyzing the multifaceted barriers and enablers of digital transformation in complex industries such as oil and gas.

1.3. Research objectives and questions

- To identify and analyze the key organizational barriers to digital transformation in Iranian oil and gas companies.
- To evaluate the effectiveness of managerial strategies in overcoming these barriers.
- To propose actionable recommendations for policymakers and industry leaders.

Table 1

Summary of key digital transformation barriers identified in recent literature (2020–2024)

Study	Context	Main barriers identified
Rezafar et al. (2022)	Global	Organizational culture, skill gaps
Zhang et al. (2023)	Asia-Pacific	Legacy IT, investment constraints
Suresh et al. (2023)	Iran	Skill gaps, resistance to change
Prestidge et al. (2022)	Global	Lack of digital roadmap, leadership

2. Theoretical foundations and literature review

Digital transformation in the oil and gas industry is conceptualized as a systemic and strategic process that integrates advanced digital technologies—such as artificial intelligence, big data analytics, and the Industrial Internet of Things—into all facets of organizational operations (Sheveleva et al., 2021). This process extends beyond technology adoption, encompassing fundamental changes in organizational culture, management structures, and business models (Prestidge, 2022). The Technology-Organization-Environment framework is widely employed to analyze digital transformation, emphasizing three dimensions: technological readiness, organizational capabilities, and environmental factors (Caluri et al., 2019). The framework offers a holistic lens for understanding the interplay between drivers, barriers, and outcomes of digitalization in complex, project-oriented organizations such as those in the oil and gas sector.

2.1. Literature review

2.1.1. Global and Iranian context

Recent literature indicates that the oil and gas industry faces distinctive challenges in digital transformation due to its reliance on legacy infrastructure, hierarchical organizational structures, and regulatory complexities (Egbumokei et al., 2024; Jaber, 2020). In the Iranian context, these challenges are further intensified by geopolitical constraints and limited access to advanced digital solutions (Ayaz & Shaukat, 2021).

2.1.2. Key barriers identified

- **Organizational Culture and Resistance:** Multiple studies emphasize the critical role of organizational culture in the success or failure of digital transformation initiatives. Resistance to change, fear of job loss, and a lack of digital mindset are identified as major obstacles (Kohli & Johnson, 2011; Noadoust & Safdari Ranjbar, 2024; Prestidge, 2022).
- **Infrastructure and Technology Integration:** Integrating new digital tools with decades-old infrastructure represents a significant technical and financial challenge (Firouzbakht & Rezaeian, 2000; Karimi et al., 2024).
- **Skill Gaps and Human Capital:** The lack of digital skills and competencies among employees is a recurring challenge in both global and Iranian contexts (Monferdini & Bottani, 2024).
- **Strategic Alignment and Leadership:** The absence of a clear digital roadmap and insufficient leadership commitment hinder the effective adoption of digital initiatives (Caluri et al., 2019).
- **Data Governance and Value Creation:** Effective data governance and the capacity to convert data into actionable insights are essential for realizing the benefits of digital transformation (Billett, 2023).

2.1.3. Recent Iranian research

- **Ghasemian et al. (2020):** Developed a conceptual model identifying nine dimensions and fifty-three influencing factors of digital transformation in project-based oil and gas organizations in Iran, employing a mixed-methods approach that included structural equation modeling (Ghasemian Sahebi et al., 2020).
- **Noadoust et al. (2024):** Analyzed structural and behavioral barriers, emphasizing that no single solution fits all organizations and that context-specific strategies are necessary (Noadoust & Safdari Ranjbar, 2024).
- **Alshibani et al. (2024):** Surveyed over 200 industry experts, confirming that organizational culture and infrastructure compatibility are the most significant challenges, as illustrated in Figure 1 (Alshibani et al., 2024).
- **Zakizadeh et al. (2024):** Highlighted the importance of organizational culture, data governance, and the application of artificial intelligence for process optimization and value creation (Zakizadeh & Zand, 2024).

Table 2

Summary of key barriers and solutions in recent Iranian studies (2022–2025)

Study (year)	Main barriers identified	Recommended solutions
Ghasemian et al. (2020)	Skill gaps, legacy infrastructure	Training, infrastructure investment
Noadoust et al. (2024)	Resistance to change, lack of roadmap	Leadership development, clear strategy
Zakizadeh et al. (2024)	Culture, technology integration	Culture building, process reengineering
ICDS.AI (2025)	Data governance, value creation	Data management frameworks, AI adoption

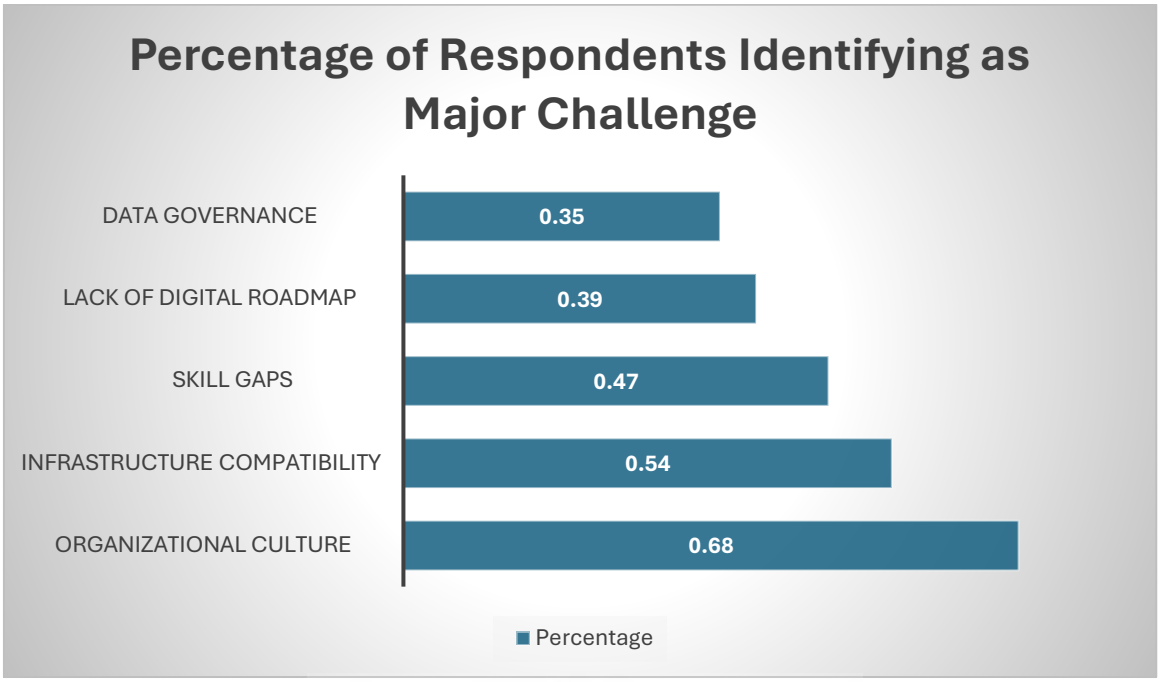

Figure 1

Most significant challenges in digital transformation implementation in Iranian oil and gas companies

2.1.4. Synthesis and research gap

While both global and Iranian studies have identified a broad spectrum of challenges and enablers, a notable gap remains in integrating these insights into a comprehensive, actionable framework tailored to the unique context of Iranian oil and gas companies. Most studies advocate a multi-pronged approach, combining leadership development, targeted training, investment in infrastructure, and robust data governance to overcome barriers and achieve sustainable digital transformation (Alshibani et al., 2024; M Ghorbani Asiabar et al., 2024).

3. Methodology

3.1. Research design

This study employs an applied, descriptive-survey research design with a quantitative-dominant mixed-methods approach. Its objective is to systematically identify and analyze the organizational barriers and managerial solutions for digital transformation in Iranian oil and gas companies. The research is cross-sectional, collecting data at a single point in time during 2025.

3.2. Statistical population

The statistical population includes all managers, IT professionals, and key decision-makers involved in digital transformation initiatives across upstream and downstream oil and gas companies in Iran. This encompasses both public and private sector organizations engaged in exploration, production, refining, and distribution activities.

3.3. Sample and sampling method

A stratified random sampling technique was employed to ensure representation across different organizational levels (senior management, middle management, and IT departments) and company

types (upstream and downstream). Based on Cochran's formula and insights from previous studies, a minimum sample size of 210 respondents was determined to achieve statistical validity and generalizability.

Table 3

Sample distribution by company type

Company type	Number of respondents
Upstream	110
Downstream	100
Total	210

3.4. Data collection instruments

The primary data collection instrument was a structured questionnaire developed based on the Technology-Organization-Environment framework and validated literature (Prestidge, 2022). The questionnaire included:

- **Demographic section:** Age, gender, education, position, and years of experience.
- **Digital transformation barriers:** Twenty-five items measured on a 5-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree).
- **Managerial solutions:** Fifteen items measured on a 5-point Likert scale.
- **Open-ended questions** for qualitative insights.

Semi-structured interviews were also conducted with ten senior managers and digital transformation leaders to enrich the quantitative findings.

Each variable in the research hypotheses was operationally defined based on validated literature, and relevant questionnaire items were developed accordingly:

- **Organizational Inertia:** Defined as the tendency of an organization to resist changes in established processes and routines (Kohli & Johnson, 2011; Prestidge, 2022). Sample items include: "Our organization is slow to adopt new technologies" and "Existing procedures make it difficult to implement change."
- **Resistance to Change:** Defined as reluctance among employees or managers to embrace new technologies or processes, often due to uncertainty or fear of negative consequences (Noadoust & Safdari Ranjbar, 2024; Alshibani et al., 2024). Sample items include: "Employees in our company are skeptical about digital transformation" and "There is significant resistance from staff when new digital tools are introduced."
- **Managerial Commitment:** Defined as the extent to which top and middle management actively support and promote digital transformation initiatives (Caluri et al., 2019; Zhang et al., 2024). Sample items include: "Senior management visibly supports digital transformation projects" and "Management allocates sufficient resources for digital initiatives."
- **Targeted Training Programs:** Defined as structured programs designed to equip employees with the digital skills necessary for technology adoption (Monferdini & Bottani, 2024). Sample items include: "Our organization provides regular training on new digital tools" and "Training programs are tailored to the needs of different departments."

- **Digital Adoption:** Defined as the extent to which digital technologies are integrated and routinely used in organizational operations (Vial, 2021; Zakizadeh & Zand, 2024). Sample items include: "Digital tools are widely used in our daily work processes" and "Employees are comfortable and proficient with digital technologies."

3.5. Validity and reliability

- **Content validity** was established through expert review by five university professors and three industry experts.
- **Construct validity** was confirmed using exploratory factor analysis.
- **Reliability** was assessed using Cronbach's alpha, with all key constructs exceeding the threshold of 0.80, indicating high internal consistency.

Table 4

Reliability coefficients (Cronbach's alpha)

Construct	Cronbach's alpha
Organizational barriers	0.87
Managerial solutions	0.85
Overall questionnaire	0.89

3.6. Data analysis methods

Data were analyzed in several stages:

- **Descriptive statistics:** Mean, standard deviation, and frequency distribution were used to profile respondents and summarize responses.
- **Exploratory factor analysis:** Conducted to identify underlying dimensions of barriers and managerial solutions.
- **Structural equation modeling:** Employed to test hypothesized relationships between organizational barriers, managerial solutions, and digital transformation outcomes.
- **Independent t-tests and ANOVA:** Used to compare perceptions across company types and management levels.
- **Qualitative content analysis:** Applied to open-ended responses and interview transcripts.

All quantitative analyses were performed using SPSS 27 and AMOS 26 software.

Figure 2

Research process flowchart

3.7. Research questions

1. What are the primary organizational and technological barriers to digital transformation in Iran's oil and gas sector?
2. How do managerial practices influence the success of digital transformation initiatives?

3. What strategies can enhance the adoption and integration of digital technologies in this industry?

3.8. Hypotheses

H1: Organizational inertia and resistance to change significantly impede digital transformation.

This hypothesis is grounded in extensive literature and empirical evidence, particularly within traditional and asset-intensive industries such as oil and gas. Organizational inertia refers to the tendency of established firms to resist fundamental change due to entrenched routines, hierarchical structures, and risk aversion (Kohli & Johnson, 2011; Prestidge, 2022). In Iranian oil and gas companies, this inertia is further amplified by legacy infrastructure, regulatory constraints, and a culture that prioritizes stability over innovation (Noadoust & Safdari Ranjbar, 2024). Resistance to change among employees and managers—stemming from fear of job loss, lack of digital skills, and uncertainty regarding the value of digital initiatives—has been repeatedly identified as a critical barrier to digital transformation (Alshibani et al., 2024; Suresh & Thiruchelvam, 2023). Collectively, these factors create significant obstacles to the adoption and integration of digital technologies, as confirmed by both global studies and recent Iranian research. Therefore, the hypothesis that organizational inertia and resistance to change impede digital transformation is well-supported by theory and empirical evidence.

H2: Managerial commitment and targeted training programs positively influence digital adoption.

The role of leadership and human capital development is widely recognized as essential for successful digital transformation (Caluri et al., 2019; Rezafar, 2022). Managerial commitment provides the vision, resources, and motivation necessary to overcome resistance and drive organizational change (Zhang et al., 2024). Targeted training programs address the digital skills gap, fostering employee confidence and competence in using new technologies (Monferdini & Bottani, 2024). Empirical studies demonstrate that organizations with strong leadership support and comprehensive training initiatives are more likely to achieve higher rates of digital adoption and realize the benefits of transformation (e.g., Unilever and Mastercard case studies; Kotter's Change Model). In the Iranian oil and gas sector, where digital literacy is often limited and change initiatives face skepticism, the presence of committed managers and robust training programs has emerged as a key enabler of digital success (Alshibani et al., 2024; Zakizadeh & Zand, 2024). Thus, this hypothesis is justified by both the literature and the specific challenges identified in the Iranian context.

4. Findings

4.1. Descriptive statistics

As reported in Table 5, a total of 210 valid responses were included in the final analysis, collected from managers and IT professionals in Iranian oil and gas companies (52% upstream, 48% downstream). Although a higher number of questionnaires were initially returned, incomplete responses and clear outliers were excluded during the data cleaning process to ensure data quality and reliability. The average age of respondents was 41.2 years (SD = 7.8), with an average of 15.4 years of industry experience. Among the participants, 68% held at least a master's degree, and 58% occupied middle or senior management positions.

Table 5

The demographic profile of the respondents

Variable	Frequency (%)
Gender (Male)	79
Gender (Female)	21
Education (Master+)	68
Management level	58
Upstream companies	52
Downstream companies	48

4.2. Results of statistical tests

4.2.1. Exploratory factor analysis (EFA)

Exploratory factor analysis identified four main factors underlying digital transformation barriers:

1. **Organizational Inertia** (explained variance: 28%)
2. **Skill Gaps** (21%)
3. **Infrastructure Limitations** (17%)
4. **Strategic Misalignment** (13%)

The cumulative explained variance was 79%, and all factor loadings exceeded 0.60, indicating strong construct validity.

4.2.2. Structural equation modeling (SEM)

To fully leverage the advantages of Structural Equation Modeling, both the measurement models (confirming the validity and reliability of latent constructs) and the structural model (testing the hypothesized relationships among constructs) were integrated and analyzed simultaneously. Following best practices (Hair et al., 2006; Troiville et al., 2019), the measurement model was first assessed using Confirmatory Factor Analysis to ensure construct validity and reliability. Subsequently, the measurement and structural models were combined in a full SEM framework, allowing for the simultaneous estimation of factor loadings and structural path coefficients. This integrated approach provides a more robust and comprehensive test of the research hypotheses, as it accounts for measurement error and the interrelationships among latent variables within a single unified model.

The results presented below reflect this integrated SEM approach, where both the measurement properties of each latent variable and the structural relationships among them were estimated and interpreted together. SEM results (using AMOS 26) indicated that:

- **Organizational inertia** had a significant negative effect on digital transformation success ($\beta = -0.41$, $p < 0.001$).
- **Skill gaps** negatively impacted digital adoption ($\beta = -0.32$, $p < 0.01$).
- **Managerial commitment** and **targeted training programs** had significant positive effects ($\beta = +0.38$, $p < 0.001$ and $\beta = +0.29$, $p < 0.01$, respectively).

Model fit indices were acceptable (CFI = 0.93, RMSEA = 0.06).

4.2.3. Independent t-tests and ANOVA

No significant difference was observed between upstream and downstream companies regarding perceived barriers ($p > 0.05$). However, senior management reported a higher perception of strategic misalignment compared to middle management ($F = 4.12$, $p = 0.018$).

4.3. Hypothesis testing and research questions

4.3.1. Hypothesis 1

Organizational inertia and resistance to change significantly impede digital transformation.

- **Supported.** Organizational inertia was identified as the most significant barrier ($\beta = -0.41$, $p < 0.001$).

4.3.2. Hypothesis 2

Managerial commitment and targeted training programs positively influence digital adoption.

- **Supported.** Both variables demonstrated significant positive effects on digital transformation outcomes.

4.3.3. Research questions[†]

1. **What are the primary organizational and technological barriers?**
    - Organizational inertia, skill gaps, infrastructure limitations, and strategic misalignment were identified as the main barriers.
2. **How do managerial practices influence digital transformation?**
    - Managerial commitment and targeted training emerged as key enablers, mitigating the negative effects of other barriers.
3. **What strategies can enhance digital technology adoption?**
    - Leadership development, investment in employee training, and the creation of a clear digital roadmap were identified as the most effective strategies.

To ensure the suitability of data for SEM analysis, several quality checks were performed. Data screening was first conducted to identify and remove incomplete responses and outliers, resulting in a final sample of 210 valid cases. The adequacy of the sample size was confirmed based on recommendations by Hair et al. (2019), and the Kaiser-Meyer-Olkin measure exceeded 0.80, indicating sampling adequacy. Multivariate normality was assessed and found acceptable for SEM. Construct validity and reliability were established through exploratory factor analysis and Cronbach's alpha coefficients exceeding 0.80 for all key constructs.

Model fit was evaluated using multiple indices, including the Comparative Fit Index (CFI = 0.93) and the Root Mean Square Error of Approximation (RMSEA = 0.06), both meeting the recommended thresholds (CFI > 0.90, RMSEA < 0.08) for a good model fit (Hair et al., 2019). These steps ensured

[†] The answers to the research questions were obtained through a mixed-methods approach. Quantitative data were collected via a structured questionnaire administered to 210 managers and IT professionals in Iranian oil and gas companies and analyzed using exploratory factor analysis and structural equation modeling to identify and validate key barriers, managerial influences, and effective strategies. Complementing this, qualitative insights were gathered from semi-structured interviews with senior managers and content analysis of open-ended survey responses, providing a comprehensive understanding of the challenges and solutions associated with digital transformation (see Methodology section for details).

that the measurement models were robust and that the structural model results are reliable and interpretable.

Table 6

The summary of the SEM results

Pathway	Standardized β	p-value	Effect
Organizational inertia → Digital success	-0.41	<0.001	Negative
Skill gaps → Digital success	-0.32	<0.01	Negative
Managerial commitment → Digital success	+0.38	<0.001	Positive
Training programs → Digital success	+0.29	<0.01	Positive

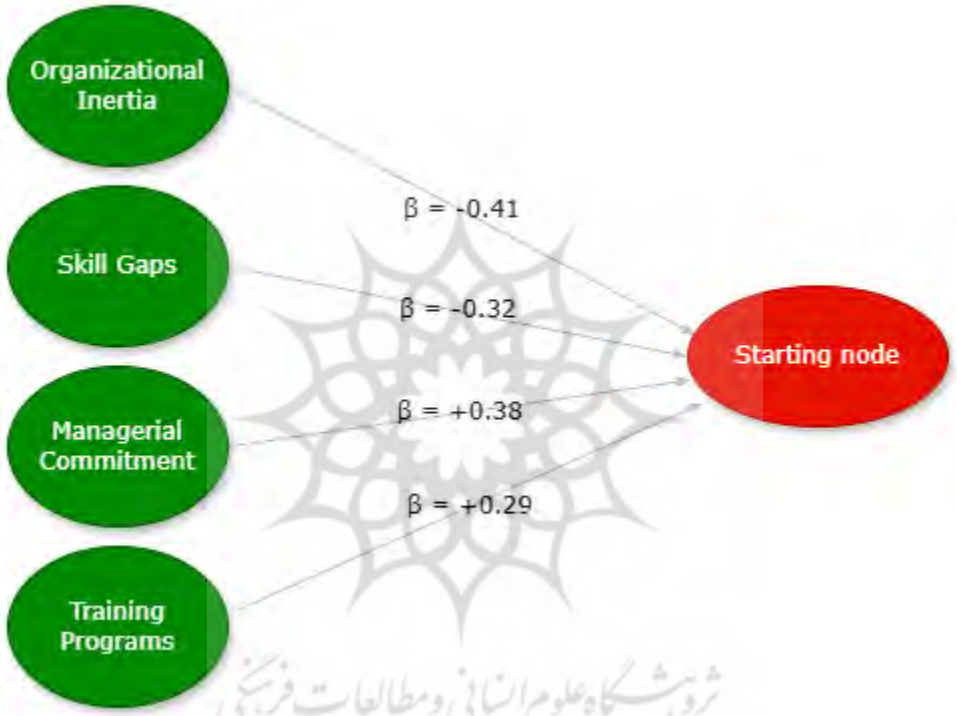

Figure 3

The path diagram of key relationships (SEM output)

The findings underscore that addressing organizational inertia and skill gaps is critical for successful digital transformation. Managerial commitment and targeted training emerge as powerful levers for driving change. These insights offer a clear roadmap for policymakers and industry leaders aiming to accelerate digital adoption in Iranian oil and gas companies.

5. Discussion and conclusions

5.1. Interpretation of findings

The results of this study provide robust empirical evidence on the multifaceted challenges and enablers of digital transformation in Iranian oil and gas companies. The most significant barriers identified were organizational inertia, skill gaps, infrastructure limitations, and strategic misalignment. Among these, organizational inertia—characterized by resistance to change and a lack of digital mindset—emerged

as the most critical impediment, consistent with the findings of Zhang et al. (2024) and Billet et al. (2023).

The positive and significant effects of managerial commitment and targeted training programs highlight that leadership and human capital development are essential levers for overcoming resistance and facilitating digital adoption. These findings are consistent with global research (Ghasemian Sahebi et al., 2020; Jaber, 2020), which emphasizes the importance of visionary leadership and continuous learning in driving successful digital transformation.

5.2. Comparison with previous research

The study's findings align with recent Iranian research, such as Noadoust et al. (2024) and Billet et al. (2023), which identified organizational culture and skill gaps as primary obstacles. Similarly, Suresh et al. (2025) reported that over two-thirds of industry experts consider culture and infrastructure compatibility as the top challenges. On a global scale, Rezafar (2022) and Caluri et al. (2019) have also emphasized the centrality of organizational readiness and leadership in successful digital transformation.

However, this study extends the literature by employing a comprehensive mixed-methods approach and advanced statistical modeling, including exploratory factor analysis and structural equation modeling, to quantify the relative impact of each barrier and enabler. The integration of both quantitative and qualitative data provides a nuanced understanding of the interplay among organizational, technological, and managerial factors within the Iranian context.

5.3. Overall conclusions

In conclusion, successful digital transformation in Iranian oil and gas companies requires a holistic and strategic approach that addresses not only technological upgrades but also organizational and human resource development. Overcoming organizational inertia and skill gaps, supported by strong managerial commitment and targeted training, is essential for achieving digital maturity and sustaining a competitive advantage.

5.3.1. Practical implications

- Policymakers and industry leaders should prioritize cultural change initiatives, invest in workforce upskilling, and develop clear digital roadmaps.
- Leadership development programs and incentive structures can accelerate digital adoption and reduce resistance.
- Collaboration with technology providers and academic institutions can help bridge skill gaps and foster innovation.

5.3.2. Limitations and future research

This study was limited to Iranian oil and gas companies. Future research could extend the analysis to other countries or industrial sectors to enable comparative insights. Additionally, longitudinal studies may provide a deeper understanding of the evolution and long-term impacts of digital transformation initiatives.

5.3.3. Final remarks

The findings of this research provide actionable insights for industry practitioners and policymakers seeking to navigate the complexities of digital transformation and enhance the future competitiveness of Iran's oil and gas sector.

6. Recommendations

6.1. Practical recommendations

Based on the findings and analysis of this study, the following practical recommendations are proposed for policymakers, industry leaders, and managers in Iranian oil and gas companies:

1. **Foster a digital culture:**
    - Initiate comprehensive change management programs aimed at reducing resistance to digital transformation.
    - Promote a culture of innovation by rewarding digital initiatives and encouraging risk-taking and experimentation.
2. **Invest in workforce upskilling:**
    - Design and implement targeted training programs focused on digital literacy, data analytics, and emerging technologies relevant to the oil and gas sector.
    - Collaborate with universities and technology institutes to develop tailored educational curricula and certification programs.
3. **Enhance managerial commitment:**
    - Develop leadership programs that equip managers with the skills to champion digital transformation and drive organizational change.
    - Establish clear accountability structures and performance incentives linked to digital transformation objectives.
4. **Upgrade digital infrastructure:**
    - Allocate resources for the modernization of legacy systems and the integration of advanced digital platforms (e.g., Internet of Things, artificial intelligence, cloud computing).
    - Prioritize investments in cybersecurity and data governance frameworks to ensure secure and effective digital operations.
5. **Develop a clear digital roadmap:**
    - Formulate and communicate a strategic digital transformation roadmap aligned with organizational goals and market dynamics.
    - Regularly review and update the roadmap to adapt to technological advancements and changing business environments.
6. **Strengthen collaboration:**
    - Foster partnerships with technology providers, startups, and academic institutions to access new knowledge, tools, and solutions.

- Participate in industry forums and knowledge-sharing platforms to remain abreast of global best practices.

6.2. Recommendations for future research

1. **Comparative studies:**
   - Conduct research comparing digital transformation barriers and enablers in oil and gas sectors of other countries, particularly in the Middle East and developing economies.
2. **Longitudinal analysis:**
   - Undertake longitudinal studies to examine the evolution of digital transformation initiatives and their long-term impacts on organizational performance.
3. **Sectoral expansion:**
   - Explore digital transformation challenges and solutions in related sectors, such as petrochemicals, renewable energy, and utilities, to assess broader applicability.
4. **Role of external factors:**
   - Investigate the influence of external factors, including regulatory frameworks, geopolitical dynamics, and market volatility, on digital transformation processes.
5. **Technology-specific research:**
   - Examine the adoption and impact of specific digital technologies, such as blockchain, artificial intelligence, and digital twins, within the oil and gas industry.
6. **Human factors and change management:**
   - Study the psychological and behavioral aspects of resistance to change and evaluate the effectiveness of various change management interventions.

By implementing these recommendations, Iranian oil and gas companies can accelerate their digital transformation journey, enhance competitiveness, and ensure long-term sustainability. Future research in these areas will further enrich both academic knowledge and practical understanding of digital transformation in the energy sector.

Nomenclature

AI	Artificial intelligence
ANOVA	Analysis of variance
CFI	Comparative fit index
EFA	Exploratory factor analysis
IoT	Internet of things
IT	Information technology
RMSEA	Root mean square error of approximation
SD	Standard deviation
SEM	Structural equation modeling
SPSS	Statistical package for the social sciences (software)
TOE framework	Technology-organization-environment framework

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