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Industry 4.0 Technologies Adoption: The Impact Of Digital Leadership And Organizational Learning On Value-Based Digital Transformation An Applied Study On Egypt's Oil And Gas Sector

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Abstract

Industry 4.0 Technologies and digitalization have irrevocably changed our world business, industry, and society. The oil and gas industry is one of the foremost vital industries that has been affected by the revolution of industry 4.0 but is still in its initiating phase and still faces significant challenges in this digital transformation journey. Despite the potential benefits of digital transformation in manufacturing, there has been a paucity of empirical research examining the impact of digital leadership and organizational learning on digital transformation success. This study is a deductive approach study exploring the lead drivers of value-based digital transformation in Egypt's oil and gas sector. The study investigates the impact of close integration between digital leadership, organizational learning, and industry 4.0 technology components on the organization's digital transformation success. In order to address this issue, a questionnaire survey is conducted for 422 oil and gas experts and leaders. Structural Equation Modeling (SEM) combines multiple regression with Confirmatory Factor Analysis (CFA) to examine the causal relationships between variables using Amos 25 software package. The study's findings reveal that Digital Leadership, Organizational Learning, and Industry 4.0 technology components have a positive impact on Value-based Digital Transformation.

Keywords: Digital transformation; Industry 4.0 technologies; digitalization; Digital Leadership; organizational learning

1. Introduction

Human technology has enabled and promoted a series of disruptive transformations in the form of industrial revolutions. These successive revolutions are called Industry 1.0, Industry 2.0, Industry 3.0, and Industry 4.0. The fourth industrial revolution (Industry 4.0) this term appeared for the first time in 2011 during the famous Hannover Fair, as a kind of project in the high-tech strategy of the German Industry (Devezas et al., 2017).

Industry 4.0 reshaped the competition rules and brought fundamental change to established industries. Digital transformation is no longer a future trend for industry; it is now at the heart of many companies' strategic and research agendas. It is no longer a question of whether digital transformation will affect business and organizations, but how to take advantage of it, create value, and achieve successive transformation through creating significant business value, which is the main issue of this research.

Despite this critical role of digital transformation, and however digital transformation intends to improve efficiency, it has a high failure rate (up to 90%), resulting in an adverse impact on firms' operations and business outcomes (Ramesh, 2019). Ramesh has explored many cases that focus on causes of failure rate when embarking on digital transformation, which differs from one case to another. The leading root causes of these failures are leadership, lack of knowledge, culture, and inaccurate selection of technology tools (Ramesh, 2019; Ustundag & Cevikcan, 2018)

This study emphasizes that the value-based digital transformation should start from transformation before digitalization. Successful digital transformation starts from digital leadership that has a clear digital vision supported by a modern learning organization to achieve a sustainable and agile business model.

This paper sheds light on three main pillars contributing to value-based digital transformation. These three pillars are industry 4.0 technologies, digital leadership, and organizational learning.

The main objectives of the research are:

1) Evaluate the impact of digital leadership on the value-based digital transformation
2) Examine the leadership characteristics that foster the digital leadership
3) Evaluate the impact of organizational learning on the value-based digital transformation
4) Examine the organizational learning practices that foster the organizational learning
5) Evaluate the impact of Industry 4.0 technology on the value-based digital transformation

This study is applied to Egypt's oil and gas sector, which emparked its digital transformation journey from 2014. The oil and gas industry implemented Industry 4.0 technologies to achieve the highest productivity and ensure operation safety and sustainability (Egypt Oil & Gas Research & Analysis, 2021). this study.

2. Literature Review and Hypotheses Development

2.1.Industry 4.0 Characteristics

Industry 4.0 is the term that describes the current movement toward a highly connected and automated system in which human, machines, and resources are integrated into an ecosystem

(Guzmán et al., 2020). While Calış Duman & Akdemir (2021) identified Industry 4.0 as a collective concept that expresses the use of the internet in the industrial sector and the digitalization of production, thus affecting all value chains of businesses. The main characteristic of Industry 4.0 is the linkage of real objects and people with information-processing and virtual objects to establish an intelligent and agile ecosystem through a variety of technological solutions such as industrial automation, computerization, digitization, internet of things, big data, data analytics, artificial intelligence, simulation, embedded systems, cloud systems, additive manufacturing, and virtualization technologies. (Ustundag & Cevikcan, 2018).

2.2.Digital Transformation

Innovation, disruption, transformation, change, agility are words that are reshaping business, influencing thinking, and opening new opportunities. In these times of increasing technological change, companies across various industries have begun to recognize the range of opportunities offered by new digital technologies. The digital transformation opportunity is at the center of business strategies today(Overton et al., 2017).

Through a review of 282 research works, Vial (2019) defined digital transformation as a process that aims to improve an entity by triggering significant changes to its properties through combinations of information, computing, communication, and connectivity technologies

However, being digital-at-the-core by itself is not enough for digital transformation success. A company's success will also depend on its capacity to create societal and economic value. Digital technology offers this potential to create an added value for all stakeholders while making business models more inclusive, sustainable, and trustworthy. This study explores the main pillars that contribute to achieving this digital transformation, which is defined in this paper as Value-Based Digital Transformation

World Economic Forum (2020), in its report "Powering the Great Reset" stated that investing in culture and modern leadership capabilities that effectively interact and execute in ecosystems and deliver a new value will result in a digital, intelligent enterprise that is resilient and adaptive to disruptive change.

2.3.Digital Leadership: Leadership 4.0

New leadership skills are required in the new digital era to achieve value-based digital transformation and avoid failures in this digital transformation journey. Openness may be a strategy key for the leadership in this new era. Critical thinking is required for both the leadership and management of the future (Donald, 2019).

Leadership in the industry 4.0 era is nominated as leadership 4.0 (Guzmán et al., 2020). Leadership 4.0 stands for leadership in the age of industry 4.0. These 4.0 leaders are called digital leaders (Oberer & Erkollar, 2018)

Industry 4.0 needs more than transformational leadership. It also needs a specific focus on technology, learning, social, and innovation. Leadership styles for industry 4.0 should guide a learning and innovation-oriented culture and focus on improving knowledge and out-of-box

thinking(Guzmán et al., 2020). Guzmánet et al. (2020) identify ten essential leadership characteristics for leading in industry 4.0. These characteristics are 1) responsive leadership, 2) swarm leadership, 3) learning and innovation leadership, 4)open leadership, 5) agile leadership, 6) participative leadership, 7) network leadership, 8) trust leadership, 9)digital leadership, and 10) collaborative leadership.

MIT Sloan Management Review and Deloitte have implemented a global survey about leading in the digital era for more than 4,300 executives, managers, and analysts. The findings show that the key traits of effective digital leadership are: providing vision and purpose, empowering people to think differently, creating conditions to experiment, and getting people to collaborate across boundaries (Kane et al., 2018).

Pwc global survey (2020)"Global Digital IQ 2020" has explored the key behaviors and traits that differentiate leaders in this digital era: encouraging idea generation from all staff levels, capturing and acting upon ideas from all staff levels, and facilitating collaboration among departments

Based on literature reviews, one of our study objectives is to examine the impact of digital leadership on Value-Based Digital Transformation. The study consequently hypothesizes that:

H1: Digital Leadership has a positive impact on the Organization's Value-Based Digital Transformation.

2.4.Organizational learning in the digital era

Organizational learning is viewed as a process-based approach that aims to build an agile learning organization that focuses on keeping resources, capabilities, and environment aligned by emphasizing adoption, development, reconfiguration, transformation, and renewal (Ruel et al., 2020).

Organizational learning refers to the organization's learning process and constantly acquiring new knowledge. Organizational learning theories are considered fundamental to successfully building an agile learning organization (Ranta, 2018).

J Daly & Overton (2017) define the new learning organization as "A living and learning organizational ecosystem that intelligently facilitates the performance and learning of its entire population and continuously transforming itself."

Based on the insight of Towards Maturity Study 2017, Overton introduced a New Learning Organization model. This new learning organization model is founded on six characteristics: Clarity of Purpose, Holistic people experience, Thriving ecosystem, Agile, digitally-enabled infrastructure, Continual engagement, and Intelligent decision-making (Jane Daly & Overton, 2017).

Kane et al. (2018) argue that digitally maturing companies are more likely to create an environment that enables learning and innovation through organizational learning. This learning organization can adapt to an ambiguous, rapidly changing, and unexpected environment by investing in experimentation and figuring out what works.

Based on these literature reviews, the second objective of our study is to examine the impact of organizational learning on Value-Based Digital Transformation. The study consequently hypothesizes that:
H2: Organizational Learning has a positive impact on the Organization's Value-Based Digital Transformation.

2.5.Industry 4.0 enabling technologies

German Academy of Science and Engineering (Acatech) has identified different technologies that must be deployed to transform the company into a learning, agile organization and enable rapid decision-making to create value across all business process areas (Schuh et al., 2017).
Industry 4.0 aims for end-to-end digital industrial ecosystem solution that relies on various technologies such as intelligent devices, Internet of Things, cloud computing, and other related industrial information integration technologies (Xu et al., 2018).
Büchi et al.(2020). illuminated how Industry 4.0 provides enabling technologies to help companies achieve more significant opportunities following improved efficiency and increased production capacity.
Industry 4.0 capabilities help oil and gas manufacturing companies dramatically reduce the time between an event occurring and appropriate response and decision-making, which is considered one of the oil and gas industry's prime operational and safety issues.
Digital transformation is accelerated by innovative technologies that fundamentally change the business models and how work is done. This study explores the Industry 4.0 dominant enabling technologies that accelerate the digital transformation journey of the oil and gas industry.
Based on these literature reviews, the third objective of our study is to examine the impact of Industry 4.0 technologies on Value-Based Digital Transformation. The study consequently hypothesizes that:
H3: Industry 4.0 technologies have a positive impact on the Organization's Value-Based Digital Transformation.

3. Research Methodology

This section highlights the research methodology that is used to achieve the aim of this research, which is to examine how much the effect of digital leadership and organizational learning on digital transformation success journey and the impact of Industry 4.0 technologies on the value-based digital transformation of Egypt's oil and gas industry.

3.1.Research Design

Sekaran and Bougie (2016) define research design as a research plan or blueprint created to answer the research questions (Sekaran & Bougie, 2016).
This study follows the deductive approach; in this type of approach, data collection is used to evaluate the research hypotheses developed from previous studies and literature reviews(Saunders et al., 2016).

The researcher examines to what extent digital leadership, organizational learning, and industry4.0 technologies affect the value-based digital transformation. The author follows Sekaran & Bougie (2016)deductive sequential steps: Identify a broad problem area; Define the problem statement; Develop a number of hypotheses; Determine Instruments and measures; Collect and gather data; Analyze data; Interpret data and conclusion.

This quantitative study uses a questionnaire as a data collection technique. The questionnaire is distributed to oil and gas industry experts and leaders in Egypt to examine the relationship between research variables.

The potential respondent participants of the Egyptian oil and gas industry experts are invited to participate in the 7-10-minutes Google form survey via professional social media LinkedIn and direct communication. The total no of participants reached 422 participants.

3.2.Conceptual Framework and Research Hypotheses

Developing the research hypotheses and formulating this research's conceptual framework are based on the previous literature. The research model in this research is supposed as follows

Research Hypotheses

H1: Digital Leadership has a positive impact on the Value-Based Digital Transformation
H2: Organizational Learning has a positive impact on the Value-Based Digital Transformation
H3: Industry 4.0 Technologies has a positive impact on the Value-Based Digital Transformation

Conceptual framework

Through literature review, data analysis, and hypothetical discussion, this study tries to introduce this conceptual framework shown in Fig 3.1

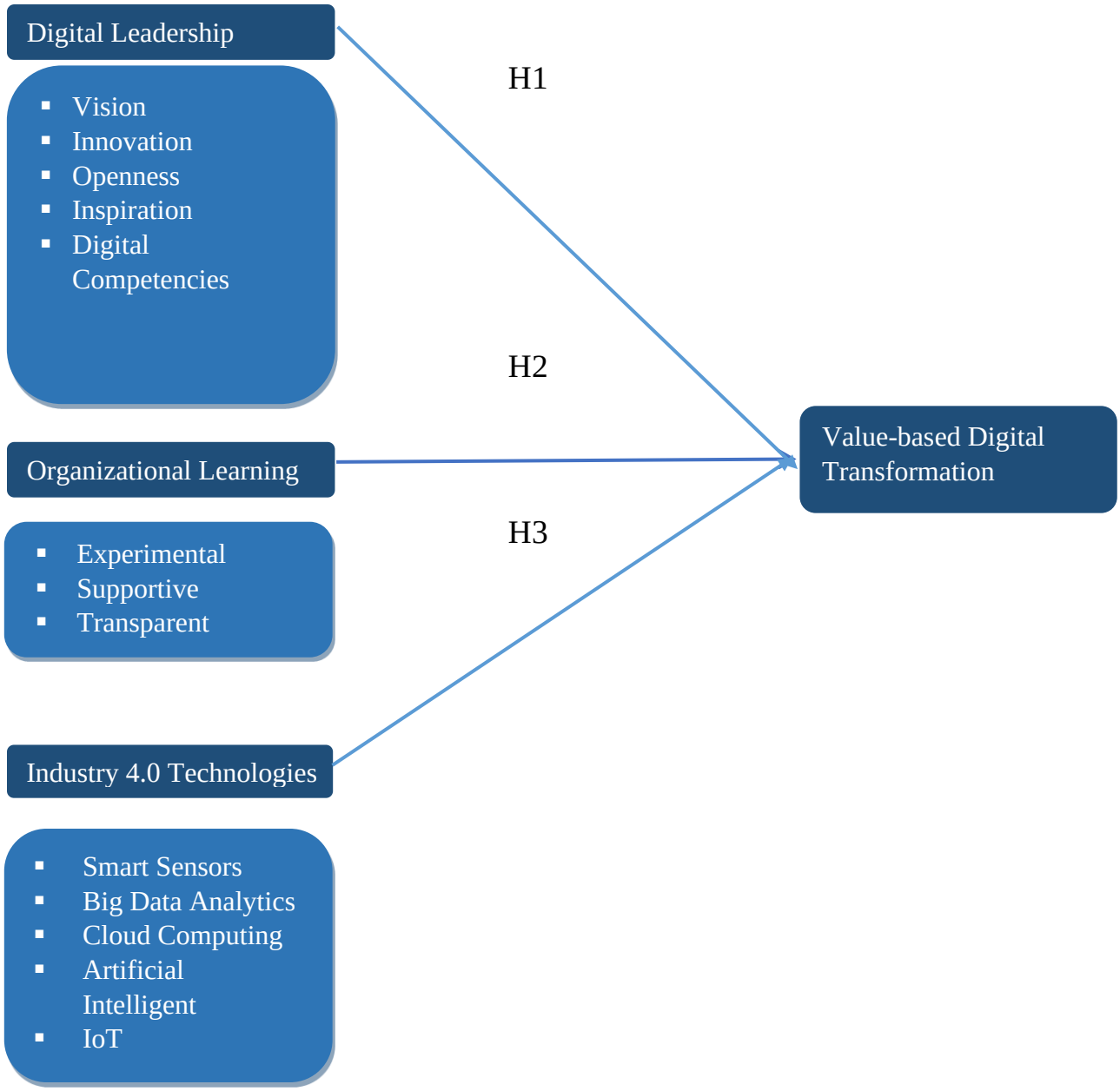


Fig 3.1 Conceptual framework

4. Data Analysis and Research Findings

The Amos 25 software package was used to perform the Structural equation modeling (SEM) that combines multiple regression with Confirmatory Factor Analysis (CFA) to examine the causal relationships between Digital Leadership, Organizational learning, Industry 4.0 technology components, and Value-Based Digital Transformation.

4.1.Measurement Model

Thirty-seven observed Items measure the model's ten latent variables. The level of internal consistency for each construct was acceptable, with the standardized loading ranging from 0.613 to 0.922, exceeding the minimum hurdle of 0.50 at the alpha level of 0.05.
Composite reliability (CR) is used to measure overall reliability and the reliability of a construct in the measurement model (Hair et al., 2019). The CR of Vision = 0.878, Innovation =0.918, Openness =0.929, Inspiration =0.938, Digital Competencies =0.879, Experimental Environment =0.767, Supportive =0.824, Transparent =0.874, Industry 4.0 technology =0.889 and Value-based DT level =0.854). So, it clearly identified that in measurement model all constructs have good reliability.

Measurement Model Fit

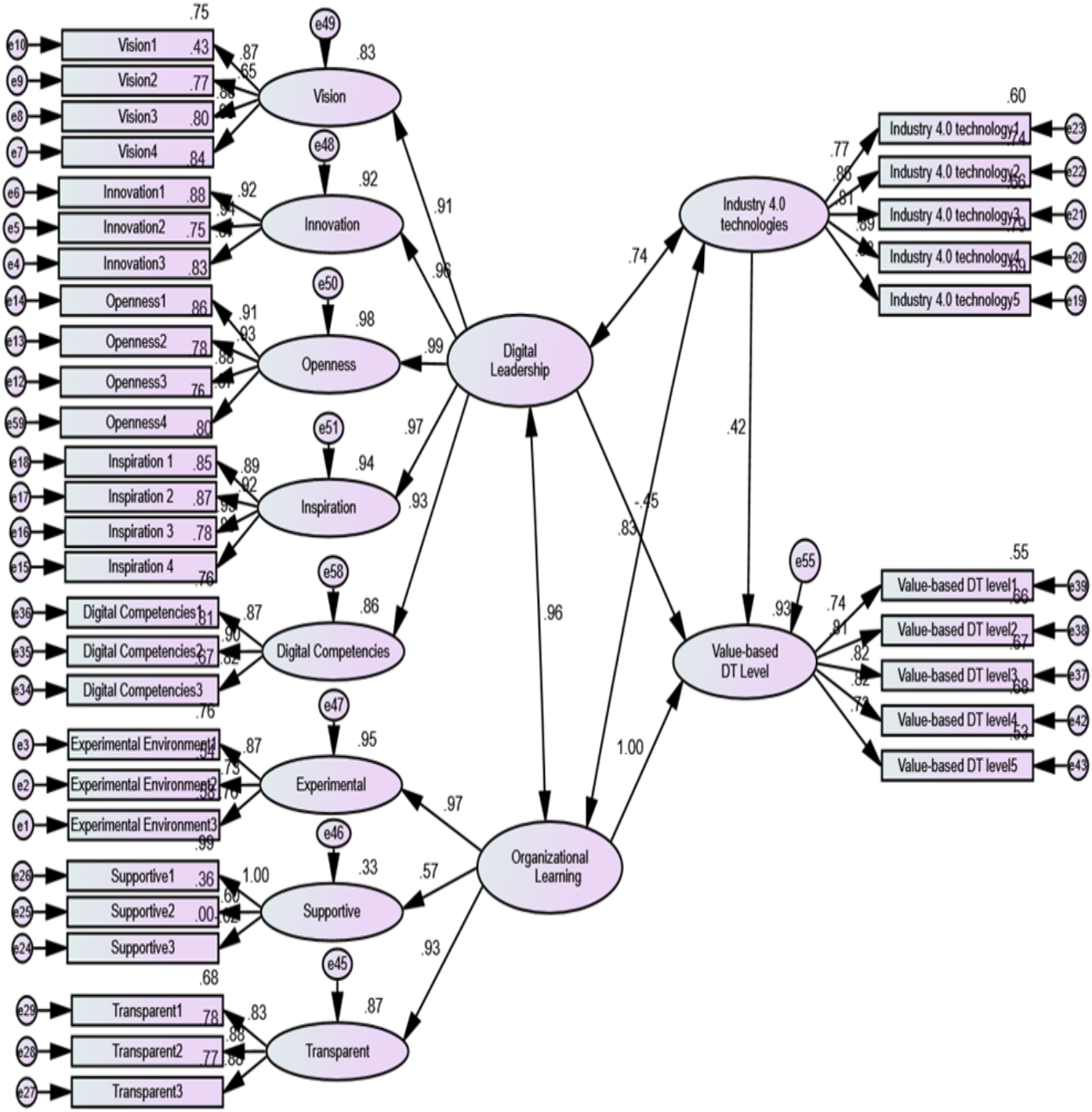
The model fit indices like the comparative fit index (CFI), Tucker Lewis index (TLI), Degrees of Freedom (DF), Chi-Square/ Degrees of Freedom ($\square^2$/DF), Chi-Square ($\square^2$), and Root Mean Square of Error Approximation (RMSEA) were chosen to evaluate the model fit (Thakkar 2020). Table 4.1 indicates that the measurement models provide good support for the factor structure determined through the CFA.

Table 4.1: Goodness of Fit (GOF) Measures

Goodness of Fit Measures	**Name of index**	**Level of acceptance** Hair et al. (2019)	**Model Result**	**Remark**
Chi-Square	$\square^2$	> 0.05	1124.321	accepted
Degrees of Freedom	DF	≥ 0	585	accepted
Chi-Square/ Degrees of Freedom	$\square^2$/DF	≤ 3	1.922	accepted
Comparative Fit Index	CFI	≥ .90	.956	accepted
Tucker Lewis Index	TLI	≥ .90	.950	accepted
Root Mean Square Error of Approximation	RMSEA	<.08	.047	accepted

4.2. Structural' model

SEM model evaluates the relationship between Industry 4.0 technology, Digital Leadership, Organizational learning, and their sub dimensions with Value-Based Digital Transformation. Fig



4.1 indicates Structure Model diagram.

The Structural Model Validity

The structural model results using the AMOS software show that DF was 620 (it should be more than 0), $\square^2$/DF has a value of 2.667, which is less than 3.0 (it should be less than or equal to 3.0). The RMSEA was .063 (it should be less than 0.08). The TLI index was .915, which is close to 1.0 (a value of 1.0 indicates perfect fit). The CFI was .921. All indices are close to a value of 1.0 in the structural model, indicating that the structural model provides good support for the factor structure determined through the structural model.

The individual tests of significance of the relationship between the variables. It reveals that, as expected a positive relation between Digital Leadership and Value-based DT Level (β =.449, CR (Critical Ratio) = 1.978, CR > 1.96, p = 0.048, p<0.05). (Innovation Beta (β) Value= .958, Vision Beta (β) Value= .914, Inspiration Beta (β) Value= .968, Digital Competencies Beta (β) Value= .926, Openness Beta (β) Value= .988)

Therefore: H1: (Digital Leadership has a positive impact on Value-based DT Level.) is supported. Moreover, pertaining to H2: Organizational Learning has a positive effect on Value-based DT Level is supported as the result shows that (β = .998, CR (Critical Ratio) = 3.425, CR > 1.96, p = 0.000, p<0.05) (Experimental Beta (β) Value= .975, Supportive Beta (β) Value= .571, Transparent Beta (β) Value= .930)

The result shows that H3: Industry 4.0 Technologies have a positive effect on Value-based DT Level is supported (β =.418, CR (Critical Ratio) = 4.661, CR > 1.96, p = 0.000, p<0.05).

Table (4.2) provides a Hypothesized path of the final structural equation model

Table 4.2: The hypothesized path of the final structural equation model

Hypothesized path			Beta (β) Value	Critical Ratio (CR.)	P-Value
Value-based DT Level	<---	Digital Leadership	.449	1.978	.048
Value-based DT Level	<---	Organizational Learning	.998	3.425	. ***
Value-based DT Level	<---	Industry 4 technologies	.418	4.661	***

Table 4.3: The hypothesized path of Variables

Hypothesized path			Beta (β) Value
Innovation	<---	Digital Leadership	.958
Openness	<---	Digital Leadership	.988
Inspiration	<---	Digital Leadership	.968
Vision	<---	Digital Leadership	.914
Digital Competencies	<---	Digital Leadership	.926
Experimental	<---	Organizational Learning	.975
Supportive	<---	Organizational Learning	.571

Transparent	<---	Organizational Learning	.930

Squared Multiple Correlations (R^2)= 0.929, which means that the estimated structural model corroborated the three hypotheses, as Digital Leadership, Organizational Learning and Industry 4 technologies constructs explained 92.9 % of Value-based DT Level variance

5. Research Conclusions and Recommendations

5.1.Research Conclusions

This research aims to fill the gap of the high failure rate of digital transformation theoretically and practically. The study formulated a value-added digital transformation model based on digital leadership, organizational learning, and industry 4.0 technologies.

The research highlighted the essential digital leadership characteristics to manage and direct this digital transformation process. These leadership characteristics are Vision, Innovation, Openness, Inspiration, and Digital Competencies

The research recommends five technologies that significantly affect the oil and gas industry. These technologies are intelligent measurement and sensors, Big Data Analytics, Cloud Computing technology, Artificial intelligence (AI) approaches and machine learning, and Internet of Things (IoT) technology.

Furthermore, the study emphasizes that the supportive, Experimental, and Transparent learning organization accelerates the transformation process.

5.2.Research Contribution and Originality

Academic Contribution:

Despite the importance of the economic impact of the oil and gas industry, there is a scarcity of academic research about digital transformation in the oil and gas industry.

This study enriches academia with a new structural model representing the main pillars of digital transformation success. This model formulates an overall perspective that integrates human, organization, and technology by evaluating the impact of close integration between digital leadership, organizational learning, and Industry 4.0 technologies, which are considered in this study as the main pillars of the organization's digital transformation success. This model explains 92.9 % of the digital transformation success ($R^2 = 0.929$).

Practical Contribution:

The main practical contribution of this study is identifying the main pillars that contribute together to ensure the digital transformation success in the oil and gas industry. These pillars successfully implement industry 4.0 technologies in Egypt's oil and gas sector to achieve value-added digital transformation.

This research has contributed practically to exploring the main digital leadership characteristics and organizational learning practices that support the organization and facilitate the digital transformation process, especially in the oil and gas industry. Furthermore, this study contributes to Egypt's oil and gas industry by highlighting the industry 4.0 technologies that accelerate the digital transformation.

5.3.Research Recommendations

The first recommendation: The organization should initiate its digital transformation journey from leadership. Leadership in this digital era requires specific characteristics. The research highlights five leadership characteristics that formulate digital leadership.
The second recommendation: The organization should invest in cultural transition by transitioning to a new learning organization that supports the digital transformation process and facilitates it.
The third recommendation: The oil and gas organizations should invest in Industry 4.0 technologies which have a significant impact on oil and gas organization performance and ensure the value-added from digital transformation such as reduced costs, minimized waste, maximum efficiency, high speed, and enhanced quality.

5.4.Research Limitations and Suggestions for Future Research

Industry 4.0 and digital transformation should not be missed in this digital revolution. More research is needed to fill the gap of the industry 4.0 revolution and enrich the literature to support the industry in its digital transformation journey.
This study has certain limitations. The first limitation is that the study is applied to Egypt's oil and gas industry, and our sample was limited to participants from Egypt's oil and gas sector. The perceptions might vary significantly between different countries and diverse cultures.
Future researches may consider this limitation and examine the model in a global context to enhance generalizability. Further research can be encouraged to cover digital transformation challenges in other industries in Egypt.
Another limitation is that the research hypothetically examined only three critical factors that significantly affect digital transformation success. Further research is recommended to incorporate additional variables into this research model to generate deeper insights. Furthermore, future research may examine other moderating variables' effects to enrich the model.
Future studies may focus on organizations via investigating corporates in case study analysis. This approach may provide a deeper understanding of how an organization can manage the challenges of digital transformation and achieve a successful transition to industry 4.0.

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