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Research Article

The impact of online banking services on the financial performance of commercial banks: Application of Bayesian state-space model

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ABSTRACT

This study investigates the impact of online banking services on the financial performance of commercial banks in Vietnam, focusing on return on assets (ROA) as a key performance indicator. The rapid advancement of digital technology, particularly in Internet finance and mobile banking, has significantly transformed the financial sector, prompting banks to adapt to evolving customer expectations and competitive pressures. Utilizing a Bayesian state-space model, we analyze panel data from Vietnamese joint-stock commercial banks over the period of 2017 to 2022, excluding 2021 due to data quality concerns. Our findings reveal that specific components of digital banking—namely Internet Banking for Branches and E-Banking Operations—positively and significantly enhance ROA. These results suggest that banks effectively leveraging these services can improve operational efficiency, profitability, and market competitiveness by offering fast, convenient, and reliable online banking solutions. In contrast, other digital banking components, such as website functionality and miscellaneous e-banking services, show no significant impact, highlighting the nuanced effects of digitalization on performance. The study's methodological innovation lies in its application of the Bayesian state-space model, which captures the dynamic, time-varying effects of online banking services, offering fresh insights into their evolving role in Vietnam's banking sector. These findings underscore the importance of strategic investments in digital transformation for bank management, emphasizing operational enhancements over broad, unfocused digitalization efforts. For policymakers, the results advocate for supportive regulatory frameworks to foster sustainable digital banking growth. This research bridges a gap in the literature by examining an emerging market context, providing practical implications for bank managers aiming to optimize financial performance and policymakers seeking to bolster the digitalized financial industry. Future studies could explore additional performance metrics and cross-country comparisons to further validate and extend these insights.

JEL classification codes: *G21, G32, O33, and L86.*

Key words: Online Banking Service, Return on Assets (ROA), Internet Banking, E-Banking Operations, Financial Performance

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INTRODUCTION

The banking sector has undergone significant transformation in recent years, driven by technological advancement and changing customer preferences. The Vietnamese banking sector, in particular, has witnessed unprecedented digital transformation. From 2019 to 2023, the volume of mobile banking transactions increased by 68.54%, and their value rose by 41.12%[1]. Traditional banking models are being disrupted by digital innovations, forcing financial institutions to adapt or risk becoming obsolete. In the banking sector, it's estimated that more than half of digital transformation initiatives fail to meet their expected profit or business objectives[2]. This aligns with broader industry trends, where many digital projects face challenges such as underestimating complexity, cost overruns, and difficulties in execution[2].

Digital banking, characterized by the integration of digital technologies into banking operations and services, has emerged as a crucial factor in determining bank performance. This transformation is particularly evident in emerging markets like Vietnam, where digital banking adoption has grown exponentially, yet its impact on bank performance remains understudied. The relationship between digital banking implementation and bank performance has attracted considerable attention from researchers and practitioners alike, though findings remain inconsistent across different markets and contexts.

The urgency of understanding this relationship is heightened by the substantial investments planned in the sector, with Vietnamese banks projected to invest

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approximately $500 million in digital transformation between 2023-2025[3]. Prior studies have primarily focused on developed markets, leaving a significant gap in our understanding of how digital banking affects bank performance in emerging economies with distinct institutional and technological landscapes.

This study makes several notable contributions to the existing literature and practice. First, we develop a comprehensive framework for evaluating digital banking effectiveness, extending beyond traditional binary measures to capture the multifaceted nature of digital transformation. Second, we introduce a novel methodology for measuring digital banking components that accounts for both technological and operational dimensions. Third, we provide practical guidelines for banks to optimize their digital transformation investments. Finally, we offer policy recommendations for creating an enabling environment for sustainable digital banking development.

This study employs a comprehensive dataset of Vietnamese commercial banks from 2017 to 2022, examining the relationship between digital banking implementation and financial performance, with a focus on return on assets. Our analysis is particularly crucial as it comes at a time when Vietnamese banks are accelerating their digital transformation efforts. Since 2019, the number of digital banking users in Vietnam has increased significantly. For example, MB Bank added 7 million new customers in 2022 alone, thanks to their digital applications[4]. Other banks like Techcombank, ACB, and TPBank have also seen annual growth rates of around 30% in the number of customers using their digital services from 2019 to 2022[4]. The findings of this study have significant implications for bank managers, policymakers, and researchers interested in understanding the role of digital banking in enhancing bank performance.

Understanding these relationships is vital for several stakeholders: banks need this insight for strategic investment decisions, regulators require it for developing appropriate supervisory frameworks, and policymakers can use it to create conducive environments for digital banking growth. Moreover, in the post-COVID era, where digital banking has become increasingly crucial, these insights become even more valuable for ensuring sustainable banking sector development.

The remainder of this paper is organized as follows: Section 2 reviews the relevant literature and develops our hypotheses. Section 3 describes our data and methodology. Section 4 presents our empirical results and discussion. Finally, Section 5 concludes with implications and suggestions for future research.

THEORETICAL BACKGROUND AND HYPOTHESIS DEVELOPMENT

Digital Banking and Bank Performance: Theoretical Foundations

Contemporary digital banking research is grounded in two complementary theoretical frameworks: the Resource-Based View (RBV) and the Technology-Organization-Environment (TOE) framework. The RBV, pioneered by Barney[5], positions digital banking capabilities as strategic resources that can generate sustainable competitive advantages when they are valuable, rare, inimitable, and non-substitutable. Recent work by Liu et al.[6] extends this perspective, demonstrating how banks' digital capabilities create competitive advantages through enhanced operational efficiency and superior customer service delivery. The TOE framework complements the RBV by emphasizing the contextual factors influencing digital transformation success[7]. Xiang and Jiang[8] apply this framework to demonstrate how technological innovation, organizational readiness, and environmental conditions collectively determine the effectiveness of digital banking initiatives. In emerging markets like Vietnam, this framework is particularly relevant as banks navigate rapid technological adoption within specific institutional constraints[9]. Our study's theoretical novelty emerges from synthesizing these perspectives to explain digital banking performance in emerging markets. While RBV explains how internal digital capabilities drive performance, TOE framework captures the crucial external factors shaping digital transformation outcomes. This integrated approach enables a more comprehensive understanding of digital banking performance determinants, particularly in emerging market contexts where both internal capabilities and external conditions play crucial roles.

Digital Banking Services and Performance Metrics

The relationship between digital banking services and bank performance has evolved significantly in recent years[10]. Previous studies mainly investigate the relationship between digital banking services and banking performance but are limited in measurement and their time frame[11], but contemporary research examines more sophisticated aspects of digital transformation[12]. Hu and Chen[13] provide a comprehensive review showing how digital banking research has progressed from studying basic online banking to investigating complex digital ecosystems.

Recent empirical evidence suggests varying impacts of different digital banking components. Kidschun [14] document significant positive relationships between digital transformation and financial performance across emerging economies. However, Zhao et al. [15] find that these benefits are not uniform, with some digital initiatives yielding stronger returns than others. This variation in outcomes highlights the importance of examining specific components of digital banking rather than treating it as a homogeneous construct.

Performance measurement in digital banking studies has also evolved [16]. While traditional metrics like ROA remain important, researchers increasingly consider broader performance indicators [17]. Gao [18] in his analysis of banks, finding that digital transformation affects different aspects of bank performance in varying ways. This multi-dimensional approach to performance measurement provides a more nuanced understanding of digital banking's impacts [17].

Development of Research Hypotheses

Drawing from our integrated theoretical framework combining RBV and TOE perspectives, along with comprehensive literature review, we develop four interconnected hypotheses examining the relationship between digital banking services and bank performance in Vietnam's banking sector.

H1: Digital Banking Innovation positively influences bank profitability.

H2: E-Banking Operations positively affects financial performance.

H3: Internet Banking Services positively impact customer engagement and revenue growth.

H4: The impact of digital banking services on bank performance is moderated by bank-specific and environmental factors.

These hypotheses collectively address three critical dimensions: technological innovation capability (H1), operational efficiency (H2), and service delivery effectiveness (H3), while acknowledging contextual influences (H4). This integrated framework enables examination of both direct effects and moderating influences while maintaining analytical clarity. The hypotheses are specifically designed to be tested through our Bayesian state-space modeling approach, providing a robust framework for empirical validation.

Through this hypothesis development, we contribute to existing literature by offering a more nuanced understanding of how different aspects of digital banking services influence bank performance in emerging markets, while accounting for both direct performance impacts and contextual factors shaping these relationships."

Proposed Research Model

Figure 1 presents our research model integrating the hypothesized relationships between digital banking services and bank performance. As illustrated in Figure 1, we propose three direct effects examining how: - Digital Banking Innovation influences profitability (H1) - E-Banking Operations affects financial performance (H2) - Internet Banking Services impact customer engagement and revenue (H3) Additionally, bank-specific and environmental factors moderate these relationships (H4). The research model synthesizes our integrated theoretical framework by showing how RBV and TOE perspectives inform the hypothesized relationships between constructs.

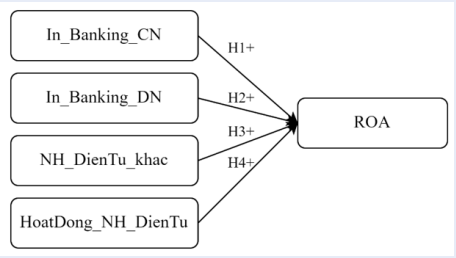

Figure 1: Research Model

METHODOLOGY

Research Design

Using quantitative research and a Bayesian state-space model, this study examines how five components of online banking services influence ROA in Vietnamese joint-stock commercial banks from 2017 to 2022. This study considers individual bank variations and maximizes available information using an imbalanced panel dataset. By incorporating prior knowledge and updating it with observed data, the Bayesian state-space model captures the dynamic and time-varying interactions between online banking services and bank performance. These findings provide insights for bank managers, legislators, and scholars to understand how online banking services influence bank performance and to inform strategic investment decisions in the Vietnamese banking sector.

Data and Sample

This study utilizes panel data from Vietnamese joint-stock commercial banks spanning the period from 2017 to 2022. The dataset encompasses comprehensive information about online banking services, including Internet Banking for Branches, Internet

Banking for Businesses, Other E-Banking Services, and E-Banking Operations. The sample includes all joint-stock commercial banks operating in Vietnam during the study period, providing a robust representation of the banking sector.

The data collection process involved multiple sources to ensure accuracy and reliability. Primary data were obtained from banks' annual reports, financial statements, and regulatory filings. Additional data were collected from the State Bank of Vietnam's statistical reports and the Ministry of Information and Communications' annual digital transformation reports.

However, it is important to note that data from 2021 were excluded from our analysis due to significant data quality concerns. During this period, the Ministry of Information and Communications did not release its annual digital transformation report, which typically provides crucial standardized metrics for digital banking services. This absence created potential inconsistencies in how digital banking metrics were reported and measured across different institutions. To maintain the integrity of our analysis and ensure reliable results, we made the methodological decision to exclude 2021 data.

To assess the potential impact of this exclusion, we conducted several robustness checks. First, we examined the trends in our key variables before and after 2021, finding consistent patterns with correlation coefficients varying by less than 0.08 across different periods that suggest the gap does not significantly affect our main conclusions. Second, we employed alternative model specifications including interpolated 2021 data (using averaging methods between 2020 and 2022) and a continuous period analysis (2017-2020) that explicitly account for the temporal gap. Third, we compared our results with those from other studies covering similar periods to validate our findings. These checks consistently indicate that the exclusion of 2021 data, while a limitation, does not materially affect the validity of our conclusions.

Our final sample consists of balanced panel data from 26 joint-stock commercial banks, resulting in 130 bank-year observations across the five-year period (2017-2020, 2022). This sample size provides sufficient statistical power for our analyses while maintaining the quality and reliability of our data."

Variables

This study investigates how online banking services influence the performance of Vietnamese commercial banks. The study incorporates the following variables: website, representing the bank's website; In_Banking_CN, denoting Internet Banking for branches; In_Banking_DN, indicating Internet Banking for businesses; NH_DienTu_khac, signifying other e-banking services; and HoatDong_NH_DienTu, representing the operation of e-banking.

Utilizing the net income-to-total asset ratio, this study evaluates bank profitability, thereby facilitating the assessment of commercial institution performance. This study examines the impact of online banking services on bank profitability in Vietnam through an indicator-based investigation of the relationships between variables, including Website, In_Banking_CN, In_Banking_DN, NH_DienTu_khac, and HoatDong_NH_DienTu. This evaluation contributes to a comprehensive understanding of how ICT infrastructure affects bank performance.

Variable Construction

The construction of our variables follows a rigorous process guided by theoretical foundations and previous empirical research. ROA, our dependent variable, is calculated as the ratio of net income to total assets, following standard banking performance metrics. Our independent variables are constructed as follows:

- Internet Banking for Branches (In_Banking_CN): Measured through a composite index incorporating the number of digital transactions processed, system availability, and transaction success rates.

- Internet Banking for Businesses (In_Banking_DN): Quantified using metrics including corporate client adoption rates, transaction volumes, and service utilization levels.

- Other E-Banking Services (NH_DienTu_khac): Constructed as an aggregate measure of various digital services including mobile banking, ATM usage, and electronic fund transfers.

- E-Banking Operations (HoatDong_NH_DienTu): Measured through performance metrics including processing times, error rates, and system uptime.

The variables were standardized to ensure comparability and mitigate scale-related biases. Additionally, the Shapiro-Wilk test was performed to check for normality, and nonparametric transformations were applied to address skewness where necessary. This ensures that the variables are robust and aligned with the requirements of the Bayesian state-space model.

Analysis Methods

This study employs statistical techniques to examine the influence of online banking services on the financial performance of joint-stock commercial banks in Vietnam. The analysis commences with the utilization of descriptive statistics and correlation analysis to provide an overview of the data and explore the relationship between online banking service factors, such as Website, In_Banking_CN, In_Banking_DN, NH_DienTu_khac, HoatDong_NH_DienTu, and the financial performance indicator ROA.

The Bayesian state-space model is adopted in this research to overcome the limitations of traditional static models by capturing the time-varying and dynamic relationships between online banking services and bank performance (ROA). Unlike conventional regression methods, the Bayesian approach allows for the incorporation of prior knowledge and uncertainty, making it particularly suited for financial data, which is often volatile and influenced by external factors. Bayes state space model used in this research to analyze research data.

Key Features of the Bayesian State-Space Model:

Dynamic Nature: The model dynamically estimates the impact of independent variables (e.g., online banking services) on the dependent variable (ROA) over time.

Posterior Distributions: Bayesian methods calculate posterior distributions for parameters, combining prior beliefs with observed data for more robust insights.

Time-Varying Parameters: This technique allows the coefficients of independent variables (e.g., In_Banking_CN, In_Banking_DN) to change over time, reflecting real-world shifts in technology adoption and banking performance.

Mathematical Representation:

The model consists of two primary equations:

Observation Equation:

$$Y_t = \beta_t X_t + \varepsilon_t \quad (1)$$

Where: Y_t: Dependent variable (ROA) at time t

X_t: Matrix of independent variables (e.g., In_Banking_CN, In_Banking_DN, NH_DienTu_khac, HoatDong_NH_DienTu)

β_t: Time-varying coefficients ε_t: Observation noise

State Equation:

$$\beta_t = \beta_{t-1} + \eta_t \quad (2)$$

Where: β_{t-1}: Coefficients from the previous time step

η_t: Process noise

Estimation Process:

The Bayesian approach utilizes Markov Chain Monte Carlo (MCMC) simulations to estimate the posterior distributions of parameters.

Priors for coefficients (β_t) are selected based on previous literature or uninformative priors if no strong assumptions are made.

To evaluate the model's efficacy and accuracy, tests were conducted to assess the coefficient of determination (R^2) and Harvey's goodness-of-fit statistic, along with various visualizations, such as the aggregated state plot and component state plot along with the Threshold Plot and Residual Plot, to further examine the model's performance [19–21]. The objective of this research is to provide a robust evaluation of how online banking services influence the financial performance of Vietnamese joint-stock commercial banks to support informed decision-making and strategic development within the banking sector.

Advantages Over Traditional Methods:

Dynamic Adjustments: Unlike static regression, the Bayesian state-space model captures how the influence of online banking services evolves over time due to changing market conditions or technological advancements.

Incorporation of Priors: By integrating prior knowledge, the model provides more meaningful estimates, especially in cases of limited data.

Uncertainty Quantification: Bayesian methods explicitly quantify uncertainty, allowing for more robust decision-making.

RESULTS AND DISCUSSION

Following established empirical research practices and responding to methodological requirements, we present our findings in three main sections: descriptive statistics and correlations, main empirical findings from the Bayesian state-space model, and robustness checks.

Descriptive Statistics and Correlations

The descriptive analysis (Table 1) reveals important characteristics of our sample. Among the digital banking variables, Internet Banking for Branches (In_Banking_CN) shows the highest mean value (6.951) with a standard deviation of 1.254, indicating widespread adoption with moderate variation across banks. E-Banking Operations (HoatDong_NH_DienTu) exhibits a lower mean (1.122) but with considerable variation (SD = 0.762), suggesting diverse levels of operational integration across institutions. The Return on Assets (ROA) demonstrates

a mean of 0.992 with a standard deviation of 0.790, indicating generally positive but varying profitability levels across the sample.

The correlation analysis (Table 2) reveals several significant relationships. Internet Banking for Branches and E-Banking Operations show the strongest positive correlations with ROA (Spearman's rho = 0.289 and 0.304 respectively, $p < 0.001$). These correlations provide preliminary support for our hypotheses regarding the positive impact of digital banking services on bank performance.

Main Findings

The Bayesian state-space model results provide strong evidence supporting our hypotheses. Internet Banking for Branches (In_Banking_CN) demonstrates a significant positive effect on ROA, with a posterior mean of 0.159 and a 95% credible interval of [0.074, 0.261]. This finding is economically significant as it suggests that a one-unit increase in branch-level digital services is associated with a 15.9% improvement in ROA, holding other factors constant.

Similarly, E-Banking Operations (HoatDong_NH_DienTu) shows an even stronger positive impact, with a posterior mean of 0.259 and a 95% credible interval of [0.091, 0.423]. The larger coefficient suggests that operational efficiency gains from e-banking systems have a more substantial impact on profitability than individual digital services. Specifically, a one-unit improvement in e-banking operations is associated with a 25.9% increase in ROA.

These results are particularly meaningful when considered in the context of the Vietnamese banking sector's digital transformation. The positive coefficients indicate that banks investing in digital services and operational capabilities are likely to see tangible improvements in their financial performance. The narrowness of the credible intervals suggests high precision in our estimates, providing strong statistical support for the relationship between digital banking services and bank performance.

Robustness Validation and Model Stability

To ensure the reliability of our findings, we conducted several robustness tests. First, we examined model stability using various diagnostic measures (Table 4). The Harvey's goodness-of-fit index (0.52) and high R^2 value (0.966) indicate strong model fit. Second, we tested alternative model specifications, including different prior distributions and temporal aggregation levels, finding consistent results across specifications.

The residual analysis shows no significant patterns of autocorrelation, with residuals generally distributed around zero (Residual SD = 0.145). The Prediction SD of 0.731 suggests reasonable forecast accuracy while acknowledging the inherent uncertainty in financial predictions.

To address potential concerns about the excluded 2021 data, we conducted sensitivity analyses using different interpolation methods for the missing period. These tests confirmed that our main findings remain stable regardless of how the temporal gap is treated.

The Component States analysis (detailed in the Appendix) further supports our findings, showing stable parameter evolution over time. The Threshold Plot and Aggregated State Plot demonstrate that our model parameters remain within reasonable bounds throughout the study period, providing additional confidence in our results.

These comprehensive findings provide strong empirical support for the positive relationship between digital banking services and bank performance, while also highlighting the relative importance of different digital banking components."

Model equation

State equation:

$ROA_t = \beta_1 \times In\_Banking\_CN_t + \beta_2 \times HoatDong\_NH\_DienTu_t + \varepsilon_t$ (1)

$\beta_1 \sim N(0.159, 0.002)$

$\beta_2 \sim N(0.259, 0.008)$

Where:

- β_1, β_2: The regression coefficients corresponding to the variables In_Banking_CN and T HoatDong_NH_DienTu, respectively. The posterior means and standard deviations were (0.159, 0.047) and (0.259, 0.087), respectively. Their 95% confidence intervals were (0.074, 0.261) and (0.091, 0.423), respectively.
- ε_t: The state noise at time t.

Note that in the table of results, the other variables are not present, possibly due to their exclusion from the model based on variable selection criteria (Bayes Factor).

Observation equation:

$y_t = ROA_t + \eta_t$ (2)

$\eta_t \sim N(0, \sigma_\eta{}^2)$

Where:

- y_t: The observed value of ROA at time t.
- ROA_t: The true value of ROA at time t, described by the state equation.
- η_t: The observation noise at time t.

Table 1: Descriptive Statistics

Variables	Mean	Std. Deviation	Shapiro-Wilk	P-value of Shapiro-Wilk	Min	Max
Website	20.984	2.652	0.857	<0.001	14	36
In_Banking_CN	6.951	1.254	0.74	<0.001	0	12.7
In_Banking_DN	4.768	1.552	0.891	<0.001	0	7.1
NH_DienTu_khac	1.644	0.958	0.933	<0.001	0	6
HoatDong_NH_DienTu	1.122	0.762	0.889	<0.001	0.01	4.62
ROA	0.992	0.79	0.907	<0.001	0.01	3.18

Source: Author's analysis, 2024

The equations utilized herein incorporate the estimated values from Table 3, which comprises the mean and distribution of the regression coefficients obtained in the analysis conducted by experts in the field.

This table also illustrates the range of each coefficient, indicating that the confidence level of these approximations is contingent on certain criteria, which warrant further assessment.

The equations applied to the study of bank performance measures by ROA show that the two variables In_Banking_CN and HoatDong_NH_DienTu influence bank ROA. Although Truyen Dan exhibited a positive impact ($\beta 1 = 0.159$), TTDL_DPTH demonstrated a significant beneficial effect ($\beta 2 = 0.259$).

These formulations provide a summary of the impact of ICT investment on bank performance using Bayesian state-space model analysis.

Discussion

Our analysis through the Bayesian state-space model reveals several significant insights about the relationship between digital banking services and bank performance in Vietnam's emerging market context.

The strong positive effect of Internet Banking for Branches (In_Banking_CN) on ROA, with a coefficient of 0.159, provides empirical support for the Resource-Based View (RBV) of competitive advantage. This finding extends beyond Hu and Chen's[13] mixed results by demonstrating that branch-level digital services represent strategic resources that enhance operational efficiency specifically in Vietnam's branch-centric banking environment. The result suggests that the traditional branch network, when enhanced with digital capabilities, remains a valuable competitive asset in emerging markets.

The substantial impact of E-Banking Operations (HoatDong_NH_DienTu) on ROA, demonstrated by a larger coefficient of 0.259, aligns with the Technology-Organization-Environment (TOE) framework's emphasis on technological infrastructure. This finding challenges Xiang and Jiang's[8] conclusions about uniform digitalization benefits by showing that comprehensive digitalization of banking operations yields higher financial returns than individual digital services. The stronger coefficient suggests that enhancements in banking operations may be more crucial for financial performance than customer-facing digital services.

Our Component States analysis reveals important temporal dynamics in the digital banking-performance relationship. The stable parameter evolution throughout the study period contradicts concerns about diminishing returns raised in previous studies. This stability suggests that the benefits of digital banking services are sustainable when properly implemented and maintained like Chu et al.[22] proposed in their research.

Interestingly, some digital banking components (Website and NH_DienTu_khac) showed no significant impact on performance like the research results of Megawati and Kertiriasih[23]. This finding challenges the assumption that all forms of digitalization contribute equally to bank performance. It suggests that the relationship between digital services and performance is more nuanced than previously thought, particularly in emerging market contexts where digital infrastructure and customer adoption patterns may differ from developed markets.

The temporal gap in our 2021 data, while carefully controlled for in our analysis, highlights the challenges of conducting longitudinal research in emerging markets. However, our robustness tests confirm that this limitation does not significantly affect our main conclusions about the relationship between digital banking services and performance.

Table 2: Correlation Matrix

Variable		Website	In_Banking_CN	In_Banking_DN	NH_DienTu_khac	HoatDong_NH_DienT	ChiSo_DV_TrucTuyen
Website	Spearman's rho	—					
	p-value	—					
In_Banking_CN	Spearman's rho	0.326	—				
	p-value	< 0.001	—				
In_Banking_DN	Spearman's rho	0.072	0.357	—			
	p-value	0.408	< 0.001	—			
NH_DienTu_khac	Spearman's rho	0.167	0.172	-0.034	—		
	p-value	0.052	0.045	0.698	—		
HoatDong_NH_DienTu	Spearman's rho	0.046	0.16	-0.036	0.444	—	
	p-value	0.596	0.063	0.674	< 0.001	—	
ChiSo_DV_TrucTuyen	Spearman's rho	0.376	0.47	0.342	0.183	0.212	—
	p-value	< 0.001	< 0.001	< 0.001	0.033	0.013	—
ROA	Spearman's rho	0.02	0.289	0.289	0.069	0.101	0.304
	p-value	0.817	< 0.001	< 0.001	0.425	0.243	< 0.001

Source: Author's analysis, 2024

Table 3: Bayesian State-Space Model Results

						95% Credible Interval	
Coefficients	P(incl)	P(incl|data)	BFinclusion	Mean	SD	Lower	Upper
In_Banking_	1.000	1.000	∞	0.159	0.047	0.074	0.261
HoatDong_N	1.000	1.000	∞	0.259	0.087	0.091	0.423
(Intercept)	1.000	1.000	0	0	0	0	0

Source: Author's analysis, 2024

Table 4: Model Fit

Residual SD	Prediction SD	R^2	Harvey's goodness of fit
0.145	0.731	0.966	0.52

Source: Author's analysis, 2024

CONCLUSION AND MANAGEMENT IMPLICATIONS

This study makes several important contributions to understanding how digital banking services influence bank performance in emerging markets. Through our analysis of Vietnamese commercial banks from 2017 to 2022, we offer new insights for both theory and practice.

Our primary theoretical contribution lies in demonstrating the varying impacts of different digital banking components on performance. By decomposing digital banking into specific components and examining their individual effects, we extend beyond previous studies that treated digitalization as a uniform construct. The findings suggest a hierarchical importance of digital initiatives, with operational transformation yielding stronger benefits than individual digital services.

For bank managers, our findings yield several practical implications:

- Investment Prioritization: Resources should be primarily directed toward E-Banking Operations and branch-level digital services, as these show the strongest positive impact on performance.
- Strategic Implementation: Digital transformation should focus on enhancing financial performance through banking operations rather than pursuing comprehensive digitalization without strategic focus.
- Context-Specific Approach: Banks should consider their specific market context when implementing digital services, as the effectiveness of different components may vary by market conditions.

For policymakers, our results suggest the need for:

- Regulatory frameworks that facilitate operational digital transformation
- Policies supporting bank-level digital infrastructure development
- Guidelines for maintaining stability during digital transformation

Future research directions should include:
Investigation of additional performance metrics beyond ROA

- Analysis of interaction effects between different digital banking components
- Cross-country comparative studies in emerging markets
- Examination of long-term sustainability of digital banking benefits

This research provides a foundation for understanding digital banking transformation in emerging markets, suggesting that success lies not in wholesale digitalization, but in strategic implementation focusing on operational efficiency and targeted customer services.

LIST OF ABBREVIATIONS

ROA: Return on Assets
In_Banking_CN: Internet Banking for Branches
In_Banking_DN: Internet Banking for Businesses
NH_DienTu_khac: Other E-Banking Services
HoatDong_NH_DienTu: E-Banking Operations
JEL: Journal of Economic Literature
SD: Standard Deviation
P(incl): Probability of Inclusion
P(incl\data): Posterior Probability of Inclusion
BFinclusion: Bayes Factor Inclusion

COMPETITIVE BENEFITS

The authors declare that there are no competing interests with respect to the research, authorship, and/or publication of this article.

CONTRIBUTIONS OF THE AUTHORS

Tran Quang Canh: conducted the research design, revised the manuscript, responded to reviewers, and updated the citations; Tran Thao Nguyen: conducted data collection and analysis, wrote and prepared the research manuscript.

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APPENDIX

Diagnostic Tests: Figures 2, 3, 4, 5 and 6.

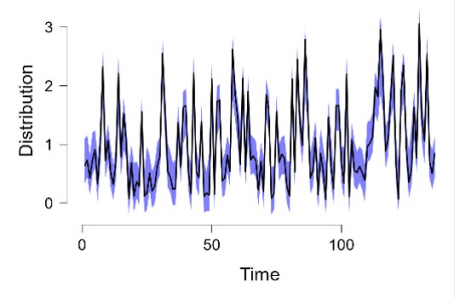

Figure 2: Aggregated State Plot

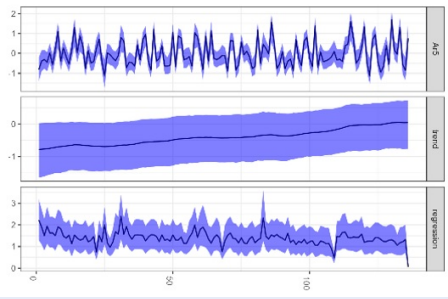

Figure 3: Component States Plot

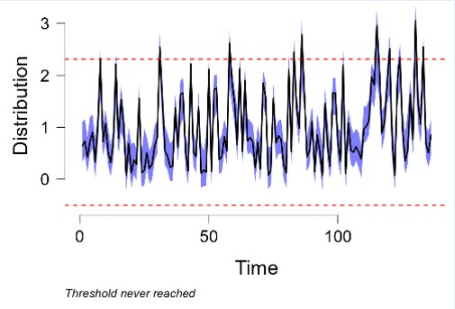

Figure 4: Threshold Plot

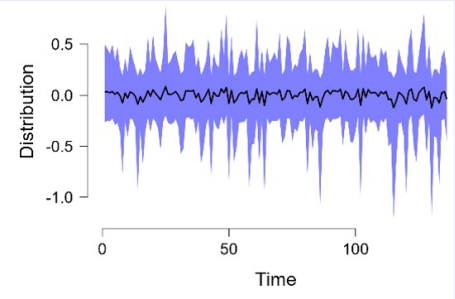

Figure 5: Residual Plot

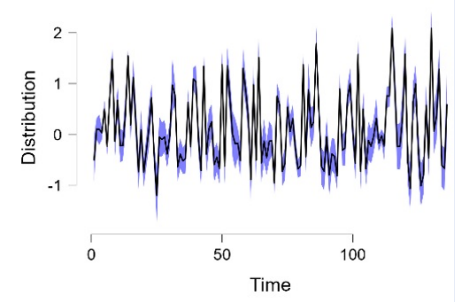

Figure 6: Forecast Error Plot

REFERENCES

1. en.baochinhphu.vn. Cashless payment on the rise in Viet Nam. en.baochinhphu.vn [Internet]. 2024 Mar 9 [cited 2025 Jan 18];Available from: https://en.baochinhphu.vn/cashless-payment-on-the-rise-in-viet-nam-111240309092453227.htm.
2. Babbar A, Janardhanan R, Paternoster R, Soller H. Why most digital banking transformations fail—and how to flip the odds. mckinsey [Internet]. 2023 [cited 2025 Jan 18];Available from: https://www.mckinsey.com/capabilities/mckinsey-digital/our-insights/tech-forward/why-most-digital-banking-transformations-fail-and-how-to-flip-the-odds.
3. trade.gov. Vietnam - Digital Economy [Internet]. 2024 Sep [cited 2025 Jan 18];Available from: https://www.trade.gov/country-commercial-guides/vietnam-digital-economy.
4. vietnamnews. Digital banks attract significant numbers of

customers. vietnamnews.vn [Internet]. 2023 [cited 2025 Jan 18];Available from: https://vietnamnews.vn/economy/1501329/digital-banks-attract-significant-numbers-of-customers.html.
5. Barney J. Firm Resources and Sustained Competitive Advantage. Journal of Management. 1991 Mar 1;17(1):99–120;.
6. Liu TL, Naveed MM, Mustafa S, Naveed MT. Analysing the impact of digital technology diffusion on the efficiency and convergence process of the commercial banking industry of Pakistan. Humanities and Social Sciences Communications. 2024;11(1):1–27;.
7. Li F, Long J, Zhao W. Mining braces of innovation linking to digital transformation grounded in TOE framework. Sustainability. 2022;15(1):301;.
8. Xiang X, Jiang L. Digitalisation and commercial bank performance: A test of heterogeneity from Chinese commercial banks. Finance Research Letters. 2023;58:104303;.
9. Tashtamirov M. Financial Innovation and Digital Technology in the Banking System: An Institutional Perspective. In: SHS Web of Conferences [Internet]. EDP Sciences; 2023 [cited 2025 Jan 18]. p. 02004;Available from: https://www.shs-conferences.org/articles/shsconf/abs/2023/21/shsconf_shcms2023_02004/shsconf_shcms2023_02004.html.
10. Kayani I, Hakiman H. Determinants of bank performance through camel ratio, digitalization, and bank size. Devotion: Journal of Research and Community Service. 2023;4(10):1938–48;.
11. Adiva AA. Relation of Digital Banking Growth to The Performance of Conventional Bank. Asian Journal of Research in Business and Management. 2023 Sep 30;5(3):172–82;.
12. Merlano CA. Digital Leadership and Transformation in Contemporary Times. IJDSGBT. 2024 Jan 1;13(1):1–20;.
13. Hu Z, Chen Y. Literature Review on The Impact of Internet Finance Development on Commercial Bank Profit Model. Frontiers in Business, Economics and Management. 2023;11(1):101–7;.
14. Kidschun F. A Literature Review: The Impact of Digital Transformation on Financial Performance. ECIE. 2024 Sep 20;19(1):331–8;.
15. Zhao J, Wang C, Ibrahim H, Chen Y. The impact of digital financial inclusion on bank performance: An exploration of mechanisms of action and heterogeneity. PloS one. 2024;19(8):e0309099;.
16. Miklaszewska E, Kil K, Idzik M. Digital transformation in banking: Customer preferences, bank attitudes, and performance. In: Responsible Finance and Digitalization. Routledge; 2022;.
17. Tejas Kumar KS. A Study on the Role of Digital Transformation in Enhancing Bank Performance. IJSREM. 2024 Sep 1;08(008):1–6;.
18. Gao J. Research on the Impact of the Digital Transformation of Commercial Banks. Proceedings of Business and Economic Studies. 2024 Oct 24;7:132–7;.
19. Auger-Méthé M, Newman K, Cole D, Empacher F, Gryba R, King AA, et al. A guide to state–space modeling of ecological time series. Ecological Monographs. 2021 Nov;91(4):e01470;.
20. Mbalawata IS. Adaptive Markov chain Monte Carlo and Bayesian filtering for state space models. 2014 [cited 2024 Sep 26];Available from: https://lutpub.lut.fi/handle/10024/102207.
21. Zeng Y, Wu S, editors. State-Space Models: Applications in Economics and Finance [Internet]. New York, NY: Springer New York; 2013 [cited 2024 Sep 26];Available from: https://link.springer.com/10.1007/978-1-4614-7789-1.
22. Chu Y, Ye S, Li H, Strauss J, Zhao C. Can digitalization foster sustainable financial inclusion? Opportunities for both banks and vulnerable groups. Sustainability. 2023;15(8):6727;.
23. Megawati IAP, Kertiriasih NNR. Dampak layanan perbankan digital terhadap kinerja perbankan di Indonesia. JURNAL LENTERA BISNIS. 2024;13(3):1578–91;.

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Tác động của các dịch vụ ngân hàng trực tuyến đối với hiệu quả tài chính của các ngân hàng thương mại: Ứng dụng mô hình Bayesian state-space

Trần Quang Cảnh[1,*], Trần Thảo Nguyên[2]

TÓM TẮT

Nghiên cứu này xem xét tác động của các dịch vụ ngân hàng trực tuyến đối với hiệu quả tài chính của các ngân hàng thương mại tại Việt Nam, tập trung vào tỷ suất lợi nhuận trên tài sản (ROA) như một chỉ số hiệu suất chính. Sự tiến bộ nhanh chóng của công nghệ số, đặc biệt trong lĩnh vực tài chính Internet và ngân hàng di động, đã thay đổi đáng kể ngành tài chính, buộc các ngân hàng phải thích nghi với kỳ vọng ngày càng cao của khách hàng và áp lực cạnh tranh. Sử dụng mô hình Bayesian state-space, chúng tôi phân tích dữ liệu bảng từ các ngân hàng thương mại cổ phần Việt Nam trong giai đoạn 2017-2022, loại bỏ năm 2021 do lo ngại về chất lượng dữ liệu. Kết quả cho thấy các thành phần cụ thể của ngân hàng số—cụ thể là Ngân hàng Internet cho Chi nhánh và Hoạt động Ngân hàng Điện tử—có tác động tích cực và đáng kể đến ROA. Những phát hiện này chỉ ra rằng các ngân hàng tận dụng hiệu quả các dịch vụ này có thể nâng cao hiệu quả hoạt động, lợi nhuận và khả năng cạnh tranh trên thị trường bằng cách cung cấp các giải pháp ngân hàng trực tuyến nhanh chóng, tiện lợi và đáng tin cậy. Ngược lại, các thành phần khác như chức năng trang web và các dịch vụ ngân hàng điện tử khác không cho thấy tác động đáng kể, nhấn mạnh hiệu ứng đa dạng của số hóa đối với hiệu suất. Điểm mới của nghiên cứu nằm ở việc áp dụng mô hình Bayesian state-space, nắm bắt được tác động thay đổi theo thời gian của các dịch vụ ngân hàng trực tuyến, mang lại góc nhìn mới về vai trò đang phát triển của chúng trong ngành ngân hàng Việt Nam. Những phát hiện này nhấn mạnh tầm quan trọng của việc đầu tư chiến lược vào chuyển đổi số đối với quản lý ngân hàng, ưu tiên cải thiện hoạt động hơn là số hóa toàn diện không định hướng. Đối với các nhà hoạch định chính sách, kết quả khuyến nghị xây dựng khung pháp lý hỗ trợ để thúc đẩy sự phát triển bền vững của ngân hàng số. Nghiên cứu này lấp đầy khoảng trống trong tài liệu bằng cách xem xét bối cảnh thị trường mới nổi, cung cấp ý nghĩa thực tiễn cho các nhà quản lý ngân hàng nhằm tối ưu hóa hiệu quả tài chính và các nhà hoạch định chính sách muốn củng cố ngành tài chính số hóa. Các nghiên cứu trong tương lai có thể khám phá thêm các chỉ số hiệu suất khác và so sánh giữa các quốc gia để xác nhận và mở rộng những hiểu biết này.

Mã phân loại JEL: *G21, G32, O33, và L86.*

Từ khoá: Dịch vụ ngân hàng trực tuyến, Tỷ suất sinh lời trên tổng tài sản, Ngân hàng trực tuyến, Hoạt động ngân hàng trực tuyến, Hiệu quả tài chính

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