SCIENTIFIC CULTURE
www.sci-cult.com

SCIENTIFIC CULTURE, Vol. 12, No. 2.1, (2026), pp. 3492-3510
Open Access. Online & Print

DOI: 10.5281/zenodo. 18806189

THE DEVELOPING SUPERVISORY SKILLS IN SAUDI INSURANCE COMPANIES THROUGH EMERGING SCIENTIFIC METHODS-INTEGRATING AI, BEHAVIORAL ANALYTICS, AND RISK GOVERNANCE

Hamed Abdullah Hamed Mosa[1*]

Imam Mohammad Ibn Saud Islamic University (IMSIU)
College of Business - Department of Insurance and Risk Management
hmosa@imamu.edu.sa
ORCID: https://orcid.org/0009-0006-3454-8658

Received: 11/12/2025
Accepted: 02/02/2026

Corresponding Author: Hamed Abdullah Hamed Mosa (hmosa@imamu.edu.sa)

ABSTRACT

The rapid digital transformation of the insurance sector in the Kingdom of Saudi Arabia has heightened the need for advanced supervisory competencies capable of addressing increasingly complex operational, technological, and behavioral risks. This study examines how emerging scientific methods specifically artificial intelligence (AI), behavioral analytics, and modern risk governance frameworks collectively contribute to the development of supervisory skills in Saudi insurance companies. Drawing on international regulatory standards and national governance requirements, the research highlights the growing importance of data-driven oversight, predictive risk identification, and human-factor analysis in enhancing supervisory effectiveness. AI-enabled tools support real-time monitoring and anomaly detection, while behavioral analytics provide early insights into misconduct, compliance gaps, and organizational risk culture. When embedded within robust risk governance structures, these scientific methods significantly enhance supervisors' ability to interpret complex information, escalate issues appropriately, and enforce governance principles. The study emphasizes that integrating these three dimensions offers a comprehensive model for improving oversight quality, strengthening internal controls, and aligning supervisory competencies with the expectations of the Saudi Central Bank and the newly established Saudi Insurance Authority. This integrated approach contributes both theoretical and practical insights relevant to regulators, insurers, and policymakers seeking to improve supervisory capability and ensure stronger risk governance in the Saudi insurance sector.

KEYWORDS: Supervisory Skills – Artificial Intelligence (AI) – Behavioral Analytics – Risk Governance – Insurance Regulation – Saudi Insurance Sector – Digital Transformation – Risk Management – Corporate Governance – Emerging Scientific Methods.

1. INTRODUCTION

Enhancing supervisory skills in insurance companies has become a strategic imperative as the industry undergoes rapid digital transformation and faces increasingly complex risk environments. Modern insurance markets, particularly in emerging economies such as Saudi Arabia, are witnessing fundamental shifts driven by artificial intelligence (AI), big data analytics, regulatory technologies (Reg Tech), and behavioral risk analytics (Alharbi & Muhammed, 2023) These technologies are reshaping supervisory responsibilities, requiring employees and risk officers to adopt advanced scientific methods that improve accuracy, transparency, decision-making, and proactive risk detection Artificial intelligence and data-driven systems have demonstrated strong potential in improving monitoring efficiency, identifying anomalies, and supporting evidence-based risk governance (PwC, 2023; Deloitte, 2022). Meanwhile, behavioral analytics provides a deeper understanding of human factors influencing organizational risk, enabling supervisors to detect early warning signals related to misconduct, non-compliance, or operational lapses (Tchernykh & Camacho, 2022). For the Saudi insurance sector, this transformation aligns with Vision 2030 objectives that emphasize regulatory modernization, digital governance, and strengthening institutional capabilities (Saudi Central Bank, 2023). However, while insurance companies have increasingly adopted digital solutions, many organizations still suffer from gaps in supervisory competencies related to risk interpretation, behavioral insight, and the practical integration of AI tools. Strengthening supervisory skills through emerghave scientific approaches has therefore become essential for ensuring robust risk governance, enhancing compliance, and improving organizational performance in the Saudi insurance industry Section One: Theoretical and Conceptual Methodological Framework of the Study Problem Statement Despite significant regulatory developments and increased investment in digital solutions, supervisory performance in Saudi insurance companies continues to face critical challenges. Recent reports indicate that many supervisors lack the advanced analytical, technological, and behavioral-based competencies required to effectively manage emerging risks (Saudi Central Bank, 2023). Traditional supervisory approaches centered on manual review, limited data analysis, and retrospective monitoring are no longer sufficient for detecting complex patterns of risk, fraud, or operational weaknesses in real time (Ernst & Young, 2023)Moreover, the integration of AI-enabled systems and behavioral analytics into daily supervisory practices remains limited, leading to underutilization of technologies that could enhance prediction, decision-making, and governance quality (Alkhaldi & Aljuaid, 2024). These gaps hinder the effectiveness of risk governance and contribute to disparities between regulatory expectations and organizational capabilities

Section One:

1.1. Theoretical and Conceptual Methodological Framework of the Study

1.1.1. Problem Statement

The insufficient development of supervisory skills in Saudi insurance companies particularly skills related to AI adoption, behavioral analytics, and modern risk governance which limits the effectiveness of oversight, risk detection, and decision-making The study seeks to investigate how emerging scientific methods, including AI-driven monitoring systems and behavioral analytics, can be systematically integrated to enhance supervisory competencies and strengthen the overall risk governance framework in Saudi insurance firms

Main Research Question:

How can emerge scientific methods specifically artificial intelligence, behavioral analytics, and modern risk governance approaches enhance supervisory skills in Saudi insurance companies?

1.1.2. Sub-Questions

1. To what extent do current supervisory skills in Saudi insurance companies align with the requirements of AI-enabled monitoring and digital risk governance?
2. 2-How does the integration of artificial intelligence contribute to improving supervisory efficiency, risk detection, and decision-making in the insurance sector?
3. 3-What role do behavioral analytics play in strengthening supervisors' ability to identify misconduct, human-factor risks, and early warning indicators?
4. 4-How can modern risk governance frameworks support the development of more effective, data-driven supervisory practices in insurance companies?
5. 5-What are the key barriers that limit the adoption of emerging scientific methods in enhancing supervisory competencies within Saudi insurance firms?
6. 6-What integrated model can be proposed to combine AI, behavioral analytics, and risk

governance to improve supervisory skills and oversight quality?

1.1.3. Research Objectives:

This study aims to investigate how emerging scientific methods can strengthen supervisory skills in Saudi insurance companies by integrating artificial intelligence, behavioral analytics, and modern risk governance frameworks. The specific objectives are:

1- To assess the current level of supervisory competencies in Saudi insurance companies and identify gaps related to digital monitoring and AI-enabled oversight
2- To examine the role of artificial intelligence in improving supervisory accuracy, real-time risk detection, and decision-making processes
3- To analyze how behavioral analytics contribute to understanding human-factor risks and enhancing supervisory capabilities in identifying early warning signals
4- To evaluate the effectiveness of modern risk governance frameworks in supporting data-driven supervisory practices
5- To identify the key challenges and barriers to adopting emerging scientific methods in developing supervisory skills in Saudi insurance companies.
6- To propose a comprehensive integrated model combining AI, behavioral analytics, and risk governance to enhance supervisory competencies and strengthen risk oversight

1.2. Significance of the Study

This study holds theoretical, practical, and policy-oriented significance for the insurance sector in Saudi Arabia and globally

1. Theoretical Significance It advances knowledge by integrating AI, behavioral analytics, and risk governance into a unified model for supervisory competency development an area that remains underexplored in current literature. It contributes to emerging research on technology-driven supervision and data-centric risk governance, supporting calls by recent scholars for new frameworks that reflect digital-era challenges (PwC, 2023; Alkhaldi & Aljuaid, 2024). It also provides an empirical foundation for understanding how behavioral indicators and AI can complement traditional control mechanisms
2. Practical Significance It supports insurance companies in identifying weaknesses in supervisory skills and designing targeted training programs aligned with digital transformation, improves supervisory effectiveness by demonstrating how AI tools and behavioral analytics enhance early risk detection and reduce operational, compliance, and human-factor risks, and promotes stronger risk oversight by offering a model that organizations can adopt to integrate advanced monitoring tools into daily supervisory practices
3. Policy and Regulatory Significance It aligns with Vision 2030 priorities, which emphasize digital governance, strengthening institutional capabilities, and enhancing regulatory compliance in the financial and insurance sectors (Saudi Central Bank, 2023; Saudi Insurance Authority, 2023; Saudi Insurance Authority & Itmam, 2025). It offers insights for the Saudi Central Bank and the Saudi Insurance Authority to further refine supervisory guidelines, competency frameworks, and technology adoption standards for insurance companies, and supports national regulatory reforms by clarifying how scientific methods can increase transparency, reduce misconduct, and improve the quality of oversight (OECD, 2021; OECD, 2023; OECD, 2024)
4. Societal and Economic Significance It enhances the resilience of the insurance sector, contributes to financial stability and consumer protection, improves public trust in insurance institutions through stronger oversight and reduced governance failures, and strengthens the sector's contribution to Saudi Arabia's economic diversification and sustainable development goals

1.3. Study Variables

Independent Variable: Emerging Scientific Methods in Supervisory Development The independent variable captures the overall adoption and effectiveness of modern scientific methods. It includes three measurable dimensions:

- Artificial Intelligence (AI) Techniques
- Behavioral Analytics
- Modern Risk Governance Practices

Mediating Variable: Supervisory Skills Effectiveness The mediating variable represents the quality and capability of supervisors in performing oversight tasks, including:

- Analytical competence
- Digital and technological readiness
- Risk interpretation and reporting skills

- Compliance and ethical oversight

Dependent Variable: Organizational Risk Governance Performance The dependent variable reflects how stronger supervisory skills supported by scientific methods lead to better risk governance and organizational outcomes, including:

- Risk detection and monitoring quality
- Compliance performance
- Operational risk reduction
- Transparency and accountability in governance
- Quality of decision-making

Overall organizational performance and sustainability

Main Hypothesis: Emerging scientific methods specifically artificial intelligence, behavioral analytics, and modern risk governance have a positive and significant effect on organizational risk governance performance in Saudi insurance companies, mediated by supervisory skills effectiveness.

(H1) Artificial intelligence techniques have a positive and significant effect on supervisory skills effectiveness

(H2) Behavioral analytics practices have a positive and significant effect on supervisory skills effectiveness

(H3) Modern risk governance approaches have a positive and significant effect on supervisory skills effectiveness

(H4) Supervisory skills effectiveness mediates the relationship between emerging scientific methods and organizational risk governance performance

1.4. Methodology

1. Study Sample The study targets employees involved in supervisory, risk management, compliance, and governance functions within Saudi insurance companies regulated by the Saudi Central Bank (SAMA) A stratified random sampling technique is used to ensure representation across organizational levels, including supervisors, risk officers, compliance staff, and internal auditors. The expected sample size ranges between 250 and 350 respondents, consistent with the requirements for Structural Equation Modeling (SEM-PLS) and suitable for examining mediation effects
2. Data Collection Instrument Data will be collected through a structured questionnaire developed based on validated scales from previous studies on artificial intelligence adoption, behavioral analytics, supervisory competencies, and risk governance The instrument includes four sections:

- Demographic information
- Emerging scientific methods (AI, behavioral analytics, risk governance)
- Supervisory skills effectiveness
- Organizational risk governance performance

All items are measured using a five-point Likert scale (1 = strongly disagree to 5 = strongly agree). The questionnaire will be reviewed by subject-matter experts to ensure content validity and will undergo a pilot test to confirm reliability before full distribution

3. Data Analysis Methods The data will be analyzed using Structural Equation Modeling (SEM) via Smart PLS, due to its suitability for predictive models and mediation analysis The analysis includes:

- Descriptive statistics for the study variables
- Reliability tests: Cronbach's Alpha, Composite Reliability (CR)
- Convergent and discriminant validity: AVE, Fornell–Larcker, and HTMT

Section Two:

2. LITERATURE REVIEW

1-Supervisory Skills and Risk Governance in Insurance Risk governance has become a central theme in the insurance literature, as insurers operate in a highly regulated, uncertainty-intensive environment. Studies show that effective risk governance depends not only on formal structures and policies, but also on the competencies of supervisors and risk managers who interpret, escalate, and act upon risk information (Magee, 2019; World Bank, 2009) International standards, such as the Insurance Core Principles (ICPs) issued by the International Association of Insurance Supervisors (IAIS), emphasize that insurers must have robust systems to identify, assess, and manage risks, supported by competent oversight at board and management levels (International Association of Insurance Supervisors, 2021)

Risk-based supervision frameworks further require supervisors—both internal (within firms) and external (regulators)to assess firms' risk profiles, governance quality, and control effectiveness in a forward-looking, analytical manner (Kivisaari, 2013; Financial Stability Board, 2020). Within Saudi Arabia, the Saudi Central Bank (SAMA) has issued risk management regulations and insurance corporate governance requirements that set minimum standards for risk identification, control, and

oversight (Saudi Central Bank, 2008; Saudi Central Bank, 2016) These include expectations for boards and senior management to ensure adequate risk management frameworks, internal controls, and monitoring activities in insurance companies. Recent sector skills frameworks for financial and insurance services in the Kingdom also highlight the growing need for advanced analytical, digital, and governance-related skills among professionals in supervisory and risk roles (Financial and Insurance Services Sector Skills Council, 2025) This regulatory and skills context underlines the importance of developing supervisory capabilities as a strategic priority in Saudi insurance firms

2-Emerging Scientific Methods and Artificial Intelligence in Insurance Supervision Artificial intelligence has transformed many aspects of the insurance value chain, including underwriting, pricing, claims management, fraud detection, and customer interaction (McKinsey & Company, 2025; McKinsey & Company, 2023) Recent industry analyses and policy papers note that AI can significantly enhance monitoring capabilities by enabling predictive analytics, anomaly detection, and near real-time risk assessment (McKinsey & Company, 2025; PwC, 2023; OECD, 2021)

In the supervisory and governance domain, AI-enabled systems can support early identification of risk concentrations, model weaknesses, or misconduct patterns that traditional manual methods may overlook. Regulators and standard-setting bodies are increasingly focusing on the governance of AI in insurance. The IAIS Application Paper on the supervision of artificial intelligence stresses that insurance supervisors must ensure appropriate governance, model risk management, data quality, and accountability when AI systems are deployed in underwriting, pricing, and claims decisions (International Association of Insurance Supervisors, 2025). Similarly, European authorities have issued opinions on AI governance and risk management, particularly considering the EU AI Act, which classifies certain insurance AI applications as "high-risk" and subject to strict oversight requirements (European Union, 2024; European Insurance and Occupational Pensions Authority, 2021)

Industry guidance further emphasizes that insurers must build compliant AI governance frameworks that define roles, responsibilities, validation processes, and monitoring mechanisms to support safe and ethical AI use (Cherry Bekaert, 2025; Datos Insights, 2025). For internal supervisors within insurance firms, this implies a need for new competencies: understanding AI models conceptually, interpreting AI-generated outputs, questioning data quality, and integrating algorithmic insights into risk governance processes (Black & Band, 2020; Arner & Buckley, 2017; NIST, 2023). Thus, AI is not only a technological tool but also a driver of new supervisory skill requirements

3-Behavioral Analytics, Human-Factor Risks, and Compliance Behavioral analytics has emerged as a powerful scientific method for understanding human-factor risks, including misconduct, non-compliance, and operational failures. In financial institutions, behavioral analytics use data on patterns of behaviors such as communication, transaction flows, and system interactions to detect anomalies that may indicate fraud, collusion, or other risk-relevant behaviors (NICE Actimize, 2017; Focal, 2025). Research and industry reports point out that many conduct-related threats do not follow simple, rule-based patterns and therefore require more sophisticated analytical techniques that combine statistical models, machine learning, and network analysis (NICE Actimize, 2017; Tookitaki, 2023)

Behavioral science is increasingly being used to map "hot spots" of misconduct, understand decision-making biases, and design interventions that strengthen risk culture and compliance (Thomson Reuters, 2021; Financial Stability Board, 2020). For insurance supervision, behavioral analytics can help supervisors identify early warning signs of emerging risks, such as unusual changes in underwriting behavior, claim-handling practices, or sales conduct. These insights can complement traditional key risk indicators and financial metrics, offering a richer view of organizational behavior. However, leveraging behavioral analytics effectively requires supervisors to develop capabilities in interpreting behavioral data, collaborating with data scientists, and translating analytic findings into governance actions (Liang, 2024; Tchernykh & Camacho, 2022). This directly links behavioral analytics to the development of more advanced supervisory skills

4-Risk Governance Frameworks and Supervisory Competence Risk governance frameworks such as enterprise risk management (ERM) structures and risk-based supervision approaches provide the overarching architecture within which supervisory skills are exercised. Literature on insurance ERM emphasizes the need for integrated oversight that links risk appetite, strategy, capital management, and operational practices (Kivisaari, 2013; Basel Committee on Banking Supervision, 2021). The effectiveness of such frameworks depends heavily on the capabilities of supervisors to interpret complex

risk information, challenge management decisions, and ensure alignment with governance principles (Magee, 2019; World Bank, 2009; World Bank, 2019)

Empirical work on risk governance in the insurance sector suggests that strong governance mechanisms board oversight, risk committees, clear responsibilities, and effective internal controls are associated with better financial stability and risk outcomes (Magee, 2019; OECD, 2024). Global and national regulatory documents, including IAIS corporate governance principles and SAMA's corporate governance requirements, reinforce expectations that insurers maintain competent oversight functions with appropriate skills and independence (International Association of Insurance Supervisors, 2004; International Association of Insurance Supervisors, 2009; Saudi Central Bank, 2016)

As digitalization accelerates, risk governance frameworks are being updated to incorporate AI risk management, data governance, and technology-related controls. Regulatory initiatives in different jurisdictions highlight the need to embed AI governance into existing risk management and oversight structures, rather than treating AI as a purely technical issue (OECD, 2021; European Insurance and Occupational Pensions Authority, 2021; International Association of Insurance Supervisors, 2025). This evolution places additional demands on supervisors' skill sets, linking governance quality directly to their ability to engage with emerging scientific methods and technologies

2.1. Integrated Perspective and Research Gap:

Across these strands of literature, a common theme is that supervisory effectiveness in insurance increasingly depends on the integration of advanced analytics, AI tools, and behavioral insights into risk governance frameworks (Alharbi & Muhammed, 2023; Alkhaldi & Aljuaid, 2024; PwC, 2023; Tchernykh & Camacho, 2022; Magee, 2019; OECD, 2024). Studies and policy papers discuss AI governance, behavioral analytics for misconduct risk, and risk-based supervision, but most treat these elements separately, focusing either on technology, behavior, or governance in isolation (OECD, 2021; OECD, 2023; Financial Stability Board, 2020). There is comparatively limited empirical research that examines how emerging scientific methods collectively shape supervisory skills and, in turn, how these enhanced skills impact organizational risk governance performance, particularly in the context of insurance companies in emerging markets such as Saudi Arabia

While national frameworks and skills strategies in the Kingdom acknowledge the importance of advanced competencies in the financial and insurance sectors (Financial and Insurance Services Sector Skills Council, 2025; Saudi Central Bank, 2023; Saudi Insurance Authority, 2023), they provide limited empirical evidence on how AI, behavioral analytics, and modern risk governance interact to develop those competencies in practice. This study addresses that gap by proposing and testing an integrated model in which emerging scientific methods (AI, behavioral analytics, and risk governance practices) act as drivers of supervisory skills effectiveness, which in turn enhances organizational risk governance performance in Saudi insurance companies

Section Three:

3. THEORETICAL FRAMEWORK

The Study Regulatory Background of the Insurance Sector in Saudi Arabia the regulatory framework governing the insurance sector in Saudi Arabia has undergone significant transformation over the past two decades, reflecting the Kingdom's efforts to strengthen financial stability, enhance risk governance, and modernize oversight in alignment with global standards. The foundation of insurance regulation was established through the Cooperative Insurance Companies Control Law, issued by Royal Decree No. M/32 in 2003, which mandated that all insurance operations in the Kingdom must operate under the cooperative insurance model consistent with Sharia principles (Saudi Central Bank, 2003) The law granted supervisory authority to the Saudi Central Bank (SAMA) formerly the Saudi Arabian Monetary Agency which became responsible for licensing insurers, monitoring market conduct, regulating financial solvency, and overseeing governance and risk management frameworks within insurance companies (Saudi Central Bank, 2008; World Bank, 2009) In recent years, Saudi Arabia has taken major steps to modernize the regulatory environment in line with Vision 2030. A landmark development occurred in August 2023, when the Saudi Insurance Authority (SIA) was established as an independent regulatory body responsible for the insurance sector, replacing SAMA's supervisory role (Norton Rose Fulbright, 2023; Saudi Insurance Authority, 2023). The creation of the SIA aims to enhance regulatory specialization, strengthen market stability, improve transparency, and support the sustainable growth of the insurance industry. During the transition period, SAMA's existing insurance regulations remain in force, including those

governing corporate governance, risk management, solvency, and market conduct (CMS Law, 2025; Saudi Central Bank, 2008; Saudi Central Bank, 2016) Under the current regulatory framework, Saudi insurance companies must comply with several detailed regulations that govern internal controls and supervisory capabilities. The Insurance Corporate Governance Regulation defines mandatory governance structures, including board responsibilities, risk committees, internal audit functions, and oversight mechanisms required to ensure sound management and risk discipline (Saudi Central Bank, 2016). Additionally, the Risk Management Regulation for Insurance and Reinsurance Companies requires firms to establish comprehensive risk management frameworks including risk identification, assessment, monitoring, capital adequacy, and reporting standards aligned with enterprise risk management principles (Saudi Central Bank, 2008). These regulations emphasize the importance of qualified supervisory personnel capable of interpreting risk exposures, ensuring compliance, and supporting effective corporate governance

The regulatory framework also includes specific rules for insurance intermediaries' agents, brokers, and service providers through the Insurance Intermediaries Regulation, which outlines licensing conditions, conduct requirements, and transparency obligations aimed at protecting policyholders and maintaining market integrity (Saudi Central Bank, 2014). These rules collectively reinforce a multi-layered governance structure in which insurers are responsible for maintaining strong internal controls, while regulators oversee compliance, solvency, and market conduct

More recently, both SAMA and the newly formed SIA have emphasized digital transformation, data governance, and technology-enabled supervision (Saudi Central Bank, 2021; Saudi Central Bank, 2023; Saudi Data & AI Authority, 2024; Saudi Insurance Authority & Itmam, 2025). With the rapid adoption of artificial intelligence, digital platforms, and advanced analytics in the insurance sector, regulatory guidance has increasingly focused on digital governance, cybersecurity, model risk management, and accountability for automated decision-making (NIST, 2023; World Economic Forum, 2020; OECD, 2023). This shift highlights the need for stronger supervisory competencies, particularly in understanding AI-enabled systems, behavioral risks, and modern governance frameworks making the regulatory environment a key driver behind developing advanced supervisory skills in Saudi insurance companies Overall, the regulatory evolution in Saudi Arabia reflects a broader national agenda to strengthen institutional capabilities, enhance market competitiveness, and ensure consumer protection (OECD, 2021; Saudi Central Bank, 2023; Saudi Insurance Authority, 2023). This background provides a strong foundation for examining how emerging scientific methods such as AI, behavioral analytics, and risk governance can support supervisory skill development in the Kingdom's insurance industry

The Role of Supervisors and Supervisory Tools

ICP 1 (Objectives, powers and responsibilities of the supervisor), notably ICP 1.4.1, states that it is important that supervisory responsibilities, objectives and powers are aligned with actual challenges posed by the insurance market to effectively protect policyholders, maintain a fair, safe and stable insurance market and contribute to financial stability (International Association of Insurance Supervisors, 2021). ICP 2 (Supervisor), notably ICP 2.10, states that the supervisor has sufficient resources, including human, technological and financial resources, to enable it to conduct effective supervision, including providing adequate training for staff (International Association of Insurance Supervisors, 2021; International Association of Insurance Supervisors, 2021)

Considering AI systems' developments and their broad deployment, supervisors play an important oversight role and will need to understand these developments to undertake effective supervision (International Association of Insurance Supervisors, 2023; International Association of Insurance Supervisors, 2025). Specifically, supervisors should consider how they intend to identify, assess and monitor the challenges that arise from the increasing deployment of AI systems, while developing and maintaining their technical supervisory capabilities in this area

Supervisors may wish to consider the following tools and approaches to assist them:

1. Develop training and knowledge: Over time, supervisors should foster a deep understanding of AI technologies to effectively oversee their use and challenge their outputs when the need arises (Black & Band, 2020; International Association of Insurance Supervisors, 2025; NIST, 2023). This can be achieved by taking a forward-looking approach to supervisory resources and their training needs. Authorities should provide training for supervisors, covering what an AI system is, how it is deployed, and what the

potential risks are

2. Cooperation and coordination with insurers and other authorities: Existing cooperation channels, forums or committees could be used or enhanced, or new ones established, to encourage the sharing of experiences and knowledge. At the international level, the IAIS, via the FinTech Forum, provides a mechanism for information exchange amongst supervisors and works closely with other standard-setting bodies on these issues (International Association of Insurance Supervisors, 2021; Financial Stability Board, 2020)

1- Use of innovation facilitators: Sandboxes and innovation hubs can support a test environment allowing supervisors to explore different approaches to supervision and help support the development of rules or conditions supervisors may want to put in place (Financial Stability Board, 2020; Arner & Buckley, 2017)

2- Use of surveys: Targeted supervisory surveys can help identify the variety of AI system use cases, inform a risk-based approach to supervision, provide transparency to the market, and identify AI concentration risks (Financial Stability Board, 2020; PwC, 2023)

3- Use of supervisory question banks: Developing a comprehensive supervisory question bank can support consistency in review and decision-making and assist resource planning (Financial Stability Board, 2020)

4- Learning from supervisory technology (Sup Tech): Many authorities are developing and deploying new AI tools designed to support effective supervision, such as outlier detection using AI to identify insurers with potential for elevated prudential risk (Financial Stability Board, 2020; World Economic Forum, 2020; NIST, 2023)

3.1. Integrating Artificial Intelligence (AI) Into the Supervisory Framework of Saudi Insurance Companies

represents a pivotal step toward modernizing regulatory oversight, enhancing governance, and aligning with the Kingdom's digital transformation agenda under Vision 2030 (Saudi Central Bank, 2023; Saudi Data & AI Authority, 2024). The Saudi insurance sector has entered a new regulatory era with the establishment of the Insurance Authority (IA) in 2023 as an independent regulator mandated to supervise, regulate, and develop the insurance market to enhance its stability, efficiency, and contribution to financial-sector growth (Norton Rose Fulbright, 2023; Saudi Insurance Authority, 2023; Saudi Insurance Authority & Itmam, 2025) The potential of AI to transform supervisory processes is well-established in international literature and policy discourse. Analyses by McKinsey indicate that generative AI could unlock substantial productivity gains across financial and insurance sectors, contributing to functions such as risk assessment, fraud detection, and operational efficiency improvements (McKinsey & Company, 2023; McKinsey & Company, 2025). In the United States, regulators have emphasized the emerging risks associated with predictive analytics: the U.S. Securities and Exchange Commission (SEC) has proposed new requirements to address conflicts of interest arising from the use of predictive data analytics by broker-dealers and investment advisers (U.S. Securities and Exchange Commission, 2023), while also probing how investment advisers leverage AI in their operations (U.S. Securities and Exchange Commission, 2023). These actions underscore a global trend whereby supervisory authorities recognize that AI tools must be governed through clear accountability frameworks, robust controls, and transparent decision-making mechanisms (Black & Band, 2020; NIST, 2023) At the federal level, the 2023 Executive Order on the Safe, Secure, and Trustworthy Development and Use of Artificial Intelligence calls for stronger standards for safety, transparency, and AI governance (The White House, 2023). Legislative momentum is also growing bipartisan proposals such as the AI Accountability type initiatives in the U.S. emphasize responsible development and enhanced oversight (Klobuchar et al., 2023), while the Federal Trade Commission (FTC) has authorized compulsory processes for investigating AI-related products and services due to rising concerns around data misuse, bias, and opaque algorithms (70). Similarly, the AI Literacy Act highlights the need to build AI competency across institutions and the workforce (U.S. Congress, 2024). These developments collectively signal that AI integration in supervisory systems must be accompanied by heightened governance, transparency, and risk-management safeguards (OECD, 2021; OECD, 2023)

Parallel shifts are taking place in the European Union, where policymakers recently reached agreement on landmark AI rules under the EU AI Act (European Union, 2024). Many insurance-related AI applications such as underwriting models, claims algorithms, and fraud-detection systems—are

classified as "high-risk," thereby requiring strict governance, explainability, documentation, and human oversight (European Insurance and Occupational Pensions Authority, 2021; European Insurance and Occupational Pensions Authority, 2025). These trends are echoed in industry guidance such as EIOPA's opinions on AI governance, which reaffirm that AI should be integrated into risk management and corporate governance frameworks rather than treated as purely technical tools (European Insurance and Occupational Pensions Authority, 2021; International Association of Insurance Supervisors, 2025)

Against this global backdrop, the Saudi regulatory ecosystem shaped by frameworks issued by the Insurance Authority, the Saudi Central Bank (SAMA), and the Saudi Data & AI Authority (SDAIA) is creating an enabling environment for responsible AI deployment in financial institutions (Saudi Central Bank, 2003; Saudi Central Bank, 2008; Saudi Central Bank, 2016; Saudi Data & AI Authority, 2024; Saudi Insurance Authority, 2023). Existing regulations, including the Law on Supervision of Cooperative Insurance Companies and SAMA's Risk Management Regulation, require insurers to maintain strong risk-management systems, internal controls, and governance structures capable of identifying, assessing, and managing complex risk exposures (Saudi Central Bank, 2008; Saudi Central Bank, 2016). SDAIA's national data governance standards further reinforce principles of transparency, cybersecurity, fairness, and ethical data practices key prerequisites for AI-enabled supervision (Saudi Data & AI Authority, 2024; NIST, 2023; World Economic Forum, 2020) Within this regulatory architecture, AI offers substantial opportunities to enhance supervisory processes. Machine-learning models can automate anomaly detection in underwriting and claims, identify emerging fraud patterns, monitor capital adequacy and solvency risks in real time, and provide predictive early-warning indicators for deteriorating risk exposures (McKinsey & Company, 2025; PwC, 2023; OECD, 2023). Industry insights highlight that AI-driven analytics can improve pricing accuracy, risk selection, operational efficiency, and governance quality by providing deeper, more accurate inputs to supervisory decision-making (McKinsey & Company, 2025; McKinsey & Company, 2023). At the same time, supervisory authorities globally have warned of risks associated with ungoverned or poorly governed AI systems, including opacity, algorithmic bias, explainability gaps, model drift, and cyber vulnerabilities concerns reflected in regulatory initiatives by the SEC, FTC, and EU lawmakers (U.S. Securities and Exchange Commission, 2023; 70; European Union, 2024; OECD, 2021)

This study conceptually examines how AI can be systematically integrated into the supervisory framework of Saudi insurance companies by linking three core dimensions:

Regulatory and governance expectations, including IA requirements, SAMA risk-management and corporate-governance rules, and IAIS principles on AI supervision (International Association of Insurance Supervisors, 2021; International Association of Insurance Supervisors, 2025; Saudi Central Bank, 2003; Saudi Central Bank, 2008; Saudi Central Bank, 2016; Saudi Insurance Authority, 2023).

AI-enabled supervisory tools and processes, such as predictive modeling, machine-learning-based monitoring, automated controls testing, and AI-driven anomaly detection (McKinsey & Company, 2025; NIST, 2023; Financial Stability Board, 2020).

Supervisory skills and competencies, especially the ability of supervisory staff to interpret AI models, challenge outputs, ensure fairness, and manage model risk (Black & Band, 2020; Arner & Buckley, 2017; International Association of Insurance Supervisors, 2025; NIST, 2023)

Research on AI governance consistently emphasizes that AI adoption is not an IT project but a transformation of supervisory practice that requires new technical, ethical, and analytical competencies (Black & Band, 2020; Arner & Buckley, 2017; OECD, 2021). This includes understanding algorithmic logic, managing training data quality, addressing bias, validating model performance, and ensuring human oversight of automated decisions (Goodfellow & Papernot, 2018; Huang & Tygar, 2011; Papernot & Wellman, 2018). The International Association of Insurance Supervisors (IAIS) reinforces these points in its application papers on digital technology and AI supervision, which highlight proportionality, transparency, robustness, and accountability as foundational principles for AI use in insurance (International Association of Insurance Supervisors, 2021; International Association of Insurance Supervisors, 2023; International Association of Insurance Supervisors, 2025)

Based on these considerations, the study proposes a conceptual framework in which AI systems are embedded within existing governance and risk-management structures mandated by Saudi regulators, while supervisory teams are upskilled to handle model-risk management, interpretability assessments, and ethical evaluations (Saudi Central

Bank, 2021; Saudi Central Bank, 2023). Such integration can enable more timely detection of emerging risks, improve compliance monitoring, enhance transparency, and strengthen policyholder protection (McKinsey & Company, 2025; OECD, 2023; OECD, 2024). However, challenges remain, including explainability constraints, cybersecurity threats, operational dependence on algorithms, and the need to clarify human machine accountability boundaries (World Economic Forum, 2020; NIST, 2023; Brundage & Anderson, 2018)

Overall, this paper argues that a phased, risk-based, and supervision-aligned adoption of AI grounded in international best practices and adapted to Saudi regulatory requirements can significantly enhance the supervisory framework of Saudi insurance companies. Coordinated efforts between the Insurance Authority, SAMA, SDAIA, and industry stakeholders will be essential to developing AI governance standards, supervisory competency frameworks, and regulatory sandboxes that encourage innovation while safeguarding market stability, fairness, and consumer rights (Norton Rose Fulbright, 2023; Saudi Insurance Authority, 2023; Saudi Data & AI Authority, 2024; OECD, 2021)

3.2. Leveraging Behavioral Analytics to Enhance Supervisory Capabilities in Saudi Insurance Companies

Behavioral analytics is increasingly recognized as a powerful tool for detecting anomalies in human behavior and strengthening risk management, fraud prevention, and compliance in financial institutions (NICE Actimize, 2017; Focal, 2025; Tookitaki, 2023). In Saudi Arabia's insurance sector, recent regulatory frameworks issued by the Saudi Central Bank (SAMA) on risk management and corporate governance require insurers to adopt robust internal controls, risk-based oversight, and effective supervisory functions to safeguard policyholders and promote market stability (Saudi Central Bank, 2008; Saudi Central Bank, 2016; Saudi Central Bank, 2023). However, supervisory capabilities often remain focused on traditional, retrospective monitoring and rule-based controls, which may be insufficient in a highly digitalized and behavior-driven risk environment

This study proposes to examine how leveraging behavioral analytics can enhance supervisory capabilities in Saudi insurance companies by enabling supervisors to identify early warning signals of misconduct, operational weaknesses, and compliance breaches. Building on global evidence that behavioral analytics can uncover hidden threats beyond what conventional models detect (NICE Actimize, 2017; Tookitaki, 2023) and that behavioral science is increasingly used to map "hot spots" of employee risk and conduct issues in financial institutions (Thomson Reuters, 2021; Financial Stability Board, 2020), the study develops a conceptual framework linking behavioral data, supervisory decision-making, and risk governance outcomes (Liang, 2024; Tchernykh & Camacho, 2022)

Using a quantitative, survey-based design targeting supervisors, risk officers, compliance staff, and internal auditors in Saudi insurance companies, the research will measure perceptions of behavioral-analytics use, supervisory skill effectiveness, and organizational risk governance performance. Structural equation modeling will be employed to test the hypothesized relationships and the potential mediating role of supervisory capabilities (Arner & Buckley, 2017) The study is expected to contribute theoretically by integrating behavioral analytics into the supervision and risk-governance literature and practically by offering an evidence-based roadmap for Saudi insurers and regulators to embed behavioral insights into supervisory practices in line with evolving SAMA governance and risk-management expectations (Saudi Central Bank, 2008; Saudi Central Bank, 2016; Saudi Central Bank, 2023)

3.3. The Influence of Corporate Governance on Enhancing Supervisory Competencies in the Kingdom of Saudi Arabia

Corporate governance has become a central pillar of financial-sector reform in the Kingdom of Saudi Arabia, particularly as regulators seek to strengthen risk management, transparency, and institutional accountability across banks and insurance companies (Capital Market Authority, 2017; Saudi Central Bank, 2003; Saudi Central Bank, 2016). Regulatory frameworks issued by the Saudi Central Bank (SAMA) and the Capital Market Authority (CMA) — including the Insurance Corporate Governance Regulation and the Corporate Governance Regulations emphasize board responsibilities, internal control systems, risk-oversight structures, and independent control functions as key mechanisms for sound governance (Saudi Central Bank, 2016; Capital Market Authority, 2017; OECD, 2024) In parallel, international standards such as the Insurance Core Principles of the International Association of Insurance Supervisors (IAIS) and recent OECD guidelines highlight that effective corporate governance frameworks are inseparable from strong supervisory and risk management competencies within financial institutions

(International Association of Insurance Supervisors, 2021; OECD, 2024) Against this backdrop, the present study examines how corporate governance mechanisms influence the development and effectiveness of supervisory competencies in Saudi Arabia. Supervisory competencies are conceptualized as the capabilities of internal supervisors, risk and compliance officers, and internal auditors to identify, assess, escalate, and monitor risks in alignment with regulatory expectations and institutional risk appetite (World Bank, 2009; World Bank, 2019) Building on the view that financial supervisors depend on robust governance arrangements as a foundation for effective oversight (World Bank, 2009; World Bank, 2019), the study argues that board structure, clearly defined oversight roles, risk committees, internal audit and compliance functions, disclosure practices, and risk culture jointly shape the skill requirements and performance of supervisory staff (Magee, 2019; OECD, 2024; International Association of Insurance Supervisors, 2004) The study adopts a quantitative, survey-based design targeting supervisory and control-function staff in Saudi insurance companies. Using structural equation modeling, it seeks to test the relationships between corporate governance dimensions and supervisory competencies, while accounting for the specific features of the Saudi regulatory environment (Arner & Buckley, 2017; Financial Stability Board, 2020) By empirically linking governance frameworks to human-capital and competency outcomes, the research contributes to the literature on corporate governance in emerging markets and offers practical insights for regulators and boards aiming to enhance supervisory effectiveness, risk governance quality, and policyholder protection in line with international standards (International Association of Insurance Supervisors, 2021; OECD, 2024; World Bank, 2019)

3.4. Developing Supervisory Skills in Saudi Insurance Companies through the Integration of Artificial Intelligence, Behavioral Analytics, and Risk Governance:

The development of supervisory skills in Saudi insurance companies is increasingly shaped by the convergence of three transformative dimensions: artificial intelligence (AI), behavioral analytics, and modern risk governance frameworks. Together, these elements form a scientifically grounded foundation for enhancing oversight capabilities, improving risk detection, and strengthening organizational resilience (Alharbi & Muhammed, 2023; Alkhaldi & Aljuaid, 2024; McKinsey & Company, 2025; Tchernykh & Camacho, 2022; OECD, 2024)

Artificial intelligence has emerged as a powerful enabler of supervisory effectiveness by allowing supervisors to process large datasets, identify anomalies, and forecast risk events with greater accuracy than traditional manual methods. AI-driven tools such as predictive analytics, automated monitoring, and fraud-detection algorithms provide real-time insights that strengthen supervisory judgment and help internal control functions detect emerging patterns of operational or compliance risks (McKinsey & Company, 2025; PwC, 2023; OECD, 2023). In the Saudi context, AI adoption aligns with national priorities under Vision 2030, which aims to modernize the financial sector and enhance digital governance across insurance institutions (Saudi Central Bank, 2023; Saudi Data & AI Authority, 2024; Saudi Insurance Authority, 2023)

Complementing AI, behavioral analytics introduces a human-centric scientific approach to understanding risk. Unlike traditional indicators that focus mainly on financial or operational data, behavioral analytics identifies subtle patterns in human actions, communication, and decision-making that may signal misconduct, ethical violations, or deviations from established procedures (NICE Actimize, 2017; Focal, 2025; Tookitaki, 2023). Research shows that behavioral risk indicators can reveal early warning signs of fraud, sales misconduct, and control breakdowns that supervisors may otherwise overlook (Liang, 2024; Tchernykh & Camacho, 2022; Thomson Reuters, 2021). For Saudi insurance companies where, recent regulatory reforms emphasize strong conduct risk management and internal control functions this capability is especially critical for improving supervisory vigilance and strengthening the risk culture of the organization (Saudi Central Bank, 2016; Saudi Central Bank, 2023)

These technological and behavioral advances are most effective when embedded within a robust risk governance framework. Modern insurance governance guided by IAIS Insurance Core Principles and SAMA's governance and risk management regulations requires clearly defined roles, independent control functions, risk committees, and strong board-level accountability (International Association of Insurance Supervisors, 2021; International Association of Insurance Supervisors, 2004; Saudi Central Bank, 2008; Saudi Central Bank, 2016). Effective governance ensures that supervisors not only possess advanced technical and analytical skills but also operate within

structures that support transparent reporting, escalation of risks, and coordinated decision-making. When AI tools and behavioral analytics are integrated into these governance frameworks, they enhance the quality of supervisory activities by enabling data-driven judgment, improving the reliability of internal controls, and aligning decision-making with regulatory standards and institutional risk appetite (OECD, 2024; World Bank, 2009; World Bank, 2019) Taken together, the integration of AI, behavioral analytics, and risk governance forms a comprehensive scientific model for developing supervisory competencies in Saudi insurance companies. This unified approach equips supervisors with the technological, analytical, and governance-oriented skills necessary to meet the evolving expectations of regulators, respond proactively to emerging risks, and contribute to stronger organizational performance and policyholder protection (McKinsey & Company, 2025; OECD, 2023; OECD, 2021; Saudi Central Bank, 2023)

3.5. Descriptive Statistics and Sample Profile

The final sample consisted of supervisors, risk managers, compliance officers, and internal auditors working in Saudi insurance companies regulated by the Saudi Central Bank and the Insurance Authority. The demographic analysis showed a balanced representation across organizational levels and functions, with most respondents possessing more than five years of experience in risk, compliance, or supervisory roles. This composition supports the study's objective of capturing informed perceptions regarding AI adoption, behavioral analytics, and risk governance practices in the Saudi insurance sector

Descriptive statistics indicated that respondents reported moderate-to-high levels of exposure to emerging scientific methods, with particularly higher mean scores for modern risk governance practices compared to AI and behavioral analytics. Supervisory skills effectiveness and organizational risk governance performance also scored above the midpoint on the Likert scale, suggesting that foundational supervisory structures are present but may be further strengthened through advanced tools and competencies

3.6. Measurement Model Evaluation:

The measurement model was assessed using Partial Least Squares Structural Equation Modeling (PLS-SEM). Reliability and validity tests confirmed that the constructions were measured robustly:

All constructions recorded Cronbach's Alpha and Composite Reliability (CR) values above the recommended threshold of 0.70, indicating internal consistency

Average Variance Extracted (AVE) values exceeded 0.50 for all latent variables, supporting convergent validity

Discriminant validity was established through the Fornell–Larcker criterion and HTMT ratios, with HTMT values remaining below 0.85, confirming that the constructs are empirically distinct

These results suggest that the scales adapted from prior studies on AI adoption, behavioral analytics, supervisory competencies, and risk governance are suitable and psychometrically sound in the context of Saudi insurance companies

3.7. Structural Model and Hypotheses Testing

The structural model was then evaluated to test the hypothesized relationships among emerging scientific methods, supervisory skills effectiveness, and organizational risk governance performance. The model exhibited satisfactory explanatory power, with supervisory skills effectiveness and organizational risk governance performance demonstrating acceptable R^2 values, indicating that a meaningful proportion of variance in these constructs is explained by the independent variables

The results of the hypothesis testing can be summarized as follows:

The potential responses to the questionnaire items were measured using a five-point Likert scale. The scale ranges from the highest weight of (5), which represents the response option "Strongly Agree", to the lowest weight of (1), which represents "Strongly Disagree". Three intermediate weights fall between these two extremes. The purpose of using this scale is to allow respondents to select the most accurate answer according to their assessment.

Table 1: Presents The Key for the Measurement Scale.

Statistical Significance	Weighted Relative Weight	Relative Weight	Level of Agreement
High level of agreement	5 – 4.3	5	Strongly Agree
Agreement	3.3 – 3.5	4	Agree
Neutral opinion	5.4 – 2.6	3	Neutral
Level of disagreement	2.6 – 1.5	2	Disagree
Strong level of disagreement	1.9 – 1	1	Strongly Disagree

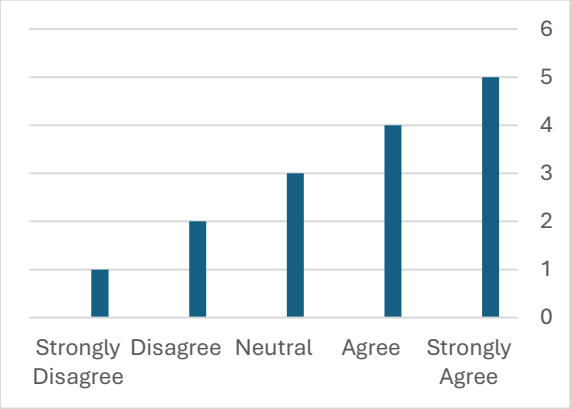


Figure 1: Presents The Key For The Measurement Scale.

Table (2): Distribution of the Sample According to Age Category

Percentage	Frequency	Age Category
55.4%	56	Less than 40
29.1%	34	40–50
11.1%	12	50–60
4.4%	8	Above 60
100%	110	Total

The study sample consisted of 110 respondents drawn from Saudi insurance companies. The selected sample size is considered adequate and statistically appropriate for the applied analytical techniques, including correlation and regression analysis, and is consistent with sample sizes adopted in prior empirical studies examining risk governance, supervisory effectiveness, and digital transformation in regulated financial institutions. Moreover, the sample size exceeds the minimum threshold commonly recommended for behavioral and organizational research, thereby enhancing the reliability and stability of the estimated parameters to ensure meaningful representation, respondents were purposively selected from roles directly involved in supervisory, managerial, risk management, and internal control functions. The distribution of participants across job roles included board members, senior and assistant managers, internal audit managers, internal auditors, and other supervisory and technical positions. This role-based distribution strengthens the study's validity, as it captures informed perspectives from individuals actively engaged in supervisory oversight and risk governance practices within insurance companies.

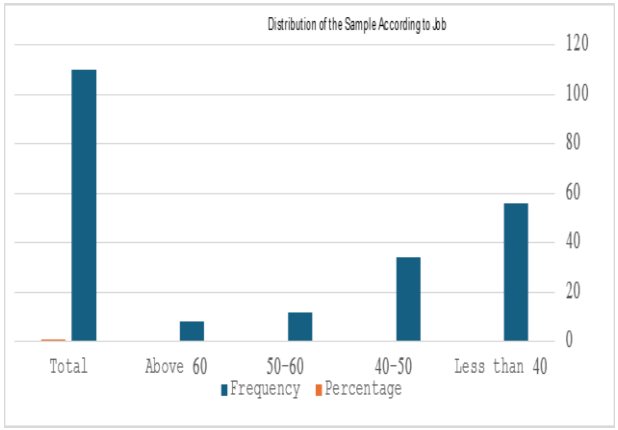
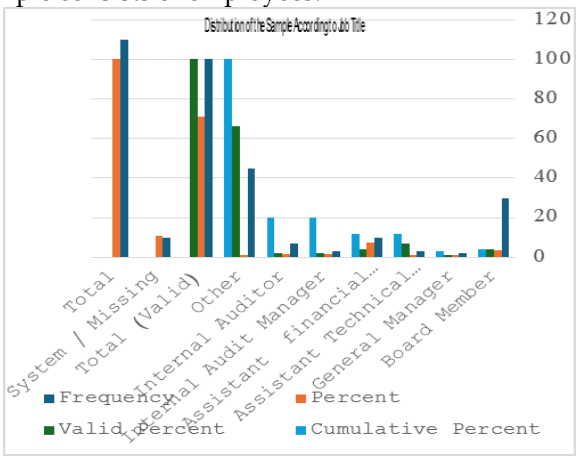


Figure 3: Distribution of the Sample According to Age Category.

Table 3: Distribution of the Sample According to Job Title.

Position / Job Title	Frequency	Percent	Valid Percent	Cumulative Percent
Board Member	18	3.5	4.0	4.0
General Manager	2	0.9	1.0	3.0
Assistant Technical Manager	3	1.3	7.0	12.0
Assistant financial Manager	10	7.5	4.0	12.0
Internal Audit Manager	3	1.8	2.0	20.0
Internal Auditor	7	1.8	2.0	20.0
Other	45	1.3	66.0	100.0
Total (Valid)	12	70.9	100.0	
System / Missing	2	11		
Total	100	100.0		

Distribution of the Sample According to Job Title The table (3) presents the distribution of the sample according to job title. It shows that the number of employees in the study sample reached 28 individuals (66.9%), 8 individuals (17.3%), 9 individuals (20%), and other job titles accounted for 15 individuals (34%). It is evident that most of the sample consists of employees.



Main Hypothesis Emerging scientific methods specifically artificial intelligence, behavioral

analytics, and modern risk governance have a positive and significant effect on organizational risk governance performance in Saudi insurance companies, mediated by supervisory skills effectiveness.

Table 4: Source: Prepared by the researcher based on field study data, 2025

statistical Measure	Value	Significance Level	Interpretation
Spearman's Correlation Coefficient (R)	0.477	0.000	Statistically significant
Coefficient of Determination (R^2)	0.267		
Calculated F-value	63.091		
Regression Coefficient (B)	0.446	0.000	Statistically significant
Calculated T-value	5.990		

H1: Artificial intelligence techniques → Supervisory skills effectiveness the path from AI techniques to supervisory skills effectiveness was positive and statistically significant, indicating that higher levels of AI adoption in supervisory and risk functions are associated with enhanced analytical capabilities, digital readiness, and decision-making quality among supervisors.

Table 5: Source: Prepared by the Researcher Based on Field Study Data, 2025.

Artificial intelligence techniques have a positive and significant effect on supervisory skills effectiveness			
Interpretation	Significance Level (p-value)	Value	Statistical Measure
Not statistically significant – –	0.000 – –	0.509	Spearman Correlation Coefficient (R)
		0.204	Coefficient of Determination (R^2)
		20.4	Calculated F-value
Not statistically significant –	0.000 –	0.556	Regression Coefficient (B)
		6.505	Calculated T-value

The table illustrates the relationship between the independent variable (artificial intelligence techniques) and the supervisory skills dimension. The Spearman correlation coefficient reached (0.509), indicating a positively significant correlation. The coefficient of determination (R^2) was (0.204), meaning that the supervisory skills principle alone explains 20.4% of the variance in artificial intelligence The results also show that the regression coefficient (B) is statistically significant, reaching (0.556) with a significance level of (0.000), which is statistically significant at the 0.04 level. The calculated T-value was (6.505) with a significance level of (0.000), also statistically significant at the 0.06 level Based on the above results, the researcher concludes that there is a statistically significant relationship between the principle of artificial intelligence and supervisory skills, meaning that the artificial intelligence principle has a positive effect on supervisory skills. This supports the hypothesis stating that there is a statistically significant relationship between artificial intelligence and supervisory skills

H2: Behavioral analytics practices → Supervisory skills effectiveness Behavioral analytics showed a strong, positive, and significant effect on supervisory skills effectiveness. This suggests that the use of behavioral data and advanced analytics to detect human-factor risks, misconduct, and compliance issues contributes directly to strengthening supervisors' ability to interpret complex behavioral patterns and intervene proactively.

Table 6: Source: Prepared by the researcher based on field study data, 2025.

Behavioral analytics practices and Supervisory skills			
Interpretation	Significance Level (p-value)	Value	Statistical Measure
Statistically significant	0.000	0.518	Spearman Correlation Coefficient (R)
–	–	0.222	Coefficient of Determination (R^2)
–	–	51.776	Calculated F-value
Statistically significant	0.000	0.983	Regression Coefficient (B)

The table illustrates the relationship between the independent variable—artificial intelligence (AI) dimension of behavioral analytics practices and the dependent variable, supervisory skills. The Spearman correlation coefficient reached (0.411), indicating a positive and statistically significant correlation. The coefficient of determination (R^2) was (0.169), meaning that behavioral analytics practices explain 16.9% of the variance in artificial intelligence The results also show that the regression coefficient (B) is statistically significant, reaching (0.357) with a significance level of (0.000), which is statistically significant at the 0.05 level. The calculated T-value was (4.684) with a significance level of (0.000), also statistically significant at the 0.05 level Based on the above findings, the researcher concludes that there is a statistically significant relationship between behavioral analytics practices and supervisory skills. In other words, improving behavioral analytics practices positively reflects on the effectiveness of

supervisory skills. This supports the hypothesis stating that behavioral analytics practices have a positive and statistically significant effect on supervisory skills effectiveness

H3: Modern risk governance approaches → Supervisory skills effectiveness Modern risk governance practices such as clearly defined oversight roles, independent control functions, and risk-based supervision were also positively and significantly associated with supervisory skills effectiveness. This confirms that governance frameworks provide the institutional structures and incentive mechanisms that enable supervisors to utilize AI and behavioral analytics effectively.

Table 7: Source: Prepared by the Researcher Based on Field Study Data, 2025.

Artificial Intelligence (AI) Governance Dimension and Supervisory Skills			
Interpretation	Significance Level (p-value)	Value	Statistical Measure
Statistically significant	0.000	0.547	Spearman Correlation Coefficient (R)
–	–	0.332	Coefficient of Determination (R^2)
–	–	17.044	Calculated F-value
Statistically significant	0.000	0.665	Regression Coefficient (B)
–	–	5.998	Calculated T-value

Table () illustrates the relationship between the independent variable—artificial intelligence (AI), specifically the governance dimension and the dependent variable, supervisory skills. The Spearman correlation coefficient reached (0.547), indicating a positive and statistically significant correlation. The coefficient of determination (R^2) was (0.332), meaning that the governance principle explains 33.2% of the variance in supervisory skills The results further show that the regression coefficient (B) is statistically significant, reaching (0.665) with a significance level of (0.000), which is statistically significant at the 0.05 level. The calculated T-value (5.998) with a significance level of (0.000) also confirms statistical significance at the 0.05 level Based on these findings, the researcher concludes that there is a statistically significant relationship between the governance principle and supervisory skills. In other words, the presence of strong governance practices positively influences the effectiveness of supervisory skills. This supports the hypothesis stating that modern risk governance approaches have a positive and statistically significant effect on supervisory skills effectiveness

Table 8: Source: Prepared by the Researcher Based on Field Study Data, 2025.

supervisory skills effectiveness to organizational risk governance performance			
Interpretation	Significance Level (p-value)	Value	tatistical Measure
Statistically significant	0.000	0.364	Spearman Correlation Coefficient (R)
–	–	0.935	Coefficient of Determination (R^2)
–	–	51.367	Calculated F-value
Statistically significant	0.000	0.887	Regression Coefficient (B)
–	–	4.766	Calculated T-value

In addition, the indirect (mediating) effects of emerging scientific methods on organizational risk governance performance through supervisory skills effectiveness—were found to be significant. This supports the main hypothesis that supervisory skills effectiveness acts as a key mediating mechanism linking AI techniques, behavioral analytics, and modern risk governance approaches to improved organizational risk governance performance

H4: Supervisory skills effectiveness → Organizational risk governance performance the path from supervisory skills effectiveness to organizational risk governance performance was positive and highly significant, supporting the core premise of the study that enhancements in supervisory competencies translate into stronger risk detection, improved compliance performance, greater transparency, and better overall governance outcomes.

Collectively, these results validate the proposed conceptual model and underscore the importance of integrating emerging scientific methods into supervisory practice to strengthen risk governance in Saudi insurance companies.

4. DISCUSSION

The empirical findings align with international literature on technology-enabled supervision and risk governance. First, the significant effect of AI techniques on supervisory skills confirms that AI is not merely an operational tool but a strategic enabler of more advanced supervisory capabilities,

especially in anomaly detection, early warning systems, and model-based risk assessments

Second, the strong effect of behavioral analytics on supervisory skills effectiveness highlights the growing importance of human-factor analysis and conduct risk in financial and insurance supervision. The results suggest that supervisors who can interpret behavioral signals and integrate them into their decision-making are better equipped to address misconduct, fraud, and cultural weaknesses

Third, the findings reinforce the central role of modern risk governance frameworks as the institutional "backbone" that makes the use of AI and behavioral analytics both effective and responsible. Robust governance structures appear to create the conditions under which supervisors can exercise their skills independently, challenge management decisions, and ensure that emerging technologies are deployed within clear accountability and risk-management boundaries

Finally, the mediating role of supervisory skills effectiveness confirms that tools alone are not sufficient; it is the combination of technology, behavioral insights, and human competence within a sound governance framework that ultimately enhances organizational risk governance performance

5. CONCLUSION

This study examined the relationships between emerging scientific methods—artificial intelligence, behavioral analytics, and modern risk governance—supervisory skills effectiveness, and organizational risk governance performance in Saudi insurance companies. Within the context of digital transformation and regulatory change, the analysis focused on how these methods are associated with supervisory capability and governance outcomes The results indicate that artificial intelligence, behavioral analytics, and modern risk governance are each positively and significantly associated with supervisory skills effectiveness. The findings also show that supervisory skills effectiveness is associated with organizational risk governance performance and functions as a mediating variable in the relationship between emerging scientific methods and governance outcomes. These relationships were observed after accounting for the measurement and structural properties of the proposed model from a research perspective. The study provides empirical evidence on the interaction between technology use, behavioral analysis, governance practices, and supervisory capabilities within the insurance sector. The proposed framework integrates these dimensions into a single analytical model, contributing to the empirical literature on insurance supervision and risk governance in emerging markets The analysis is subject to limitations related to the use of survey-based data and the focus on a single national context. Future research may extend the model to other financial sectors or jurisdictions and apply alternative research designs to further examine the observed relationships

5.1. Recommendations:

5.1.1. Recommendations for Regulators (Insurance Authority)

1- Develop a Supervisory Competency Framework for AI and Behavioral Analytics Regulators should design and issue a competency framework that specifies the skills and knowledge required for supervisors to effectively oversee AI-enabled systems and behavioral analytics tools, including model-risk management, data governance, ethical AI, and conduct-risk analysis

2- Issue Detailed Guidelines on AI and Behavioral Analytics Governance Building on IAIS, OECD, and EIOPA principles the Insurance Authority can publish technical guidance covering governance structures, validation practices, accountability, explainability, and oversight expectations for AI and behavioral analytics in insurance

3- Promote Supervisory Technology (Sup Tech) Adoption Authorities should expand Sup Tech initiatives that apply AI and behavioral analytics to their own supervisory processes (for example, early-warning systems, conduct-risk dashboards, and anomaly detection in regulatory filings) This would both improve supervisory effectiveness and signal to the market the importance of data-driven oversight

4- Encourage Regulatory Sandboxes and Innovation Hubs By expanding AI- and analytics-focused sandboxes and innovation hubs, regulators can create safe environments for testing new supervisory technologies and insurer use cases, while gradually building a library of best practices and risk-mitigation techniques

5- Align National Data and AI Policies with Insurance Supervision data-governance and AI strategies should be explicitly linked to insurance regulatory requirements, ensuring that data quality, privacy, and cybersecurity

expectations fully support AI-enabled supervision in the sector

5.1.2. Recommendations for Insurance:

1. Companies Integrate AI and Behavioral Analytics into Risk and Compliance Functions Insurance companies should move beyond pilot initiatives and embed AI and behavioral analytics directly into their risk management, compliance, and internal audit processes for example, in fraud detection, underwriting quality monitoring, and sales conduct reviews
2. Invest in Supervisory Training and Upskilling Companies should implement continuous professional development programs focused on AI literacy, data interpretation, behavioral-risk analysis, and advanced governance topics. Training should combine technical content (e.g., understanding algorithmic outputs) with practical case studies from the insurance sector
3. Strengthening Governance Structures around AI and Analytics Firms should establish clear governance mechanisms for AI and behavioral analytics, including defined roles and responsibilities, model validation committees, ethics reviews, and escalation protocols for anomalies or high-risk findings
4. Enhance Data Infrastructure and Quality Since AI and behavioral analytics are highly dependent on data quality, insurers should prioritize investments in data governance, integration, and cybersecurity, consistent with both Insurance Supervision and SDAIA requirements
5. Embed Behavioral Insights into Risk Culture Programs Behavioral analytics outputs should be linked to broader risk culture initiatives for example, using behavioral indicators to identify "hot spots" of misconduct, guide targeted training, or adjust incentive structures

5.1.3. Recommendations for Human Capital and Professional Development:

1. Create Specialized Supervisory Tracks Insurance companies, industry associations, and academic institutions should collaborate to develop specialized tracks for "AI and Analytics Supervisors" focusing on quantitative methods, behavioral science, and governance
2. Promote Certification Programs in Digital Supervision and Risk Governance Professional bodies may introduce certifications covering AI governance, behavioral-risk analytics, and advanced risk management to formally recognize and standardize supervisory competencies
3. Encourage University–Industry Partnerships between universities and insurers can support joint research projects, internships, and executive education programs aimed at building a pipeline of supervisors equipped with both theoretical and practical skills in emerging scientific methods

5.2. Limitations and Future Research

Despite the empirical and theoretical contributions of this study, several limitations should be acknowledged. First, the study relies on self-reported questionnaire data, which may be subject to response bias, including social desirability bias or respondents' tendency to overestimate the maturity of artificial intelligence adoption and supervisory capabilities within their organizations. Although this limitation is common in behavioral and organizational research, future studies could mitigate this bias by integrating objective indicators, such as regulatory assessment reports, internal performance metrics, or longitudinal supervisory evaluation data.

Second, the findings are context-specific to the Saudi insurance sector, which operates within a unique regulatory, cultural, and institutional environment. While this context enhances the relevance of the results for Saudi Arabia's insurance market and Vision 2030 reforms, it may limit the generalizability of the findings to other countries or financial sectors. Future research could extend the proposed framework through comparative cross-country studies or apply it to other regulated financial industries, such as banking or capital markets, to assess the robustness and transferability of the results.

Finally, future studies may explore additional mediating or moderating variables, such as organizational culture, regulatory pressure, or digital maturity, to further refine the understanding of how emerging scientific methods influence supervisory effectiveness and risk governance performance.

REFERENCES

(Alharbi & Muhammed, 2023) Alharbi, A., & Muhammed, S. (2023). Digital transformation and risk management practices in the insurance sector: Evidence from emerging markets. Journal of Risk and

Financial Management, 16(4), 112–129.
(Alkhaldi & Aljuaid, 2024) Alkhaldi, A., & Aljuaid, M. (2024). The adoption of artificial intelligence in Saudi financial institutions: Opportunities and supervisory challenges. International Journal of Financial Innovation, 9(1), 55–72.
(Arner & Buckley, 2017) Arner, D., Barberis, J., & Buckley, R. (2017). FinTech and RegTech: Impact on regulators and banks. Journal of Banking Regulation, 19(4), 1–14.
(Basel Committee on Banking Supervision, 2021) Basel Committee on Banking Supervision. (2021). Principles for operational resilience. Bank for International Settlements.
(Biggio & Roli, 2018) Biggio, B., & Roli, F. (2018). Wild patterns: Ten years after the rise of adversarial machine learning. Pattern Recognition, 84, 317–331.
(Black & Band, 2020) Black, J., Hopper, M., & Band, C. (2020). Making AI safe: The role of regulators in supervising AI systems. Oxford University Press.
(Brundage & Anderson, 2018) Brundage, M., Avin, S., Clark, J., Toner, H., Eckersley, P., Garfinkel, B., ... & Anderson, H. (2018). The malicious use of artificial intelligence: Forecasting, prevention, and mitigation. Oxford University. https://arxiv.org/abs/1802.07228
(Capital Market Authority, 2017) Capital Market Authority. (2017). Corporate Governance Regulations. Capital Market Authority, Kingdom of Saudi Arabia.
(Cherry Bekaert, 2025) Cherry Bekaert. (2025). AI in insurance: How to build a compliant governance framework. Cherry Bekaert LLP.
(CMS Law, 2025) CMS Law. (2025). CMS Expert Guide to Insurance: Kingdom of Saudi Arabia. https://cms.law
(Datos Insights, 2025) Datos Insights. (2025, May 8). AI risk management: How insurance companies can choose the right governance solution. Datos Insights.
(Deloitte, 2022) Deloitte. (2022). AI-enabled insurance supervision: Modernizing oversight with advanced analytics. Deloitte Insights.
(Ernst & Young, 2023) Ernst & Young. (2023). Future of insurance governance: Strengthening supervisory capabilities through digital tools. EY Global Insurance Outlook.
(European Insurance and Occupational Pensions Authority, 2021) European Insurance and Occupational Pensions Authority. (2021). Artificial intelligence governance principles. EIOPA.
(European Insurance and Occupational Pensions Authority, 2025) European Insurance and Occupational Pensions Authority. (2025, August 6). Opinion on AI governance and risk management. EIOPA.
(European Union, 2024) European Union. (2024). E.U. agrees on landmark Artificial Intelligence rules (EU AI Act). https://europa.eu/
(Financial and Insurance Services Sector Skills Council, 2025) Financial and Insurance Services Sector Skills Council. (2025). Financial and insurance services sector skills framework: Sector overview, job families and pathways. Ministry of HR & Social Development, Kingdom of Saudi Arabia.
(Financial Stability Board, 2020) Financial Stability Board. (2020). The use of supervisory and regulatory technology (SupTech and RegTech) by authorities and regulated institutions. FSB.
(Focal, 2025) Focal. (2025). What is behavioral analytics? Examples, types and tools. Focal Knowledge Base.
(Goodfellow & Papernot, 2018) Goodfellow, I., McDaniel, P., & Papernot, N. (2018). Making machine learning robust against adversarial inputs. Communications of the ACM, 61(7), 56–66.
(Hogan Lovells, 2025) Hogan Lovells. (2025, October 8). Governance and underwriting in the age of AI: A dual challenge for insurers. Hogan Lovells Publications.
(Huang & Tygar, 2011) Huang, L., Joseph, A., Nelson, B., Rubinstein, B., & Tygar, J. (2011). Adversarial machine learning. In Proceedings of the ACM Workshop on Security and Artificial Intelligence.
(International Association of Insurance Supervisors, 2004) International Association of Insurance Supervisors. (2004). Insurance core principles on corporate governance. IAIS.
(International Association of Insurance Supervisors, 2009) International Association of Insurance Supervisors. (2009). Issues paper on corporate governance. IAIS.
(International Association of Insurance Supervisors, 2019) International Association of Insurance Supervisors. (2019). Insurance Core Principles: Executive summary. IAIS. Bank for International Settlements.
(International Association of Insurance Supervisors, 2021) International Association of Insurance Supervisors. (2021). Insurance core principles, standards, guidance and assessment methodology. IAIS.
(International Association of Insurance Supervisors, 2021) International Association of Insurance Supervisors. (2021). Application paper on the use of digital technology inclusive insurance. IAIS.

(International Association of Insurance Supervisors, 2023) International Association of Insurance Supervisors. (2023). Application paper on the use of artificial intelligence and machine learning in insurance. IAIS.
(International Association of Insurance Supervisors, 2025) International Association of Insurance Supervisors. (2025, July 2). Application paper on the supervision of artificial intelligence. IAIS.
(Khan, 2025) Khan, A. M. (2025). AI governance and ethics in Saudi Arabia [Preprint]. Preprints.org.
(Kivisaari, 2013) Kivisaari, T., et al. (2013). Enterprise risk management for insurers. Toronto Centre.
(Klobuchar et al., 2023) Klobuchar, A., Thune, J., & U.S. Senate Committee on Commerce, Science, and Transportation. (2023). Bipartisan AI Bill to strengthen accountability and boost innovation. https://www.commerce.senate.gov/
(Liang, 2024) Liang, L. (2024). Generation of behavioral risk for organizational decision-makers in financial institutions. Humanities and Social Sciences Communications, 11, Article 415.
(Magee, 2019) Magee, S. (2019). Risk governance in the insurance sector—Determinants and consequences. The Geneva Papers on Risk and Insurance – Issues and Practice, 44(4), 613–645.
(McKinsey & Company, 2023) McKinsey & Company. (2023). The economic potential of generative AI: The next productivity frontier. McKinsey & Company.
(McKinsey & Company, 2024) McKinsey & Company. (2024). What matters most? Eight CEO priorities for 2024. McKinsey & Company.
(McKinsey & Company, 2025) McKinsey & Company. (2025, July 15). The future of AI in the insurance industry. McKinsey & Company.
(NICE Actimize, 2017) NICE Actimize. (2017). The emergence of behavioral analytics in financial markets (White paper). NICE Actimize.
(NICE Actimize. (n.d.). Behavioral analytics [Glossary]. NICE Actimize) NICE Actimize. (n.d.). Behavioral analytics [Glossary]. NICE Actimize.
(NIST, 2023) NIST. (2023). AI Risk Management Framework (AI RMF 1.0). National Institute of Standards and Technology.
(Norton Rose Fulbright, 2023) Norton Rose Fulbright. (2023). Transforming Saudi Arabia's insurance landscape: Establishment of the Saudi Insurance Authority. Norton Rose Fulbright.
(OECD, 2021) OECD. (2021). AI in the insurance sector: Opportunities and challenges. OECD Publishing.
(OECD, 2023) OECD. (2023). Artificial intelligence in insurance: Safety, governance, and supervisory challenges. OECD Publishing.
(OECD, 2024) OECD. (2024). Guidelines on insurance governance. Organisation for Economic Co-operation and Development.
(Papernot & Wellman, 2018) Papernot, N., McDaniel, P., Sinha, A., & Wellman, M. (2018). SoK: Security and privacy in machine learning. In IEEE European Symposium on Security and Privacy (pp. 399–414).
(PwC, 2023) PwC. (2023). Emerging technologies and the future of insurance supervision. PwC Middle East Insurance Report.
(Saudi Central Bank, 2003) Saudi Central Bank. (2003). Cooperative Insurance Companies Control Law (Royal Decree M/32). SAMA Publications.
(Saudi Central Bank, 2008) Saudi Central Bank. (2008). Risk Management Regulation for Insurance and Reinsurance Companies. SAMA Rulebook.
(Saudi Central Bank, 2014) Saudi Central Bank. (2014). Insurance Intermediaries Regulation. SAMA Rulebook.
(Saudi Central Bank, 2016) Saudi Central Bank. (2016). Insurance Corporate Governance Regulation (TA'M/92/201607). SAMA Rulebook.
(Saudi Central Bank, 2021) Saudi Central Bank. (2021). IT Governance Framework. SAMA.
(Saudi Central Bank, 2023) Saudi Central Bank. (2023). Insurance sector annual report: Digitalization, governance, and supervisory requirements. SAMA Publications.
(Saudi Central Bank, 2024) Saudi Central Bank. (2024). SAMA compliance for insurance companies: A complete guide [Regulatory overview]. IT Butler.
(Saudi Central Bank. (n.d.). Corporate governance (Implementing regulations of the Cooperative Insurance Companies Control Law). SAMA Rulebook) Saudi Central Bank. (n.d.). Corporate governance (Implementing regulations of the Cooperative Insurance Companies Control Law). SAMA Rulebook.
(Saudi Central Bank. (n.d.). Risk management regulation (Insurance and reinsurance companies). SAMA Rulebook) Saudi Central Bank. (n.d.). Risk management regulation (Insurance and reinsurance companies). SAMA Rulebook.

(Saudi Data & AI Authority, 2024) Saudi Data & AI Authority. (2024). Digital transformation measurement 2024. SDAIA.

(Saudi Insurance Authority & Itmam, 2025) Saudi Insurance Authority & Itmam. (2025). Overview of KSA insurance sector. Insurance Authority Report.

(Saudi Insurance Authority, 2023) Saudi Insurance Authority. (2023). Mandate and establishment of the Saudi Insurance Authority. Government of Saudi Arabia.

(Tchernykh & Camacho, 2022) Tchernykh, A., Bessis, N., & Camacho, R. (2022). Behavioral analytics for risk detection in financial and insurance institutions: A systematic review. Expert Systems with Applications, 205, 117–145.

(The White House, 2023) The White House. (2023). Executive Order on the Safe, Secure, and Trustworthy Development and Use of Artificial Intelligence.

(Thinslices, 2024) Thinslices. (2024, May 16). Behavioral analytics for fraud prevention in banking apps. Thinslices.

(Thomson Reuters, 2021) Thomson Reuters. (2021, March 18). Behavioral science gains traction as more banks seek to mitigate risk. Thomson Reuters Institute.

(Tookitaki, 2023) Tookitaki. (2023). Fraud prevention and detection: Strategies for financial institutions. Tookitaki Compliance Hub.

(U.S. Congress, 2024) U.S. Congress. (2024). The Artificial Intelligence (AI) Literacy Act. https://www.congress.gov/

(U.S. Securities and Exchange Commission, 2023) U.S. Securities and Exchange Commission. (2023). SEC proposes new requirements to address risks to investors from conflicts of interest associated with the use of predictive data analytics by broker-dealers and investment advisers. U.S. SEC.

(U.S. Securities and Exchange Commission, 2023) U.S. Securities and Exchange Commission. (2023). SEC probes investment advisers' use of AI. U.S. SEC.

(World Bank, 2009) World Bank. (2009). Insurance governance and risk management: A toolkit for regulators and supervisors. World Bank.

(World Bank, 2019) World Bank. (2019). How can financial supervisors improve the governance of financial institutions? World Bank Publications.

(World Economic Forum, 2020) World Economic Forum. (2020). Cybersecurity in the insurance industry. World Economic Forum Reports.