

Integrating Digital Transformation and Risk Management: Leading Models from Saudi Arabia's Energy, Industrial, and Telecommunications Sectors

Nabila Makhoulouf

University of Mohamed Khider Biskra, Algeria

Email: nabila.makhoulouf@univ-biskra.dz

ORCID: <https://orcid.org/0009-0000-5298-5348>

Hanane Maalla

University of Martyr Hamma Lakhdar, El Oued, Algeria

Email: maalla-hanane@univ-eloued.dz

ORCID: <https://orcid.org/0009-0008-4759-4367>

Youssera Djehiche

University of Algiers 3, Algeria

Email: djehiche.youssera@univ-alger3.dz

ORCID: <https://orcid.org/0009-0005-0518-4384>

Abstract

This study investigates how the integration of digital transformation strengthens risk management capabilities in three leading Saudi companies—Saudi Aramco, Saudi Basic Industries Corporation (SABIC), and stc Group—representing the energy, industrial, and telecommunications sectors, respectively. The study employs a descriptive-analytical methodology combined with a comparative multiple-case study design to examine how these organizations deploy digital technologies in identifying, assessing, monitoring, and mitigating sector-specific risks. The findings indicate that all three companies are moving from predominantly reactive risk-control practices toward proactive and predictive risk management models supported by artificial intelligence, advanced analytics, automation, and real-time data systems. However, the effectiveness of digital transformation is determined less by the scale or technological sophistication of individual solutions than by their strategic alignment with the nature, severity, and operational characteristics of the risks encountered in each sector. The comparative analysis further demonstrates that high-quality, integrated, and timely data constitute the fundamental infrastructure of predictive risk management. The study contributes to the literature by presenting a sector-sensitive framework for understanding the relationship between digital transformation and organizational risk management in the Saudi context. It recommends that organizations prioritize digital investments according to their most critical vulnerabilities, strengthen data governance and quality assurance, and integrate technological capabilities with organizational strategy, human expertise, and risk-governance structures.

Keywords: digital transformation; risk management; artificial intelligence; predictive analytics; data governance; Saudi Arabia.

JEL Classification: G32; L71; L86; M15; O33.

Introduction:

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Today, digital transformation has become a cornerstone for enhancing competitiveness and ensuring business sustainability, particularly in light of the rapid technological advancements occurring worldwide. The integration of modern technologies, such as artificial intelligence, automation, and advanced analytics, has evolved beyond merely improving operational efficiency; it now serves as a critical driver reshaping the entire concept of risk management.

Companies have shifted from adopting a reactive, wait-and-see approach to crises toward implementing proactive and predictive intervention strategies. This transition has enabled companies to develop advanced capabilities that allow them to identify potential risks and analyze them in unprecedented depth, thereby strengthening business continuity in an increasingly dynamic environment.

Problem Statement:

In light of the preceding discussion, the central research problem can be formulated as follows:

How has the integration of digital transformation contributed to the development of risk management methodologies in major companies in the Kingdom of Saudi Arabia (SABIC, Aramco, etc)?

For the purpose of understanding and addressing this problem, the following sub-questions were formulated:

1. What are the common strategic objectives that large companies aim to achieve the integrating of digital transformation and risk management?
2. How do the digital tools and technologies used in each company (such as AI and automation) differ according to the nature and types of risks they face?

Study hypotheses:

1. The common goal of the integration process is to shift from reactive management to a proactive, prediction-based approach.
2. The different types of risks faced by each sector lead to variations in the choice of digital technologies used in risk management.

Study objectives:

- Identify the basic concepts related to digital transformation and risk management;
- Determine the common and distinct strategic objectives associated with predictive transformation in the companies under study;
- Analyze the relationship between the types of risks faced by each sector and the digital technologies most effective in addressing them;
- Provide practical recommendations for companies seeking to develop digital risk management strategies.

Importance of the study:

The significance of this study lies in providing practical and clear indicators for decision-makers and risk managers across various regarding best practices for aligning appropriate digital technologies with specific types of risks. Such analysis enhances the practical understanding of how to develop robust, proactive risk-prediction strategies rather than merely reacting to emerging threats. Ultimately, this contributes to ensuring business continuity and strengthening the competitiveness of companies in an increasingly dynamic and rapidly evolving global environment.

Study methodology:

This study adopts a descriptive- analytical approach in its theoretical component, aiming to describe and analyze the concepts of digital transformation and risk management. In the practical component, a comparative case study approach is employed, examining the experiences of three major companies in the Kingdom of Saudi Arabia -SABIC, Aramco and etc- responding different sectors during the year 2024. These cases are then compared to identify common patterns and key differences in the strategies used to align digital technologies with specific types of risks faced by each company.

Theoretical Framework of the Study

Digital Transformation:**Definition of Digital Transformation:**

Digital transformation is defined as: the use of all available digital technologies to improve business performance and contribute to raising the overall standard of living..(afif & khaloufi, 2022, p. 278)

It is also defined as: The process of transitioning organizations from a traditional business model to another model that relies on digital technologies for innovation in products and services, as well as management and marketing methods, while providing new channels for revenue through the development of a digital strategy. This can only happen through an assessment of digital capabilities and a study of digital investment requirements in light of digital marketing activities and a willingness on the part of management to embrace digital transformation.(ben said, 2022, p. 316)

Digital Transformation Goals: The goals of digital transformation are as follows: (bourahla, saihi, & elhamza, 2023, pp. 20-21)

- Providing a vast amount of information on digital media;
- Facilitating the process of searching digital collections and retrieving information through various means and methods;
- Providing information services using new technologies;
- Preserving original information sources from damage;
- Making information available to the largest number of users and customers through digital platforms;
- Streamlining administrative procedures, which means reducing paperwork and eliminating the need to copy paper documents if they are available electronically;
- Increasing productivity and reducing performance costs by using technology based on information networks.

Digital Transformation Requirements: Digital transformation is implemented across a spectrum that includes technologies, data, human resources, and processes, as detailed below: (Chaouchi & khelouf, 2023, pp. 19-20)

- **Technologies:** Digital transformation is achieved using a system of devices, data, storage, and software that operate within technical environments and information centers that allow all assets to be used with uninterrupted operational efficiency. It also requires ensuring an appropriate level of service for the organization's employees, customers, and suppliers through teams responsible for managing the technical system and network infrastructure.
- **Data:** Business organizations are expected to manage and analyze data regularly and effectively. This is to provide reliable and complete data while providing and developing appropriate tools for statistical analysis and data mining to predict the future. Data must also be monitored continuously to ensure its continuous flow and utilization in line with the organization's goals and expectations.
- **Human Resources:** Human resources are a vital aspect without which it is difficult for organizations to implement digital transformation. Qualified personnel capable of using technology and analyzing data effectively must be provided. Vision planning and implementation require human competencies and scientific and practical expertise, as well as a belief in development.
- **Processes:** Business organizations must establish an effective technical structure that allows for the integration and development of internal and external performance. This is to ensure the optimal implementation of digital transformation, which includes creating a technical structure that includes policies and procedures covering all of the organization's activities and processes, interconnected with the necessary technologies, developed applications, and processed data.

Risk Management

Risk management is defined as: "A core component of governance and a principal control function, which is fundamental to establishing policy and strategy. It enables organizations to set

objectives, effectively assess and identify both opportunities and risks, and ultimately ensure the achievement of their overall goals." (Biresaw & Sibindi, 2025, p. 58)

It is also defined as: "the measures that companies systematically implement to address the risks associated with their activities, with the aim of achieving sustainable benefits from each activity and from their portfolio of activities." (Belkacem elayachi, 2016, p. 12)

It is also defined as: "The management of predictable events that could result in potential losses at the corporate level if not handled appropriately." (bakouche & boughazi, 2022, p. 151)

Benefits of Risk Management:

The benefits of risk management are achieved provided that there is an effective approach to planning and implementation in accordance with a specific corporate culture, and that it includes: (Laroissi graine, 2021, pp. 66-67)

- Awareness of high-level risks, helping with effective resource planning.
- An effective action plan for high-level risks.
- Appreciation of responsibility and accountability.
- Assistance in achieving strategy and business planning.
- Enhanced focus on internal review, needs assessment, and planning.
- Early problem solving, which reduces the cost of dealing with risks.
- Preparation of contingency plans.
- Avoidance of missed deadlines and improved predictability.
- Reduce costs resulting from disruptive events and prevent budget overruns.
- Protect senior management and board members from legal liability.
- Maintain continuous operation with regulated licenses.
- Avoid corporate fines for non-compliance with regulations and legislation.
- Improve shareholder value and confidence in projects, given the repercussions in times of crisis.
- Reduce operating costs by minimizing losses and improving the efficiency of operational processes.
- More reliable forecasting of specific business plans, based on more accurate risk management information.
- Improved business performance as a result of measures taken by acting on recommendations and adjustments.
- Competitive advantage through improved and supported decision-making based on more accurate risk management information.

Risk Management Steps:

This process is essential to enhance the company's ability to face its risks and involves the following steps: (Bouzerouata & Hammadi, 2024, p. 208)

- **Setting Objectives:** This is the first objective and requires ensuring that the organization's goals are achieved and that all its activities are safe in order to ensure its survival and continuity and avoid heavy losses.
- **Risk Detection:** This is done by analyzing and studying all the organization's activities, from production and storage to purchasing, sales, financing, and others, to detect the risks that the organization will face, whether they are insurable or not.
- **Risk Assessment:** Once the risk has been identified, it is assessed by measuring the potential loss and the probability of its occurrence, using several models such as the risk and opportunity model and the general analysis model.
- **Identifying Alternatives:** Selecting the appropriate means and strategy to address all identified risks. This step is part of the decision-making process regarding the selection of the best means.
- **Implementing The Decision:** Implementation is carried out either by selecting prevention and protection measures, designing programs for them, and implementing them, or by selecting a means of transferring the risk through negotiation with insurance companies.

- **Evaluation and review:** Reviewing the risk management plan to identify and correct deviations.

Integrating Digital Transformation And Risk Management: Case Studies Of SABIC, Aramco, And Stc Group

The importance of this part of the study lies in the transition from the theoretical framework to concrete practical reality, as we seek to explore how these giant economic entities have translated these concepts into concrete actions. Our study focuses on three leading models in the Saudi economy, representing vital and diverse sectors: the industrial sector (SABIC), the energy sector (Aramco), and the telecommunications and digital services sector (stc).

First: Integrating Digital Transformation with Risk Management At SABIC

1. Risk Management Framework At SABIC

1.1. Risk Management Governance.

The Enterprise Risk Management and Governance team plays a pivotal role in implementing a comprehensive approach to risk management and business continuity. This includes monitoring and identifying risks, collaborating with relevant parties, and preparing and enhancing resilience to proactively assess and mitigate potential risks or minimize their impact should they occur. Our focus is on ensuring the resilience and preparedness of critical infrastructure to guarantee continuity in the provision of essential products and services. SABIC seeks to achieve its strategic objectives of maximizing shareholder value by addressing a range of calculated risks within the framework of the company's comprehensive risk management. The Enterprise Risk Management department provides leadership in delivering early warnings of potential and emerging risks from internal or external events that could impact the company's strategic objectives. SABIC follows a well-established risk management environment supported by an integrated governance system. SABIC's risk management process, which is based on international best practices (such as ISO and COSO standards), and others, aims to identify, understand, and manage threats to the company while capitalizing on opportunities to achieve strategic objectives. This process also helps set risk limits and controls, determine monitoring and reporting frequencies, and enable business units and central departments to achieve their objectives. (Consolidated Annual Report for 2024, 2024, p. 43)

1.2. Risk Management Procedures: Key risk management procedures include the following: (Consolidated Annual Report for 2024, 2024)

- Framework and ongoing review
 - o Scope, context, and criteria: This is the starting point for defining the framework within which risk management will take place.
 - o Monitoring and review: This is an ongoing process that is performed periodically to track and evaluate the effectiveness of the risk management measures that are in place.
 - o Communication and consultation: An ongoing process of sharing information and advice about risks with internal and external stakeholders.
- Periodic assessment: This periodic process consists of the following steps:
 - o Identification: Recognizing and documenting potential risks.
 - o Analysis: Understanding the nature of the risks, identifying their sources, likelihood of occurrence, and potential impact.
 - o Evaluation: Compare the level of analyzed risks with defined criteria to make decisions about the need to address them.
- Treatment and Documentation
 - o Risk Response: Take appropriate actions and measures to address risks (e.g., avoid, reduce, transfer, or accept risks).
 - o Recording and reporting: Documenting the risk management process and its results, and communicating them to the relevant parties.

1.3. Risk Categories

SABIC classifies the risks it faces into four main categories to ensure comprehensive coverage of all aspects that may affect its performance:

The main risk categories faced by SABIC can be summarized in the following table:

Table No (01): Risk Categories at SABIC

Strategic risks	Operational risks	Financial risks	Compliance risks
These risks relate to the long-term competitive and geopolitical environment and include: • Highly competitive industrial sectors. • The cyclical nature of the petrochemical sector and market conditions. • Climate change. • Rapidly changing regulations related to sustainability, environmental and social practices, and corporate governance. • Digital transformation and artificial intelligence.	These risks are centered around the efficiency of daily operations and company resources, most notably: • Talent and competency management. • Disruption of supply chain services. • Geopolitical instability and the spread of epidemics. • Use of information technology. • Measures inherent in the safety of work procedures. • Projects under development.	These risks include the direct financial aspects of the company's business, the most important of which are: • The creditworthiness of customers. • Currency exchange rates. • Insurance policies.	These risks relate to the legal and regulatory environment in which SABIC operates and include: • Intellectual property and technology licenses. • Disputes, lawsuits, or both. • International trade regulations. • Use and handling of SABIC materials and products. • Regional chemical regulations.

Source: Prepared by researchers based on (Consolidated Annual Report for 2024, 2024, p. 45)

2. Digital transformation technologies and their contribution to risk management at SABIC

SABIC is pursuing an ambitious digital transformation strategy with the aim of leveraging the power of digital technologies to unlock new value, accelerate growth, and improve customer experience and business outcomes. The rapid evolution of digital technologies is significantly shaping the global petrochemical industry, challenging traditional business models and creating new opportunities and risks. In response, SABIC is seeking to harness the potential of these technologies to improve business processes and value chain efficiency, drive innovation, and open up new avenues for growth and value creation.(Consolidated Annual Report for 2024, 2024, p. 91)

Digital Transformation Strategy Pillars:

SABIC's digital transformation strategy prioritizes the digitization of core processes. Its current areas of focus include: (Consolidated Annual Report for 2024, 2024, p. 91)

- Identify and implement innovative digital solutions to streamline operational processes and create new sources of revenue.
- Develop analytical capabilities at SABIC, increase computing power, and develop artificial intelligence solutions.

- Equip our employees with the digital skills needed to succeed in the evolving digital age by encouraging and promoting the adoption of new digital solutions and increasing awareness and knowledge of data analytics and artificial intelligence.
- Strengthen integration and collaboration with relevant internal and external parties, including Saudi Aramco, academic institutions, and government entities, to drive digital innovation.
- Strengthen the company's data foundations and improve governance and guidelines for data and artificial intelligence.
- Enhance the capabilities of the enterprise resource planning system through digital transformation.

Digital Operations Platform (STAR Program):

The Digital Operations Platform is one of the key pillars of this transformation and has been developed through the Transformation and Renewal (STAR) program, which forms the cornerstone for future business processes, applications, and systems. As the next generation of ERP, STAR will replace the current ERP system and bring about a significant transformation in the way SABIC operates. (Consolidated Annual Report for 2024, 2024, p. 92)

Role in Risk Management:

Through the STAR program, SABIC connects people, devices, and business networks around the world, ensuring the flow of information and reducing operational risks resulting from fragmented systems.

It contributes to financial and compliance risk management by enhancing the capabilities of the comprehensive resource planning system and improving the enhanced financial record.

Key digital achievements for 2024 and contribution to risk management:

SABIC's digital transformation efforts are closely monitored by multiple executive departments led by the CEO, and the program's achievements are measured across multiple metrics, including value generated, adoption and usage of digital solutions, and digital improvement and maturity benchmarks. The most notable achievements of 2024 were as follows: (Consolidated Annual Report for 2024, 2024, p. 92)

- Develop and deploy several key digital solutions across various business segments (SABIC) to address work process issues and performance reliability issues in factories.
- Conduct a comprehensive assessment to advance the company's journey toward digital maturity.
- Improve our digital ecosystem by prioritizing value-based digital initiatives and aligning them with business objectives.
- Establish a culture of digital innovation by offering specialized data science programs and intensive training sessions.

SABIC is also leveraging the power of artificial intelligence and new industrial technologies to drive improvements that serve risk management. Examples include:

- **Enhancing asset reliability through an AI-powered asset care solution:** An AI-powered monitoring system is currently in use at all SABIC plants worldwide, predicting potential failures of critical equipment and enabling technicians to perform proactive maintenance. This system is expected to reduce material losses over the life cycle of assets.

✚ Contribution to risk management:

- Reduces operational risks related to equipment failure and unplanned downtime.
- Limits financial risks resulting from physical losses and emergency maintenance costs.
- **Extending asset life and enhancing safety:** Through advanced inspection techniques, such as robots and drones, SABIC now identifies ongoing issues and conducts inspections on tanks and flare tips, extending asset life and reducing exposure to critical safety conditions.

✚ Contribution to risk management:

- o Reduces operational risks related to worker safety by avoiding exposure to critical safety conditions.
- o Mitigates financial risks by extending asset life and reducing the need for early replacement.
- **Improving overall plant performance:** SABIC integrates data on raw material quality, work procedure standards, and environmental conditions into digital predictive tools to determine optimal production settings, maximize yield, and extend equipment operating life.

✚ **Contribution to risk management:**

- o Reduces operational risks associated with raw material waste and suboptimal production.
- o Ensures optimal operational continuity and extends equipment operating life, mitigating long-term operational and financial risks.

Second: Integrating Digital Transformation with Risk Management at Aramco

1. Risk Management Framework at Aramco

1.1. Risk Management Objectives

Saudi Aramco operates in an industry characterized by market volatility, hazardous operations, and projects with uncertain outcomes. Taking calculated risks is a key and necessary part of Saudi Aramco's business. Saudi Aramco manages its strategic, operational, financial, and compliance risks through continuous assessment and appropriate response, and makes business decisions after thoroughly weighing the associated gains and risks. (Annual Report for 2024, 2024, p. 70)

1.2. Risk Management Governance

The Board of Directors is responsible for overseeing risk management as part of its leadership of strategic risk, and the Sustainability, Risk Management, Health and Safety Committee and the Audit Committee of the Board of Directors are responsible for overseeing the risk management framework and monitoring specific risks.

The primary role of the Sustainability, Risk Management, Health and Safety Committee is to collaborate with the company's overall risk management and assist the Board of Directors in the following: (Annual Report for 2024, 2024, p. 70)

- Leadership, guidance, and oversight responsibility related to the company's risk appetite, risk tolerance, risk framework, and risk strategy.
- Governing strategic and operational risk management, sustainability risk, and environmental, social, and governance issues.
- Instilling a culture within the company that emphasizes the benefits of risk management and highlights its advantages.

Saudi Aramco's enterprise risk management framework consists of a set of policies, procedures, systems, and organizational structure for comprehensive risk management, following a three-line model: operational business segments and support departments constitute the first line, and because these sectors and departments are the owners of the risks, they bear the primary responsibility for identifying and managing their risks. The second line includes specialized risk management departments and divisions that are responsible for monitoring and reporting on risks and providing guidance to risk owners. These departments and divisions include loss prevention and environmental protection, information security, emergency management and business continuity, compliance management, financial risk management departments, and the enterprise risk management group. The Internal Audit Department represents the third line of defense and is responsible for providing independent assurance to company management and the Audit Committee on the effectiveness of internal control systems.

1.3. Risk Categories:

The main risk categories for Saudi Aramco can be summarized in the following table:

Table No (02): Risk Categories at Aramco

Risks related to Saudi Aramco's business and activities	Risks related to legal and regulatory aspects	Risks related to the Kingdom
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• Supply and demand for crude oil. • Climate change. • Economic or political developments in Asia. • Competition risks. • Implementation of current and future projects. • Inadequate insurance. • Acts of terrorism and armed conflicts. • Hydrocarbon reserves. • Environment and resources. • Disclosure of acquisitions and integrations. • Saudi Aramco's dependence on certain countries. • Senior management and key personnel. • Reliance on information technology systems.	• Lawsuits and legal proceedings. • Regulatory changes. • Sanctions and trade restrictions. • Government licenses and permits. • Environmental regulations. • Parity pricing mechanism.	• Government guidance on maximum sustainable production capacity. • Domestic demand for gas. • Hydrocarbon sector. • Political and social instability. • Saudi riyal pegged to the US dollar. • Government projects.
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Source: Prepared by researchers based on (Annual Report for 2024, 2024, p. 71)

2. Digital transformation technologies and their contribution to risk management at Aramco:

Aramco is adopting a range of new technologies, including: (Digital technologies, 2024)

• **Artificial intelligence (AI):** A broad term describing the use of computers, robots, and other digital devices to perform tasks that previously required human intelligence. One common form of AI is the use of intelligent algorithms to analyze operational data, extract insights, and then apply automatic improvements to processes to increase efficiency.

✚ **Contribution to risk management:** Aramco has developed an in-house safety product called i4Safety 2.0, which uses artificial intelligence technology to predict risks and accidents. This product uses historical data to predict potential risks and accidents in the workplace, enabling the company to improve safety and efficiency in its operations.

• **Supercomputing and quantum computing:** The high-speed Dammam-7 supercomputer at Saudi Aramco's Exploration & Production Computing Center is now entering a new phase of development as a host for a quantum computing simulator, as part of an ambitious collaborative project with NVIDIA. In January 2021, Saudi Aramco launched its supercomputer, Dammam-7, which is used to support the company's seismic imaging activities. It was soon joined by a second supercomputer, Al-Ghawar-1, which began its first uses in reservoir simulation during the first half of 2022. Dammam-7, the more powerful of the two, was one of the 10 most powerful computers in the world at the time of its launch. This phase came after years of serving to support the company's exploration efforts and operational improvements.

✚ **Contribution to risk management:** Quantum computing has promising potential to bring about sweeping changes in the way advanced computers tackle the most complex problems facing various industries, including the energy industry. Exploration for new reserves requires sophisticated computational methods, enabling geoscientists to process vast amounts of seismic survey data measured in petabytes to produce accurate images of the subsurface, reducing the risk of exploration inaccuracy. Although quantum computers are still in the early stages of

commercialization, the rapid pace of development in 2025 was remarkable. Quantum simulators are among the most notable innovations in this field, enabling the creation of virtual models of quantum algorithms and computers, which can be run and tested on traditional supercomputers such as Dammam-7. Saudi Aramco worked closely with NVIDIA to increase the speed of DMM7, then created and tested one of the largest quantum computing simulators in the region, the DMM7Q quantum processing system. (DMM7Q). Completed in 2025, this project marks the beginning of a strategic collaboration between Saudi Aramco and NVIDIA to explore the potential of hybrid supercomputers. The collaboration involved using NVIDIA's CUDA-Q platform on the DMM7Q to detect seismic faults for 3D seismic surveys. The team also explored the use of the Hadamard quantum algorithm for edge detection to clarify fine details in seismic images of the subsurface.

- **Blockchain:** A digital ledger for recording information that makes it difficult or impossible to hack or alter. Blockchain can be used to settle smart contracts, which are secure, self-executing digital contracts that allow a complete agreement or parts of it to be executed with a supplier once specific conditions are met.

- ✚ **Contribution to risk management:** Blockchain also provides a secure way to store records and exchange documents. The company has also developed blockchain technologies in oil fields and refineries in an effort to improve performance and settle contracts with its service providers, reducing the legal and financial risks associated with contracts.

- **Digital Twin Technology:** A virtual model of integrated digital solutions designed to represent physical assets in real time, whether they are materials, systems, or processes.

- ✚ **Contribution to risk management:** Digital twin technology enables the company to convert many manufacturing processes to a digital system, including project engineering design, construction implementation planning, supply chain, material handling, facility operations and maintenance. The company has used digital twin technology in the Al-Hassaba field and is working to expand its use, enabling the monitoring and prediction of potential operational risks in assets before they occur.

- **Automating operational processes using robots (RPA):** These are software robots developed to automate tasks and functions performed by humans.

- ✚ **Contribution to risk management:** They offer many benefits, including an improved customer experience, service quality, team productivity, efficiency, and cost reduction. Aramco is conducting preliminary research to explore the potential of this technology to automate a significant number of working hours, giving its employees space to perform more important and enjoyable tasks, thereby reducing the risk of human error in routine tasks.

- **Cloud Services:** Provides an inexpensive, scalable, and flexible digital platform to host and run Fourth Industrial Revolution technologies, including artificial intelligence, analytics and big data tools, and the Internet of Things in the industrial sector.

- ✚ **Contribution to risk management:** The use of cloud services can significantly reduce a company's capital expenditure on computers and equipment, while making digital storage, maintenance, and cybersecurity solutions more cost-effective. Through this technology, the company seeks to improve supply chain operations and convert documents into cloud data by creating an electronic marketplace (e-Market Place), which will contribute to providing important digital capabilities for supply chains in the Kingdom.

- **Internet of Things (IoT) and Industrial Internet of Things (IIoT):** These are systems consisting of a group of computers and machines that are interconnected and digitally connected to each other to improve daily life or manage and improve industrial processes.

✚ **Contribution to risk management:** Industrial IoT sensors are used to collect real-time data from oil wells. These sensors can be linked to digital analysis and self-diagnostic tools to automatically monitor and improve well performance. The company has developed a new technology capable of detecting gas using electrochemical sensors. The smart gas detection tool uses industrial IoT technologies to provide highly accurate self-diagnostics compared to traditional detection devices, reducing safety risks in the workplace.

- **Virtual reality (VR) and augmented reality (AR):** Hands-free VR and AR headsets provide Aramco employees with real-time data and 3D videos.

✚ **Contribution to risk management:** Virtual reality and augmented reality can be used to improve employee training and safety programs. They are also used to connect field employees with their colleagues, enabling real-time communication and collaboration, ensuring a rapid and accurate response to on-site risks.

- **3D Printing:** Also known as “additive manufacturing,” this is a method of producing a three-dimensional object, layer by layer, using a computer-generated design.

✚ **Contribution to risk management:** 3D printing can be used to simplify the production of complex components or prototypes, and also enables the manufacture of spare parts in remote locations. The Iktafa program contributed to the establishment of the first additive manufacturing center in the Kingdom, which is an integrated facility that prints a wide range of 3D products for industrial use, reducing the risk of delays in supply chains and ensuring business continuity.

Third: Integrating digital transformation with risk management at stc Group

1. Risk management framework at stc Group

1.1. Risk Management Objectives

stc solutions focuses on strengthening and developing risk management practices, based on a robust infrastructure that follows international practices and standards, such as COSO ERM and ISO 31000. This approach is integrated with stc solutions' strategy to contribute to risk-based strategic decision-making. (Annual Report 2024, 2024, p. 42)

1.2. Risk Management Governance

stc management is committed to defining and clarifying the key strategic objectives for the company's success and ensuring compliance with the timelines for achieving and sustaining them in the long term.

The company has a well-established organizational structure, with Risk Management (RMD) reporting directly to the Board Risk Management Committee (BRMC), ensuring effective oversight. Recognizing that risk is an integral part of business, stc implements robust controls to mitigate risk to an acceptable level, supporting the achievement of corporate and functional objectives.

The company adheres to comprehensive governance protocols, clearly defining approval processes, assigning responsibilities, and providing a framework for monitoring strategic initiatives. Stc remains fully compliant with all applicable laws and regulations, fostering a culture of accountability and risk awareness across its operations. (Enterprise Risk Management, 2024)

1.3. Risk Management Activities: These include: (Annual Report 2024, 2024, p. 42)

- Practices certified according to ISO 31000.
- Quarterly monitoring of key risks.
- Annual update of risk assessment.
- Monthly, quarterly, semi-annual, and annual monitoring of key risk indicators.
- Regular training and awareness programs to promote a culture of risk management and develop relevant knowledge.
- Annual internal control assessment.

stc solutions works to integrate risk management across all organizational levels and ensure its integration with decision-making procedures to support the implementation of the business strategy, where internal and external risk values are formed in a deeper and more comprehensive manner through a comprehensive risk management framework and effective cooperation and communication between different business units, All of this is leveraged to develop customer care approaches and methods for risk management and challenge detection, in line with the company's objectives and strategy.

Stc solutions are committed to developing and implementing a comprehensive risk management program that adopts best practices and leading standards in this field. This program also adopts a proactive approach to identifying risks and challenges across all elements of risk management processes using data-driven methodologies and advanced technologies to support decision-making to meet stakeholder expectations and achieve the highest relevant standards.

1.4. Risk categories:

Solutions by stc classify the risks it faces into six main categories to ensure comprehensive coverage of all aspects that may affect its performance:

Table No. (03): Risk Categories in the Stc Group

Risks	Factors
Regulatory risks	These risks relate to the legal and regulatory environment in which the company operates: * Non-compliance with laws and regulations, resulting in fines and financial penalties. Second: Sustainability risks These risks focus on the efficiency of daily operations and company resources, most notably: * Risks related to sustainability and the resulting decline in the company's rating or the position of the government and companies, and legislative changes that impose new controls that harm partners and consumers.
Sustainability risks	These risks are centered around the efficiency of daily operations and company resources, most notably: * Risks related to sustainability and the resulting decline in the company's rating or the position of the government and companies, and legislative changes that impose new controls that harm partners and consumers.
Geopolitical risks	These risks include the direct financial aspects of the company's operations: * Risks arising from complex and dynamic transactions that pose a threat to the company's operations and strategic projects, leading to disruption in supply chains and services.
Risks of emerging technologies	These risks relate to the technological and competitive environment: * The risk of being unable to adopt innovative technologies or adopting unsuitable technologies, resulting in weak competitive flexibility.
Cybersecurity and IT risks	These risks center around data protection and digital infrastructure: * Our growing dependence on digital developments, communications services, and information technology exposes us to the risk of breaches of sensitive data, networks, and systems.
Risks of competition	These risks relate to the competitive environment in the market: * Risk of declining market position, resulting in lost opportunities to offer better promotions to all customers.

Source: Prepared by researchers based on (Annual Report 2024, 2024, p. 43)

2. Digital transformation technologies and their contribution to risk management at stc Group:

Stc Group has successfully transformed its operations into more streamlined, secure, and integrated processes by: (Annual Report 2024, 2024, pp. 71-72)

- **Robotic Process Automation (RPA):** Automation aims to transform processes to become more streamlined, secure, and integrated through data migration and automation measures, contributing to cost reduction and enhanced profitability.

✚ **Contribution to risk management:** Increased efforts in robotic process automation have resulted in significant financial savings and high operational efficiency, achieving:

- Savings of \$1.8 million compared to 2023.
- A reduction of 10,000 working hours per year.
- A reduction of 6.3 full-time employees per month.
- A return on investment of 209%.

These results directly reduce the financial and operational risks associated with manual processes.

- **Enterprise Resource Planning (ERP) Integration:** The increasing integration of ERP software encompasses the management of vital aspects such as accounting, procurement, project progress, risk, compliance, and supply chain operations.

✚ **Contribution to risk management:** This integration has significantly contributed to increased operational efficiency, particularly in terms of internal processes and customer service. The inclusion of risk and compliance management within integrated systems is a strategic step toward ensuring risk monitoring and reducing the likelihood of non-compliance.

- **Migration of services to the cloud environment (Cloud Adoption):** The cloud environment is the basis for developing an integrated solutions architecture and improving efficiency.

✚ **Contribution to risk management:** In 2024, stc completed the migration of the customer experience management system to the cloud for the Call Centers Company (ccc). This step is in line with the Group's approach to supporting its subsidiaries and contributes to improving system efficiency and ensuring business continuity through a flexible cloud platform.

- **Developing internal solutions and converting them into commercial products (Innovation Monetization):** The group focuses on converting its successful internal solutions into new sources of revenue.

✚ **Contribution to risk management:** The Takia app, designed to enhance interaction among stc by solutions employees, was launched and quickly evolved into a commercially registered product targeting external customers. This approach reduces the risks associated with relying on a single source of income and supports the Group's growth. In addition, internal products such as Mysolutions, Shary-E, and partner relationship management platforms contribute to more efficient solutions.

- **Infrastructure and Specialized Solutions (Infrastructure and Specialized Solutions):** stc by solutions has strengthened its presence as a key provider of core services and advanced solutions to strategic customers, cementing its technical position.

✚ **Contribution to risk management:**

- Leading technical progress at Saudi Aramco: Completion of one of the world's largest IT initiatives reflects the ability to manage complex projects and reduce technical implementation risks at the national level.
- Supporting government business continuity: Supporting the Saudi Data and Artificial Intelligence Authority (SDAIA) with immediate solutions that ensure business continuity in the event of critical isolated network outages, a direct application of disaster recovery management.
- Mobile Command Center: Launch of the first prototype truck to serve as a mobile command center for the Saudi Electricity Company, enabling a flexible and effective response to crises and emergencies, thereby reducing the damage and risks caused by outages.

Fourth: Comparative Analysis of Models For Integrating Digital Transformation And Risk Management (SABIC, Aramco, And Stc Group)

The comparative analysis aims to identify how three major companies, SABIC, Aramco, and stc Group integrate their digital transformation plans and risk management approaches. In this analysis, we focus on the similarities between them in terms of their goal of shifting to risk prevention before it occurs (proactive prediction), as well as the differences in the technical tools each company has chosen to suit the nature of its work and the challenges of its sector.

Table No. (04): Analytical Comparison of Digital Transformation Applications in Risk Management at SABIC, Aramco, And Stc

Comparison standard	SABIC (Industry)	Aramco (Energy)	stc Group (telecommunications)
The most focused digital technologies	•Artificial Intelligence (AI) •OperationsPlatform (Star Program)	•Artificial intelligence (AI) • Supercomputing • Digital twinning	• Robotic Process Automation (RPA)
Key risks targeted by the technology	• Operational risks • Financial risks • Compliance risks	• Risks related to its business and activities, such as hydrocarbon reserves, dependence on information technology systems, and the environment • Legal and regulatory risks, such as contracts and lawsuits	• Cybersecurity and IT risks •Emerging technology risks - Competition risks • Sustainability risks
The main objective of the merger	Make equipment operate at very high efficiency and improve the entire workflow.	Anticipate difficult threats in advance and ensure the safety of employees and equipment	Reduce costs and make internal processes faster and more secure
Risk Management Approach	Working in advance to avoid problems and ensure equipment safety	Using technology to predict future risks and experiment with ways to deal with them.	Focus on strengthening internal procedures and control mechanisms

Source: Prepared by researchers based on the above information.

➤ Analysis of Comparison Results

After comparing the three cases, it became clear that there are two key factors governing the integration of digital technologies into risk management:

✓ Similarities in Risk Management Approaches

Although these companies operate in completely different sectors, the comparison revealed a clear consensus among them: they all want to stop solving problems after they occur and start preventing them before they happen. This means that the primary goal of using digital technologies has become enabling the company to predict risks. The new approach to risk management is to rely on tools such as artificial intelligence and automation to anticipate and prevent risks in advance, which in itself is a major change in the way organizations operate.

✓ Differences in The Technologies Used

The technologies chosen by each company were very different, depending on the nature of the risk they faced:

- **In the energy and industry sector (Aramco and SABIC):** The focus was on complex and powerful technologies such as artificial intelligence and digital twinning, which were used to deal with large asset risks and environmental risks that require very accurate predictions.
- **In the telecommunications and services sector (stc):** The focus was on robotic process automation (RPA), and this technology was used to deal with employee errors and internal operational efficiency, which are risks that require quick solutions aimed at reducing human error.

Conclusion:

After presenting and analyzing the models of leading companies (SABIC, Aramco, stc), this study conclusively demonstrated that integrating digital transformation and risk management is no longer an option, but rather a strategic necessity for growth. The comparative analysis also revealed fundamental similarities and differences in the adoption of technologies, providing a solid basis for drawing key conclusions and making the necessary recommendations to ensure effective risk management in the future.

Study findings:

- The most important goal agreed upon by the three companies is to stop solving problems after they occur and start preventing them before they happen (predictive management).
- Experience has shown that digital technologies, whether AI or automation, are effective tools for applying risk management principles and are not merely cosmetic.
- The success of technology integration depends on the precise match between the digital tool we choose and the type of strategic risk it faces.
- Companies' practical decisions have shown that the nature of the risk determines the type of technology.

Study recommendations:

- Design digital solutions to target the organization's greatest weakness, rather than using generic solutions.
- Focus on data quality, as it is the key element on which risk prediction relies.
- Build flexible action plans that ensure business continuity in the face of any unexpected technological challenges.

Declarations

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