Contents lists available at Scopus

ECONOMICS - Innovative and Economics Research Journal

Journal homepage: www.economicsrs.com

INTERNAL CONTROL SYSTEMS AND TECHNOLOGICAL CAPABILITIES AS DRIVERS OF BANK RISK MANAGEMENT FOR ADVANCING SUSTAINABLE DEVELOPMENT GOAL 16

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Received 18.10.2025. | Sent to review 10.11.2025. | Accepted 23.02.2026.

Original article

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JEL Classification:
M42, G21, M15, C83

Doi: 10.2478/eoik-2026-0012

UDK: 351.822:[657.6+336.71

ABSTRACT

We thus conduct this study to investigate the contribution of both internal control systems and technological capabilities on bank-wide risk management and its effect on institutional transparency, and towards SDG 16 (Sustainable Development Goal). Based on data from 448 senior managers of 26 commercial banks in Vietnam, this study utilizes Partial Least Squares Structural Equation Modelling to analyse the relationships among various internal control elements, technological integration, risk management, and institutional outcomes. We found that all five elements of the internal control mechanism help enhance risk management. For monitoring, it has the strongest effect, followed in the order of information and communication, control activities, control environment, and risk assessment. The big data capability has little effect on the application of artificial intelligence, but the application of artificial intelligence does have a real impact on risk management. The research also suggests that risk management contributes to the SDG directly and to institutional transparency. Institutional transparency, in addition, contributes positively to SDG as well as being a partial mediator between risk management and SDG. These results indicate that enhancements in internal control mechanisms and adoption of technology enhance risk governance, resulting in more institutional transparency and advancement towards SDG. The study adds to the literature by explaining how risk management and transparency link and contribute towards sustainable development in banking. It also has implications for the policymakers and banking executives who wish to enhance institutional integrity and resilience in emerging economies.

Keywords: *Artificial intelligence, Audit; Big data analytics, COSO framework, Internal control systems, Risk management, SDG16, Vietnamese banking sector*

1. INTRODUCTION

Sustainable Development Goal 16 (SDG16) focuses on peace, justice and strong institutions as one of the objectives of the 2030 Agenda (Nayal et al., 2023). Within a framework such as that outlined above, the banking system is of particular significance for promoting efficient financial intermediation, fostering economic growth and consolidating governance. With sound inter-

nal controls and risk management, banks can improve accountability, transparency and public confidence. All these contribute to the institutional fortitude necessary for achieving SDG16 (Kashyap & Iveroth, 2021). Institutional transparency has become a key governance condition connecting a sound risk management approach with institutional integrity and sustainable development results more generally (Adeniran et al., 2024).

Risk in banking is based on internal control systems that are comprehensively constructed by the COSO framework (Mohammed et al., 2021). The five elements; control environment, risk assessment, control activities, information and communication and monitoring offer a systematic approach for identifying and mitigating risks. From a resource-based perspective, risk management capabilities are seen as strategic resources creating sustained competitive advantage (Mishra et al., 2019). The dynamic capability perspective accentuates further that banks utilize technologies like artificial intelligence (AI) and big data to refine their resources, manage new risks and extract new opportunities (Nisar et al., 2023). These perspectives argue that internal controls and technological capabilities act as both compliance mechanisms and dynamic enablers of transparency, accountability and long-term institutional resilience. But only as these tools translate into real improvement in risk management, which brings increased institutional transparency.

For the SDGs, it is becoming clear that risk management can play an important role in enhancing the contribution to SDG16 through reducing corruption risks, increasing transparency and enhancing accountability (Mugellini & Villeneuve, 2019). However, evidence on the joint role of internal control systems and digital technologies in influencing these results is not yet rigorous and mixed. Some studies suggest strong positive governance impacts, while others report weak or indirect effects, especially in developing economies where institutional maturity is lower (Indriyani et al., 2024; Aziz et al., 2025). While AI and big data have shown strong promise in fraud detection and credit scoring, the wider institutional side-effects are still poorly understood, and likely disparate results. Such discrepancies highlight the importance of further empirical exploration.

The Vietnamese banking system offers a particular context. With Vietnam's increasing economic diversification and digital transformation, it presents both opportunities and challenges for banks that want to enhance its risk management (Hoque et al., 2024). While insolvency, credit and operational risks have decreased, deficits exist in resource allocation, supervisory practices and responsiveness (Le & Nguyen, 2024). Governance mechanisms, such as audit committee independence and expertise, impact risk management effectiveness significantly and vary considerably depending on committee size and type of risk (Nguyen & Dang, 2022). The advent of digital transformation, which can lead to increasing levels of automation, cybersecurity and data analytics is accompanied by the emergence of new security risks such as cyber threats, data security and third-party dependency (Vu & Pham, 2024). Nevertheless, there exists a scarce amount of evidence regarding how the integrated role of internal controls and digital technologies supports effective risk management alongside risk governance towards the realization of SDG16 in Vietnam, especially with respect to the mediating role of institutional transparency.

This study fills these gaps and fills the previous gaps in research by reviewing the combined impact and effects of different approaches to bank risk management between the internal control system using COSO based internal control system, technological capabilities and the perspectives of the resource-based and dynamic capabilities and the bank risk management. It also examines on the one hand, the role of risk management in driving institutional transparency to enhance risk management and on the other hand, how transparency mediates the connection between risk management and SDG16. The present study contributes to this research in two main directions. First, it provides empirical evidence that transparency is mediating between risks and institutional resilience, showing how transparency can be considered a route to the

latter. Second, it constitutes one of the first co-occurring investigations within the Vietnamese banking sector of AI and big data, which adds an empirical dimension to the literature on digital transformation and governance in underdeveloped countries. The study contributes theoretically and practically to the building of resilient, transparent and sustainable financial institutions by combining the internal control, resource-based and dynamic capability perspectives.

The rest of this article consists of Section 2 presenting the theoretical framework and hypotheses; Section 3 describing methodology; Section 4 providing the empirical results; Section 5 presenting the findings; Section 6 including limitations and future directions for research.

2. LITERATURE REVIEW AND THEORETICAL FRAMEWORK

2. 1. CONTROL ENVIRONMENT AND RISK MANAGEMENT

The COSO framework serves as an institutionalised normative grounding for internal control and risk governance, directing organizations how to systematically identify, assess, and address risks in an open and accountable fashion (Kazan & Kocamış, 2023). In this framework, the Control Environment forms the focus, and includes leadership commitment, organizational culture and structure, and human resource policies that define how risks are perceived and managed (Zahari et al., 2024). Structural Equation Modeling (SEM), we use it to explore these relationships in this study. A good Control Environment promotes a risk-aware atmosphere and ties internal control processes to risk-mitigation objectives, and so lays down a solid base for the successful management of risk. Literature is also consistent in showing that a robust Control Environment supports the potential for better risk management. For example, Taherdoost (2018) demonstrates that organizations with strong control environments are more likely to prevent fraud, manage operational risks, and realize enhanced performance. Moreover, by integrating risk management into operations daily, the organisation encourages proactive rather than reactive risk handling. Drawing on this evidence, this study postulates that:

H_1: A robust control environment positively influences the effectiveness of risk management.

2. 2. RISK ASSESSMENT AND RISK MANAGEMENT

Risk Assessment is an essential element of the COSO framework and determines the way in which an enterprise would be able to establish, assess and control risk using various ways of systematically identifying and analysing risks and their effects, and then deciding how to address them (Kazan & Kocamış, 2023). Efficient risk management drives from responding to, to thinking about taking informed, proactive actions on potential risks. Empirical insights have demonstrated that the value of a holistic risk assessment is strategic in nature. Moschella et al. (2023) show that strong assessment processes enhance understanding of risk exposure, thereby enhancing an organization's abilities to mitigate risks. This helps organizations make risk management strategies more targeted and effective by defining potential threats. Thus, this study hypothesizes that:

H_2: Systematic and comprehensive risk assessment practices significantly enhance risk management.

2. 3. CONTROL ACTIVITIES AND RISK MANAGEMENT

Control Activities, according to the COSO framework, are policies, procedures, and practices that enable companies to properly implement internal controls at all levels of the company. These actions are critical to avoiding mistakes, anomalies, fraud, and inefficiencies, and they contribute directly to the overall risk management process (Hashim et al., 2020). Control Activities work by embedding controls into the day-to-day operations of business. It has emerged

empirically that well-defined and implemented Control Activities play an important role in the control of financial, operational, and compliance risks. According to Mikhael et al. (2020), companies that include structured Control Activities not only have reduced instances of fraud and errors, but they are also more efficient at managing risk. This is consistent with the notion that Control Activities are a critical tool in bolstering risk management mechanisms. Thus, drawing upon this evidence base, we put forward the following hypothesis:

H_3: Well-designed and effectively implemented control activities significantly contribute to strengthening risk management.

2. 4. INFORMATION AND COMMUNICATION AND RISK MANAGEMENT

Information and Communication systems are crucial for the timely and accurate flow of information across the organization, ensuring that decision-makers have access to the information needed to manage risks (Igwe-nmaju, 2025). Effective Information and Communication systems, as one of the steps laid out in the COSO framework, ensure that relevant risk-related data reaches all levels of the organization (Chan et al., 2021). This transparency helps organizations proactively address risks and respond swiftly to emerging threats. Several studies have emphasized the importance of Information and Communication in risk management. Mikalef et al. (2019) argue that organizations with robust communication systems are more likely to manage risks effectively, as these systems facilitate the rapid sharing of information across departments. When risk-related information flows seamlessly to decision-makers, it enables them to take timely action and reduce the potential impact of emerging risks (Courage Oko-Odion & Omogbeme Angela, 2025). Thus, the following hypothesis is proposed:

H_4: Effective information and communication systems positively influence the overall effectiveness of risk management.

2. 5. MONITORING AND RISK MANAGEMENT

Monitoring, as outlined in the COSO framework, involves the ongoing evaluation of the effectiveness of internal controls and risk management processes. Regular monitoring activities ensure that risk management practices remain aligned with organizational objectives and adapt to changing circumstances (Settembre-Blundo et al., 2021). Monitoring also provides valuable feedback on the performance of internal controls, enabling organizations to make necessary adjustments and improvements.

Empirical evidence supports the role of monitoring in enhancing risk management. COSO framework highlights that effective monitoring activities help organizations identify emerging risks and adapt their risk management strategies accordingly. Regular evaluations of internal controls ensure that the organization remains compliant with regulations while continuously improving its ability to manage risks (Nwachukwu et al., 2024). Research further shows that Monitoring activities enhance an organization's ability to respond to dynamic risk environments and contribute to the continuous improvement of risk management strategies (Dahmen, 2023). Therefore, the final hypothesis is:

H_5: Continuous monitoring of internal controls significantly enhances the long-term effectiveness of risk management.

2. 6. BIG DATA CAPABILITY AND AI APPLICATION

This is where the Dynamic Capabilities View comes in to assist (Anning-Dorson et al., 2025) banks, which can exploit and revamp technology stacks like AI and big data analytics that help solidify risk governance while keeping pace with the evolution of their environment. Big Data capability represents a strategic technological resource enabling data-led decision-making and AI implementation. Banks can integrate and reconfigure Big Data resources from the Dynamic Capabilities View perspective to enhance AI applications (Anning-Dorson et al., 2025). According to Hou et al. (2020), Big Data enables the collection, processing, and analysis of vast amounts of structured and unstructured data from multiple sources, providing a foundation for AI algorithms. Big Data enables pattern recognition, anomaly detection, and trend analysis in real time, according to empirical evidence, and as such it enhances forecasting accuracy, risk identification, and decision quality (Mikalef et al., 2019). Rooted in these theoretical and empirical implications, the following are suggested by this study:

H_6: Big Data capability positively influences the extent of AI application.

2. 7. AI APPLICATION AND RISK MANAGEMENT

AI has become a pivotal technology for transforming risk management practices. AI offers significant potential in areas such as fraud detection, operational forecasting, and credit risk modelling (Oko-odion, 2025). Through its predictive analytics capabilities, AI enhances the ability to assess, monitor, and manage risks in real time. AI applications allow for more precise identification of emerging risks, better response optimization, and improved decision-making (Diameh et al., 2025). AI systems, by analysing large datasets and predicting future trends, enable institutions to proactively manage risks and improve their overall risk management efficiency. The ability of AI to learn from historical data and adapt its models accordingly allows for more accurate risk assessments and timely intervention (Assessment & Olukoya, 2025). This technological advancement enhances organizational resilience by offering solutions that anticipate potential risks and facilitate quicker responses.

According to the Dynamic Capabilities View, organizations are equipped with dynamic capabilities that allow them to sense emerging risks, seize opportunities for risk mitigation, and reconfigure their strategies in alignment with technological advances (Sen et al., 2020). Given AI's role in improving risk management capabilities, it can be hypothesized that AI positively influences the effectiveness of risk management.

H_7: AI application positively influences risk management effectiveness.

2. 8. RISK MANAGEMENT, INSTITUTIONAL TRANSPARENCY AND SUSTAINABLE DEVELOPMENT GOAL 16 ACHIEVEMENT

In the COSO framework, effective risk management promotes transparency and accountability in organizations by systematically identifying, evaluating, and mitigating risks (Kazan & Kocamış, 2023). Open reporting of the risk enables the communication of potential threats and appropriate control methods to internal and external stakeholders, increasing institutional authority. Chan et al. (2021) posits that structured risk management increases information sharing, and Courage Oko-Odion and Omogbeme Angela (2025) argue that governance structures and control systems also make institutional information more easily digestible as well as clear to the public. From a COSO angle and SDG16 aspect, thus effective risk management serves as an important antecedent to the transparency of governance.

Transparency of institutions is core to SDG16, which is focused on accountability, equality, and

transparency in governance. The work of Efunniyi and Abhulimen (2024) shows that transparent disclosure builds stakeholder trust, accountability, and governance efficiency by fostering accountability, and therefore, transparency and accountability. Similarly, Araz et al. (2020) argue that transparency contributes to knowledge of the legitimacy of evidence-based decisions, decreases corruption and increases the institutional legitimacy-key aspects of SDG16. Including COSO, the natural resource-based view and SDG16 perspective in the discussion, transparency and governance development emerge as a governance outcome as well as a strategic resource for banks towards sustainability and accountability standards.

Risk management plays a vital role to achieve SDG16 by building robust and accountable institutions. In financial institutions, COSO-assisted risk management protects against corruption problems, enhances governance standards, and provides institutional adaptability (Chan et al., 2021; Adeniran et al., 2024). Several studies have already shown that strong risk management systems enhance ethical governance and decrease the risk of financial crises and contribute to the preservation of the integrity of institutions and thereby to the attainment of SDG16 (Courage Oko-Odion & Omogbeme Angela, 2025).

Although risk management enhances internal governance, its influence on SDG16 outcomes is mediated through institutional transparency. Sunaryo et al. (2025) argue that these benefits of risk management occur when organizations release information and remain accountable. Hassani et al. (2021) and Bogataya et al. (2022) add that transparency disseminates risk controls to stakeholders, improves institution reputation, and contributes to fulfilling SDG16 principles of integrity and justice. Thus, transparency is viewed as the fundamental channel through which internal risk management governance and institutional sustainability are linked.

Drawing on this structure, the proposed study presents the following hypotheses:

H_8: Risk management positively affects institutional transparency.

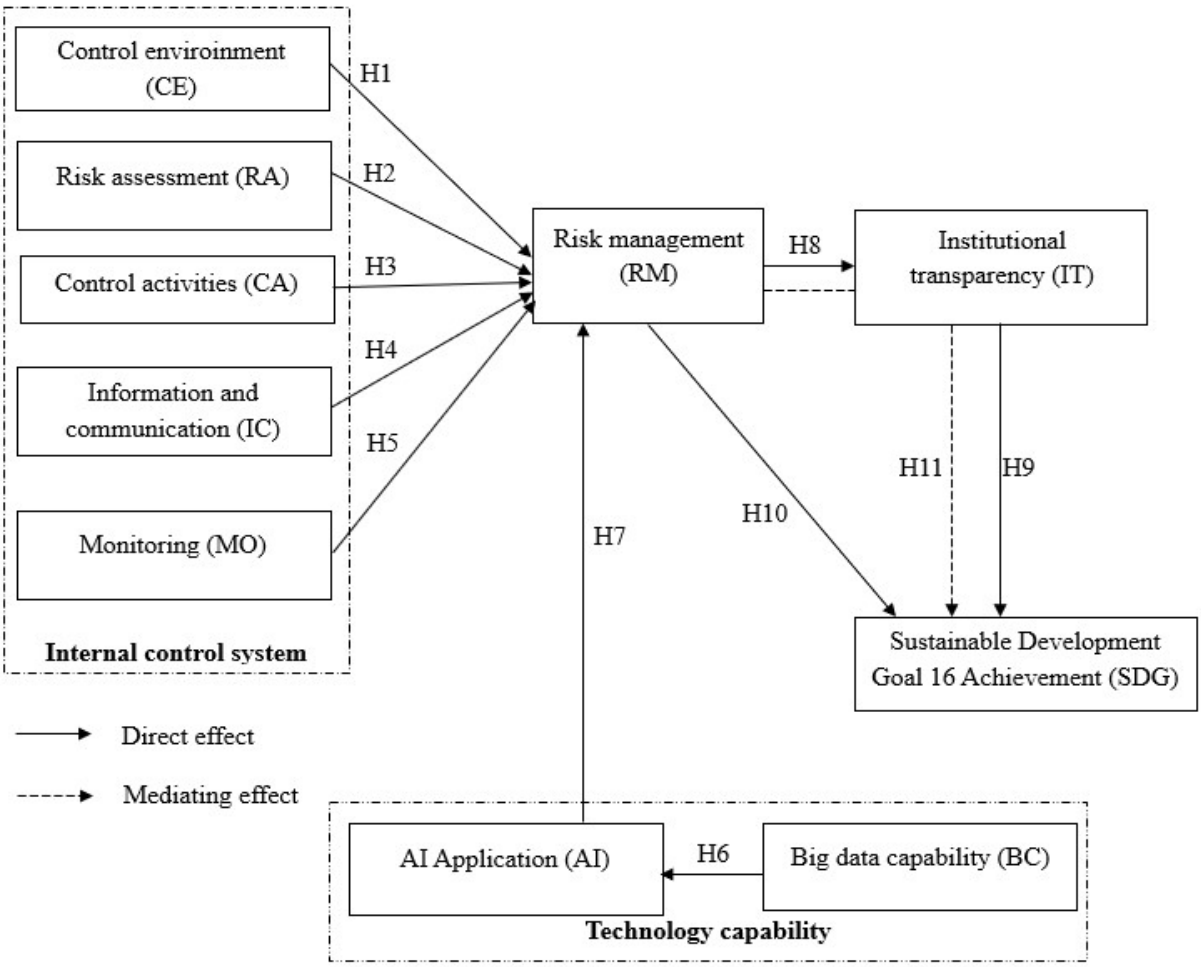
H_9: Institutional transparency positively affects the attainment of SDG16.

H_{10}: Risk management positively influences the achievement of SDG16.

H_{11}: Institutional transparency mediates the relationship between risk management and the achievement of SDG16.

Based on these relationships, the research model explains that internal control structures and technological capacity improve banking risk management, which further fosters institutional transparency and promotes SDG16. Figure 1 presents the proposed framework of relationships in the fields of big data capability, application of AI, risk management, institutional transparency, and SDG16 on direct and indirect dimensions.

Figure 1. Proposed research model



Source: Authors own work

3. RESEARCH METHOD

3. 1. MEASUREMENT SCALES

To assess the constructs, we adapted existing scales from the literature and measured all items utilizing a 7-point Likert scale from 1 (strongly disagree) to 7 (strongly agree), which allowed for a finer separation among the respondents' perceptions. The Control Environment (CE) construct was measured using eight items (Tanbour et al., 2025) such as internal control enhancement and organizational structure alignment, recruitment policy clarity, and employee training to explore how organizational culture and leadership shapes risk management. The Risk Assessment (RA) scale contained eleven items (Tanbour et al., 2025), consisting of clarity of objectives, risk identification and response strategies as well as fraud risk evaluation and reporting of unacceptable risk levels. Control Activities (CA) were assessed with nine items (Tanbour et al., 2025) that focused on task segregation, the restriction of manual interventions, administrative procedure clarity, and internal audit activities. The Information and Communication (IC) scale assessed effectiveness of internal communication, and the timely sharing of risk information was completed using eight items (Tanbour et al., 2025). Monitoring (MO) was assessed with seven items measuring audit independence, fraud control and continuous assessment of internal control systems (Tanbour et al., 2025). The AI Application (AI) construct was evaluated with nine items (Al Qudah et al., 2025) focusing on AI's use functions in risk modelling, in real-time

oversight, and predictive analytics for reduction of risk. RM was evaluated with six items (Al Qudah et al., 2025) that represents proactive risk checking and control measures. The achievement of SDG 16 (SDG) was assessed using three items (Malik et al., 2025) indicating peace, justice, strong institutions and accountability. Big Data Analytics Capabilities (BD) were measured by 5 items (Dubey et al., 2019) as a reflection of how extensively advanced analytical tools or integrated multi-source data. Finally, Institutional Transparency (IT) which was measured with three items (Rodriguez-Saavedra et al., 2024) focused on clarity, openness and accessibility of organizational information and the institution's organizational accountability to stakeholder.

3. 2. DATA COLLECTION

Data were collected using a structured questionnaire distributed to senior managers and professionals involved in risk management, AI application, and Big Data analytics across 26 banks. The sample was selected using a random sampling method, which ensured a diverse representation of banking institutions. This method enabled the inclusion of banks of different sizes and types, which helps ensure the sample was representative of the broader banking sector. The participants were selected from professionals who play key roles in managing risk and utilizing technological advancements in their respective banks. The questionnaire comprised both closed-ended questions and 7-point Likert scale items, designed to assess participants' perceptions of the various constructs. This approach ensured a comprehensive understanding of the factors influencing risk management and SDG 16 achievement from the perspectives of individuals actively involved in these areas.

3. 3. DATA ANALYSIS METHOD

The data were analysed using Partial Least Squares Structural Equation Modelling with SmartPLS software. PLS-SEM techniques were chosen as they are appropriate for complex models with a combination of latent factors, they do not need normally distributed data and are well-suited for prediction-based studies and mediation modelling (Hair et al., 2021). The analysis was conducted according to the conventional two-step protocol. The measurement model was first evaluated among the indicator loadings, Cronbach's Alpha, Composite Reliability and Average Variance Extracted in a reliability and convergent analysis to ensure valid outcomes. Discriminant validity was measured according to HTMT criterion. Secondly, the structural model was tested by estimating path coefficients and their impact using bootstrapping over 5000 subsamples. Exploratory power and predictive importance of the model were assessed using R^2, f^2 and Q^2 scores, while VIF scores were checked to eliminate multicollinearity. Before the start of conducting the main survey, a pilot study was performed to improve the measurement instruments and verify their reliability and validity. The participants included 26 representative banks from Vietnam's banking system. Respondents were from a range of top functional areas like risk management, internal audit, compliance, IT, and data analytics to reach out expertise. After data filtering, 448 responses were retained with a 97.6% response rate. Sample size reached the recommended threshold according to Hair et al. (2019) and the "10-times rule," which gave us enough statistical power. To minimize common method bias, both procedural and statistical procedures were used. Anonymity was guaranteed, with predictor and outcome items being separated whenever possible. No bias was found through Harman's single-factor test and full-collinearity variance inflation factor analysis (Kock, 2015) because all VIF values were below the thresholds accepted. Using a marker-variable method for additional checks also provided a further confirmation of the absence of bias.

4. RESEARCH RESULTS

The study participants included 58% men and 42% women. Most participants (69.6%) were aged between 31 and 50. Over 46% of the participants held postgraduate qualifications. Participants worked in risk management, audit, compliance, IT, data analytics, and operations. Most respondents (85.7%) had more than five years of professional experience. Half of the participants reported over ten years of experience. The survey was conducted across 26 out of 38 commercial banks, including most large and mid-sized banks that play a leading role in the market. The total assets of these 26 banks account for approximately 76% of the total assets of all commercial banks in Vietnam, indicating broad coverage and a strong reflection of the sector's overall characteristics. Therefore, the sample can be considered representative of the Vietnamese commercial banking system.

Table 1. The measurement model assessment results

Variable code	Items	Loading	Cronbach Alpha	Rho_A	AVE	VIF
Control environment (CE) (Tanbour et al., 2025)						
CE1	Enhancement of internal control	0.747	0.801	0.817	0.524	2.263
CE2	Alignment of organizational structure	0.824				2.004
CE3	Clarity of recruitment policy	0.746				1.653
CE4	Development of strategic plans	0.755				1.796
CE5	Employee training policies	0.835				1.999
CE6	Code of ethics and integrity	0.830				2.727
CE7	Clarity of job descriptions	0.786				2.743
CE8	Specialized staff knowledge	0.747				1.900
Risk assessment (RA) (Tanbour et al., 2025)						
RA1	Clarity of objectives	0.801	0.840	0.856	0.522	2.556
RA2	Identification of risks	0.767				2.831
RA3	Response to potential risks	0.723				2.705
RA4	Evaluation of fraud risks	0.870				1.847
RA5	Assessment of occupational fraud risks	0.803				2.895
RA6	Risk reporting to the board	0.887				1.065
RA7	Assessment of fraud exposure	0.783				1.919
RA8	Evaluation of external risks	0.717				1.954
RA9	Approval of risk assessments	0.756				1.175
RA10	Discussion of high-risk acceptance	0.767				1.885
RA11	Reporting of rejected risk levels	0.784				2.319
Control activities (CA) (Tanbour et al., 2025)						
CA1	Reasonable division of tasks	0.872	0.851	0.873	0.610	1.923
CA2	Limitations of manual interventions	0.899				2.494
CA3	Clarity of administrative procedures	0.860				2.627
CA4	Monitoring of employee living standards	0.857				1.067
CA5	Comparison of performance with budgets	0.775				1.354
CA6	Delegation of authority	0.871				2.222
CA7	Monitoring of strategic plan results	0.865				1.684
CA8	Internal audit of controls and risks	0.806				1.299
CA9	Integration of control activities into daily duties	0.767				1.228

Variable code	Items	Load-ing	Cronbach Alpha	Rho_A	AVE	VIF
Information and communication (IC) (Tanbour et al., 2025)						
IC1	Strategic plan for information systems	0.809	0.840	0.842	0.605	1.839
IC2	Generation of performance reports	0.862				1.109
IC3	Provision of timely information	0.742				2.445
IC4	Customer communication channels	0.857				1.729
IC5	Employee access to necessary information	0.889				1.697
IC6	Communication system effectiveness	0.870				1.619
IC7	Feedback mechanisms	0.876				1.253
IC8	Fraud reporting hotline	0.800				1.849
Monitoring (MO) (Tanbour et al., 2025)						
MO1	Evaluation of fraud controls	0.885	0.837	0.851	0.625	1.870
MO2	Reporting of violations	0.902				2.351
MO3	Enhancement of audit independence	0.890				2.522
MO4	Independence of internal audit	0.770				2.266
MO5	Reporting of control deficiencies	0.870				2.176
MO6	Internal audit support for the branch needs	0.836				2.582
MO7	Reduction of fraudulent practices	0.797				2.368
AI Application (AI) (Al Qudah et al., 2025)						
AI1	Feasibility assessment	0.845	0.829	0.849	0.538	2.528
AI2	Comprehensive data analysis	0.838				2.578
AI3	Automation of routine tasks	0.817				2.503
AI4	Optimization of scheduling and resources	0.833				2.528
AI5	Risk modeling for mitigation	0.798				1.923
AI6	Alternative project planning	0.705				2.494
AI7	Real-time project monitoring	0.791				2.627
AI8	Real-time risk tracking	0.790				1.067
AI9	Predictive analytics for delays	0.763				2.354
	Risk management (RM) (Al Qudah et al., 2025)					
RM1	Early budget identification	0.806	0.898	0.900	0.666	2.055
RM2	Proactive cost estimation	0.886				1.566
RM3	Cost control and monitoring	0.885				1.267
RM4	Timely risk assessment	0.777				1.998
RM5	Proactive scheduling	0.820				2.217
RM6	Real-time delay monitoring	0.706				1.520
Sustainable Development Goal 16 Achievement (SDG) (Malik et al., 2025)						
SDG1	Promoting inclusive and peaceful communities	0.807	0.837	0.836	0.658	2.288
SDG2	Ensuring equal access to justice	0.825				2.647
SDG3	Reducing violence, corruption, and money laundering	0.773				2.369

Variable code	Items	Loading	Cronbach Alpha	Rho_A	AVE	VIF
Big data analytics capabilities (BC) (Dubey et al., 2019)						
BC1	Use of advanced analytical tools	0.808	0.868	0.893	0.712	2.528
BC2	Multi-source data utilization	0.880				2.578
BC3	Data visualization for decision-making	0.803				1.503
BC4	Diagnostic dashboards	0.882				2.528
BC5	Connected dashboard applications	0.840				1.903
	Institutional transparency (IT) (Rodriguez-saavedra et al., 2024)					
IT1	Publication of audit results	0.861	0.882	0.883	0.708	1.592
IT2	Perceived transparency in institutional environmental processe	0.725				2.148
IT3	Clarity of audited procedures for relevant stakeholders	0.825				2.614

Source: Authors own work

The measurement model assessment results in Table 1 indicate that all scales employed achieved reliability and convergent validity. Specifically, most observed variables had factor loadings above 0.7, ensuring statistical significance. The Cronbach's Alpha and Rho_A coefficients ranged from 0.813 to 0.900, surpassing the acceptable threshold of 0.7 and reflecting strong internal consistency. At the same time, the AVE values for all constructs were above 0.5, demonstrating that the latent variables adequately explained the variance of their indicators. These findings confirm the reliability and convergent validity of the measurement model.

Table 2. HTMT results

	AI	BC	CA	CE	IC	IT	MO	RA	RM
BC	0.277								
CA	0.238	0.337							
CE	0.141	0.370	0.144						
IC	0.117	0.078	0.128	0.209					
IT	0.066	0.072	0.125	0.082	0.214				
MO	0.211	0.673	0.222	0.405	0.232	0.163			
RA	0.390	0.152	0.093	0.201	0.346	0.054	0.224		
RM	0.115	0.547	0.170	0.398	0.160	0.047	0.759	0.238	
SDG	0.194	0.571	0.298	0.358	0.133	0.091	0.588	0.195	0.615

Source: Authors own work

The HTMT results presented in Table 2 indicate that all values are below the 0.85 threshold, confirming adequate discriminant validity among the constructs. The highest correlation is observed between Risk Management and Monitoring (0.759), which is strong but still acceptable. Overall, the results show that the constructs are sufficiently distinct, and no issues of multicollinearity or conceptual overlap are detected.

Table 3. The results of the structural model evaluation

Hypothesis	Relationship	Path	t-value	p-value	Conclusion
H_1	Control environment → Risk management	0.156	2.480	0.009	Confirm
H_2	Risk assessment → Risk management	0.104	2.217	0.027	Confirm
H_3	Control activities → Risk management	0.158	2.389	0.005	Confirm
H_4	Information and communication → Risk management	0.267	4.563	0.000	Confirm
H_5	Monitoring → Risk management	0.802	27.255	0.000	Confirm
H_6	Big data capability → AI Application	0.056	1.480	0.139	No confirm
H_7	AI Application → Risk management	0.130	3.816	0.000	Confirm
H_8	Risk management → Institutional transparency	0.112	2.228	0.008	Confirm
H_9	Institutional transparency → Sustainable Development Goal 16 Achievement	0.169	2.062	0.007	Confirm
H_{10}	Risk management → Sustainable Development Goal 16 Achievement	0.536	11.977	0.000	Confirm
H_{11}	Risk management → Institutional transparency → Sustainable Development Goal 16 Achievement	0.056	2.168	0.030	Confirm

Source: Authors own work

In Table 3, each of the five aspects of the COSO framework were shown to have a significant effect on risk management effectiveness. More precisely, the control environment (H1: $\beta = 0.156$, $p < 0.01$), risk assessment (H2: $\beta = 0.107$, $p < 0.05$), control activities (H3: $\beta = 0.177$, $p < 0.01$), and information and communication (H4: $\beta = 0.156$, $p < 0.01$) all exert important effects. These findings confirm past research that prioritizes an ethical culture, proactive risk identification, and structured controls as key to more robust governance processes (Bracci & Tallaki, 2021). Whereas control activities and risk assessment have often been noted as both a top determinant of the effect of financial risk variables on performance in developed economies (Naili & Lahrichi, 2022; Rikhardsson et al., 2021), monitoring seems to be the most important one in the Vietnamese banking context. This disparity indicates that underdeveloped governance systems in emerging economies will depend more on continuous oversight to secure institutional resilience. Notably, monitoring turned out to be the most critical feature for control effectiveness (H5: $\beta = 0.847$, $t = 18.655$, $p < 0.001$), indicating that monitoring plays an important supporting role in ensuring control systems are adaptable and transparent to contribute to operational goals of organizations. This reinforces the framework of the COSO, stating that continuous oversight is essential for effective risk governance. How it works, however, could be attributed to the fact that Vietnamese banks operate on a regulatory regime in which maturity of their governance is still evolving. In such a context monitoring continuously makes up for shortcomings of other control devices by verifying compliance, discovering fraud early and maintaining accountability. In contrast to developed countries, in which the institutional protections are more robust, the monitoring mechanism becomes the key instrument to establish the transparency and to allow to be flexible governance practice in face of rapid changes in Vietnam. As a comparison, our results with findings in developed economies (where the role of control functions or risk assessment often plays a dominant role) indicate a unique contextual trend in Vietnamese banking sector, which means that less mature governance environments tend to depend too heavily on systematic surveillance for effectively managing risk. For stability and reliability of these empirical results, a series of robustness checks was performed. For the analysis, bootstrapping

performed 5,000 repetitions to see if path coefficients stayed significant and consistent between samples. Results indicated that all significant relationships maintained their magnitude and significance, confirming stable effects. The analysis additionally confirms that technological capabilities, specifically AI, positively affect the effectiveness of risk management (H7: $\beta = 0.130$, $t = 3.816$, $p < 0.001$). Big Data capability didn't have an immediate positive impact on applying AI in this situation (H6: $\beta = 0.056$, $t = 1.480$, $p > 0.05$) but still integration of AI with risk management is essential. This leads to the dynamic abilities perspective where technology resources are not enough without the integration into organisational habits and governance systems (Anning-Dorson et al., 2025). AI can aid in predictive analytics, detection of fraud, and operational forecasting, thereby increasing risk visibility and decision-making quality.

Regarding SDG, the results confirm that risk management positively influences institutional transparency (H_8: $\beta = 0.112$, $t = 2.228$, $p < 0.01$), which in turn promotes SDG (H_9: $\beta = 0.169$, $t = 2.062$, $p < 0.01$). Moreover, risk management directly contributes to SDG (H_{10}: $\beta = 0.536$, $t = 11.977$, $p < 0.001$), and its indirect effect through institutional transparency is also significant (H_{11}: $\beta = 0.056$, $t = 2.168$, $p = 0.030$). These findings highlight that risk management serves both as a direct driver and an enabling mechanism for sustainable governance outcomes, reinforcing the notion that robust internal controls and proactive risk practices are essential for advancing transparency, accountability, and institutional integrity.

Importantly, the study situates these results within the integrated theoretical framework of COSO, Dynamic Capabilities View, and the 2030 Agenda with SDG16. While COSO components provide the structural and procedural foundation for risk governance, AI and Big Data represent dynamic and technological capabilities that amplify organizational resilience. The significant mediation of risk management in linking technological capabilities to SDG 16 underscores that digital tools must operate within robust governance frameworks to achieve meaningful institutional outcomes.

Besides, the R^2 values show that 74.2% of the variance in Risk Management and 61.5% of the variance in SDG are explained by the model, implying good explanatory power (Cohen, 1988). Stone-Geisser Q^2 values are positive ($Q^2 = 0.523$ for Risk Management; $Q^2 = 0.447$ for SDG 16), indicating predictive relevance. The effect size (f^2) analysis demonstrates a very large effect of monitoring on risk management ($f^2 = 0.621$), while those of AI ($f^2 = 0.093$) and Big Data ($f^2 = 0.128$) are small-to-moderate, in accordance with Cohen's benchmarks. Together these indicators support the fact that the suggested model is statistically strong and substantively meaningful in the case of the Vietnamese banking sector. The results reveal a synergistic effect between internal control mechanisms and technological capabilities. COSO-based components form a basis for governance, and AI improves risk management, thus supporting institutional transparency and the achievement of SDG 16. Monitoring therefore becomes the linchpin of this system because, absent continuous oversight, the internal levers of governance and technological tools likely will end up simply not providing sustainable governance outcomes. This highlights the critical practical implication that emerging-market banks must prioritize systematic monitoring, and that AI and Big Data analytics should be built into risk management routines in a meaningful manner to create firms that are strong, transparent, and accountable aligned with SDG 16.

5. CONCLUSION AND MANAGERIAL IMPLICATIONS

5. 1. CONCLUSION

This study empirically shows the interrelation between internal control systems and technological capabilities that supports risk management and contributes to the achievement of SDG16.

The measurement model indicates good consistency and validity for all constructs and the structural model reveals support for 10 of the 11 hypotheses (except for Big Data Capability and AI Application, which is not confirmed). The five COSO components are all crucial in strengthening the effectiveness of risk management, with monitoring being the most influential, highlighting the need for continuous monitoring of governance practices to ensure alignment with institutional goals. Risk management is identified as the mechanism through which internal controls and technological tools lead to sustainable governance outcomes. Institutional transparency emerges even more strongly as a mediator, acting as the instrument by which improved risk governance leads to accountability, openness, and stakeholder trust. These results show that the contributions to SDG16 come not just from more robust risk management mechanisms, but also from improved transparency that helps build resilient institutions. The study builds on theory by integrating enterprise risk management, a dynamic capabilities perspective, and a sustainable development framework into a holistic analytical context. The findings indicate that internal controls serve as a foundational pillar of governance while technological capabilities (especially the use of AI) create adaptive, data-driven risk responses. A direct link between big data capability and AI application is absent, which also indicates that the constructs are different and require different conditions to provide value through organizations. Finally, the results indicate a dual mediation mechanism: risk management channels the impact of internal controls and technology into governance outcomes, while institutional transparency transforms these improvements into broader institutional benefits consistent with SDG16. This illustrates that progress toward peace, justice, and resilient institutions hinges not only on internal efficiency but also on transparency and accountability.

5. 2. MANAGERIAL IMPLICATIONS

The results will be useful in terms of management and policy, for banks and regulators which are in the business of good governance and sustainable development. There is strong evidence that “ongoing monitoring” is a powerful driver of effective risk management and the necessity of maintaining robust monitoring. Managers at banks must emphasize audit independence, better detect fraud, and provide clear feedback in regular business to counter operational or financial risks and win over long-term institutional trust. The recently reported cases of credit mismanagement and weak supervision by the State Bank of Vietnam serve to emphasize the need to reinforce branch level audits and adopt various digital monitoring dashboards for the purpose of strengthening institutional resilience. Such technological capabilities, and artificial intelligence in particular, contribute significantly to risk management via predictive analytics, fraud detection and operational optimization. While big data analytics does not directly lead to the application of AI, it can offer a holistic view on organizational performance and looming risks, allowing organizations to make proactive decision-making. Algorithmic bias, data privacy and cybersecurity are examples of ethical issues to be tackled so that the adoption of technology accords with transparency and accountability principles. Examples from Vietcombank and Techcombank, such as AI-empowered credit scoring and anti-money laundering systems, demonstrate that localised technology adoption can enhance governance in emerging markets. But technical progress is only effective within an environment of strong internal control. An organizational culture based on ethical behaviour, accountability and risk response is relevant. Technology has been integrated with a robust control environment, clear communication channels, and structured control tasks; it means that banks have the tools required to build a resilient and adaptive level of governance system. This is very appropriate in Vietnam where rapid digitization has at times outstripped thorough risk governance. From a policy viewpoint, the findings favour a multi-level approach. Over the short term, regulators must provide clear guidance on digital risk management, encourage a strict division of responsibility that is anchored in branch

level audit oversight and create incentives for AI-driven systems that can incorporate advanced analytics, as well as the adoption of automated systems on the AI and advanced analytics approaches in internal control systems. Medium-term strategies will need to focus on capacity development, the development of digital infrastructure and the integration of risk governance measures and standards into supervisory structures to enhance the transparency and accountability. Ultimately, over a longer time frame, policies need to institutionalize tech-enabled oversight, integrate ethical standards throughout banking operations as well as coordinate nationwide governance and align governance with global sustainability objectives. These consequences highlight that if effective risk management, ongoing surveillance and responsible utilisation of technology is to be maintained within a strong governance regime there need to be synergistic actions to ensure both operational excellence and meaningful contributions to sustainability.

6. RESEARCH LIMITATIONS

This study has several limitations that open avenues for future research. First, the data were collected from Vietnamese banks, which may limit the generalizability of findings to other emerging economies with different institutional and regulatory contexts. Second, the use of a cross-sectional survey design restricts the ability to capture causal dynamics and long-term effects of internal control systems and technological capabilities. Third, self-reported measures may introduce bias despite statistical remedies. Future studies could adopt longitudinal or mixed-method approaches, expand the scope to include multiple countries, and explore additional variables such as organizational culture, regulatory enforcement, and environmental sustainability dimensions.

Funding declaration

This research is partly funded by University of Economics Ho Chi Minh City (UEH), Vietnam.

This research is partly funded by Ho Chi Minh University of Banking, Ho Chi Minh City, Vietnam (contact email used in this article: sangtm@hub.edu.vn)

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