The inverted U-shaped relationship between FinTech development and bank stability: Evidence from Viet Nam using Google Trends data

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Abstract

Due to the ongoing global debate regarding the relationship between FinTech development and banks, this study aims to investigate this relationship in Vietnam, an emerging nation. Using a sample of 27 Vietnamese commercial banks from 2012 to 2023, we construct a FinTech development index tailored to the Vietnamese banking industry based on data from Google Trends. Estimating fixed-effects model (FEM) and system generalized method of moments (System GMM), we find a significant inverted U-shaped relationship between FinTech development and bank stability. At moderate levels, FinTech development positively contributes to bank stability; however, when FinTech development becomes extensive, it introduces risks that may offset these stability benefits. To ensure the robustness of the results, alternative stability measures and econometric specifications are employed. Furthermore, heterogeneity analysis reveals that the impact of FinTech varies by bank size, emphasizing the importance of institutional characteristics. Taken together, these findings imply that banks and regulators should aim for a calibrated, "optimal" level of FinTech adoption and complement digital expansion with stronger cybersecurity, third-party oversight, and risk governance to sustain stability gains, while investors should monitor whether rapid FinTech scaling is matched by adequate controls.

1. Introduction

As central pillars of financial systems, banks play a crucial role in allocating resources between savers and borrowers. Their ability to perform this function effectively depends on their financial soundness and resilience to internal and external shocks. Bank stability is especially critical in developing countries, where banks are the primary vehicles for financial intermediation, and their health directly affects economic performance. Stable banks tend to exhibit better loan performance, stronger capital buffers, and more consistent profit generation. However, as the financial sector embraces digital innovation, the risk environment surrounding banking also evolves.

Vietnam's financial system remains heavily bank-dependent, meaning that the performance and stability of commercial banks directly affect the entire economy. The rapid expansion

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of the country's FinTech sector, driven by innovations in mobile money, peer-to-peer lending, digital personal finance, and blockchain, positions Vietnam as one of the fastest-growing FinTech hubs in the Asia-Pacific region. At the same time, the regulatory framework has been reshaped to accommodate and steer these developments. Decree 52/2024/NĐ-CP (Government of Vietnam, 2024) replaces Decree 101/2012 and updates the non-cash payment regime and formally recognizes e-money, while Circular 16/2020/TT-NHNN (State Bank of Vietnam, 2020) allows eKYC for opening payment accounts and Decision 316/QD-TTg (Prime Minister of Vietnam, 2021) pilots Mobile Money for small-value payments. More recently, Decree 94/2025/NĐ-CP (Government of Vietnam, 2025) establishes a regulatory sandbox for banking-sector FinTech pilots. Together, these measures lower frictions, push more activity into formal channels, and phase in innovation under supervision, but they may also alter competition and operational and cyber risk, suggesting that FinTech can have both stabilizing and destabilizing effects on banks.

Vietnam has experienced a notable surge in FinTech activity over the last decade. According to data from the State Bank of Vietnam (SBV), the number of FinTech companies operating in the country grew to 187 by 2023. These firms span various service segments, including electronic payments, lending platforms, blockchain applications, insurtech, and digital wealth management. Given their increasingly similar functionalities to banks, particularly in credit provision, risk assessment, and transaction processing, FinTech firms are beginning to exert significant influence on the operational and financial strategies of commercial banks. In light of this evolving landscape, this study seeks to address the central research question: "Does FinTech development influence the stability of commercial banks in Viet Nam?"

Existing scholarship on this topic presents divergent perspectives. Some researchers (Fuster et al., 2019; Liem et al., 2022; Philippon, 2015; Tang, 2019) argue that FinTech enhances financial stability by improving risk diversification, lowering transaction costs, and expanding access to credit. Others caution that heightened competition and technological complexity may amplify systemic risks, particularly if regulatory frameworks lag behind innovation (Bilgin et al., 2021; Buchak et al., 2018; Fung et al., 2020; Li et al., 2022; Nguyen et al., 2022; Pacelli et al., 2022, 2022; Thakor, 2012). A third group of studies proposes a nonlinear, inverted U-shaped relationship, where FinTech development initially improves stability but may have destabilizing effects if pursued excessively or without appropriate safeguards (Daud et al., 2022; Fung et al., 2020; Nguyen et al., 2022; Wang et al., 2021). These varying interpretations underscore the complexity of FinTech's role in shaping bank behavior. However, the existing evidence is largely drawn from advanced economies or cross-country samples, and there is very limited work that explicitly examines the FinTech-stability nexus in Vietnam. Vietnamese studies primarily analyse the determinants of FinTech adoption or digital transformation in banks, rather than the consequences of FinTech development for bank risk and stability or how these effects differ across banks with distinct characteristics. This paper addresses this gap by providing bank-level evidence for Viet Nam and exploring heterogeneity in the impact of FinTech development on bank stability.

Using panel data from 27 Vietnamese commercial banks over the period from 2012 to 2023 and conducting FEM and System GMM, this study contributes to the literature in three key ways. First, it extends empirical research on the intersection of FinTech and bank stability in the context of Viet Nam, a market that remains underexplored despite its growing digital economy. Second, this paper employs a FinTech index, developed as an extension of Pham et al. (2024), to capture annual FinTech development in Viet Nam. Third, it investigates how bank size influences the FinTech-stability relationship, highlighting heterogeneity in FinTech's impact based on institutional characteristics. We build on the notion that large, well-

capitalized banks with stronger IT capacity can primarily use FinTech to enhance efficiency and reduce risk, whereas smaller, more liquidity-constrained banks may rely on FinTech in a more aggressive, risk-taking manner to remain competitive. By empirically testing this size-related heterogeneity in an emerging-market setting that has received limited attention in the existing literature, particularly in Viet Nam, the paper adds a novel institutional dimension to the FinTech–bank stability nexus.

The content of this paper is organized as follows: Section 2- Literature review; Section 3- Research methodology; Section 4 discusses the baseline regression results and heterogeneity tests; Section 5 presents robustness checks to verify the stability of findings; Section 6 discusses the results and concludes the study, then offers suggestions for future research based on our paper's limitations.

2. Literature review and hypothesis development

2.1. Theoretical framework

Bank stability is the ability of a bank to absorb shocks and continue its core functions, taking deposits, supplying credit, and making payments, without slipping into distress or failure. In practice, stability reflects solvency, earnings strength, and liquidity, and it matters at both the individual-bank and system levels (Čihák & Hesse, 2010; Laeven & Valencia, 2013).

FinTech first improves bank efficiency through technology spillovers. When FinTech firms launch new tools, banks learn by observing, partnering, hiring, and competing, which helps them digitize processes and use data better (Griliches, 1992). Consequently, costs fall and service quality rises, setting up a positive link between early FinTech development and stability.

Building on this, innovation theory explains how digital tools reshape production inside banks. Following Schumpeter, software and analytics replace branch-intensive, manual workflows, lowering unit costs and enabling faster monitoring and control (Schumpeter, 2013). In turn, stronger balance sheets and timelier risk management reinforce the spillover gains at low to moderate adoption. However, competition-fragility theory shows how these gains can erode as adoption deepens. As FinTech raises expectations for price and speed, banks may expand too quickly, relax standards, or add complex digital processes without adequate safeguards, increasing credit, operational, and cyber risk (Allen & Gale, 2004; Boyd & De Nicoló, 2005). Thus, rising rivalry can offset earlier efficiency benefits.

Linking these outcomes, the Unified Theory of Acceptance and Use of Technology (UTAUT) clarifies when adoption is safe versus risky. Banks adopt when they expect performance gains, yet adoption also brings effort and complexity and depends on facilitating conditions- capital, skills, IT and cyber capacity, and regulation (Venkatesh et al., 2003, 2012). Moreover, social influence and competitive pressure can push adoption beyond a bank's absorption capacity, tying internal decision rules to the external forces above.

Taken together, these theories imply a non-linear, inverted-U effect on stability. At low to moderate adoption, spillovers and innovation dominate, so stability improves; beyond a threshold, complexity, tighter competition, and weak facilitating conditions outweigh the gains, so stability declines.

2.2. The relationship between FinTech development and bank stability

Recent studies have explored the diverse effects of FinTech development on the banking sector, showing that its impact varies widely. For example, Bilgin et al. (2021) found that economic uncertainty increases default risk for conventional banks but not for Islamic banks, indicating differences in how banks respond to financial and technological pressures. Li et al. (2022) showed that FinTech's links to traditional financial institutions become stronger during downturns, which can raise systemic risk. In the European context, Pacelli et al. (2022) found that during market declines, risk

spillovers from traditional banks to FinTech firms are more pronounced. Chaudhry et al. (2022) observed that while technology firms face higher risk levels, they are less likely than banks to experience distress aftermarket shocks.

In terms of stability, some scholars argue that FinTech can make banks more vulnerable. Thakor (2012) suggested that financial innovations may increase banks' susceptibility to crises. Buchak et al. (2018) studied the shadow banking market in U.S. residential mortgages and concluded that FinTech firms contribute to shadow banking, raising issues of moral hazard and potentially destabilizing the financial system. Based on the above discussion, we propose the following hypothesis:

H_{1a}: FinTech development has a negative relationship with the stability of Vietnamese banks.

However, several other studies argue that FinTech can play a constructive role in strengthening financial intermediation, thereby enhancing the overall stability of the banking system. By leveraging digital technologies, FinTech firms can reduce operational frictions and lower transaction and intermediation costs, which traditionally arise from multi-layered banking procedures. Philippon (2015) emphasized that one of the key advantages of FinTech lies in its ability to reduce inefficiencies in the financial sector, helping to compress the cost of providing financial services while maintaining or improving quality and outreach.

Moreover, Fuster et al. (2019) demonstrated that technology-driven lending platforms, particularly in the mortgage segment, significantly improve the efficiency of loan origination and approval processes. Their findings highlight how automated underwriting and data-driven risk assessment tools used by FinTech lenders allow for quicker, more accurate responses to credit demand fluctuations, especially during periods of economic uncertainty or housing market stress.

Tang (2019) also contributed to this view by showing that peer-to-peer (P2P) lending platforms serve as effective substitutes for traditional banking in specific market segments. These platforms offer alternative credit access to borrowers who may be underserved by conventional banks, while simultaneously providing attractive returns to investors. Through such innovations, FinTech expands financial inclusion and diversifies the channels of credit distribution, potentially enhancing systemic stability by spreading risk more evenly across the financial ecosystem. Thus, we propose the following hypothesis:

H_{1b}: FinTech development has a positive relationship with the stability of Vietnamese banks.

Several recent studies have provided nuanced insights into the multifaceted impact of FinTech on bank performance and stability, with evidence suggesting both beneficial and adverse effects depending on the context and intensity of adoption. For instance, Lv et al. (2022) analyze data for the Industrial and Commercial Bank of China (ICBC) and identify a U-shaped relationship between FinTech development and bank profitability. Their empirical results indicate that in the initial stages, FinTechs disrupt traditional banking business and reduce profitability, whereas in the middle and later stages, as FinTech advantages strengthen and are better integrated into operations, bank profitability gradually increases.

Nevertheless, several studies underscore that FinTech's positive effects on stability may only hold up to a certain point, after which risks start to intensify. Wang et al. (2021) documented an inverted U-shaped relationship between FinTech adoption and bank risk-taking in China, highlighting that while moderate FinTech use improves operational control and reduces risk exposure, excessive adoption, especially in poorly regulated environments, can lead to greater volatility and systemic vulnerability. Nguyen et al. (2022) confirmed this pattern within the Vietnamese context, emphasizing that high levels of FinTech exposure may surpass the risk absorption capacity of some banks, particularly smaller or less digitally mature institutions. At the international level, Daud et al. (2022) found that in a cross-country analysis of 63 economies, FinTech

generally contributes to financial stability, but the magnitude of its effects varies by country-specific factors such as institutional quality and regulatory capacity. Similarly, Fung et al. (2020) argued that while regulatory sandboxes encourage FinTech development and stability in emerging markets, they may induce moral hazard and excessive risk-taking in advanced economies if not tightly monitored. So, we propose the second hypothesis:

H_2: From a dynamic evolution standpoint, FinTech development has an inverted U-shaped impact on the stability of Vietnamese commercial banks.

FinTech development impacts banks of different sizes in varied ways. Large banks tend to be more risk-averse due to their substantial liquidity buffers and capital reserves. These resources shield them from acute liquidity shortages, allowing large banks to invest heavily in FinTech without significantly affecting their overall risk profile. With ample capital, these banks can leverage FinTech innovations to enhance efficiency and reduce operational and financing costs, enabling them to adopt lower-risk strategies while maintaining a competitive edge in the FinTech space (Bertay et al., 2013). Their strong capital positions lessen the need to pursue high-risk activities for returns, allowing a focus on steady, long-term gains.

On the other hand, smaller banks often face tighter liquidity constraints and have less capital available for FinTech investments. This can compel them to take on riskier practices to stay competitive with larger banks and other financial service providers. Limited capital resources may drive smaller banks to seek higher-yield, higher-risk opportunities, such as extending credit to riskier borrowers or adopting FinTech solutions that promise high returns but carry greater risk exposure (Banna et al., 2021). Additionally, smaller banks may adopt FinTech as a strategy to differentiate themselves within niche markets, which often requires more aggressive approaches. In contrast, larger banks, with broader resources and established customer bases, can take a more conservative approach, using FinTech primarily to improve operational efficiencies without significantly changing their risk profile. This difference highlights the complex relationship between FinTech innovation and risk-taking across the banking sector, with bank size being a significant factor that shapes risk strategies and outcomes. Based on these discussions, we propose a third hypothesis:

H_3: FinTech development has heterogeneous impacts on different Vietnamese banks from different size.

3. Methodology

3.1. Sample collection and data source

In this research the author uses yearly bank-level panel dataset, collected from audited financial statements as well as notes to the financial statements of 27 out of 27 joint-stock listed banks, spanning from 2012 to 2023 on three Vietnam Stock Exchanges (the Hanoi Stock Exchange, the Ho Chi Minh City Stock Exchange, and the Unlisted Public Company Market). Based on this secondary data set we calculate the dependent variables of bank stability and control variables of banks' characteristics. For the macroeconomic variables, we collect data from the World Bank database. With 27 selected banks in 12 years, we collected 324 samples.

3.2. Variables construction

3.2.1. Measuring bank stability

In the academic literature, financial risk and banking stability are commonly evaluated through three methodological approaches: the signal method, the modeling method, and the stress index method (Chen et al., 2022). Due to the limitations of the signal and modeling methods in the Vietnamese context, this study adopts the third technique- the stress index method.

To quantify the stress levels and assess bank stability, this study utilizes the ZEQTA index- an accounting-based risk measure first introduced by Hannan and Hanweck (1988). The

ZEQTA score has been applied extensively in the banking literature to evaluate bank risk-taking behavior, including in works by Ahmad et al. (2008), Lepetit and Strobel (2013), Maria et al. (2022), Yudaruddin et al. (2023), Yusgiantoro et al. (2019).

The ZEQTA index captures the extent to which a bank's earnings can decline before its equity is fully eroded and insolvency occurs. The risk index ZEQTA is calculated as follows:

$ZEQTA_{i,t} = (ROA_{i,t} + EQTA_{i,t})/SD(ROA)$

Where ROA (Return on Assets) is the ratio of net income to total assets, EQTA is the ratio of equity capital to total assets, and SD(ROA) is the standard deviation of ROA over a five-year period, representing earnings volatility. A higher ZEQTA value reflects stronger stability, indicating that a bank can endure larger earnings shocks without breaching its capital base. In contrast, a lower ZEQTA score signals heightened insolvency risk and financial fragility.

To ensure consistency across the regression models and account for the right-skewed distribution of ZEQTA values (which may include zeros), we compute log(1 + ZEQTA) rather than log(ZEQTA) to avoid undefined values when ZEQTA equals zero. This transformation helps reduce heteroskedasticity and improves the reliability of econometric analysis, as recommended in previous studies (Ahmad et al., 2008; Li et al., 2022).

3.2.2. Measuring FinTech index

This study extends the Google-search-based FinTech index proposed by Pham et al. (2024). We adapt and refine the FinTech index for the banking sector by regrouping the FinTech-related keywords into four banking-oriented dimensions that correspond to core activities of Vietnamese commercial banks. Similar to Pham et al. (2024), we use internet search data from Google Trends and construct an Average Google Searching Value (AGSV) index over a 52-week rolling window for a set of FinTech-related keywords. In an era where the internet is the main channel for sharing information, a higher volume of online news, public attention, and discussion indicates stronger FinTech development (Wang et al., 2021). The intensity of these searches can therefore be used as an indicator of how actively society and the banking sector are engaging with FinTech.

Specifically, we formed a bank FinTech development index using a three-step model approach: (i) Forming a bank FinTech glossary, (ii) calculate Average Google Searching Value (AGSV) Index, (iii) calculate the FinTech index.

Step 1: Forming a bank FinTech glossary

First, the author constructed a list of functional keywords from the four dimensions of FinTech, based on FinTech applications in the commercial banking business, as shown in Table 1.

The four dimensions and keyword set was compiled based on the lists of keywords used in studies by Chen et al. (2022), Guo and Shen (2016), Li et al. (2022).

Step 2: Calculating Average Google Searching Value (AGSV) Index

Next step, we used Google Trends, a big data source, to construct an index for FinTech development in Vietnam. Following Bijl et al. (2016), Huynh (2019), Kim et al. (2019), Pham

Table 1. Glossary of FinTech keywords

Dimensions	Keywords
Information transfer	financial technology (FinTech), openAPI, digital banking, e-banking, digitalization
Clearing and payment	cashless payment, e-wallet, mobile banking, e-payment, internet banking
Resource allocation	online lending, crowdfunding, online disbursement, online investment, peer-to-peer lending (P2P)
Technical base	blockchain, big data, cloud computing, eKYC, artificial intelligence (AI)

Source: Compiled by authors

et al. (2024), we apply the AGSV{t}^{k} equation of the Google Search Volume Index (GSVI) at week t of keyword k with $SDG_{SVI\{t\}^\{k\}}$ of the standard deviation of GSVI for the past 52 weeks to measure the components of FinTech variables.

$$AGSV\{t\}^\{k\} = (GSVI\{t\}^\{k\} - 1/52 \sum\{1\}^\{52\} GSVI\{t-1\}^\{k\})/SDG_{SVI\{t\}^\{k\}}$$

By construction, AGSV{t}^{k} is a standardized measure: a value of zero indicates that weekly search intensity equals its one-year average, while a value of one (minus one) indicates that search intensity is one standard deviation above (below) that average.

Step 3: Calculate the FinTech index

At Step 3, given the standardized weekly AGSV series obtained in Step 2, we construct the FinTech index in three aggregation layers. First, for each keyword k and year y , we compute its annual score as the arithmetic average of its weekly AGSV values in year y :

$$\overline{AGSV}_{k,y} = 1/T_y \sum\{t\varepsilon y\} AGSV\{t\}^\{k\}$$

where T_y is the number of weeks in year y. Second, for each of the four FinTech dimensions d, we calculate a dimension-level index as the simple average of the annual scores of all keywords belonging to that dimension:

$$FTI_{d,y} = 1/N_d \sum\{k\varepsilon d\} \overline{AGSV}_{k,y}$$

where N_d is the number of keywords in dimension d. Third, the overall FinTech index is defined as the arithmetic average of these four dimension indices:

$$FTI_y = 1/4 \sum\{d=1\}^\{4\} FTI_{d,y}$$

We intentionally use simple arithmetic means at each stage because all selected keywords within a dimension are designed to proxy the same underlying construct and are therefore treated as equally informative, and the four dimensions themselves are intended to capture equally important facets of FinTech development. Since each keyword series is standardized in Step 2, the resulting FTI_y is a unit-free, standardized measure, so that a one-unit increase in FTI_y can be interpreted as roughly a one-standard-deviation increase in the average intensity of FinTech-related search activity.

3.2.3. Control variables

To ensure robust estimation of the relationship between FinTech development and bank stability, and to address concerns related to omitted variable bias and multicollinearity, this study incorporates a set of control variables at both the micro (bank-level) and macroeconomic levels. These variables are grounded in theoretical frameworks and empirical findings from prior research on banking stability.

Bank Size (SIZE)

According to the theory of economies of scale and scope, banks can reduce unit costs and credit risk as they grow larger (Li et al., 2022). Larger institutions typically benefit from greater diversification, enhanced operational efficiency, and better access to funding (Khan et al., 2023). Therefore, bank asset size is included as a control variable to capture the impact of scale on stability. To normalize the skewed distribution and reduce heteroskedasticity, asset size is transformed using the natural logarithm of total assets.

Capital Adequacy (CAP)

The capital structure of a bank reflects its capacity to absorb losses and maintain solvency in the face of shocks. Well-capitalized banks have greater resilience and are more likely to manage technological transitions effectively. As Khan et al. (2023) explain, banks with higher capital reserves are better positioned to withstand disruptions and mitigate risks arising from FinTech adoption, especially in volatile or transitioning markets. Consequently, we include the equity-to-total assets ratio as a proxy for capital adequacy.

Liquidity (LDR)

Liquidity risk is a critical component of overall financial stability. Insufficient liquidity may result in a bank's inability to meet its short-term obligations, potentially triggering insolvency, market distrust, and systemic spillovers. The loan-to-deposit ratio (LDR) is a widely accepted proxy for bank liquidity, capturing how aggressively a bank transforms deposits into loans. Prior research has shown that liquidity

constraints can amplify risks during market stress. For example, Wagner (2007) emphasized that insufficiently liquid assets weaken banking stability by limiting response capacity to withdrawals, while Qi (1994) provided a theoretical model indicating that liquidity shortages are a key channel through which banking crises propagate. Additional evidence from Haq et al. (2022) and Papanikolaou and Wolff (2014) also links liquidity indicators to performance and risk exposure. Thus, LDR is introduced to control for the influence of liquidity risk.

GDP Growth (GDP)
Macroeconomic conditions, particularly economic growth, play a significant role in shaping the financial health of commercial banks (Guo & Shen, 2016; Li et al., 2022; Ozili, 2018). A higher GDP growth rate typically reflects stronger economic fundamentals, greater consumer confidence, and better repayment capacity among borrowers. These dynamics reduce default rates and risk exposure for banks. Empirical literature often documents an inverse relationship between GDP growth and risk-taking, as economic expansion tends to improve asset quality and lower credit risk (Chen et al., 2022; Khan et al., 2023).

Inflation (INF)
Inflation can influence bank stability in complex, possibly non-linear ways (Khan et al., 2023; Li et al., 2022). On one hand, higher inflation erodes the real value of bank capital and pushes up operating costs, weighing on profitability and stability. On the other, when inflation reflects monetary expansion, it can temporarily boost the nominal value of assets and liabilities- sometimes benefiting banks, especially if they are net debtors. Yet in overheating phases, central banks typically tighten policy, raising funding costs and curbing credit, which pressures banks. For these reasons, we include inflation as a macro-level control.
In summary, our variables are illustrated in the Table 2.

4. Econometric models

Our econometric model is specified as follows:
$ZEQTA_{it} = \alpha + \beta FTI_{it} + \gamma Controls_{it} + Firm\ FE + \varepsilon_{it}$
where the dependent variable ZEQTAit is the indicator of the banks stability. FTIit represents the index measuring the development of FinTech in Viet Nam. Controlsit denotes the vectors of bank characteristics and macroeconomic variables. Firm FE is the time-invariance bank-specific effect, and εit is the error term. α, β, and γ are the coefficients to be estimated.
To examine how FinTech development changes over time, the squared independent variable for FinTech is included in the baseline regression to capture this nonlinear effect:
$ZEQTA_{it} = \alpha + \beta_1 FTI_{it} + \beta_2 FTI\{2\}\text{^}\{it\} + \gamma Controls_{it} + Firm\ FE + \varepsilon_{it}$
Throughout the regressions, we use Newey–West standard errors to control for potential serial correlation matters and heteroskedasticity which may lead to biased standard error estimate. All regression analyses are conducted using RStudio.

4.1. Descriptive statistics

Table 3 reports the descriptive statistics of the main variables in this study, including those associated with bank stability, FinTech development, and other bank-specific characteristics. The stability measure, ZEQTA, has a mean of 3.52, with a median of 3.46, indicating slight positive skewness, and ranges from 1.18 to 7.08. Regarding FinTech development, the FinTech Index (FTI) shows an average of 26.41 with considerable variability (standard deviation of 13.96), reflecting diverse levels of FinTech development across institutions.
Table 4 shows a positive link between bank stability (ZEQTA) and FinTech development (FTI) (correlation is 0.2785), suggesting modest stability gains with greater FinTech development, consistent with efficiency and engagement channels. SIZE is strongly positively correlated with FTI (correlation is 0.4135), indicating larger banks adopt FinTech more, likely due to

Table 2. Main variables' description

	Symbol	Description	Existing literature
Dependent variables			
Bank risk	ZEQTA	The natural logarithm of: $ZEQTA_{i,t} = (ROA_{i,t} + EQTA_{i,t})/SD(ROA))$	Ozili (2018); Yudaruddin et al. (2023)
Loan loss coverage ratio	LLC	Loan loss provisions to non-performing loans	
Independent variable			
FinTech index	FTI	The author calculated this index based on the data collected from Google Trend	Pham et al. (2024)
Control variables			
Operating Scale	SIZE	The natural logarithm of total assets	Li et al. (2022), Khan et al. (2023)
Liquidity	LDR	Loan-to-deposit ratio = total loans / total deposits	Li et al. (2022), Chen et al. (2022)
Capital Structure	CAP	Bank capital shows a bank's sufficient capital status and safety and health. CAP = equity capital / total assets	Li et al. (2022), Khan et al. (2023)
Economic Development	GDP	Growth rate of Gross Domestic Product of Vietnam	Li et al. (2022), Guo and Shen (2016), Ozili (2018), Chen et al. (2022), Khan et al. (2023)
Inflation	INF	Consumer Price Index of Vietnam	Li et al. (2022), Khan et al. (2023)

Source: Compiled by authors

greater resources. Macroeconomically, inflation (INF) is negatively correlated with both ZEQTA (correlation is −0.1769) and FTI (correlation is −0.3921), implying inflationary pressure can weaken stability and dampen FinTech investment. GDP exhibits weak correlations with the other variables.

4.2. Results of baseline model

The regression results in Table 5 examine the linear impact of FinTech development on the stability of Vietnamese banks, as measured by ZEQTA. Specifically, column (1) reports the results of the regression model without

Table 3. Descriptive statistics for main variables

	Mean	Median	St.dev.	Min	Max	Obs
ZEQTA	3.52	3.46	0.73	1.18	7.08	324
FTI	26.41	23.74	13.96	10.85	49.18	324
SIZE	32.59	32.56	1.17	30.28	35.37	324
CAP	8.97	8.18	3.46	4.06	23.84	324
LDR	88.26	88.43	16.59	36.33	142.82	324
GDP	5.95	6.53	1.69	2.65	8.24	324
INF	3.72	3.25	2.15	0.63	9.27	324

Source: Compiled by authors

Table 4. Correlation matrix

	ZEQTA	FTI	SIZE	CAP	LDR	GDP	INF
ZEQTA	1.0000						
FTI	0.2785	1.0000					
SIZE	0.1094	0.4135	1.0000				
CAP	-0.1036	-0.1119	-0.4173	1.0000			
LDR	0.0971	0.4505	0.3124	0.1441	1.0000		
GDP	-0.0135	-0.2332	-0.0797	-0.0259	-0.0508	1.0000	
INF	-0.1769	-0.3921	-0.2443	0.2434	-0.1801	-0.0533	1.0000

Source: Compiled by authors

Table 5. The impacts of FinTech development on bank stability

	Linear relationship		Non-linear relationship	
	ZEQTA		ZEQTA	
	(1)	(2)	(3)	(4)
FTI	0.015***	0.015**	0.075***	0.081***
	(0.003)	(0.006)	(0.016)	(0.019)
FTI2			-0.001***	-0.001***
			(0.0003)	(0.0003)
SIZE		-0.079		-0.063
		(0.178)		(0.179)
CAP		-0.01		0.007
		(0.019)		(0.019)
LDR		0.002		-0.0002
		(0.004)		(0.003)
GDP		0.017		0.024
		(0.019)		(0.019)
INF		-0.025		-0.003
		(0.02)		(0.021)
Bank fixed effect	YES	YES	YES	YES
Observations	324	324	324	324
Adjusted R2	0.0262	0.0227	0.077	0.067

*Note: ***, ** and * represent 1%, 5% and 10% significance levels, respectively. To address the potential issue of heteroskedasticity and autocorrelation, Newey-West standard error is estimated (Newey & West, 1987).*

Source: Compiled by authors

any control variables and in columns (2), we include bank characteristic variables and macroeconomic variables as control variables The result of column (2) shows that when FTI increases by 1 unit, ZEQTA increases by 0.015 (in ZEQTA units). The result is consistent in

the model with and without control variables and suggests a consistent positive relationship between FinTech development and bank stability, providing support for Hypothesis H_{1b}. In other words, based on the result of baseline model, we accept the hypothesis H_{1b} and reject hypothesis H_{1a}. This finding implies that as Vietnamese banks increase their FinTech development, they experience improvements in stability, likely driven by efficiencies gained through technological innovation, enhanced service delivery, or risk diversification. This result aligns with the finding of Cizel et al. (2019), Daud et al. (2022), Fuster et al. (2019), Liem et al. (2022), Tang (2019).

The regression results in Table 5 also examine the non-linear impact of FinTech development on the stability of Vietnamese banks. In both models, the coefficient for FTI is positive and statistically significant at the 1% level. At the lower levels of FinTech development, when FTI increases by 1 unit, stability of bank will increase by 0.075 units (as shown in the column (3) of Table 5). This positive coefficient suggests that at lower levels of FinTech development, an increase in FinTech development is associated with improved bank stability, likely due to efficiency gains, enhanced risk management, and increased financial accessibility enabled by technological innovations.

Conversely, in columns (3) and (4) of Table 5, the coefficient on FTI^2 is negative and highly significant at the 1% level (-0.001 in both specifications), confirming an inverted U-shaped relationship between FinTech development and bank stability. In the quadratic model, the marginal effect of FTI on stability is given by , so it depends on the level of FTI. Using the estimated coefficients, the implied turning points are around in column (3) and in column (4). This implies that when FTI is below these values, greater FinTech development is associated with higher bank stability, whereas beyond this threshold additional FinTech expansion reduces stability. For example, based on column (4), an increase in FTI from 40 to 50 is associated with a decline in ZEQTA of about 0.09 units , indicating that economically meaningful increases in FinTech intensity beyond the turning point are accompanied by a non-trivial deterioration in bank stability. In other words, it indicates a diminishing and eventually negative effect of high levels of FinTech development on bank stability. This finding supports Hypothesis H_2, which posits a inverted U-shaped impact of FinTech on bank stability. The findings align with research of Nguyen et al. (2022), Wang et al. (2021). In the early stages of FinTech development, FinTech companies have yet to establish a strong position in the financial market, allowing banks to benefit from reduced operational costs and improved service quality through the adoption of digital services. As the FinTech sector grows and takes on more intermediary services traditionally reserved for commercial banks, these banks may start losing customers to the competition and may need to increase their risk-taking to maintain their revenue. The growth in the number of FinTech companies and FinTech transactions reveals an inverted U-shaped relationship with the level of bank stability or risk-taking. This means that in the initial stages, FinTech development enhances operational efficiency, thereby reducing banks' incentives to take on high risks to sustain profits.

Among the control variables, none are statistically significant, indicating that other bank-specific factors, such as size, capital ratio, loan-to-deposit ratio, GDP growth, and inflation, do not exhibit a strong linear or non-linear relationship with bank stability in this model. Two factors may help explain this pattern. First, the fixed-effects specification absorbs most of the cross-sectional differences across banks, so the coefficients on the control variables are mainly identified from within-bank variation over time, which is relatively small in our sample. Second, the macroeconomic controls (GDP growth and inflation) vary only at the annual level, providing limited time-series variation and reducing statistical power. Therefore, the insignificance of the control variables does not necessarily contradict previous evidence on bank stability in Viet Nam. In this study, the control variables are included

primarily to mitigate omitted-variable bias, while the discussion focuses on the economic significance of FinTech development, which is our main variable of interest.

4.3. Heterogeneity analysis

While the baseline results demonstrate an overall nonlinear (inverted U-shaped) relationship between FinTech development and bank stability, it is important to recognize that the effect of FinTech is unlikely to be homogeneous across all types of banks. To further investigate this heterogeneity, we create a dummy variable based on bank asset size (S_dummy) and conduct a comprehensive heterogeneity analysis.

$$LC_{it} = \alpha + \beta_1 FTI_{it} + \beta_2 FTI_{it} * S\_dummy_{it} + S\_dummy_{it} + \gamma Controls_t + FirmFE + \varepsilon_{it}$$

The size dummy variable is set to one for banks whose total asset is greater than or equal to the mean, and zero for the rest. As shown in the equation below, these three sets of dummy variables were introduced into the model as interaction terms with bank FinTech. The corresponding regression results are displayed in Table 6.

The heterogeneity analysis in Table 6 investigates how the impact of FinTech development on bank stability varies with bank size. Based on the coefficients for FTI and FTI², we can see that the finding aligns with the results of baseline model, suggests a nonlinear, inverted U-shaped relationship, where moderate levels of FinTech development boost stability, but excessive FinTech development introduces risks that could destabilize banks. In other words, while FinTech offers initial benefits, too much reliance on it might expose banks to new vulnerabilities.

The size dummy variable, S_dummy, is positive and significant (0.819), indicating that on average, large banks are more stable than small banks, even without FinTech effects. However, the interaction term FTI*S_dummy is negative (-0.080) and significant, suggesting that as FinTech development increases, the positive impact on stability becomes less pronounced for larger banks.

Table 6. Heterogeneity analysis

	ZEQTA
FTI	0.112***
	(0.026)
FTI^2	-0.002***
	(0.000)
S_dummy	0.819**
	(0.396)
FTI*S_dummy	-0.080**
	(0.033)
FTI^2 *S_dummy	0.001**
	(0.001)
Control variables	YES
Bank fixed effect	YES
Observations	324
Adjusted R^2	0.078

*Note: ***, ** and * represent 1%, 5% and 10% significance levels, respectively. To address the potential issue of heteroskedasticity and autocorrelation, Newey-West standard error is estimated (Newey & West, 1987).*

Source: Compiled by authors

Additionally, the interaction between the squared FinTech term and the size dummy (FTI^2*S_dummy) is positive (0.001) and significant. This suggests that large banks are less vulnerable to instability risks at higher levels of FinTech development compared to small banks This result may reflect larger banks' ability to manage and adapt to high levels of FinTech development more effectively than smaller banks.

5. Robustness test

In this section, the GMM model is applied to further address potential endogeneity issues and to test the robustness of the main findings using an alternative proxy for bank stability.

5.1. Addressing endogeneity concerns

To address potential endogeneity concerns and

ensure the robustness of the empirical analysis, this study employs the System Generalized Method of Moments (System GMM) estimator, as proposed by Blundell and Bond (1998) (see Table 7).

Given the likelihood that a bank's current risk exposure is partially shaped by its risk profile in previous periods, this study introduces lagged values of the main explanatory variable, specifically ZEQTAt−1, into the model specification. The results in Table 7 show that the lagged dependent variable ZEQTAt-1 is positive and highly significant in both models, with coefficients of 0.388 and 0.492, respectively. This suggests that bank stability shows a strong persistence over time, meaning that a bank's stability in the current period is influenced by its stability in the previous period. This finding highlights the dynamic nature of bank stability, where past conditions continue to play an important role in the present.

The results of FinTech index indicate a non-linear, inverted U-shaped relationship. These findings align with the baseline model's results, affirming its robustness.

The diagnostic tests validate the model's reliability. The Sargan test p-values of 0.831 and 0.989 confirm that the instruments used in the GMM estimation are valid, with no overidentification problems. Additionally, the AR(2) p-values (0.031 and 0.057) indicate no evidence of second-order autocorrelation, further supporting the model's accuracy.

5.2. Alternative measure of bank stability

This study also incorporates a complementary indicator, the Loan Loss Coverage Ra-

Table 7. Robustness tests

	GMM estimator		Alternative measure of bank stability Robustness tests		
	ZEQTA		LLC		
	(1)	(2)	(4)	(5)	(6)
$ZEQTA_{t-1}$	0.388***	0.492***			
	(0.100)	(0.066)			
LLC_{t-1}					0.888***
					(0.028)
FTI	0.006*	0.045**	0.030***	0.022**	0.017**
	(0.004)	(0.022)	(0.008)	(0.009)	(0.008)
FTI^2		-0.001*	-0.0003**	-0.0003**	-0.0004**
		(0.0004)	(0.0001)	(0.0001)	(0.0001)
Control variables	YES	YES	YES	YES	YES
Bank fixed effect	YES	YES	YES	YES	YES
Observations	324	324	324	324	324
Sargan test	0.831	0.989	0.095	0.126	0.910
AR(2)	0.031	0.057			0.585

*Note: ***, ** and * represent 1%, 5% and 10% significance levels, respectively. Column (1) is the GMM model result for the linear relationship and column (2) is the GMM model result for the non-linear relationship.*

Source: Compiled by authors

tio (LLC), to enhance the robustness of the analysis. The LLC is calculated as the ratio of loan loss provisions to non-performing loans (NPLs):

LLC= (Loan loss provisions)/(Non-performning loans)

This ratio reflects a bank's capacity to absorb potential loan defaults through existing provisions. A higher LLC indicates that a bank is better prepared to cover its impaired assets, thereby implying stronger financial stability. Conversely, a lower LLC may signal insufficient provisioning, which can heighten vulnerability to credit risk shocks and undermine confidence in a bank's balance sheet integrity. In Table 7, the results align with the results obtained from the baseline regression. FTI shows a positive and significant effect across all models (the result of two-way fixed effect models are in columns (4) and (5), and column (6) is GMM model's result). This suggests that increased FinTech development generally enhances stability in Vietnamese banks. However, the squared term, FTI^2, is negative and significant in all models, indicating an inverted U-shaped relationship. This implies that while moderate FinTech development strengthens stability, excessive FinTech integration may introduce risks that reduce stability. In essence, FinTech's impact on bank stability is positive up to a certain point, beyond which further adoption could potentially weaken stability.

6. Discussion and Conclusion

The findings of this study reveal that FinTech development has a generally positive impact on the stability of commercial banks in Vietnam. FinTech can help banks expand their customer base by providing convenient and accessible online financial applications and services. From the perspective of lending activities, the primary source of revenue for Vietnamese banks, the application of FinTech in their operations has helped commercial banks expand customers and increase credit (Wu et al., 2024) by enabling banks to provide highly accessible services to their customers (Chen, 2016; Maskara et al., 2021) and improving the efficiency of lending processes (Fuster et al., 2019). In addition, with the use of modern financial technologies, banks can minimize information asymmetry (Wu et al., 2024), and by using technology such as artificial intelligence and big data, banks can analyze customer data more accurately and make credit decisions more effectively (Hung et al., 2020). This helps banks better meet customer needs, create new products, and attract more users to their services. From the perspective of payment services, the development of FinTech not only enables banks to adopt new technologies to develop new payment products and upgrade existing ones, but also creates opportunities to collaborate with FinTech companies that provide e-wallet services. This collaboration expands the customer base, increases profits, and enhances stability.

However, the inverted U-shaped relationship, where FinTech's positive impact on stability decreases at high levels of adoption, aligns with findings from Lv et al. (2022) and Wang et al. (2021). In the early stages of FinTech development, FinTech firms do not yet dominate the financial market, allowing banks to enjoy lower costs and better service quality through digital solutions. However, as FinTech companies grow and start providing services traditionally handled by banks, banks may lose customers to this new competition and feel pressured to take on more risks to maintain their income. In other words, in Vietnam, as FinTech use expands, banks are exposed to new challenges like operational and cybersecurity risks, as well as increased competition from FinTech companies offering similar services at lower prices. Integrating too much FinTech without strong risk controls can lead to problems such as data breaches or system failures, which could weaken stability. This rapid adoption can also stretch banks' risk management systems, especially for smaller banks that might not have the resources to manage these risks effectively.

The study's heterogeneity analysis indicates that the impact of FinTech on stability is not

uniform across banks of different sizes. Larger banks, with more substantial resources, may be better positioned to implement FinTech solutions safely and efficiently, benefiting more from moderate levels of FinTech integration, which is supported by Nguyen et al. (2022). In Viet Nam, larger banks have the infrastructure and capital to adopt FinTech innovations effectively, which likely contributes to their stability. Conversely, smaller banks may find it challenging to manage the risks associated with high levels of FinTech integration, leading to a more volatile impact on their stability.

These results carry practical implications for key stakeholders. For bank managers, FinTech should be treated as a strategic tool for sustainable growth, requiring not only greater technology investments but also stronger cybersecurity, risk management, and skilled human capital. Collaborating with FinTech firms can help diversify products and improve customer experience. For regulators, the findings highlight the need for an adaptive legal framework that promotes responsible innovation while safeguarding stability. Priority should be given to standardized guidelines, improved data-sharing, enhanced cybersecurity, and financial literacy programs for consumers. For investors, the evidence suggests that FinTech development up to an optimal level signals stronger performance and stability, but overly aggressive expansion may reduce benefits. Careful monitoring of how banks balance FinTech intensity with risk governance is therefore crucial for long-term value.

Despite its contributions, the study has several limitations. First, the measurement of FinTech development is only an indirect proxy. Our FinTech index is constructed from Google Trends search intensity for a set of FinTech-related keywords at the national level. This index does not distinguish between searches made by banks, other financial institutions, FinTech firms, or retail users, and it may also capture general public interest or media attention rather than the actual deployment of FinTech solutions within commercial banks. Moreover, because the index is available only at the country level, it varies over time but not across banks. As a result, the estimated coefficient on the FinTech index should be interpreted as the association between aggregate FinTech activity in the economy and bank stability, conditional on bank characteristics, rather than as the effect of each individual bank's own FinTech development. Consequently, the correlations reported in the paper must be interpreted with caution and should not be viewed as precise causal estimates of bank-level FinTech initiatives. Second, the analysis period may also miss long-term impacts as the FinTech landscape evolves beyond 2023. While System GMM helps address endogeneity, unobserved factors could still influence both FinTech development and stability. The inverted U-shaped relationship may also be shaped by external forces such as regulation, macroeconomic shocks, or competition from non-bank institutions. Finally, the heterogeneity analysis only considers bank size, overlooking other important factors like ownership structure, market focus, or governance, which merit further study. ■

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