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Original Research Article

Analyzing the impact of digital transformation and smart banking on financial efficiency and operational risk of banks (Case study: Bank Saman): A combined approach of structural equations and fuzzy multi-criteria decision making

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This study investigates the effects of digital transformation and smart banking on financial efficiency in the banking sector, with operational risk considered as a potential mediating mechanism. Data were collected from 220 managers and employees of Bank Saman and analyzed using partial least squares structural equation modeling (PLS-SEM), while Fuzzy TOPSIS was employed to prioritize digital strategies.
The results indicate that digital transformation ($\beta = 0.36$) and smart banking ($\beta = 0.41$) positively affect financial efficiency, while both constructs significantly reduce operational risk ($\beta = -0.29$; $\beta = -0.33$). Operational risk partially mediates these relationships.
Fuzzy TOPSIS rankings further reveal that smart banking has higher strategic priority in achieving an optimal balance between efficiency improvement and risk reduction.
The findings highlight the importance of advancing from general digital transformation toward smart banking supported by robust operational risk management frameworks.

Keywords: Digital Transformation, Smart Banking, Financial Efficiency, Operational Risk, Structural Equation Modeling, Fuzzy TOPSIS
JEL Classification*:* G21, G32, O33, O14, D81

1 Introduction

Digital transformation has become one of the most influential forces reshaping the banking industry, going beyond the simple digitalization of traditional banking services (Alsobai & Aassouli, 2025). It represents a strategic and organizational shift through which banks leverage digital technologies to fundamentally redesign business models, operational processes, and value

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creation mechanisms (Benatiya Andaloussi et al., 2025; Feng et al., 2025). Empirical evidence suggests that digitally mature banks demonstrate greater agility, improved customer responsiveness, and enhanced operational productivity (Chen et al., 2024; Zhang et al., 2025).

Importantly, digital transformation should not be interpreted solely as a technological upgrade; rather, it entails deep organizational changes involving digital leadership, structural alignment, and human capital development. Prior research indicates that banks that implement digital transformation in an integrated and strategically aligned manner tend to achieve superior financial outcomes compared to traditional institutions (Bindel Sibassaha et al., 2025; Handani, 2024).

Smart banking has emerged as a more advanced evolutionary stage of digital transformation. Unlike electronic banking, which primarily focuses on digitizing service delivery channels, smart banking emphasizes the integration of intelligent technologies such as artificial intelligence, machine learning, and big data analytics to enable automated decision-making, personalized services, and intelligent customer interaction (Kasula, 2023; Anumakonda, 2025; Jingrong et al., 2024). Recent studies suggest that smart banking can help reduce costs,, faster service delivery, and improved customer experience (Rohit et al., 2025; Shanti et al., 2024).

A central performance outcome associated with digital initiatives is financial efficiency. Financial efficiency reflects a bank's ability to optimally utilize resources efficiently, thereby improving profitability and reducing operational costs, commonly evaluated through indicators such as ROA, ROE, and cost-to-income ratios (Kamel et al., 2022). Empirical findings across countries indicate that banks with higher levels of digitalization tend to outperform their less digitalized counterparts (Ren et al., 2024; Nguyen et al., 2023; Zhu & Jin, 2023).

Simultaneously, digital transformation and smart banking significantly influence banks' operational risk profiles. Operational risk refers to the potential for losses arising from inadequate processes, human errors, system failures, or external disruptions (Haryanti et al., 2025). While automation and digital controls can reduce traditional operational risks by minimizing manual errors and enhancing transparency, digital technologies may also introduce emerging risks such as cybersecurity threats, technological dependency, and system complexity (Grimwade, 2023; Cornwell et al., 2023). Recent reviews emphasize that the net effect of digital transformation on operational risk is contingent upon digital maturity and governance quality (Hoai & Vu, 2024).

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Conceptually, operational risk constitutes a critical transmission mechanism linking digital initiatives to financial efficiency. Reductions in process failures, operational disruptions, and unexpected losses can directly enhance cost efficiency, profitability, and financial stability. Therefore, examining operational risk as a mediating variable provides a more nuanced understanding of how digital transformation and smart banking translate affect financial outcomes.

Despite the growing body of research on digital transformation and smart banking, several gaps remain. First, prior studies have largely examined financial performance or risk outcomes in isolation rather than within an integrated framework. Second, limited empirical attention has been given to the mediating role of operational risk in explaining the digitalization–efficiency relationship. Third, evidence from emerging economies, particularly within the Iranian banking system, remains scarce.

In the context of Iran, banks face unique structural, regulatory, and technological challenges that may alter the dynamics of digital transformation. Financial constraints, heterogeneous IT infrastructures, regulatory complexities, and heightened environmental uncertainties render digitalization both an opportunity and a potential source of operational vulnerability. However, comprehensive empirical models that simultaneously assess financial efficiency and operational risk implications remain limited.

Accordingly, this study develops and tests an integrated analytical framework examining the effects of digital transformation and smart banking on financial efficiency, incorporating operational risk as a mediating mechanism. By combining Structural Equation Modeling (PLS-SEM) with Fuzzy TOPSIS, the study not only examines the hypothesized relationships among the study variables but also prioritizes digital strategies based on multiple decision criteria. This hybrid approach contributes to both theory and practice by providing a multidimensional understanding of banking digitalization outcomes.

The remainder of this paper is structured as follows. Section 2 reviews the theoretical foundations and develops the research hypotheses. Section 3 describes the combined methodology of structural equation modeling (PLS-SEM) and fuzzy multi-criteria decision making (Fuzzy TOPSIS). Section 4 presents the empirical results, including measurement model evaluation, structural model testing, and the ranking of digital strategies. Section 5 discusses the findings, and Section 6 concludes by outlining theoretical

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implications, practical recommendations for Bank Saman, and limitations for future research.

2 Theoretical Background and Research Framework

2.1 Review of Theoretical Foundations

Digital transformation, as a strategic phenomenon in the fields of management and financial technologies, represents a structural and organizational process through which financial institutions acquire the capability to redesign their business models, operational processes, and value creation logic by leveraging advanced digital technologies (Anning-Dorson et al., 2025). In the scholarly literature, digital transformation is defined not merely as the development of digital service channels, but as a comprehensive transformation encompassing organizational structures, culture, processes, and services, with the potential to improve flexibility, responsiveness, and productivity (Benatiya Andaloussi et al., 2025; Malikov, 2024).

Within the banking industry, digital transformation has increasingly become a focal point of academic research, as banks play a central role in the transition toward a digital economy through the integration of digital technologies into operational structures and the creation of value-added financial services. In this context, digitalization in banking involves the utilization of big data analytics, artificial intelligence, cloud computing, and predictive analytics to enhance operational efficiency and customer satisfaction (Ibragimov & Najmiddinov, 2025).

One of the key dimensions emphasized in digital transformation research is financial efficiency. Financial efficiency can be defined as a bank's ability to optimally utilize its available resources and capacities to increase returns while reducing costs. Specifically, bank financial efficiency refers to the extent to which a bank can maximize profits or minimize costs through the optimal deployment of financial, human, and physical resources in the process of financial intermediation. In other words, an efficient bank can either generate the maximum possible output from a given set of inputs or achieve a given level of output at the lowest possible cost (Kamel et al., 2022).

Furthermore, financial efficiency reflects the degree to which a bank can effectively organize its income structure, asset composition, and cost management practices while maintaining risk at an acceptable level and generating sustainable financial returns relative to its peers or the industry's efficient frontier (Ren et al., 2024; Ortaköy & Özsürünç, 2019). Recent empirical studies indicate that banks which have deeply embedded digital

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transformation into their operations tend to outperform others in terms of financial efficiency indicators. For example, evidence from China demonstrates a positive relationship between the level of digital transformation and financial performance, particularly among banks that benefit from supportive regional policies (Chen & Zhang, 2021).

In addition to financial efficiency, operational risk constitutes another critical dimension of bank performance. In financial research, operational risk is defined as the potential for losses resulting from failures in internal processes, systems, human errors, or external events (Cornwell et al., 2023). Recent studies suggest that the digitalization of banking processes can reduce certain traditional operational risks by enabling integrated controls and automated procedures. However, at the same time, advanced digital technologies introduce emerging risks, including cybersecurity threats, dependence on technology, and increased systemic complexity, which require novel analytical and managerial approaches to be effectively managed (Haryanti et al., 2025; Grimwade, 2023).

Within the banking literature, the concept of smart banking has been introduced as an advanced evolutionary stage of digital transformation, emphasizing the use of intelligent technologies to enhance decision-making effectiveness, service personalization, and customer interaction optimization. Smart banking refers to the integrated application of advanced digital technologies—such as artificial intelligence, big data, the Internet of Things, and cloud computing—within banking processes to improve decision accuracy, automate operations, reduce costs, and enhance the quality of financial services (Dash et al., 2023).

Smart banking represents a strategic paradigm within the financial system, whereby banks leverage intelligent data analytics and decision-support systems to deliver personalized, secure, and real-time financial services. Through this approach, banks not only enhance customer experience but also improve operational efficiency and achieve sustainable competitive advantage (Hrytsenko et al., 2024).

In summary, recent studies indicate that the most effective outcomes of digital transformation in banking are achieved when digital initiatives are accompanied by the comprehensive implementation of intelligent technologies, process reengineering, and coherent strategic alignment. This underscores the necessity of developing robust analytical frameworks capable of simultaneously assessing the effects of digital transformation and smart banking on financial efficiency and operational risk. Such an approach can

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provide a clearer understanding of the strategic implications of digitalization in the banking sector.

2.2 Hypotheses Development

2.2.1 Digital Transformation and Financial Efficiency

Digital transformation enhances financial efficiency by enabling process automation, cost optimization, and revenue diversification. From a resource-based view, digitally integrated infrastructures, data platforms, and analytics capabilities can evolve into strategic assets that improve productivity and reduce operational redundancies (Benatiya Andaloussi et al., 2025; Malikov, 2024). Empirical studies show that digitalization of credit evaluation, transaction processing, and back-office functions improves cost-to-income ratios and asset utilization efficiency (Zhang et al., 2025; Yang & Masron, 2023).

Moreover, digital platforms facilitate the development of innovative financial services, expanding non-interest income streams and strengthening profitability indicators such as ROA and ROE (Nguyen et al., 2025; Nguyen et al., 2023). However, efficiency gains are contingent upon governance quality, managerial commitment, and digital capability alignment (Kovac et al., 2025; Osika, 2024). Accordingly:

H1: Digital transformation has a positive and significant effect on banks' financial efficiency.

2.2.2 Smart Banking and Financial Efficiency

Smart banking represents a higher level of digital maturity characterized by intelligent automation, predictive analytics, and real-time data-driven decision-making (Dash et al., 2023; Hrytsenko et al., 2024). Unlike general digitalization, smart banking directly enhances decision accuracy, customer targeting, and service personalization, thereby increasing value-added services and operational scalability (Alqararah et al., 2025; Feng et al., 2025; Chen et al., 2024).

From the perspective of Dynamic Capabilities Theory, smart banking strengthens banks' sensing, learning, and reconfiguration capabilities, allowing them to adapt rapidly to market changes and customer demands. These capabilities improve revenue generation efficiency and reduce structural cost inefficiencies (Shanti et al., 2024; Anumakonda, 2025). Thus:

H2: Smart banking has a positive and significant effect on banks' financial efficiency.

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2.2.3 Digital Transformation and Operational Risk

Digital transformation reduces traditional operational risk by standardizing processes, strengthening internal controls, and minimizing human error (Haryanti et al., 2025). Automation decreases reliance on manual interventions and enhances traceability and transparency in transaction processing (Jingrong et al., 2024).

Although digitalization may introduce emerging risks—such as cybersecurity vulnerabilities and system interdependencies (Grimwade, 2023; Cornwell et al., 2023)—the dominant expectation in the literature is that well-governed digital transformation reduces overall operational risk exposure, particularly when supported by mature risk management systems (Hoai & Vu, 2024). Therefore:

H3: Digital transformation has a negative and significant effect on banks' operational risk.

2.2.4 Smart Banking and Operational Risk

Smart banking enhances proactive risk management through AI-based anomaly detection, predictive modeling, and real-time monitoring systems (Dash et al., 2023; Rohit et al., 2025). Intelligent systems can identify transaction irregularities, operational disruptions, and fraud patterns more efficiently than traditional control mechanisms.

However, smart banking also introduces algorithmic risk, model bias, and risks associated with dependence on technology (Shanti et al., 2024; Rohit et al., 2025). The net effect depends on governance quality and supervisory capacity. In environments with structured algorithmic oversight and robust data governance, smart banking is expected to reduce operational risk more effectively than basic digital transformation. Thus:

H4: Smart banking has a negative and significant effect on banks' operational risk.

2.2.5 The Mediating Role of Operational Risk

Operational risk constitutes a transmission channel linking digital initiatives to financial efficiency. Reductions in operational failures, process disruptions, and unexpected loss events lower compliance costs, enhance operational stability, and improve financial sustainability (Cornwell et al., 2023; Haryanti et al., 2025).

Conceptually, digital transformation improves financial efficiency indirectly by stabilizing internal processes and reducing operational losses. Smart banking, in contrast, not only stabilizes processes but also enhances predictive risk control through intelligent systems. Therefore, although both

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constructs are expected to influence financial efficiency through operational risk, the underlying mechanisms differ in intensity and sophistication.

Importantly, in emerging economies such as Iran—characterized by regulatory complexity, heterogeneous IT infrastructure, and financial constraints—the mediating role of operational risk may be more pronounced, as inefficient risk governance can neutralize potential digital efficiency gains.

Accordingly, two distinct mediation hypotheses are proposed:

H5: Operational risk mediates the relationship between digital transformation and financial efficiency by transmitting efficiency gains derived from process automation and error reduction.

H6: Operational risk mediates the relationship between smart banking and financial efficiency by transmitting efficiency gains derived from intelligent monitoring and predictive risk management capabilities.

3.5 Research Contribution and Positioning

While domestic studies have examined digital transformation and smart banking in the Iranian banking context, existing research remains fragmented and largely descriptive. Prior studies have focused on digital transformation drivers, governance models, innovation strategies, or customer-related outcomes, often without empirically testing causal mechanisms or mediating effects.

The present study contributes to the literature by proposing an integrated analytical framework that simultaneously examines the effects of digital transformation and smart banking on banks' financial efficiency and operational risk. By combining Structural Equation Modeling (PLS-SEM) with Fuzzy TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) the study not only empirically tests direct and mediating relationships but also ranks digital banking strategies based on expert evaluations. Furthermore, by explicitly modeling operational risk as a mediating mechanism, this research extends the existing literature by examining a pathway that has rarely been studied within a unified empirical framework. Finally, the study's focus on an Iranian commercial bank and the localization of measurement indicators provides context-specific insights while offering practical guidance for bank managers seeking to transition from digital transformation toward smart banking in emerging economies

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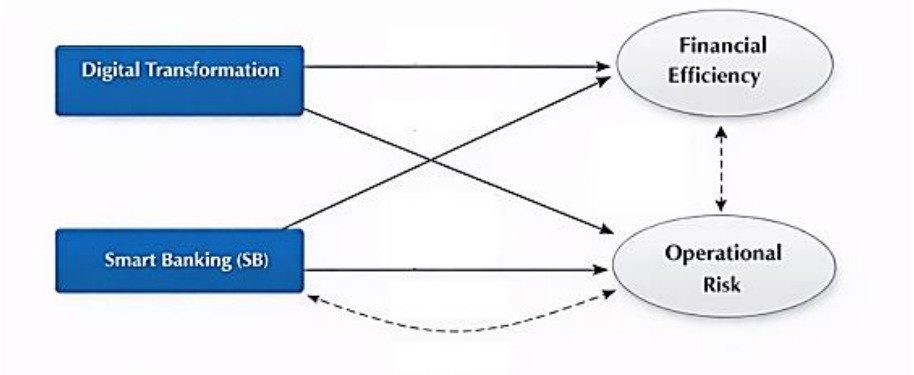

Figure 1. Conceptual Framework of the Study
Source: Research Findings

The conceptual model of this study is grounded in the Resource-Based View (RBV) and Dynamic Capabilities Theory. From the RBV perspective, digital transformation and smart banking are not merely technological initiatives but strategic organizational resources that can generate sustainable competitive advantage when they are valuable, rare, and difficult to imitate. Digital infrastructures, analytics capabilities, and intelligent systems enable banks to enhance operational efficiency, optimize resource utilization, and improve financial outcomes. Complementarily, Dynamic Capabilities Theory explains how banks integrate, reconfigure, and leverage digital and intelligent technologies to respond to environmental uncertainty, regulatory pressures, and evolving customer expectations. Within this theoretical lens, operational risk is conceptualized as key organizational outcome that reflects the effectiveness of digital capabilities and may also act as a mechanism linking digital initiatives to financial efficiency. This dual-theoretical foundation provides a coherent explanation of why digital transformation and smart banking influence financial efficiency both directly and indirectly through operational risk dynamics.

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3 Research Methodology

3.1 Research Design and Analytical Approach

This study adopts an applied research orientation and employs a descriptive–analytical design using a mixed-methods approach. The research integrates quantitative Structural Equation Modeling (SEM) with qualitative Fuzzy Multi-Criteria Decision-Making (FMCDM). The quantitative phase aims to test causal relationships among digital transformation, smart banking, financial efficiency, and operational risk. The qualitative–fuzzy phase complements the structural analysis by prioritizing digital strategies under conditions of uncertainty and subjective expert judgment. This sequential explanatory design enhances methodological rigor by combining hypothesis testing (SEM) with decision prioritization (Fuzzy TOPSIS), thereby providing both statistical validation and strategic evaluation.

3.2 Population, Sampling, and Case Selection

The target population of this study comprises managers, senior experts, and specialized staff working at Saman Bank across five key functional domains: information technology, digital transformation, electronic banking, financial management, and operational risk management. These roles were selected due to their direct involvement with digital initiatives and their strategic or operational insight into financial efficiency and risk-related outcomes. Saman Bank was selected as the case study through purposeful sampling based on three primary criteria: (a) its pioneering role in digital banking initiatives within Iran, (b) its advanced implementation of smart banking services, and (c) its established digital infrastructure and innovation orientation. This case-based sampling strategy aligns with contemporary digital transformation research, which emphasizes context-rich organizational analysis, particularly in emerging economies where institutional and technological conditions differ markedly from developed settings.

Although focusing on a single bank limits statistical generalizability, this approach strengthens internal helps control for inter-organizational heterogeneity in regulatory environments, governance structures, and technological maturity. Data were collected using a structured questionnaire comprising **45 items**, designed to measure the constructs of digital transformation, smart banking, operational risk, and financial efficiency. The questionnaire was distributed to eligible respondents after a pilot test ensured clarity and relevance.

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3.3 Sample Size Justification

In the quantitative phase, 220 valid questionnaires were collected using stratified purposive sampling. The adequacy of this sample size is supported by established methodological guidelines for structural equation modeling (SEM). According to Hair and Alamer (2022), the minimum sample size in partial least squares structural equation modeling (PLS-SEM) must satisfy two key criteria:

The "10-times rule": sample size should be at least 10 times the maximum number of structural paths pointing at any single construct.

Statistical power requirements: statistical power should be ≥ 0.80.

Given the structure of the proposed model and the number of indicators per construct, a sample of 220 respondents exceeds the recommended thresholds. This sample size ensures stable parameter estimation, acceptable statistical power, and reliable bootstrapping results for hypothesis testing. Data entry and preliminary descriptive analyses were performed using Microsoft Excel, followed by more advanced modeling procedures in dedicated PLS-SEM software. In the qualitative and fuzzy decision-making phase, an expert panel of 15 senior specialists was selected using judgmental purposive sampling. This panel size is consistent with best practices in fuzzy multi-criteria decision-making (fuzzy MCDM) studies, where small expert groups are preferred to maintain analytical depth and consensus reliability. Fuzzy TOPSIS calculations were conducted using Microsoft Excel as the primary computational tool.

3.4 Data Collection Instruments

Quantitative data were collected using a structured questionnaire developed based on established literature. All items were measured on a five-point Likert scale.

- Validity and reliability procedures included:
- Content validity (CVR, CVI via expert evaluation)
- Construct validity (Confirmatory Factor Analysis)
- Reliability (Cronbach's alpha, Composite Reliability)
- All indices exceeded recommended thresholds.

In the qualitative phase, expert judgments were elicited using linguistic variables and pairwise comparisons, enabling modeling of uncertainty through triangular fuzzy numbers.

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3.5 Data Analysis Techniques

Quantitative analysis was conducted using SPSS and SmartPLS. The measurement model and structural model were evaluated through:

- Reliability and validity assessments
- Path coefficients and significance testing
- Mediation analysis
- R^2, Q^2, and f^2 effect sizes

The qualitative–fuzzy analysis employed the Fuzzy TOPSIS method implemented in Excel/MATLAB.

3.6 Integration of SEM and Fuzzy TOPSIS

The integration of SEM and Fuzzy TOPSIS follows a complementary logic.

PLS-SEM evaluates causal relationships, effect strengths, and mediation mechanisms among latent constructs. Fuzzy TOPSIS prioritizes strategic alternatives (digital transformation vs. smart banking) based on multiple criteria (financial efficiency and operational risk).

SEM provides statistical validation of relationships, while Fuzzy TOPSIS provides decision-oriented ranking under uncertainty.

This hybrid approach enables:

- Explanation of how variables influence outcomes (SEM)
- Evaluation of which strategy is preferable (TOPSIS).

Thus, Fuzzy TOPSIS does not replicate SEM results but extends them into a managerial decision-making framework.

Table 1

Conceptual and Operational Definitions of Research Variables

No.	Construct	Conceptual Definition	Operational Definition	Items	Sources
1	Digital Transformation	Digital transformation is a strategic and organizational process through which banks redesign their structures, processes, organizational culture, and value creation logic by leveraging advanced digital technologies to enhance flexibility, productivity, and responsiveness.	Mean scores of items related to digital strategy maturity, process reengineering, technological infrastructure adequacy, and employees' digital skills, measured on a five-point Likert scale.	12	Anning-Dorson et al. (2025); Benatiya Andaloussi et al. (2025); Ibragimov & Najmiddinov (2025)

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2	Smart Banking	Smart banking represents an advanced stage of digital transformation that integrates intelligent technologies, data analytics, and decision-support systems to improve decision-making quality, service personalization, and banks' operational efficiency and resilience.	Mean scores of items related to intelligent decision-making systems, service personalization, reduction of operational errors, and enhanced monitoring and security, measured on a five-point Likert scale.	12	Dash et al. (2023); Hrytsenko et al. (2024)
3	Financial Efficiency	Financial efficiency reflects a bank's ability to optimally utilize financial, human, and physical resources to maximize returns and minimize costs while maintaining an acceptable level of risk.	Respondents perceived improvement in cost-to-income ratio, return on assets, return on equity, resource productivity, and financial performance sustainability, measured on a five-point Likert scale.	10	Kamel et al. (2022); Ren et al. (2024); Ortaköy & Özsürünç (2019)
4	Operational Risk	Operational risk refers to the probability of loss resulting from inadequate or failed internal processes, systems, human errors, or external events that may adversely affect bank performance and stability.	Mean scores of items related to the frequency of operational errors, system disruptions, cybersecurity threats, control effectiveness, and operational resilience, measured on a five-point Likert scale.	11	Cornwell et al. (2023); Grimwade (2023); Haryanti et al. (2025)

Note. Compiled by the authors based on the studies listed in the References.

4 Data Analysis and Results

Table 2

Descriptive Statistics and Normality Test Results

Construct	Items	Mean	SD	Skewness	Kurtosis
Digital Transformation	12	3.78	0.64	−0.41	0.23
Smart Banking	12	3.85	0.61	−0.36	0.18
Financial Efficiency	10	3.69	0.67	−0.29	−0.12
Operational Risk	11	3.42	0.72	0.38	0.46

Source: Research findings

The mean values exceed the scale midpoint (3.00), indicating moderate-to-high levels of digital maturity and smart banking practices. Skewness and kurtosis values fall within the acceptable ±2 range, suggesting no severe distributional concerns.

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Table 3
Reliability and Convergent Validity

Construct	Number of Items	Cronbach's Alpha (α)	Composite Reliability (CR)	Average Variance Extracted (AVE)
Digital Transformation	12	0.89	0.91	0.56
Smart Banking	12	0.90	0.92	0.58
Financial Efficiency	10	0.87	0.90	0.54
Operational Risk	11	0.88	0.91	0.55

Source: Research findings

All constructs meet or exceed the recommended thresholds (α and CR > 0.70; AVE > 0.50), confirming satisfactory internal consistency and convergent validity.

Table 4
Fornell–Larcker Criterion

Constructs	Digital Transformation	Smart Banking	Financial Efficiency	Operational Risk
Digital Transformation	0.75	0.62	0.58	−0.46
Smart Banking	0.62	0.76	0.64	−0.51
Financial Efficiency	0.58	0.64	0.73	−0.55
Operational Risk	−0.46	−0.51	−0.55	0.74

Note: Diagonal elements represent the square root of AVE for each construct.
Source: Research findings

Based on the Fornell–Larcker criterion, discriminant validity among digital transformation, smart banking, financial efficiency, and operational risk is well established, as the square root of the AVE for each construct exceeds its correlations with the other constructs.

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Table 5
HTMT Criterion

Constructs	Digital Transformation	Smart Banking	Financial Efficiency	Operational Risk
Digital Transformation	—	0.71	0.66	0.54
Smart Banking	—	—	0.73	0.59
Financial Efficiency	—	—	—	0.62
Operational Risk	—	—	—	—

Source: Research findings

As reported in Table 5, all Heterotrait–Monotrait (HTMT) ratios are below the conservative threshold of 0.85, suggesting low conceptual overlap among the constructs. These results provide further support for adequate discriminant validity and confirm that each construct is empirically distinct from the others.

Table 6
Measurement Model Fit Indices

Index	Value	Threshold
SRMR	0.052	< 0.08
NFI	0.90	≥ 0.90

Source: Research findings

The results in Table 6 indicate that all measurement model fit indices fall within the recommended thresholds commonly recommended in the structural equation modeling literature. Collectively, these findings confirm that the measurement model demonstrates satisfactory goodness-of-fit, allowing for progression to the structural model evaluation.

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Table 7
Path Coefficients and Hypothesis Testing Results

Hypothesis	Relationship Path	Type of Effect	Path Coefficient (β)	t-value	Sig.	Result
H1	Digital Transformation → Financial Efficiency	Direct	0.36	5.84	<0.001	Supported
H2	Smart Banking → Financial Efficiency	Direct	0.41	6.72	<0.001	Supported
H3	Digital Transformation → Operational Risk	Direct	−0.29	4.96	<0.001	Supported
H4	Smart Banking → Operational Risk	Direct	−0.33	5.41	<0.001	Supported
H5	Digital Transformation → Operational Risk → Financial Efficiency	Indirect (Mediated)	0.11	3.87	<0.001	Supported
H6	Smart Banking → Operational Risk → Financial Efficiency	Indirect (Mediated)	0.14	4.23	<0.001	Supported
H7	Operational Risk → Financial Efficiency	Direct	−0.26	4.37	<0.001	Supported

Source: Research findings

Digital transformation and smart banking both exert significant positive effects on financial efficiency, with smart banking demonstrating the stronger impact ($\beta = 0.41$). Both constructs significantly reduce operational risk, which in turn negatively affects financial efficiency ($\beta = -0.26$), confirming its mediating role. The simultaneous significance of direct and indirect effects indicates partial mediation.

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Table 8

Structural Model Quality

Endogenous Variable / Path	R^2	Level of Explanation	Q^2	Predictive Relevance	f^2	Effect Size
Financial Efficiency	0.52	Strong	0.34	Strong	—	—
Operational Risk	0.38	Moderate	0.26	Moderate	—	—
Digital Transformation → Financial Efficiency	—	—	—	—	0.18	Medium
Smart Banking → Financial Efficiency	—	—	—	—	0.24	Strong
Digital Transformation → Operational Risk	—	—	—	—	0.15	Medium
Smart Banking → Operational Risk	—	—	—	—	0.20	Medium to Strong
Operational Risk → Financial Efficiency	—	—	—	—	0.16	Medium

Source: Research findings

The model explains 52% of the variance in financial efficiency and 38% in operational risk. Effect sizes indicate that smart banking exerts the strongest influence on financial efficiency.

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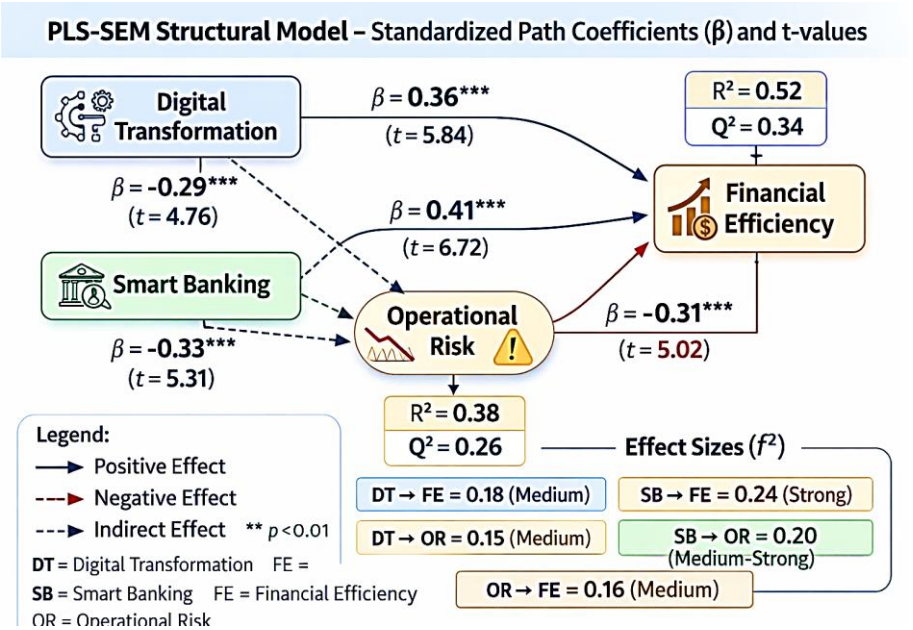

Figure 2. Structural Model with Estimated Significant Path Coefficients
Source: Research findings

As illustrated in Figure 2, the figure presents the structural equation model of the study along with the standardized path coefficients (β) and their corresponding t-values. As shown, both independent variables—digital transformation (β = 0.36, t = 5.84) and smart banking (β = 0.41, t = 6.72)—exert a direct, positive, and statistically significant effect on the dependent variable, financial efficiency .In parallel with these direct paths, both independent variables significantly contribute to the reduction of operational risk, with standardized coefficients of −0.29 and −0.33 for digital transformation and smart banking, respectively. Furthermore, operational risk itself has a negative and statistically significant effect on financial efficiency (β = −0.31, t = 5.02) .This configuration of relationships indicates the presence of an indirect (mediating) effect, implying that part of the positive impact of digital transformation and smart banking on financial efficiency is realized through the reduction and effective management of operational risks. All

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estimated path coefficients are statistically significant at the 1% significance level ($p < 0.01$), providing support for the proposed structural relationships.

4.1 Fuzzy TOPSIS Multi-Criteria Decision-Making Analysis

To rank the strategic alternatives and complement the results obtained from the structural equation modeling, a fuzzy TOPSIS multi-criteria decision-making (MCDM) approach based on triangular fuzzy numbers was employed. This method was selected due to its capability to handle uncertainty in expert judgments and its effectiveness in comparing alternatives simultaneously based on benefit and cost criteria. In this study, the decision alternatives include digital transformation and smart banking, while the evaluation criteria consist of financial efficiency (benefit criterion) and operational risk (cost criterion). The implementation of the fuzzy TOPSIS method followed several sequential steps. First, expert opinions were collected using standardized linguistic scales and subsequently converted into triangular fuzzy numbers. Next, the fuzzy decision matrix and the fuzzy weight vector of the criteria were constructed. The decision matrix was then normalized according to the nature of the criteria (benefit versus cost), and the weighted normalized fuzzy decision matrix was computed. Subsequently, the fuzzy positive ideal solution (FPIS) and the fuzzy negative ideal solution (FNIS) were identified. The distance of each alternative from these ideal solutions was calculated, and finally, the closeness coefficient (CC) was calculated and used as the basis for ranking the alternatives. All computations were performed automatically using Microsoft Excel, and the complete calculation file is provided in the Appendix to the article.

Table 9
Ranking Results of Alternatives Using the Fuzzy TOPSIS Method

Rank	Closeness Coefficient (CC)	Distance from Ideal Negative (D^-)	Distance from Ideal Positive (D^+)	Research Alternative
1	0.67	0.42	0.21	Smart Banking
2	0.52	0.33	0.31	Digital Transformation

Source: Research findings

The results of the fuzzy TOPSIS ranking indicate that smart banking achieves the highest closeness coefficient to the ideal solution and is therefore

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ranked first among the strategic alternatives. This finding suggests that smart banking, compared to digital transformation in a more general sense, establishes a more favorable balance between enhancing financial efficiency and reducing operational risk. Although digital transformation plays a significant role in improving banking performance, expert evaluations indicate that its effectiveness is comparatively lower when advanced intelligent technologies and decision-support systems are not fully implemented. The fuzzy TOPSIS results are consistent with the findings of the structural equation modeling, reinforcing the conclusion that transitioning from digital transformation toward smart banking can exert a more decisive influence on improving financial efficiency and managing operational risks in banks. This methodological synergy between SEM and fuzzy TOPSIS enhances the robustness and credibility of the research findings and provides a more comprehensive perspective on the strategic implications of digitalization within the banking sector.

5 Discussion and Conclusion

The This study examined how digital transformation and smart banking influence financial efficiency directly and indirectly through operational risk. The findings provide three main theoretical insights.

First, both digital transformation and smart banking significantly improve financial efficiency, but smart banking exerts a stronger effect. This result is consistent with previous empirical evidence from China and emerging markets (e.g., Ren et al., 2024; Nguyen et al., 2023) showing that digitalization can improve financial performance and profitability. However, the present study extends this literature by distinguishing between general digital transformation and intelligent smart banking capabilities. The stronger effect of smart banking suggests that efficiency gains are not merely driven by digitization of processes, but by the integration of AI-based analytics, predictive systems, and intelligent automation. This aligns with Dynamic Capabilities Theory, indicating that sensing and reconfiguration capabilities may contribute more effectively to improved financial outcomes than basic technological adoption alone.

Second, the negative relationship between digital initiatives and operational risk confirms that well-governed digitalization reduces process failures and manual errors. This supports the risk-reduction argument proposed by Cornwell et al. (2023) and Haryanti et al. (2025). Importantly, the stronger risk-reduction effect of smart banking suggests that predictive monitoring and intelligent anomaly detection systems provide a more

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proactive risk management mechanism than traditional automation. Thus, the study provides empirical evidence suggesting that technological sophistication matters in risk mitigation.

Third, the mediation analysis reveals that operational risk partially transmits the effects of both digital transformation and smart banking on financial efficiency. This finding contributes to the literature by empirically validating the "risk–efficiency transmission mechanism," which has often been conceptually discussed but has rarely been tested within a unified structural model. In practical terms, digital investments improve financial efficiency not only through revenue enhancement but also through stabilization of operational processes and reduction of unexpected losses.

The Iranian banking environment presents structural characteristics—regulatory rigidity, financial constraints, heterogeneous IT infrastructures, and external economic uncertainty—that may intensify the mediating role of operational risk. In such contexts, digital transformation without robust governance mechanisms may fail to translate into financial gains. Therefore, the findings should be interpreted within emerging economy conditions where risk governance maturity plays a decisive role.

The Fuzzy TOPSIS results complement the structural model by translating statistical relationships into strategic prioritization. While SEM explains how digital constructs influence efficiency and risk, TOPSIS evaluates which strategic alternative provides the optimal balance between benefit (financial efficiency) and cost (operational risk). The convergence of both methods provides complementary support for the prioritization of smart banking as the preferred strategic alternative.

5.2 Managerial and Policy Implications

Drawing on the empirical findings and the integrated application of structural equation modeling and fuzzy TOPSIS, several practical implications can be derived for the banking sector, particularly for Bank Saman.

Digital transformation should transcend fragmented and technology-driven initiatives and be positioned as an enterprise-wide strategic agenda aligned with core business objectives. Banks are advised to design an integrated digital transformation roadmap centered on the reengineering of key banking processes, reduction of redundant activities, and increased automation. Aligning digital initiatives with financial and operational targets—such as cost-to-income ratios and error reduction—can enhance measurability and strategic impact.

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Managerial implication: Establish a dedicated Digital Transformation Office with clearly defined responsibilities, digital KPIs, and performance-monitoring dashboards.

Given that smart banking demonstrates a stronger capacity to balance financial efficiency and operational risk mitigation, banks should prioritize investments in intelligent platforms, advanced analytics, and artificial intelligence. The development of smart decision-support systems across operational, tactical, and strategic levels can substantially improve performance outcomes.

Managerial implication: Implementing AI-driven customer analytics, financial recommendation engines, intelligent chatbots, and predictive risk systems.

Digital and smart banking initiatives are unlikely to succeed without parallel investments in human capital. Banks should implement structured training programs and professional certifications in data analytics, predictive modeling, and intelligent technologies. Forming cross-functional teams that integrate IT, data science, and business expertise can further enhance organizational learning and innovation.

Managerial implication: Develop a digital career pathway with promotion criteria explicitly linked to digital and analytical competencies.

The strong risk-reducing effect of smart banking underscores the necessity of robust data governance frameworks. Banks must ensure data security, quality, and regulatory compliance while proactively managing technology-related risks, including algorithmic errors and system interdependencies.

Managerial implication: Establish specialized units for data governance and technology risk management, supported by change-management processes and continuous algorithm monitoring.

The mediating role of operational risk highlights the importance of real-time risk monitoring. Banks should deploy intelligent surveillance systems capable of detecting anomalies, operational failures, and cyber threats in real time, supported by advanced analytics for early-warning detection.

Managerial implication: Implement SIEM platforms, real-time transaction monitoring, and intelligent alert systems integrated into managerial dashboards.

Big data represents a critical asset for enhancing efficiency and revenue generation. Banks should integrate transactional, customer, and operational data into centralized data warehouses and apply machine learning techniques for customer behavior prediction, demand forecasting, and portfolio management.

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Managerial implication: Establish centralized analytics teams and utilizing cloud-based infrastructures for scalable data storage and processing.

To effectively evaluate the outcomes of digital transformation and smart banking, banks should adopt comprehensive performance measurement frameworks encompassing financial, operational, and risk-related indicators.

Managerial implication: Develop executive dashboards tracking metrics such as digital cost-to-income ratios, transaction processing time, operational loss events, and customer satisfaction with smart services.

Given the positive impact of smart banking on financial efficiency, banks should actively develop AI-enabled value-added services, including digital investment advisory, intelligent credit scoring, and personalized financial solutions.

Managerial implication: Establish innovation units focused on digital services and emerging business models.

7 Directions for Future Research

Several avenues for future research emerge from this study:

Longitudinal and Panel Data Analysis

Future studies may employ panel or time-series data to examine the dynamic and long-term effects of digital transformation and smart banking on financial efficiency and operational risk, capturing lagged effects and the sustainability of these relationships over time.

Moderating Organizational and Institutional Factors:

Further research could investigate the moderating roles of corporate governance quality, organizational digital culture, risk management maturity, technological readiness, and regulatory frameworks in shaping digitalization outcomes.

Comparative and Cross-Country Studies:

Comparative analyses between public and private banks, or between domestic and international banking systems, could reveal structural and institutional differences in the implementation and outcomes of digital transformation and smart banking.

Incorporating Emerging Digital Risks:

Future models may explicitly incorporate emerging risks such as algorithmic bias, data privacy concerns, cybersecurity threats, and excessive reliance on automated systems to develop more comprehensive operational risk frameworks.

Advanced Hybrid and Intelligent Methodologies:

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Subsequent studies may benefit from integrating SEM with other fuzzy MCDM techniques (e.g., fuzzy VIKOR, DEMATEL, or ANP) or applying machine learning approaches to capture nonlinear and complex relationships among variables.

8 Limitations of the Study

Despite its contributions, this study is subject to several limitations. First, the findings are based on cross-sectional data, which restricts the ability to draw conclusions about causal relationships and their evolution over time. Second, the empirical analysis focuses on a single banking context, potentially limiting the generalizability of the results. Third, perceptual measures were employed, which may be subject to respondent bias despite rigorous validity and reliability assessments. Future research addressing these limitations could further enhance the robustness and external validity of the findings.

References

Alqararah, E., Shehadeh, M., & Yaseen, H. (2025). The role of digital transformation capabilities in improving banking performance in Jordanian commercial banks. *Journal of Risk and Financial Management*, *18*(4), 196.

Alsobai, B., & Aassouli, D. (2025). Assessing Digital Transformation Strategies in Retail Banks: A Global Perspective. *Journal of Risk and Financial Management*, *18*(12), 710.

Anning-Dorson, T., Baba, F., Zulu, M., & Acheampong, G. (2025). Data-driven dynamic capabilities in emerging markets: A grounded theory approach to digital transformation in african retail banking. *International Journal of Information Management*, *84*, 102914.

Anumakonda, R. C. (2025). Smart Banking: How AI and Machine Learning Are Reshaping the Financial Landscape. *Journal Of Engineering and Computer Sciences*, *4*(7), 843-850.

Benatiya Andaloussi, M., El Hadiri, M., Nouib, A., & El Krami, Y. (2025). Corporate digital transformation: a comprehensive definition and conceptual framework for enhancing business performance. *Journal of Information Technology Management*, *17*(Special Issue on Strategic, Organizational, and Social Issues of Digital Transformation in Organizations), 81-102.

Bindel Sibassaha, J. L., Pea-Assounga, J. B. B., & Bambi, P. D. R. (2025). Influence of digital transformation on employee innovative behavior: roles of challenging appraisal, organizational culture support, and transformational leadership style. *Frontiers in Psychology*, *16*, 1532977.

Chen, J., Tian, Y., & Shen, Z. (2024). Research on the Impact of Digital Transformation on Commercial Bank Performance. *Frontiers in Management Science*, *3*(3), 31-34.

[Downloaded from jme.mbri.ac.ir on 2026-11-08]

Chen, S., & Zhang, H. (2021). Does digital finance promote manufacturing servitization: Micro evidence from China. *International Review of Economics & Finance*, *76*, 856-869.

Cornwell, N., Bilson, C., Gepp, A., Stern, S., & Vanstone, B. J. (2023). The role of data analytics within operational risk management: A systematic review from the financial services and energy sectors. *Journal of the Operational Research Society*, *74*(1), 374-402.

Dash, B., Swayamsiddha, S., & Ali, A. I. (2023). Evolving of smart banking with NLP and deep learning. In *Enabling Technologies for Effective Planning and Management in Sustainable Smart Cities* (pp. 151-172). Cham: Springer International Publishing.

Feng, C., Weng, F., & Zhenyuan, L. (2025). Evaluation index system for value co-creation in integrated care within the context of digital transformation. *Scientific Reports*, *15*(1), 18118.

Grimwade, M. (2023). The potential impacts of the digital revolution on the operational risk profiles of banks. *Journal of Risk Management in Financial Institutions*, *17*(1), 71-88.

Hair, J., & Alamer, A. (2022). Partial Least Squares Structural Equation Modeling (PLS-SEM) in second language and education research: Guidelines using an applied example. *Research methods in applied linguistics, 1(3), 100027*.

Handani, D. (2024). Organizational culture change and adaptation in the face of digital transformation: A study of Jambi's banking sector. *Enigma in Economics*, *2*(2), 110-121.

Haryanti, R. A., Anugrah, B., Gustama, A., Rahmadani, D. F., & Hanggraeni, D. (2025). The Impact of Digital Transformation on Organizational Performance and Operational Risks in Banking Sector. *Journal Pendidikan Indonesia*, *6*(1).

Hoai, P. T. T., & Vu, N. T. (2024). Assessing the impact of digital transformation on risk management in Vietnam's joint-stock commercial banks. *Migration Letters, 21(S2), 372-384*.

Hrytsenko, L. L., Pakhnenko, O. M., Kuzior, A., & Kozhushko, I. (2024). Smart technologies in banking.

Hrytsenko, L., Pakhnenko, O. Kuzior, A. & Kozhushko, I. (2024). Smart technologies in banking. *Financial Markets, Institutions and Risks, 8(1), 81-93*. https://doi.org/10.61093/fmir.8(1).81-93.2024.

Ibragimov, S. S., & Najmiddinov, M. B. (2025). The Role and Importance of Digital Transformation in Banking Services. *European International Journal of Pedagogics*, *5*(05), 104-109.

Jingrong, H., Shan, H., Zhaobin, C., Yu, L., & Yingying, L. (2024). Ai-driven digital transformation in banking: A new perspective on operational efficiency and risk management. *Information Systems and Economics*, *5*(1), 82-90.

Kamel, M. A., Mousa, M. E. S., & Hamdy, R. M. (2022). Financial efficiency of commercial banks listed in Egyptian stock exchange using data envelopment

[Downloaded from jme.mbri.ac.ir on 2026-11-08]

analysis. *International Journal of Productivity and Performance Management*, *71*(8), 3683-3703.

Kasula, V. K. (2023). AI-driven banking: A review on transforming the financial sector. *World Journal of Advanced Research and Reviews*, *20*(02), 1461-1465.

Kovač, M., Omanović, L., Pintar, M., & Zupan, M. (2024). The state's role in commercialising new technologies. In P. Domadenik Muren, M. Koman, & T. Redek (Eds.), *Engineering the industrial transformation. Časnik Finance*.

Malikov, A. (2024). Digital transformation and its impact on the structure and efficiency of modern business. *Annali D'italia*, (62), 112-115.

Nguyen, H. M., Pham, H. T. N., Tran, K. M., Nguyen, M. T. T., & Nguyen, Y. T. H. (2025). Digitalization and its impact on commercial banks' profitability in Vietnam. *Ho Chi Minh City Open University Journal of Science-Economics and Business Administration*, *15*(1), 152-164.

Nguyen, Q. T. T., Ho, L. T. H., & Nguyen, D. T. (2023). Digitalization and bank profitability: evidence from an emerging country. *International Journal of Bank Marketing*, *41*(7), 1847-1871.

Ortaköy, S., & Özsürünç, Z. (2019). The effect of digital channel migration, automation and centralization on the efficiency of operational staff of bank branches. *Procedia Computer Science*, *158*, 938-946.

Osika, G. (2024). The scopes of digital competences. *Scientific Papers of Silesian University of Technology. Organization & Management/Zeszyty Naukowe Politechniki Slaskiej. Seria Organizacji i Zarzadzanie, (210), 455*.

Ren, X., Song, K., Zhu, K., & Yang, X. (2024). Does digital transformation increase bank profit efficiency? Evidence from China. *Pacific-Basin Finance Journal*, *86*, 102388.

Rohit, K., Kumari, P., Singh, N., & Alofaysan, H. (2025). Smart banking chatbots and consumer engagement: the role of trust and privacy in AI-driven banking. *Journal of Strategic Marketing*, 1-18.

Shanti, R., Siregar, H., & Zulbainarni, N. (2024). Revolutionizing banking: Neobanks' digital transformation for enhanced efficiency. *Journal of Risk and Financial Management*, *17*(5), 188.

Yang, F., & Masron, T. A. (2023). Does financial inclusion moderate the effect of digital transformation on banks' performance in China?. *Cogent Economics & Finance*, *11*(2), 2267270.

Zhang, C., Wang, Y., & Zhang, Y. (2025). Can digital transformation improve commercial banks' performance?. *The Journal of Technology Transfer*, *50*(4), 1341-1362.

Zhu, Y., & Jin, S. (2023). How does the digital transformation of banks improve efficiency and environmental, social, and governance performance? *Systems*, *11*(7), 328.

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