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Financial Technology Adoption and Financial Performance: A Dynamic Panel Analysis of Banking Institutions in ASEAN Countries

Sudirman Sudirman and Muhammad Wahyuddin Abdullah
State Islamic University of Alauddin, Makassar, Indonesia

Muhammad Ardi
State Islamic Institute of Sultan Amai Gorontalo, Indonesia

Rapid digital transformation has reshaped banking systems worldwide, positioning financial technology adoption as a strategic driver of performance. This study investigates the impact of financial technology adoption on the financial performance of commercial banks in Association of Southeast Asian Nations economies. A quantitative research design is employed using an unbalanced bank-level panel dataset covering the period 2015–2023. The analysis applies a dynamic panel estimation framework based on the system generalized method of moments to address endogeneity, unobserved heterogeneity, and performance persistence. Financial technology adoption is operationalized through a composite index derived from digital service provision, mobile usage intensity, and technology investment. The empirical results demonstrate that greater adoption significantly improves profitability indicators while reducing operational inefficiency. These effects remain robust across alternative model specifications and diagnostic tests, indicating sustained performance gains associated with digital capability development. The findings support innovation diffusion arguments emphasizing efficiency, scalability, and observable performance benefits. Overall, financial technology adoption emerges as a critical mechanism for strengthening bank competitiveness and resilience in emerging financial systems. The study provides actionable insights for strategic investment prioritization and adaptive regulatory design aimed at fostering stable and inclusive digital financial ecosystems .

Keywords: financial technology adoption; bank performance; dynamic panel estimation; digital transformation; operational efficiency; emerging banking systems.

During the last decade, rapid digital progress has substantially transformed the global financial environment, with financial technology (FinTech) emerging as a pivotal driver of innovation in banking services and operational restructuring (Basdekis et al., 2022; Zuo et al., 2021). Innovations associated with FinTech, such as mobile banking platforms, digital payment infrastructures, blockchain applications, big data analytics, and artificial intelligence, aim to improve operational efficiency, expand financial inclusion, and reinforce institutional competitiveness within increasingly complex and digitally integrated markets (Anifa et al., 2022; Offiong et al., 2024; Sajid et al., 2023). Growing empirical findings also indicate that digital financial transformation contributes positively to bank-level performance and market valuation, particularly within emerging financial systems (Khan et al., 2023, 2026).

Correspondence concerning this article should be addressed to Sudirman Sudirman and Muhammad Wahyuddin Abdullah Faculty of Economics and Islamic Business, State Islamic University of Alauddin, Makassar, Indonesia Email: sudirman.andi@uin-alauddin.ac.id

Across the ASEAN region, the pace of FinTech adoption has intensified markedly in recent years (ASEAN Statistical Yearbook, 2023), supported by widespread internet access, rising levels of digital capability, and enabling regulatory mechanisms, including the implementation of regulatory sandbox frameworks (Hamdan & Anshari, 2021; Warokka et al., 2025). Countries such as Indonesia, Singapore, and Malaysia have progressively established themselves as prominent regional centres for FinTech advancement, as reflected in increasing investment inflows and the deep integration of digital technologies into core banking operations (Alam et al., 2021; Anifa et al., 2022; Pradipta et al., 2023). In line with international evidence emphasizing the moderating influence of regulatory quality and digital governance on FinTech-related outcomes (Khan et al., 2023; Khan & Al-Harby, 2022), ASEAN economies exhibit diverse institutional characteristics that may shape the performance implications of digital adoption.

Despite the increasing prominence of FinTech, empirical studies examining its impact on bank performance in ASEAN remain limited, fragmented, and contextually inconsistent. Existing literature often neglects the region's structural heterogeneity, divergent regulatory environments, and the dynamic interplay between FinTech adoption and banking stability. Moreover, prior research presents conflicting evidence: while some studies highlight improvements in profitability, operational efficiency, and service accessibility (Li et al., 2022; Rashwan & Kassem, 2023; Awasthi, 2025), others emphasize trade-offs such as high implementation costs, cybersecurity risks, and organizational resistance transitions (Alexandri et al., 2023; Meyer & Okoli, 2023; Mustapha et al., 2023; Singhvi & Dadhich, 2023). Recent cross-country studies further indicate that the performance implications of FinTech adoption are not uniform, but instead differ according to bank size, capital strength, and the level of institutional development (Khan et al., 2026). This heterogeneity highlights the importance of conducting context-sensitive and methodologically rigorous investigations within ASEAN settings. Accordingly, the observed fragmentation and mixed empirical findings point to a significant research gap, namely the limited availability of robust, region-focused, and causally grounded evidence regarding the effects of FinTech adoption on bank performance in developing ASEAN economies.

To address this research gap, the present study seeks to deliver a comprehensive empirical evaluation of the nexus between FinTech adoption and banking performance across ASEAN economies. In particular, the analysis captures both short-run and long-run effects, while rigorously controlling for potential endogeneity, unobserved heterogeneity, and the persistence of profitability through the application of a dynamic panel system GMM estimator. Such a methodological framework is consistent with recent empirical approaches employed in advanced panel studies on digital finance and banking performance (Khan et al., 2026), thereby strengthening the robustness of causal interpretation and ensuring dynamic coherence of the estimated relationships.

This study contributes to the existing body of knowledge by directly linking FinTech adoption to measurable aspects of bank performance. It responds to the limited availability of regionally focused empirical research, enhances analytical rigor through the use of dynamic panel estimation methods, and helps reconcile mixed evidence regarding both the benefits and potential vulnerabilities associated with digital financial innovation. In this regard, the study both complements and expands upon recent findings from other emerging markets (Khan et al., 2023; Khan & Al-Harby, 2022) by offering dynamic evidence specific to the ASEAN context. In addition, the research provides practical implications for policymakers and banking industry practitioners, supporting more informed decision-making related to digital banking strategies, regulatory frameworks, and investment allocation aimed at fostering sustainable and inclusive financial development.

Literature Review

Research on FinTech adoption and its impact on bank performance has grown significantly, reflecting the rapid digital transformation within the financial sector. Recent cross-country analyses indicate that digital financial transformation has a substantial effect on bank profitability, operational efficiency, and valuation, especially in emerging economies (Khan et al., 2023, 2026; Aduba et al., 2023). This study adopts

the Diffusion of Innovation (DOI) Theory (Rogers, 1995) as its central theoretical framework, while selectively integrating additional perspectives to address institutional and risk-related dimensions without overlapping explanatory mechanisms. By grounding the analysis in DOI theory, the study maintains theoretical coherence and parsimony in elucidating how FinTech adoption drives bank performance.

According to DOI theory, the adoption of innovations is influenced by five principal attributes: relative advantage, compatibility, complexity, trialability, and observability, which collectively determine organizational acceptance and institutionalization of new technologies (Rogers, 1995). In the banking sector, relative advantage pertains to efficiency improvements and revenue diversification; compatibility reflects alignment with existing operational and regulatory frameworks; complexity denotes implementation challenges; trialability allows for incremental testing; and observability enables performance benchmarking (Ismail, 2006; Jwaifell & Gasaymeh, 2020). This framework aligns with recent evidence highlighting that regulatory quality and digital governance can enhance or constrain the benefits of financial innovation (Khan et al., 2023; Khan & Al-Harby, 2022). Together, these attributes offer a cohesive theoretical perspective linking the intensity of FinTech adoption to dynamic bank performance outcomes.

Empirical research largely corroborates the diffusion of innovation perspective that the adoption of financial technology contributes positively to bank performance by enhancing operational efficiency and broadening service reach (Agustin, 2023; Issa et al., 2023; Nanda & Yunus, 2024; Dhanraj, 2024). In particular, process automation and digital distribution platforms are associated with lower transaction expenses, while advanced data analytics facilitate more accurate credit assessment and risk-based pricing, ultimately supporting higher profitability and improved cost-to-income efficiency. Evidence from extensive panel datasets also reveals that performance outcomes are not uniform across institutions, but instead vary according to factors such as capitalization levels, organizational scale, and the degree of institutional development (Khan et al., 2026). This heterogeneity underscores the diffusion of innovation argument that technologies demonstrating tangible relative advantages and visibility tend to produce observable improvements in performance metrics.

Nevertheless, the diffusion of innovation framework recognizes that technology adoption is accompanied by uncertainty and transitional costs. Existing scholarship highlights several potential drawbacks, including heightened exposure to cybersecurity threats, technological vulnerabilities, and internal resistance to organizational change (Cortellazzo et al., 2019; Saeed et al., 2023; Vaska et al., 2021). More recent empirical investigations further suggest that rapid digitalization can intensify operational and systemic risks in environments where governance structures and regulatory oversight remain insufficient (Khan et al., 2023). These issues reflect the complexity dimension within the diffusion of innovation theory, indicating that the performance implications of financial technology adoption are conditional upon organizational preparedness and the broader quality of institutional frameworks.

In emerging markets, bank performance is influenced by institutional and structural attributes, including scale, capital adequacy, and the quality of governance frameworks, as well as by prevailing macroeconomic dynamics (Khan et al., 2023). Within ASEAN, empirical findings on the FinTech–performance nexus remain fragmented, reflecting heterogeneity in regulatory maturity and digital infrastructure (Benny Alexandri et al., 2023; Low & Wong, 2021). Comparative evidence from other emerging markets highlights that institutional quality and financial intermediation structures critically mediate digital finance outcomes (Khan & Al-Harby, 2022; Shira, 2023), reinforcing the need for ASEAN-specific analysis.

Against this background, the current study offers three key contributions. First, it enriches Diffusion of Innovation theory by broadening its scope beyond adoption decisions toward dynamic financial performance, thereby connecting innovation characteristics with the persistence of profitability. Second, it delivers empirical evidence from multiple ASEAN countries through the application of a dynamic panel system Generalized Method of Moments methodology that rigorously accounts for endogeneity concerns

and adjustment processes. Third, by synthesizing insights from recent global empirical research (Khan et al., 2023, 2026), the analysis situates ASEAN-specific findings within wider emerging-market dynamics while maintaining sensitivity to regional institutional contexts.

Anchored in Diffusion of Innovation theory, the formulation of hypotheses builds upon the preceding literature review. FinTech adoption is defined as the depth and intensity of digital transformation rather than the implementation of discrete technological tools, reflecting the relative advantage and observability attributes highlighted within the theoretical framework. In line with recent panel-based evidence indicating economically meaningful impacts of digital transformation on firm performance (Khan et al., 2026), higher levels of adoption intensity are anticipated to generate improved profitability and operational efficiency, subject to firm-level and macroeconomic control factors.

H1: The adoption of financial technology, indicative of the degree of digital transformation, exerts a positive and statistically significant influence on the financial performance of banks within ASEAN nations.

The conceptual framework is formulated ex ante on the basis of Diffusion of Innovation theory, outlining the causal mechanisms through which FinTech adoption influences bank performance across ASEAN economies. FinTech adoption is proxied by three key dimensions: (1) the breadth of digital banking services offered, (2) the intensity of mobile banking utilization, and (3) the proportion of technology-related investment, reflecting relative advantage, trialability, and observability. Bank performance is evaluated using Return on Assets, Return on Equity, and the Cost-to-Income Ratio. To enhance the robustness of the dynamic specification, several control variables are incorporated, including bank size, capital structure, economic growth, and inflation. This modeling configuration is consistent with contemporary empirical approaches in digital banking studies (Khan et al., 2026) and captures the role of institutional heterogeneity highlighted in cross-country analyses (Khan & Al-Harby, 2022). Overall, the framework facilitates a systematic examination of the causal and intertemporal effects of FinTech adoption on banking performance.

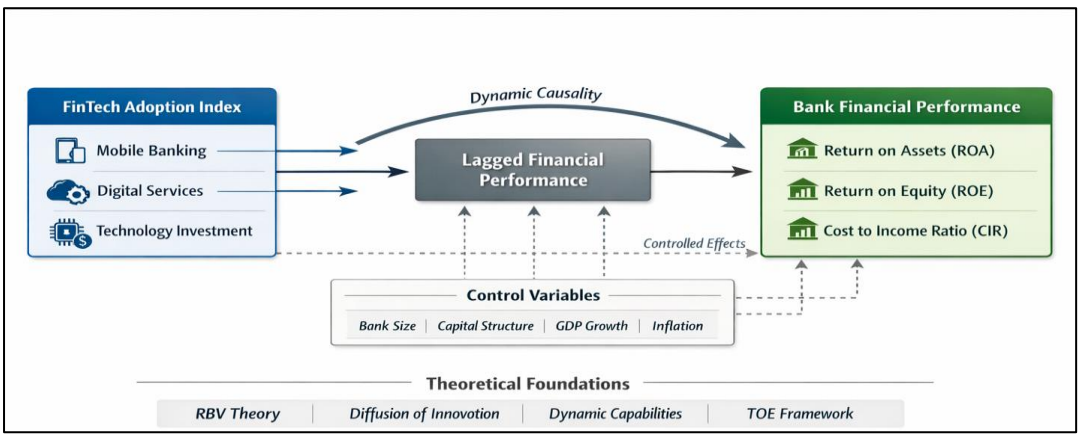

Figure 1. **Research Conceptual Framework**

Method

This research adopts a quantitative framework based on a dynamic panel system Generalized Method of Moments estimation strategy (Blundell & Bond, 1998), which facilitates causal inference while systematically mitigating endogeneity concerns, controlling for unobserved bank-level heterogeneity, and capturing the intertemporal persistence of profitability within bank-specific panel observations.

Data Types and Sources

This research employs secondary annual panel data spanning the period from 2015 to 2023, obtained from bank annual reports, the World Bank, the IMF, the ADB, and national financial regulatory authorities

across ASEAN. The unit of analysis consists of commercial banks operating within ASEAN member countries, thereby facilitating cross-country comparability.

Research Variables

- Dependent variables represent bank financial performance, proxied by Return on Assets, Return on Equity, and the Cost-to-Income Ratio, which jointly capture dimensions of profitability and operational efficiency. Return on Assets serves as the primary dependent variable in the baseline system-GMM estimation, whereas Return on Equity and Cost-to-Income Ratio are incorporated in robustness tests to verify the stability of the estimated FinTech effects across alternative performance indicators.
- Independent variables proxy the intensity of FinTech adoption, operationalized through three dimensions: (i) the extent of digital banking service implementation, (ii) the rate of mobile banking utilization, and (iii) the proportion of technology-related investment relative to total assets. Collectively, these indicators reflect banks' digital transformation intensity across operational deployment, customer usage, and strategic investment domains.
- Control variables comprise bank size (measured by the logarithm of total assets), capital structure (proxied by the debt-to-equity ratio), as well as macroeconomic indicators such as GDP growth and annual inflation. These variables are included to ensure that the estimated impact of FinTech adoption on bank performance reflects its net effect, after accounting for relevant firm-specific and economic conditions.

FinTech adoption variables are integrated into a validated FinTech Adoption Index, which is developed through Principal Component Analysis and standardized aggregation procedures. Specifically, the first principal component is retained as it effectively represents the shared variation among the three FinTech indicators. This composite index is subsequently used as a single explanatory variable in the system-GMM estimation to mitigate multicollinearity and measurement error.

To evaluate the effect of FinTech adoption on bank performance within a dynamic framework, this study applies the system Generalized Method of Moments (system-GMM) estimator proposed by Blundell and Bond (1998). This technique is particularly appropriate for banking datasets because it accounts for performance persistence by incorporating lagged dependent variables, mitigates endogeneity concerns stemming from simultaneity and reverse causality, and controls for unobserved, time-invariant bank-specific characteristics. By simultaneously estimating equations in both first differences and levels with the use of internally constructed instruments, the system-GMM estimator yields consistent and efficient parameter estimates for dynamic panel data characterized by a large cross-sectional dimension and a moderate time span

Within this framework, bank performance is examined using three complementary dynamic specifications. The baseline specification utilizes return on assets as a proxy for overall managerial efficiency and the effectiveness of asset utilization. In addition, return on equity and the cost-to-income ratio are employed as alternative dependent variables to assess the robustness and the multidimensional characteristics of the relationship between FinTech adoption and bank performance.

The baseline model specification is:

- Baseline Dynamic Model: Bank Profitability (ROA)

$$ROA_{it} = \alpha_0 + \alpha_1 ROA_{i,t-1} + \beta_1 FTI_{it} + \beta_2 Size_{it} + \beta_3 DER_{it} + \beta_4 GDP_{it} + \beta_5 Inflation_{it} + \mu_1 + \varepsilon_{it} \quad (1)$$

To capture the effect of FinTech adoption on shareholder returns, the following alternative performance specification is estimated:

- Alternative Performance Model: Return on Equity (ROE)

$$ROE_{it} = \alpha_0 + \alpha_1 ROE_{i,t-1} + \beta_1 FTI_{it} + \beta_2 Size_{it} + \beta_3 DER_{it} + \beta_4 GDP_{it} + \beta_5 Inflationt_{it} + \mu_1 + \varepsilon_{it} \quad (2)$$

Finally, to assess the implications of FinTech adoption for operational efficiency, bank performance is also evaluated using the cost-to-income ratio:

- Efficiency Model: Cost-to-Income Ratio (CIR)

$$CIR_{it} = \alpha_0 + \alpha_1 CIR_{i,t-1} + \beta_1 FTI_{it} + \beta_2 Size_{it} + \beta_3 DER_{it} + \beta_4 GDP_{it} + \beta_5 Inflationt_{it} + \mu_1 + \varepsilon_{it} \quad (3)$$

Where:

- i denotes bank i = 1, …, N
- t denotes year t = 2015, …, 2023
- ROA_{it}: Return on Assets of the bank *i* in the year *t*
- ROA_{it-1}: Return on Assets of the previous year (variable lag)
- ROE_{it}: Return on Equity of the bank *i* in the year *t*
- ROE_{it-1}: Return on Equity of the previous year (variable lag)
- CIR_{it}: cost-to-income ratio of the bank *i* in the year *t*
- CIR_{it-1}: cost-to-income ratio of the previous year (variable lag)
- FTI_{it}: FinTech Adoption Index (FTI) derived from PCA of three FinTech indicators
- $Size_{it}$: Bank size (total asset log)
- DER_{it}: Debt-to-Equity Ratio
- GDP_{it}: Growth of the Bank's Gross Domestic Product
- Inflation$_{it}$ The country's annual inflation rate
- μ_1 Fixed individual effects (unobserved heterogeneity)
- ε_{it}: Error term acak

Model Validation and Statistical Testing

The model in this study was estimated using a system-GMM estimator (Blundell & Bond, 1998), replacing the earlier difference-GMM specification to address endogeneity, instrument weakness, and profitability persistence more effectively:

- The Hansen test is applied to assess the validity of the instruments utilized in the system-GMM estimation. A p-value exceeding 0.05 suggests that the null hypothesis of instrument validity cannot be rejected, indicating the absence of overidentification problems and confirming that the instruments are statistically valid.
- The Arellano–Bond autocorrelation tests, specifically AR(1) and AR(2), are employed to identify the presence of serial correlation in the first-differenced residuals. Although first-order autocorrelation (AR(1)) is typically anticipated, the lack of second-order autocorrelation (AR(2)) constitutes a crucial requirement for ensuring the validity of the moment conditions underlying the system-GMM estimator

In addition to the main diagnostic tests, several additional tests were also performed to improve the reliability of the estimated results:

- The Variance Inflation Factor was utilized to evaluate potential multicollinearity among the explanatory variables, thereby confirming that the robustness and consistency of the coefficient estimates remained unaffected.
- Robust two-step GMM standard errors were applied to address heteroscedasticity and within-panel autocorrelation.
- Robustness checks included (i) alternative FinTech proxies, (ii) difference-GMM, and (iii) collapsed-instrument specification, all confirming coefficient stability.

The entire estimation and validation process is carried out using Stata 17 software, which has the complete capabilities to manage dynamic panel data and support various forms of GMM estimation, both academically and professionally.

Results

Descriptive

This study utilizes an unbalanced panel dataset consisting of 70 commercial banks operating across ASEAN countries during the period 2015–2023, resulting in a total of 630 bank–year observations. The data are sourced from banks' annual reports, national financial regulatory authorities, and reputable international databases, including those maintained by the World Bank and the International Monetary Fund.

Table 1

Descriptive Statistics of Research Variables

Variable	N	Mean	Std. Dev.	Min	Max
ROA	630	1.26	0.87	-0.45	3.82
ROE	630	10.34	5.76	-2.11	24.90
Cost-to-Income Ratio	630	53.28	12.91	31.02	81.33
Mobile Banking Usage (%)	630	54.21	20.14	10.00	92.00
Digital Services Count	630	7.45	2.81	2.00	14.00
Technology Investment Ratio	630	2.63	1.09	0.50	6.80
Bank Size (log assets)	630	15.43	1.13	13.10	18.30
Capital Structure (DER)	630	5.64	2.49	2.20	11.90
GDP Growth (%)	630	4.82	1.38	1.32	7.01
Inflation (%)	630	3.11	1.47	0.48	6.90

Table 1 presents the descriptive statistics for all variables incorporated in the empirical investigation. The mean ROA of 1.26% reveals considerable heterogeneity in bank profitability, underscoring structural and operational disparities across ASEAN banking systems. This dispersion reinforces the suitability of employing a dynamic panel estimation approach and offers empirical support for examining the hypothesized FinTech-induced differences in performance. Furthermore, the three FinTech-related measures documented in the table serve as the foundational elements for developing the FinTech Adoption Index (FTI) through Principal Component Analysis (PCA), which is subsequently utilized in the multivariate regression framework.

Construction and Validation of the FinTech Adoption Index (FTI)

The FinTech Adoption Index (FTI) is calculated for each bank–year observation using the first principal component (PC1) obtained from Principal Component Analysis (PCA). This procedure enables the index to capture the predominant shared variation among FinTech-related indicators while eliminating reliance on subjective weighting approaches. Consequently, the FTI serves as a theoretically impartial and empirically robust proxy for the degree of FinTech adoption, making it appropriate as the principal explanatory variable in dynamic panel analyses employing the system-GMM estimator.

In the empirical specification, the FTI functions as the key independent variable representing the extent of digital transformation at the bank level. The index is systematically derived from three indicators that reflect distinct yet complementary dimensions of FinTech adoption: (i) the number of digital banking services introduced by each bank, representing the operational dimension; (ii) the level of mobile banking usage, capturing the utilization dimension; and (iii) the proportion of technology investment relative to total assets, reflecting the investment dimension. This multidimensional construction ensures consistency between the empirical operationalization and the conceptual definition of FinTech adoption articulated in the hypothesis development. All indicators are measured at the bank–year level, allowing the FTI to account for both cross-sectional heterogeneity across banks and temporal variation in FinTech adoption.

Before constructing the index, all FinTech indicators are standardized using z-score normalization to ensure comparability across different measurement scales and to avoid any single indicator disproportionately influencing the composite measure. Missing observations, representing less than 5% of the dataset, are treated using bank–year linear interpolation in order to maintain panel consistency and reduce potential information loss. These data preprocessing steps help ensure that the estimated impact of FinTech is not biased by irregular data patterns or extreme values. Furthermore, potential outliers are controlled through winsorization at the 1st and 99th percentiles.

The principal component analysis (PCA) results show that the first principal component (PC1) has an eigenvalue of 2.17, surpassing the Kaiser criterion benchmark of 1, and accounts for 72.4% of the total variance among the three FinTech indicators. This substantial explanatory capacity indicates that PC1 effectively represents the underlying FinTech adoption dimension relevant for hypothesis evaluation. In contrast, the second and third principal components display eigenvalues below one and contribute only minimally to the overall variance; consequently, they are excluded from the index construction.

Table 2

Construction, Validation, and Key Statistics of the FinTech Adoption Index (FTI)

Testing Aspect	Method / Indicator	Statistical Value	Criteria / Interpretation
Unit of observation	Bank–year specific	70 banks × 2015–2023	Index varies across banks and over time
FTI component indicators	Number of digital banking services	–	Operational dimension
	Mobile banking usage intensity	–	Utilization dimension
	Technology investment ratio	–	Investment dimension
Data standardization	Z-score normalization	Mean = 0; SD = 1	Ensures comparability across indicators
Treatment of missing values	Linear interpolation	< 5% of observations	Preserves panel continuity
Outlier treatment	Winsorization	1st–99th percentile	Mitigates extreme-value distortion
Index construction method	Principal Component Analysis (PCA)	–	Dimensionality reduction without subjective weighting
Eigenvalue of PC1	Kaiser criterion	2.17	> 1 (retained)
Variance explained by PC1	Explained variance	72.4%	Dominant representation of FinTech variation
Eigenvalue of PC2	–	0.51	< 1 (not retained)
Eigenvalue of PC3	–	0.32	< 1 (not retained)
KMO measure	Sampling adequacy	0.71	> 0.60 (adequate)
Bartlett's test	Test of sphericity	$\chi^2 = 186.4$; $p < 0.001$	Significant inter-indicator correlations

Testing Aspect	Method / Indicator	Statistical Value	Criteria / Interpretation
Factor loadings (PC1)	Digital banking services	0.58	High contribution
	Mobile banking usage	0.62	Highest contribution
	Technology investment ratio	0.53	Significant contribution
Index score construction	PC1 scores	Weighted linear combination	Annual FTI score per bank
Robustness test	Single-indicator proxies	Consistent sign and significance	Index robust to alternative specifications

Additional diagnostic tests confirm the suitability of PCA. The Kaiser–Meyer–Olkin (KMO) further diagnostic assessments support the appropriateness of applying Principal Component Analysis (PCA). The Kaiser–Meyer–Olkin (KMO) statistic of 0.71 reflects satisfactory sampling adequacy, while Bartlett's Test of Sphericity is highly significant ($\chi^2 = 186.4$; $p < 0.001$), thereby rejecting the null hypothesis that the correlation matrix is an identity matrix. Collectively, these findings indicate the existence of meaningful interrelationships among the FinTech indicators.

The weighting scheme for the index is determined endogenously using the factor loadings associated with the first principal component (PC1). Specifically, the relative contributions amount to 0.58 for digital banking services, 0.62 for mobile banking utilization, and 0.53 for the technology investment ratio. Accordingly, the FinTech Index (FTI) is constructed as a data-driven weighted linear composite, rather than being based on subjective or normative researcher judgments. This methodological approach enhances the credibility of the causal interpretation attributed to the FinTech coefficients obtained from the dynamic panel estimations.

The computed FTI values are generated for each bank–year observation and subsequently incorporated as a unified explanatory variable within the system-GMM framework. To further ensure robustness, alternative model specifications that include each FinTech indicator individually are also estimated. The results consistently demonstrate similar coefficient directions and levels of statistical significance, thereby reinforcing the validity and reliability of the FTI measure.

Table 3

Pearson Correlation Matrix

Variable	ROA	ROE	CIR	FinTech Adoption Index
ROA	1	0.712	-0.653	0.511
ROE		1	-0.602	0.489
CIR			1	-0.435
FinTech Adoption Index				1

The correlation matrix reveals that the FTI is positively related to profitability indicators (ROA and ROE) and negatively related to the cost-to-income ratio, aligning with theoretical predictions. Although these correlations offer preliminary evidence in favor of the proposed hypotheses, they are inherently descriptive and do not establish causality, thus justifying the application of a dynamic system-GMM estimator.

Table 4

Coefficient of Determination (R^2) from Linear Regression Models

Model	R	R^2	Adjusted R^2	Std. Error
FinTech vs ROA	0.611	0.373	0.368	0.687
FinTech vs ROE	0.587	0.345	0.339	4.130
FinTech vs CIR	0.523	0.273	0.268	9.121

The reported R^2 statistics reflect initial correlations between FinTech adoption and bank performance; nevertheless, they do not account for potential endogeneity concerns or the presence of dynamic persistence. Therefore, these findings are not employed to validate the study's hypotheses but are presented exclusively as exploratory reference points. To derive consistent and causally meaningful estimates, the analysis subsequently applies the system-GMM estimation approach.

Table 5

Dynamic System-GMM Estimation Results: ROA, ROE, and CIR

Independent Variables	ROA	ROE	CIR
Lagged dependent variable	0.421*** (0.071)	0.387*** (0.083)	0.462*** (0.065)
FinTech Adoption Index	0.018** (0.007)	0.092** (0.041)	−0.156*** (0.049)
Bank Size	0.006 (0.004)	0.031* (0.018)	−0.087** (0.036)
DER	0.024** (0.011)	0.118*** (0.039)	−0.064* (0.034)
GDP Growth	0.013* (0.007)	0.067* (0.036)	−0.052 (0.041)
Inflation	−0.009 (0.006)	−0.041 (0.028)	0.073* (0.039)
Number of Banks (Groups)	112	112	112
Number of Observations	896	896	896
Number of Instruments	24	24	24
AR(1) p-value	0.000	0.000	0.000
AR(2) p-value	0.284	0.317	0.261
Hansen Test p-value	0.421	0.398	0.446

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Table 5 presents the dynamic system-GMM estimation outcomes for three alternative indicators of bank performance, namely return on assets (ROA), return on equity (ROE), and the cost-to-income ratio (CIR). These model specifications are deliberately constructed to examine the proposed hypotheses concerning the impact of FinTech adoption on bank profitability and efficiency. By incorporating multiple dependent variables, the analysis offers a comprehensive evaluation of the performance consequences of FinTech adoption, capturing dimensions of profitability, shareholder value creation, and operational efficiency within a single dynamic empirical framework.

Across all estimated specifications, the lagged dependent variables exhibit positive and highly statistically significant coefficients, with values of 0.421 for ROA, 0.387 for ROE, and 0.462 for CIR (all $p < 0.01$). These estimates point to strong persistence in bank performance, suggesting that present profitability and operational efficiency are largely shaped by historical outcomes. Such evidence aligns with the predictions of dynamic banking theory and validates the suitability of the system-GMM approach for testing the proposed hypotheses.

The FinTech Adoption Index (FTI) demonstrates statistically significant and economically relevant effects across the three performance dimensions. In particular, FTI shows a positive association with ROA (coefficient = 0.018; $p < 0.05$) and ROE (coefficient = 0.092; $p < 0.05$), implying that greater adoption of financial technology contributes to improvements in both asset-based profitability and equity returns. These findings support the acceptance of the hypotheses that anticipate a beneficial influence of FinTech adoption on bank profitability. Conversely, FTI is found to be negatively and significantly related to CIR (coefficient = −0.156; $p < 0.01$), indicating that digitalization enhances operational efficiency by lowering operating expenses relative to income, thereby corroborating the efficiency-enhancement hypothesis. The uniformity in both direction and statistical significance across different performance proxies underscores the robustness and multidimensional character of the performance improvements linked to FinTech adoption.

With respect to bank-level control variables, bank size exerts a positive and weakly significant effect on ROE (coefficient = 0.031; $p < 0.10$), while showing a negative and statistically significant impact on CIR (coefficient = −0.087; $p < 0.05$). This pattern suggests that larger banking institutions are able to exploit scale economies that foster greater efficiency and enhance returns to shareholders. Furthermore, the debt-to-equity ratio (DER) enters the ROA and ROE models with positive and significant coefficients (0.024 and 0.118, respectively), while displaying a negative influence on CIR (−0.064; $p < 0.10$). These results emphasize the supportive role of financial structure in strengthening the performance benefits associated with FinTech adoption.

Macroeconomic factors likewise contribute to shaping banking performance. Economic growth, as proxied by GDP expansion, demonstrates a positive association with both ROA and ROE at the 10% significance threshold, underscoring the procyclical characteristics of bank profitability. In contrast, inflation shows a positive yet only marginally significant influence within the CIR specification, while its coefficients in the profitability models remain statistically insignificant. This pattern suggests that inflationary dynamics do not consistently lead to either improvements or deteriorations in bank profitability throughout the observed period.

The robustness of the system-GMM estimations is substantiated through a comprehensive set of diagnostic assessments. The Arellano–Bond tests reveal the expected presence of first-order serial correlation in the differenced residuals (AR(1) p-values = 0.000), which is typical in dynamic panel frameworks. Importantly, the absence of second-order serial correlation is verified by the statistically insignificant AR(2) test outcomes, with p-values ranging from 0.261 to 0.317. In addition, the Hansen tests for overidentifying restrictions generate p-values between 0.398 and 0.446, implying that the null hypothesis concerning the validity of the instrumental variables cannot be rejected.

Further transparency in the estimation process is achieved by explicitly disclosing the sample composition, including the number of banks (112) and the total number of instruments (24) employed in each model specification. The relatively limited instrument count, which remains substantially lower than the number of cross-sectional observations, helps alleviate potential concerns related to instrument proliferation and enhances confidence in the consistency of the estimated parameters.

Overall, the consistent empirical patterns observed across the ROA, ROE, and CIR models, coupled with satisfactory diagnostic indicators, offer compelling evidence that FinTech adoption constitutes an important determinant of sustainable banking performance. By clearly affirming hypothesis acceptance on the basis of statistically sound system-GMM results, this analysis establishes a coherent linkage between the theoretical propositions and the empirical evidence, thereby reinforcing the causal interpretation of FinTech-driven digital transformation as a performance-enhancing mechanism within the banking industry.

Discussion

This study offers strong empirical evidence that the adoption of financial technology (FinTech) has a statistically significant and economically substantial effect on bank performance across ASEAN economies. In line with the system-GMM estimation outcomes, the FinTech Adoption Index (FTI) demonstrates a positive and significant relationship with profitability measures, namely return on assets (ROA) and return on equity (ROE), while exhibiting a negative association with the cost-to-income ratio (CIR). These results provide support for Hypothesis 1. The confirmation of this hypothesis is grounded in both the size and consistency of the estimated coefficients, which remain robust under alternative model specifications, alongside satisfactory diagnostic test results that validate the model, including the Hansen test and the Arellano–Bond serial correlation tests. Overall, the findings suggest that FinTech adoption improves bank profitability and operational efficiency after rigorously accounting for potential endogeneity concerns, unobserved firm-specific heterogeneity, and the dynamic persistence of performance.

From a theoretical standpoint, these findings are closely consistent with the Diffusion of Innovations (DOI) Theory (Rogers, 1995), which constitutes the central conceptual basis of this research. In the DOI perspective, FinTech adoption in the banking sector represents an innovation that delivers distinct relative advantages, particularly through enhanced cost efficiency and diversified revenue streams. It also demonstrates strong observability, reflected in quantifiable improvements in financial performance, as well as adequate compatibility with prevailing organizational practices and regulatory frameworks. The empirical evidence indicating sustained improvements in profitability and operational efficiency substantiates the functioning of these DOI mechanisms within the ASEAN banking environment. Furthermore, the identified positive and enduring impacts imply that banks in the ASEAN region have generally advanced beyond the experimental or pilot phases of adoption toward the routinized and institutionalized integration of digital technologies.

The empirical findings further align with the theoretical propositions of the Resource-Based View (RBV) (Barney, 1991). FinTech capabilities, measured through a composite indicator encompassing digital service delivery, the extent of mobile banking utilization, and the intensity of technology-related investments, may be viewed as strategic resources that possess value and remain, at least over the short to medium horizon, difficult for competitors to replicate. Banks that leverage these digital resources more extensively are better positioned to streamline operational processes, expand customer access, and achieve efficiency improvements, ultimately contributing to enhanced profitability. Diverging from earlier studies that report limited or inconclusive impacts of FinTech adoption, often constrained by initial adoption phases or geographically narrow samples, these findings underscore the performance significance of continuous and system-wide digital transformation.

A central empirical contribution of this study is the validation of profitability persistence within the ASEAN banking sector, demonstrated by the consistently positive and highly significant coefficients of the lagged dependent variables across all model specifications. This finding aligns with the Dynamic Capabilities framework (Teece et al., 1997) and corroborates existing banking literature that highlights the cumulative nature of competitive advantages and performance outcomes over time. Within this conceptualization, the adoption of FinTech enhances banks' capacity for dynamic adjustment, enabling digital investments to produce reinforcing, path-dependent performance effects. The reliability of this inference is further reinforced by the uniformity of results across alternative performance indicators, such as ROE and CIR.

With respect to bank-specific characteristics, the findings reveal that larger bank size is positively correlated with profitability and inversely related to operational inefficiency. This observation highlights the presence of economies of scale in digital transformation and aligns with the Structure–Conduct–Performance (SCP) framework. Larger banks are generally better equipped to absorb fixed technology expenditures, invest in specialized digital expertise, and implement FinTech solutions across business segments, thereby achieving enhanced efficiency outcomes. The reduced significance of leverage in explaining performance once FinTech adoption is accounted for suggests that digital capabilities may partially replace traditional balance-sheet-driven performance mechanisms.

Macroeconomic factors serve a complementary, albeit secondary, role in influencing bank performance. Positive GDP growth is associated with higher profitability, indicating that favorable macroeconomic conditions amplify the returns from FinTech investments by stimulating credit demand and transaction volumes. This interaction implies that FinTech adoption yields the greatest benefits when supported by a conducive macroeconomic environment. In contrast, inflation does not exhibit a statistically significant impact on profitability, suggesting that fluctuations in price levels are largely mitigated by banks' cost management strategies and regulatory measures.

A key contextual consideration pertains to regulatory heterogeneity across ASEAN countries. Although this study does not explicitly include regulatory indicators in the empirical model, incorporating bank-specific fixed effects within the system-GMM framework absorbs time-invariant institutional and

regulatory differences across nations. The stability and persistence of the estimated FinTech coefficients indicate that the primary performance effects of digital adoption remain robust despite regulatory diversity, although variations in regulatory frameworks may affect the pace, depth, and risk profile of digital transformation. This limitation highlights an avenue for future research to integrate regulatory quality indices or interaction effects to refine cross-country policy recommendations.

From a methodological perspective, employing the system-GMM estimator enhances the causal interpretation of the results by addressing simultaneity, reverse causality, and unobserved heterogeneity. The favorable outcomes of the Hansen test and the absence of second-order serial correlation in the Arellano–Bond tests validate the instrument set and support the dynamic model specification. Compared to static panel models or single-equation approaches used in parts of the existing literature, the dynamic framework applied in this study provides a more rigorous evaluation of the FinTech–performance relationship.

Overall, the evidence indicates that FinTech adoption acts as a strategic driver of bank performance rather than a reactive response to digitalization pressures. By systematically integrating hypothesis testing, dynamic estimation, and theoretical interpretation, this study offers a coherent explanation of how FinTech-driven digital transformation fosters sustainable profitability and operational efficiency in emerging banking systems.

Conclusion

This study provides compelling dynamic-panel evidence that the adoption of financial technology (FinTech) positively influences bank performance across ASEAN countries. Employing a system-GMM methodology that addresses endogeneity, unobserved heterogeneity, and profitability persistence, the results indicate that increased FinTech adoption significantly enhances profitability (ROA and ROE) while simultaneously reducing operational inefficiencies (CIR). Consequently, the conclusion focuses on summarizing the key empirical findings rather than reiterating detailed discussion points.

From a theoretical standpoint, these results extend the Diffusion of Innovations framework by demonstrating a connection between FinTech adoption and sustained financial performance outcomes. The evidence further supports the Resource-Based View and Dynamic Capabilities perspectives, suggesting that the accumulation of digital capabilities yields enduring competitive advantages over time. These theoretical contributions are succinctly presented here, with comprehensive interpretation provided in the discussion section.

Empirically, this research contributes to the relatively sparse ASEAN-focused literature by delivering multi-country, bank-level evidence within a rigorous dynamic econometric framework. The confirmation of profitability persistence and consistent FinTech effects highlights the importance of dynamic analytical approaches for understanding digital innovation in the banking sector.

The findings offer clear implications for both practitioners and policymakers, though detailed managerial and policy recommendations are consolidated in Section 5.3 to preserve a focused and non-redundant conclusion.

Implications of Research Results

The findings of this study carry substantial theoretical, managerial, and policy-related implications for advancing the digital banking sector within the ASEAN region.

Theoretical Implications

This research contributes to the digital finance literature by offering rigorous empirical support that substantiates the Technology–Organization–Environment (TOE) framework and the Resource-Based View (RBV) as essential lenses for strategic digital capability development. By integrating the concept of dynamic

persistence, the study further advances these frameworks beyond traditional static adoption–performance relationships.

Practical Implications

For the banking sector, this study's findings indicate that deliberate and strategic investment in digital technologies substantially improves operational efficiency and profitability. Instead of recommending particular technologies, the results underscore the criticality of coherent and continuous development of digital capabilities in alignment with the strategic goals of banks.

Policy Implications

For regulators and policymakers, the results highlight the critical need to develop proactive and adaptable regulatory frameworks that effectively balance the promotion of digital innovation with strong prudential safeguards to maintain systemic stability. Considering the diversity of regulatory environments across ASEAN nations, approaches that are flexible and grounded in overarching principles may prove particularly effective. Consequently, the implications of this research are multifaceted, offering a solid empirical basis to inform strategic decision-making by banks, regulators, and other stakeholders within the broader financial ecosystem.

Research Limitations

This study has several limitations that should be noted. First, the assessment of FinTech adoption relies on observable indicators, which may not fully capture banks' latent digital capabilities and organizational readiness. Second, the analysis is confined to selected ASEAN countries, suggesting that future research could broaden the scope to include cross-country comparisons or other financial sectors. Third, the study period ends in 2023, potentially omitting recent FinTech innovations and regulatory changes. These limitations underscore the need for future studies to integrate more comprehensive institutional data, extend the temporal coverage, and explore alternative dynamic estimation methods.

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