Exploring the relationship between fintech by Google search and bank stability: Evidence from Vietnam

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Abstract: Due to the ongoing global debate regarding the relationship between fintech and banks, including developing countries, this study aims to investigate this relationship in the case of Vietnam, an emerging nation. Using a sample of 27 Vietnamese commercial banks from 2012 to 2023, we construct a fintech index tailored to the Vietnamese banking industry based on data from Google Trends. This index reveals substantial growth in fintech adoption within the Vietnamese banking sector over the study period. Our empirical analysis demonstrates a significant inverted U-shaped relationship between fintech development and bank stability. At moderate levels, fintech adoption positively contributes to bank stability; however, when fintech adoption becomes extensive, it introduces risks that may offset these stability benefits. This study provides important insights for bank managers, investors, and policymakers seeking to optimize fintech integration for sustainable banking stability.

Keywords: Bank stability, Fintech, Vietnam

1 Introduction

In the digital era, technology drives Vietnam's socioeconomic transformation, with information technology playing a key role. Since transitioning to a market-based economy in the late 1980s and early 1990s, Vietnam has followed a cautious liberalization path, maintaining state-owned banks as dominant players with government-backed advantages. This mirrors gradual banking reforms in China and Russia [1], [2]. Fintech, the application of technology to financial services, is reshaping the industry, impacting banks by introducing both opportunities and challenges [3]. While fintech enhances financial intermediation, it also introduces risks that banks must navigate to maintain stability. In Vietnam's bank-based economy, fintech innovations—such as mobile payments and peer-to-peer lending—are rapidly expanding, positioning the country as a key fintech hub in Asia-Pacific.

This study examines the impact of fintech on the stability of 27 Vietnamese commercial banks from 2012 to 2023. The literature presents mixed findings, with some studies highlighting fintech's stabilizing effects through risk diversification and efficiency, while others warn of increased competition and potential instability. Some suggest an inverted U-shaped relationship, where moderate fintech adoption enhances stability, but excessive adoption may undermine it.

The study makes three key contributions: (i) extending research on fintech's impact on bank stability in Vietnam, (ii) introducing a novel Fintech Index using Google Trends data, and (iii) analyzing the role of bank size in this relationship.

2 Literature review and hypothesis development

2.1 Background of banking in Vietnam

Compared to well-established banking systems in the US, Europe, and other emerging markets, Vietnam's banking sector exhibits distinct characteristics. A small number of large state-owned banks dominate the market, leaving private banks with significantly smaller shares. This dynamic suggests that government-funded projects often depend on state-owned banks rather than private financial institutions [4].

As the backbone of Vietnam's economy, the banking sector operates under strict regulation by the State Bank of Vietnam (SBV). Before 1990, Vietnam had a one-tier banking system, where the SBV handled both regulatory and commercial functions. To enhance financial sector diversification and eliminate the State Bank's monopoly, Vietnam transitioned to a two-tier banking system, separating regulatory

oversight from commercial banking operations. This reform aimed to promote competition and expand banking services.

Following the 2007–2009 financial crisis, Vietnam faced economic challenges, including high inflation and slowed growth. In response, the SBV implemented various monetary policies to stabilize the economy and support recovery. Between 2007 and 2021, Vietnam's economy grew at an average annual rate of 5.8%, with commercial banks supplying 60%–80% of the economy's capital needs [5]. The rising demand for business and production capital fueled significant credit expansion within the banking system.

The global economic crisis of 2022, triggered by post-pandemic disruptions in supply chains, pushed many businesses toward bankruptcy. In response, the SBV introduced monetary policies to regulate inflation, real estate, securities, bonds, and credit supply—significantly impacting commercial bank lending. Additionally, the rapid advancement of technology, alongside the effects of COVID-19, accelerated digital transformation within the banking sector. As a result, banks increasingly integrated technology to enhance efficiency and profitability, making digitalization a key priority for both investors and researchers in the post-pandemic recovery phase.

2.2 Fintech in Vietnam

Fintech activity in Vietnam has grown exponentially and has been playing an important role in transforming the financial services sector. However, there is still potential for further growth. Access to technology along with a young population structure with increasing per capita income has laid the foundation for the rapid growth of Fintech. The development of the Fintech market in Vietnam is most evident through the number of startups in this field that is always growing year by year. Along with the rise in the number of Fintech companies, the Fintech industry in Vietnam is also a potential market that has received the amount of funding value reaching a significant number year by year. The prolonged pandemic in 2021 has resulted in record investment volume in Fintech in Vietnam, along with increasing adoption of Fintech solutions such as e-wallets, cryptocurrencies and online investment platforms.

It can be seen that FinTech is rapidly developing in Vietnam with a wide range of functions, offering diverse services related to payments, lending, blockchain/crypto, digital banking, wealth management, insurtech, and more. With functions similar to those of banks, FinTech activities have a strong impact on the operations of traditional banks, thereby affecting the financial stability of banks in Vietnam.

Due to its rapid and prominent development, FinTech has become a popular topic for researchers. There have been numbers of papers worldwide, in the context of the industrial revolution 4.0 taking place strongly and creating a trend of digital transformation in the banking system, choose Fintech-related indicators to analyze

banks' performance. However, existing studies in Vietnam mostly measure FinTech's impact on bank performance, such as the studies by Pham et al. [6], Vu et al. [7], and L. Nguyen et al. [8], or focus on user acceptance of FinTech, as in the research by Huong et al. [9]. Studies examining FinTech's impact on the stability or risk-taking levels of Vietnamese banks are still quite new. Utilizing this research gap, this paper will explore the relationship between FinTech development and the stability of commercial banks in Vietnam.

2.3 Relationship between bank stability and fintech development

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. [10] 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. [11] 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. [12] found that during market declines, risk spillovers from traditional banks to fintech firms are more pronounced. Chaudhry et al. [13] observed that while technology firms face higher risk levels, they are less likely than banks to experience distress after market shocks.

In terms of stability, some scholars argue that fintech can make banks more vulnerable. Thakor [14] suggested that financial innovations may increase banks' susceptibility to crises. Buchak et al. [15] 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 hypotheses:

H1a: Fintech development has a negative relationship with the stability of Vietnamese banks.

However, other research suggests that fintech can positively affect financial intermediation. Philippon [16] emphasized how fintech can reduce intermediation costs, while Fuster [17] found that fintech platforms streamline lending, particularly for mortgages, allowing quicker responses to demand fluctuations. Similarly, Tang [18] reported that peer-to-peer lending platforms offered effective alternatives to traditional banking. Thus, we propose the following hypothesis:

H1b: Fintech development has a positive relationship with the stability of Vietnamese banks.

Several studies have highlighted fintech's mixed impacts on bank performance. Lv et al. [19] discovered a U-shaped relationship between fintech and bank profitability: fintech initially lowers profitability but eventually boosts it. Zhao et al. [20] noted that fintech lowers profitability and asset quality for large state-owned

banks, but it can improve their capital adequacy and efficiency. Nguyen et al. [8] observed that while fintech competes with banks, it also enhances stability by improving risk performance. Yudaruddin [21] found that fintech startups negatively impact bank lending and performance. Wang et al. [22] observed that while fintech adoption initially reduces bank risk-taking, high levels of adoption can increase risks. Nguyen et al. [8] also noted the destabilizing potential of fintech under certain conditions. International studies echo this complexity, for example, Daud et al. [23] found that fintech promotes financial stability in a sample of 63 countries. Fung et al. [24] reported that fintech innovation, represented by regulatory sandboxes, supports stability in emerging markets but poses risks in developed economies. Liem et al. [25] used global fintech credit data to show fintech's positive role in financial stability across 73 countries. So, we proposed the second hypothesis:

H2: From a dynamic evolution standpoint, fintech development has a U-shaped impact on the stability of Vietnamese commercial banks.

The literature presents diverse perspectives on the impact of fintech on banks. The relationship can be positive, negative, or follow an inverted U-shape, depending on factors like technology level, regulatory environment, and bank characteristics.

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 [26]. 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 [27]. For smaller banks, FinTech adoption may thus require a careful balance between using technology to spur growth and managing the associated risks. Based on these discussions, we propose a third hypothesis:

H3: FinTech development has heterogeneous impacts on different size of banks.

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, which are the Hanoi Stock Exchange (HNX), the Ho Chi Minh City Stock Exchange (HSX) and the Unlisted Public Company Market (UPCOM). 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.

For the glossary of fintech development, we mainly based on previous literature. To ensure the list of keyword is applicable in Vietnam, we refer to Vietnam Financial Times - a newspaper house which is under the management of Vietnamese Ministry of Finance (thoibaotaichinhvietnam.vn), Banking Magazine – a financial press under the State Bank of Vietnam (tapchinganhang.gov.vn), and a fintech dictionary in English [28], as well as from the reports and articles published by the investigated banks themselves. For the calculation of Fintech development index, we collect data from Google trend and then construct this index.

3.2 Variables construction

3.2.1 Measuring bank stability

Research literature shows that the indicators used in financial risk assessments vary, including capital-asset ratios, expected default rates, capital adequacy ratios, stock volatility, non-performing loan ratios, and Z-values [29]. This study uses the ZEQTA variable, which represents the Hannan & Hanweck [30] accounting model of bank risk index. This index has been used in various studies to measure bank risk-taking, such as Lepetit & Strobel [31], Yusgiantoro et al. [32], Maria et al. [33], Yudaruddin et al. [34], and Ahmad et al. [35]. The risk index ZEQTA is calculated as follows:

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

where ROA is the return on average assets, EQTA is the equity capital-to-asset ratio, and SD(ROA) is the standard deviation of ROA. ROA is calculated as net income divided by total assets. We calculate SD(ROA) for each bank using a five-year time series approach and derive the ZEQTA value.

ROA provides an overview of the bank's performance, while its standard deviation describes the volatility of bank earnings, therefore, the equity capital-to-total assets ratio shows the amount of equity capital available to absorb unexpected losses [35]. The index captures three essential aspects of bank risk, assessing how much earnings can decrease before the bank's book value becomes negative, potentially resulting in insolvency [36]. A low ZEQTA score indicates a riskier bank, while a higher ZEQTA score implies a safer bank. The ZEQTA value has its unique characteristics, showing a tail after the peak, so the logarithm of this value must be taken during regression [11]. When we did the calculation, considering the fact that the Z value may be zero, we used log (1+ ZEQTA) instead of log (ZEQTA).

3.2.2 Measuring fintech index

In this study, we use Google Trends to collect data on the level of interest in search activity related to FinTech. In today's era of rapidly advancing information technology, things that develop more tend to attract greater public attention and information searches. Therefore, we believe that the public's interest in FinTech can serve as a proxy for the level of FinTech development in Vietnam.

Internet search data, particularly from Google, is strongly linked to socioeconomic indicators [37]. Google, as a leading search engine, provides cost-effective, readily available, and continually updated data (hourly, daily, weekly, monthly, and yearly), which can be segmented by time and region, offering advantages over traditional survey data. When specific keywords are queried on Google Trends, the search volume time series appears as the Google Search Volume Index (GSVI), ranging from 0 to 100, representing the frequency of keyword searches from lowest to highest.

By following literature, the author 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.

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)

Table 4
Glossary of Fintech keywords
Source: compiled by author.

The keyword set was compiled based on the lists of keywords used in studies by Guo & Shen [38], Li et al. [1], and B. Chen et al. [29]. To ensure the keywords are relevant and applicable in the Vietnamese context, we consulted the Vietnam Financial Times - a publication under the Vietnamese Ministry of Finance (thoibaotaichinhvietnam.vn) and the Banking Magazine, which is managed by the State Bank of Vietnam (tapchinganhang.gov.vn). Additionally, we referenced an English-language FinTech dictionary [28], as well as reports and articles published by the banks included in the study.

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. [39], Kim et al. [40], Huynh [41], and Pham, Pavelkova, et al. [6], we apply the $AGSV_t^k$ equation of the GSVI at week t of keyword k with $SD_{GSVI_t^k}$ of the standard deviation of GSVI for the past 52 weeks to measure the components of fintech variables.

$$AGSV_t^k = \frac{GSVI_t^k - \frac{1}{52}\sum_1^{52} GSVI_{t-1}^k}{SD_{GSVI_t^k}}$$

Step 3: Calculate the fintech index

After computing the AGSV index weekly for each keyword, we derive the annual score of each keyword by taking its arithmetic average. The next step is to calculate the score for each dimension based on the average annual score of the keywords. Finally, the overall FinTech index is created from the average of these four dimension scores.

3.2.3 Control variables

To better analyze changes in the dependent variables and reduce multicollinearity more effectively, the author incorporated several control variables at both the macro and micro levels.

In line with the existing literature on bank stability and according to the theory of economies of scale and scope, expanding bank scale can reduce credit risk. Therefore, bank asset size is included as a control variable, with the asset size transformed by taking its logarithm.

According to the theory of economy of scale and scope, the expansion of scale can reduce the credit risk faced by banks. We have taken the bank's asset size as one of the control variables and taken the logarithm of the asset size.

Well-capitalized banks have more resources and expertise to effectively manage and mitigate the risks associated with FinTech adoption [42]. Their substantial capital reserves also provide a cushion against potential losses or disruptions caused by new technologies. Therefore, we included capital structure (equity-to-total assets) as a control variable.

In addition, liquidity plays a crucial role in bank stability [43], [44], [45], [46]. A lack of liquidity can lead to insolvency, erode market confidence, and even trigger bank runs [42]. This can cause reluctance in the interbank market to lend, force asset sales at distressed prices, prompt regulatory intervention, and exacerbate the maturity mismatch between assets and liabilities. Thus, the loan-to-deposit ratio, an important indicator of a bank's liquidity level, is included in this thesis as a control variable.

The higher the GDP growth rate, the better the economic development, which affects the business and operations of commercial banks. Generally, there is an inverse relationship between the GDP growth rate and the risk-taking of commercial banks.

There are three possibilities for the impact of inflation (INF) on bank risk. First, inflation will increase bank costs, which is adverse for banks. Second, the central bank's currency is over issued, and inflation is beneficial for the bank, which is the debtors. Third, when the economy is prosperous, inflation will make the country use tight monetary policy to curb inflation, which is adverse for the banking system.

In summary, our variables are illustrated in the Table 5 below:

	Symbol	Description	Existing literature
Dependent variables			
Bank risk	ZEQTA	The natural logarithm of: $ZEQTA_{i,t} = \frac{ROA_{i,t} + EQTA_{i,t}}{SD(ROA)}$	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, Pavelkova, 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), B. 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 & Shen (2016), Ozili (2018), B. Chen et al. (2022), Khan et al. (2023)
Inflation	INF	Consumer Price Index of Vietnam	Li et al. (2022), Khan et al. (2023)

Table 5
Main variable description
Source: compiled by author.

3.3 Econometric models

Our econometric model is specified as follows:

$$\mathbf{ZEQTA_{it} = \alpha + \beta FTI_{it} + \gamma Controls_{it} + Firm\ FE + Year\ FE + \varepsilon_{it}}$$

where the dependent variable $ZEQTA_{it}$ is the indicator of banks stability. FTI_{it} represents the index measuring the development of fintech in Vietnam. $Controls_{it}$ denotes the vectors of bank characteristics and macroeconomic variables. Year FE and Firm FE are year fixed effect and the time-invariance bank-specific effect respectively, and ε_{it} 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:

$$\mathbf{ZEQTA_{it} = \alpha + \beta_1 FTI_{it} + \beta_2 FTI^2_{it} + \gamma Controls_{it} + Firm\ FE + Year\ FE + \varepsilon_{it}}$$

Furthermore, we include bank fixed-effects and year fixed-effects to control for time-invariant unobserved heterogeneity and biases related to potentially omitted explanatory variables as well as time fixed-effects to account for time-specific unobservable factors which may systematically influence the level of bank stability. 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.

4 Empirical Results

4.1 Descriptive statistics

	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

Table 3
Descriptive statistics for main variables
Source: compiled by author.

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 adoption across institutions. Overall, the statistics in Table 3 illustrate a comprehensive view of the banking environment, highlighting diverse fintech adoption levels, capital and liquidity positions, and macroeconomic conditions that may influence bank stability.

	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

Table 4
Correlation matrix
Source: compiled by author.

Table 4 presents the correlation matrix, illustrating the relationships between bank stability (ZEQTA), fintech development (FTI), bank-specific characteristics (SIZE, CAP, LDR), and macroeconomic indicators (GDP, INF). The results reveal a positive correlation between bank stability (ZEQTA) and fintech development (FTI) with correlation equal 0.2785, suggesting that greater fintech adoption is modestly associated with enhanced bank stability. This finding aligns with the notion that fintech innovations may support stability through improved operational efficiencies and customer engagement.

4.2 Fintech development in in Vietnam

Based on the Fintech Index for Vietnam that we calculated, it reveals a steady upward trend from 2012 to 2023, highlighting the country's increasing adoption and development of financial technologies (see Figure 1).

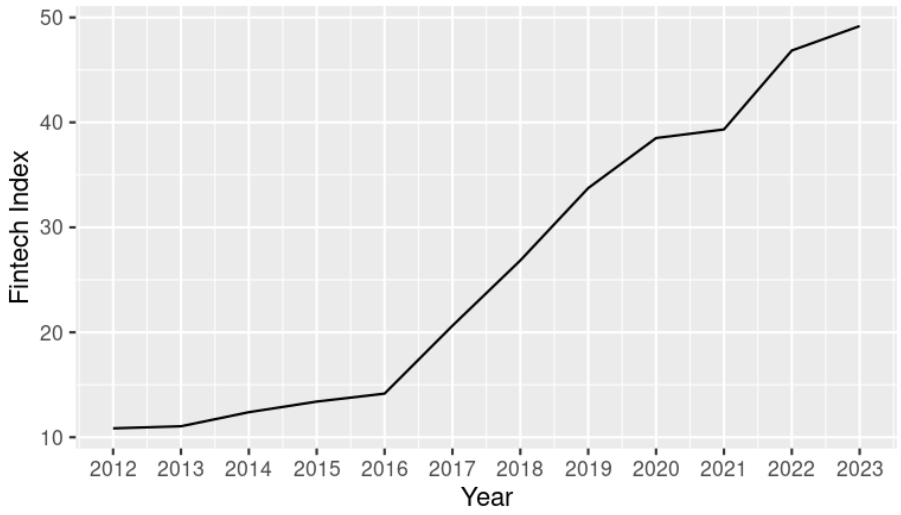

Figure 1
Time series of FinTech Index
Source: compiled by author.

Between 2012 and 2016, Vietnam's Fintech Index remained low and stable (around 10), reflecting limited development due to regulatory barriers, low adoption, and weak digital infrastructure. Fintech's potential was not yet widely recognized in the financial sector. A major shift occurred in 2017, with rapid growth through 2021, driven by supportive regulations, technological advances, and changing consumer behavior. Government policies boosted digital payments, while smartphone adoption and venture capital fueled fintech expansion. A young, tech-savvy population further accelerated adoption. From 2021 to 2023, growth slowed, signaling market consolidation and steady expansion. The COVID-19 pandemic reinforced digital trends, while fintech diversified into insurtech, wealth management, and blockchain.

4.3 Results of baseline model

	ZEQTA	
	(1)	(2)
FTI	0.015***	0.015**
	(0.003)	(0.006)
SIZE		-0.079
		(0.178)
CAP		-0.01
		(0.019)
LDR		0.002
		(0.004)
GDP		0.017
		(0.019)
INF		-0.025
		(0.02)
Bank fixed effect	YES	YES
Year fixed effect	YES	YES
Observations	324	324
Adjusted R2	0.0262	0.0227

Table 5

The impacts of fintech development on bank stability – linear relationship

Source: compiled by author. 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 [49].

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 two-way fixed effect regression model without 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 standard deviation, ZEQTA will increase by 0.015 * 13.69/3.52= 5.83% points (0.015 is coefficients on FTI, 13.69 is the standard deviations of FTI, and 3.52 is the mean of ZEQTA). Based on the result of baseline model, we accept the hypothesis H1b which posits a positive association between fintech adoption and stability and reject hypothesis H1a. This finding implies that as Vietnamese banks increase their fintech adoption, 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. [50], Fuster et al. [17], Tang [18], Daud et al. [23], and Liem et al. [25].

	ZEQTA	
	(1)	(2)
FTI	0.075***	0.081***
	(0.016)	(0.019)
FIT^2	-0.001***	-0.001***
	(0.0003)	(0.0003)
SIZE		-0.063
		(0.179)
CAP		0.007
		(0.019)
LDR		-0.0002
		(0.003)
GDP		0.024
		(0.019)
INF		-0.003
		(0.021)
Bank fixed effect	YES	YES
Year fixed effect	YES	YES
Observations	324	324
Adjusted R2	0.077	0.067

Table 6

The impacts of fintech development on bank stability – non-linear relationship

Source: compiled by author. 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 [49].

The regression results in Table 6 examine the non-linear impact of fintech development on the stability of Vietnamese banks. The inclusion of both the Fintech Index (FTI) and its squared term (FTI^2) allows for the exploration of a potential U-shaped relationship. In both models, the coefficient for FTI is positive and statistically significant at the 1% level. That mean, at the lower levels of fintech development, when FTI increases by 1 standard deviation, stability of bank will increase by 29,16% (0.075* 13.69/3.52) points. This positive coefficient suggests that at lower levels of fintech adoption, 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, the coefficient for FTI^2 is negative and also highly significant at the 1% level in both models (-0.001), indicating that, with high level of fintech development, when FTI increases by 1 standard deviation, stability of bank will decrease by 0.39% (-0.001* 13.69/3.52) points. In other words, it indicates a diminishing and eventually negative effect of high levels of fintech development on bank stability.

This finding supports Hypothesis H2, which posits a inverted U-shaped impact of fintech on bank stability. Specifically, while moderate levels of fintech adoption appear to enhance stability, excessive fintech development could introduce destabilizing effects, possibly due to increased operational complexity, heightened competition, or emerging technological risks that may undermine traditional risk management practices. The findings align with research of Lv et al. [19], Wang et al. [22], and Nguyen et al. [8]. 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.

4.4 Heterogeneity analysis

According to previous studies, the application of financial technologies by banks may have different effects on liquidity creation for banks with various characteristics. To further investigate this heterogeneity, we create a dummy variable based on bank asset size (S_dummy) and conduct a comprehensive heterogeneity analysis.

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

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 7.

	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
Year fixed effect	YES
Observations	324
Adjusted R2	0.078

Table 7

Heterogeneity analysis

Source: compiled by author. 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 [49].

The heterogeneity analysis in Table 7 investigates how the impact of fintech development on bank stability varies with bank size. The results show a significant positive coefficient for FTI (0.112), indicating that fintech development generally has a positive effect on bank stability. However, the squared term for FTI (FTI^2) has a negative coefficient (-0.002), which is also significant. This finding align with the results of baseline model, suggests a nonlinear, inverted U-shaped relationship.

The interaction term FTI*S_dummy is negative (-0.080) and significant, suggesting that as fintech adoption increases, the positive impact on stability becomes less pronounced for larger banks. This could mean that while larger banks benefit from fintech at moderate levels, they might face diminishing returns at higher levels of adoption. Additionally, the interaction between the squared fintech term and the size dummy (FTI^2*S_dummy) is positive (0.001) and significant. This result show that for larger banks, excessive fintech adoption may initially reduce stability but eventually leads to a stabilizing effect. This pattern may reflect larger banks' ability to manage and adapt to high levels of fintech adoption more effectively than smaller banks.

Overall, these findings highlight the complexity of fintech's impact on bank stability. Moderate fintech adoption generally supports stability, particularly for larger banks, but extensive fintech adoption can introduce new challenges that require careful management, especially for banks with greater resources and market presence.

5 Robustness test

In this part, we employ GMM model to address endogeneity concerns and use the alternative measure of bank stability and to conduct robustness tests. Additional models will be implemented in this stage to enhance the validity and reliability of the baseline regression results by undertaking robustness tests from several different perspectives.

5.1 Addressing endogeneity concerns

To reduce potential endogeneity problems, a system GMM approach is used in the thesis (see Table 8). Considering that bank risk has dynamic continuation effects, the current risk-taking level maybe influenced by the risk level from the previous period. Therefore, one-period lagged explanatory variables, $ZEQTA_{t-1}$, are introduced in the paper to construct a dynamic panel model, and the GMM estimation method is used to test the baseline results.

	ZEQTA	
	(1)	(2)
$ZEQTA_{t-1}$	0.388***	0.492***
	(0.100)	(0.066)
FTI	0.006*	0.045**
	(0.004)	(0.022)
FTI^2		-0.001*
		(0.0004)
SIZE	0.069***	0.045***
	(0.012)	(0.010)
Control variables	YES	YES
Bank fixed effect	YES	YES
Year fixed effect	YES	YES
Observations	324	324
Sargan test	0.831	0.989
AR(2)	0.031	0.057

Table 8

Addressing endogeneity concerns - GMM estimator

Source: compiled by author. 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.

The results in Table 8 show that the GMM analysis reinforces the idea that fintech development has a complex relationship with bank stability. While moderate fintech adoption improves stability, excessive reliance on fintech may introduce risks. The findings also suggest that larger banks are generally more stable, benefiting more

from moderate fintech adoption. These insights are essential for bank managers and policymakers, highlighting the need for a balanced approach to fintech integration in the banking sector.

5.2 Alternative measure of bank stability

In this section, an alternative measure of bank stability is also employed in this study. The loan loss coverage ratio (LLC) is calculated as the ratio of loan loss provisions to non-performing loans [47]. A higher LLC provides greater protection against loan losses, contributing to improved banking stability, whereas a lower LLC may indicate insufficient protection [47].

$$LLC = \frac{Loan\ loss\ provisions}{Non - performning\ loans}$$

In **Table 9**, 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 (1) and (2), and column is GMM model's result). This suggests that increased fintech adoption 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.

	LLC		
	(1)	(2)	(3)
LLC_{t-1}			0.888***
			(0.028)
FTI	0.030***	0.022**	0.017**
	(0.008)	(0.009)	(0.008)
FTI^2	-0.0003**	-0.0003**	-0.0004**
	(0.0001)	(0.0001)	(0.0001)
Control variables	YES	YES	YES
Bank fixed effect	YES	YES	YES
Year fixed effect	YES	YES	YES
Observations	324	324	324
Adjusted R^2	0.095	0.126	
Sargan test			0.910
AR(2)			0.585

Table 9

Robustness tests – Alternative measures of bank stability

Source: compiled by author. 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 [49].

6 Discussion

The findings of this study reveal that fintech development has a generally positive impact on the stability of commercial banks in Vietnam. However, the results also highlight a nonlinear, inverted U-shaped relationship between fintech development and bank stability.

The positive impact of fintech on bank stability aligns with previous studies that suggest fintech can enhance operational efficiency and risk management. 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 [51]. Morover, the growth of digital payments, online lending and mobile internet have improved financial inclusion in the community by enabling firms to provide highly accessible services to their customers [52], [53]. This helps banks attract more customers, including small and medium-sized businesses that were previously overlooked due to lack of cash flow and collateral. [17] found that fintech platforms improve the efficiency of lending processes, allowing banks to process loans faster and adapt more flexibly to shifts in demand.

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. [19] and Wang et al. [22]. These studies show that while moderate fintech adoption can strengthen stability, too much reliance on fintech can bring added complexities and risks. 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.

The study's heterogeneity analysis indicates that the impact of fintech on stability is not uniform across banks of different sizes. This finding is supported by Nguyen et al. [8], who argue that competitive pressures from fintech firms push banks to adopt new technologies and strategies to maintain market share. In Vietnam, 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.

Conclusion

In the past decade, the rise of the FinTech industry and increasing use of its applications in the banking sector have played a prominent role in financial markets and drawn academic attention to this area. Nevertheless, the recent literature has focused on the external impact of the FinTech industry on the banking sector or the relationship between banks' FinTech development and their performance (credit risk and failure risk) and, specifically, on banks in Vietnam. Thus, the effect of FinTech development on stability of the Vietnamese banking sector are unexplored in the existing empirical literature. To address this gap in the literature, we use data on a sample of the 27 commercial banks in Vietnam using a yearly frequency period from 2012 to 2023. Further, we ultitze the data from Google Trends to construct a new fintech index specifically tailored for the Vietnamese banking industry. Our index indicates a notable increase in fintech development within the Vietnamese banking sector during the sample period.

Our empirical findings consistently support our hypotheses, providing convincing evidence that there is a significant U-shaped relationship between fintech development and bank stability within the Vietnamese banking sector. At moderate levels, fintech adoption appears to support bank stability, but excessive fintech expansion may introduce risks that counteract these benefits.

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