Print ISSN: 1738-3110 / Online ISSN 2093-7717
JDS website: http://www.jds.or.kr/
http://dx.doi.org/10.15722/jds.20.06.202206.43

The Effect of Investing into Distribution Information and Communication Technologies on Banking Performance the Empirical Evidence from an Emerging Country

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Received: March 28, 2022. Revised: May 01,2022. Accepted: June 05, 2022.

Abstract

Purpose: This study aims to investigate the impact of investing into technology development on banking performance in an emerging country. **Research design, data and methodology:** Based on the data of 12 commercial banks listed in Vietnam from 2011 to 2019 and performing multivariable regression analyses as well as conducting a variety of robustness tests, we carry out the empirical investigation to discover this impact. **Results:** Our empirical evidence shows that these spending help to improve significantly performance of banks. Particularly, the technology expenditures have positive effect on the net interest margin and the non-interest income in which the level of influence on the latter is relatively remarkable in comparison with the former. At the same time, the result does not support the view that increasingly spending on technology may lead banks to face the risk of instability. **Conclusions:** Overall, our empirical analysis indicates that increasing investment into distribution information and communication technologies will help to enhance business strategies of banks and thus we advocate the bright side of technology development and digitalization in banking sector. We believe that the research is useful for both managers, regulators and policy makers in Vietnam as well as in countries having similar financial structure.

Keywords: Distribution; Information and Communication Technology; Digital Transformation; Investment Strategy; Banking Performance.

JEL Classification Code: G21, G00, O31

1. Introduction

Nowadays, the revolution of technology has been playing a vital role in all dimensions of social and economic life over the world. During the Covid-19 pandemic, technological applications have brought useful facilities for people, companies, governments and the banking sector is not an exception case. However, the effects of technology development on operating banks are still controversial. In fact, the rapid changes of the digital era bring both 'creation' and 'destruction' for banks (Lee, Li, Yu, & Zhao, 2021).

On the one hand, the prior studies suggest that technology may encourage banks in diversifying business strategy into new services and products (Berger, 2003);

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consolidating the resilience to sharing risk-taking (Allen & Rai, 1997); deploying and allocating efficiently economic resources (Houston, Lin, Lin, & Ma, 2010); enhancing the loyalty of customers (Chohan, Aras, Indra, Wicaksono, & Winardi, 2022). By contrast, other studies alarm that to survive in the paradigm shifts of digital environment, banks have to continuously invest into technology regardless of whether these spendings are really effective (Kauffman, Liu, & Ma, 2015; Uddin, Ali, & Hassan, 2020). Furthermore, the emergence of Fintech firms could lead the financial market to become more fiercely competitive. As a result, banks may face the risk of reducing market share and vulnerability (Vives, 2019). Taking a typical example in Vietnam, TPBank is considered as one of the most modern banks and always at the top of ones investing into technology in this country. However, it lost around US$ 1 million in 2015 due to the cybersecurity incidences. With that in mind, through this study, we will answer the straightforward question is that whether continuous investments into technology help to improve banking performance. By providing the empirical evidence based on the landscape of an emerging country that Vietnam is the typical example, our findings support the bright side of technology development, at least in Vietnam context. The result remains mostly unchanged when we employ some robustness tests.

We take a developing nation as the experimental environment due to there are several key reasons. First, the prior studies mainly focus on discovering the effects of technology on banking operation relying on developed countries (Beccalli, 2007), or international settings (Uddin, Ali, & Hassan, 2020), or Chinese market (Lee et al., 2021). Therefore, our study makes a difference when providing one of the first empirical results in an emerging market. Furthermore, the wake of technological innovation in banking system has generated a crucial issue for both regulators as well as policymakers in Vietnam. In fact, since 2017 Vietnamese government has issued Directive No. 16 on "The strengthening of the ability to access the fourth industrial revolution". Unfortunately, as Frame and White (2004) said that "Everybody talks about financial innovation, but (almost) nobody empirically tests hypotheses about it". Indeed, it seems to be an absence of empirical studies to uncover the relationship between banks' performance and technology-investing regardless of calling constantly from politicians in this country. Hence, such absence gives the opportunity to us to carry out this research as our attempt to filling the vital gap. Additionally, banking system in Vietnam plays a crucial role in allocating economic resources due to the underdeveloped financial systems (Le, 2018). Increase fluctuation in operating banks will impact directly on the economic grown of this nation. Thus, Vietnam provides as an appropriate laboratory for our setting to evaluate the influences of technological investments on banking performance.

To reach a clear answer of our main concerns, following Uddin, Ali and Hassan (2020), we use the (natural logarithm) total bank's technology investments (TECHINVEST), the key dependent variable, as the proxy of spending on distribution information and communication technologies. These spendings are the total annual expenditures of software, hardware, data processing, outsourced technical support collected from the financial statements of banks. At the same time, we use the net interest margin (NIM), the ratio of non-interest incomes over net operating incomes (NIIR) and the natural logarithm of total non-interest incomes (NII) respectively as the proxy of banking performance. While NIM reflects the effectiveness of bank operation, NIIR and NII are performed as a means to delving deeper into capturing the effects of technology spendings. To some extent, NIIR and NII indicators also help us to shine more light on diversification activities of banks (see more: Tran, Hassan, & Houston, 2019; Tran, 2020). On the other hand, Uddin, Ali and Hassan (2020), Vives (2019) argue that relying on technology-investing to expanding banking business means that banks have incentives to taking more risk. To deal with this issue, we use Z-score as the proxy of bank stability, which is also accepted as a measure of bank risk in the wide literature (see more: Tran & Ashraf, 2018; Tran & Lu, 2021). Controlling for the effects of different bank characteristics and time fixed effects, our empirical analysis shows the positive relation between technology investments and banking performance. Accordingly, the effect of these spendings on NIM is insignificant while the magnitude of that on NIIR and NII is relatively more significant. Nevertheless, we do not seem to find empirical evidence supporting the view that the expansion to technological spendings will lead banks to face the instability. Our results survive through several sensitivity tests consisting of: (i) with adding variables to mitigate the problem of omitted variables, (ii) with using alternative measure of technology spendings, (iii) employing alternative econometric approach.

This study contributes to the literature in several ways. First, to the best of our knowledge, this research provides one of the first examinations of the impact of technology investments on banking performance in Vietnam and thus, our result brings more understandings for the broad literature of the effects of technological development on banking sector, especially in emerging countries. Additionally, under our perspective, prior studies mostly focus on the relationship between risk-taking and expanding investments into technology of banks. We make the complementary difference when assessing the marginal return of banks. Our main result suggests that such spending on distribution information and communication technologies helps banks to enhance the efficient operation

and become one of the necessary investment strategies in operation of ones. Therefore, the finding supports the bright side of technological development rather than cast doubt on it. Eventually, we strongly believe our study is of interest for policy makers and regulators in this time of reform, especially in Vietnam where there are increasingly more calls to intensify expansion and investment into technology evolution.

We construct the remainder of this paper as follows. The next section reviews the literature. Section 3 describes the data and variables. Section 4 delineates the main results and alternative measure as well as robustness tests. We present the effect of technology investments on bank stability in Section 5. Section 6 concludes the study.

2. Literature Review

As we mentioned above, although the rapid development of technology has been the unavoidable trend, the conclusion about the impact of technological innovation on the banking sector remains still controversial. It is not exaggeration to say that the influences of financial innovation fueled by technology seem to be a double-edged sword. They could bring both 'creative innovation' as well as 'destructive innovation' for banking operation.

On the one hand, many studies emphasize the bright side of this evolution that has positive effects on banking activities. For instance, Furst, Lang and Nolle (2002) find that banks adopting the Internet banking application achieve higher non-interest incomes and increase bank size besides the expenses are also higher. Similarly, Sullivan (2000) shows that referring Internet website in the banking transaction affects positively both non-interest expenses and non-interest incomes. The study of Chohan et al. (2022) shows that using QR code becomes one of the most important tools of banks in the digital era due to it help to increase the loyalty of customers, especially about the trust and satisfaction when doing payments. The recent studies also heighten the benefits of technology in enhancing the efficient operation and boosting the growth of banks in the landscape of the globalization. Besides that, the pace of rapid changes of technological innovation may help banks to offer new intermediate products, financial services such as payments, savings in virtual environment at a highly effective cost. Therefore, the technology development, in turn, creates opportunities for banks to get distinct advantages that eventually allow them to strengthen the market power and build profit cushion. As a result, banks have enough ability to preserve resources against potentially adverse financial shocks during uncertain times (Tchamyou, Erreygers, & Cassimon, 2019). Additionally, the intensification of technological innovation will improve the functions of financial system through reducing problems of agency cost, boosting risk-sharing and allocating effectively economic resources (Allen & Rai, 1997; Houston, Lin, Lin, & Ma, 2010). In firm industry, the role of technological progress is also received great attention from academics. For instance, Alzyadat and Almuslamani (2021) find that adopting technology will contribute to grow in the distribution sector. This finding is consistent with the previous study of Lakhwani, Dastane, Satar and Johari (2020), who show that changes in technology have the positive effects on the productivity of a company. These arguments suggest that banking operation fueled by technological innovation investments may bring a huge of benefits for banks, and thus increasing marginal returns. We call this investing channel *the innovation-growth hypothesis*.

On the other hand, the scenario of fast changes in the digital era also rases various concerns, the dark side of technological innovation. One of the key issues is the emergence of Fintech firms that lead financial market to be more fiercely competitive. The main reason is that the ability of these newcomers in providing an enormous number of innovative facilities such as business models, technology applications, operating processes at a lower cost (Lee et al., 2021). The problem becomes more complicated when traditional banks face the rise of the tighter constraints arisen from regulations as in the aftermath of the global financial crisis. Such regulatory burdens might allow these nonbank finance companies to enter the shadow banking market. Consequently, the market share of banks may likely decrease. To deal with this circumstance, banks have few choices in which they have to either continuously expand into technology investments regardless of that may erode the marginal profitability or build partnerships with these firms and eventually accepting to narrow market share (Uddin, Ali, & Hassan, 2020). Based on a global sample from 43 countries, the authors' empirical evidence also shows that spending one dollar on technology will lead banks to be instability after achieving a definite threshold point. This result seems to be consistent with the previous finding of Beccalli (2007), who considers that increasing technological spendings have an adverse effect on European banks' profitability. In the same spirit, Kauffman, Liu and Ma (2015) indicate that to enhance efficient operation, banks usually spend their resources on digital infrastructure regardless of these spendings do not regularly bring profits. Furthermore, the operational risk might rise because the interdependence between banks (and between banks and fintech companies) on the development of technology (Uddin, Mollah, & Ali, 2020). These arguments suggest that banks may face the increasing risk when expanding into technology investments. We call this investing channel *the innovation-fragility hypothesis*.

Taken together, we point out hypotheses as follows:

H1: Investing into technology of banks has played a role of the innovation-growth channel.

H2: Expanding into technology investments has been the innovation-fragility channel.

Through exploring the hypothesizes mentioned above, our study will shed more light on the straightforward question of how technology investments influence banking performance by employing the empirical environment in an emerging country. Hence, our findings are seen as complementary to previous studies such as Beccalli (2007); Uddin, Mollah and Ali (2020), who take developing countries or international settings as the sample. Also, our empirical evidence contributes to the current debate on the effects of technological development on banking operation, which is still controversial.

3. Data and Variables

To tackle our main concerns, we collect the data of 12 commercial banks listed in Vietnam from the audited financial statements and Datastream from 2011 to 2019. As we described in the first section, Vietnam provides one of the appropriate environments to discover our investigation and the given period witnesses many changes in domestic banking system from the regulations, opening to foreign investors, to calling constantly for technological investment from politicians in this country. At the same time, even though our sample just includes 12 banks but their total asset accounted for near 60% that of Vietnamese banking system in 2019. Therefore, to some extent, these banks offer the presentative sample for our examination. As mentioned above, according to Uddin, Ali and Hassan (2020), we use the (natural logarithm) total bank's technology investments (TECHINVEST) as our primary explanatory variable, which are the total annual expenditures of software, hardware, data processing, outsourced technical support collected the notes to the financial statements. We also use the net interest margin (NIM), the ratio of non-interest incomes over net operating incomes (NIIR) and the natural logarithm of total non-interest incomes (NII) respectively to compute the marginal return of banks. To examine the stability of banks, we calculate Z-score that a higher value of this proxy reflects a lower likelihood of insolvency. We also control for fundamental characteristics of bank including banks size (SIZE), capital ratio (CAPITAL), costs to incomes (EXPENSE), loan loss reserve ratio (LLR), which are used extensively in the finance literature. Our dataset obtains roughly 108 observations for 12 banks. All variables are winsorized at 1% level on the top and bottom of their distribution to reduce the effects of outliers. The table 1 depicts the definition of variables, and the table 2 describes the descriptive statistic as well as the correlation matrix.

Table 1: Variables Definitions

This table presents definitions of all main variables used in the analysis.

Variables	Definitions	Source
NIM (%)	The net interest margin	Datastream
NII	The natural logarithm of total non-interest incomes	Datastream
NIIR (%)	Non-interest incomes over the net operating incomes	Datastream
ZSCORE	The sum of average ROA and the equity-to-total assets ratio, divided by the standard deviation of ROA. A two-year moving windows is used to estimate the average and the standard deviation of ROA	The authors estimate from the audited financial statements
TECHINVEST	The natural logarithm of total technology expenditures consisting of the total annual expenditures of software, hardware, data processing, outsourced technical support	The authors estimate from the notes to the financial statements
TECHRATE (%)	Total technological overheads as the percentage of non-interest operating expenses	The authors estimate from the notes to the financial statements
SIZE	The natural logarithm of gross total assets	Datastream
CAPITAL (%)	Book value of equity over gross total assets	Datastream
EXPENSE (%)	The ratio of total operating expenses to total operating income before provisions and taxes	Datastream
LLR (%)	The loan loss reserve ratio	Datastream
STATE	A dummy variable equal one if the commercial bank is owned by the state and equal 0 otherwise	Datastream
GRGDP (%)	The annual GDP growth of Vietnam	World Bank World Development Indicators
INFLR (%)	The annual inflation rate in Vietnam	World Bank World Development Indicators

Table 2: Summary Statistics

This table depicts summary statistics for the main sample of V.N. commercial banks used in the analysis. All variables are winsorized at 1% and 99% levels.

Panel A: Variables descriptive statistics

	(1)	(2)	(3)	(4)	(5)
VARIABLES	**N**	**mean**	**sd**	**min**	**max**
NIM	108	0.0301	0.00922	0.0156	0.0507
NII	104	26.98	1.719	21.99	29.09
NIIR	108	0.200	0.176	-0.00431	1.137
TECHINVEST	107	24.16	1.466	20.10	26.56
TECHRATE	108	0.0147	0.0157	0.000436	0.0866
ZSCORE	108	3.696	6.299	0.146	35.66
GRGDP	108	0.0630	0.00628	0.0525	0.0708
IFLR	108	0.0589	0.0506	0.00879	0.187
CAPITAL	108	0.0821	0.0296	0.0415	0.185
SIZE	108	32.96	1.074	30.55	34.81
LLR	108	-0.0242	0.0649	-0.274	0.0220
EXPENSE	108	0.565	0.252	0.306	1.572

Panel B: Correlation matrix (pairwise)

Pairwise correlations

Variables	(NIM)	(TECHINVEST)	(SIZE)	(CAPITAL)	(EXPENSE)	(LLR)
NIM	1.000					
TECHINVEST	0.263*	1.000				
	(0.006)					
SIZE	0.067	0.657*	1.000			
	(0.492)	(0.000)				
CAPITAL	0.271*	-0.282*	-0.590*	1.000		
	(0.005)	(0.003)	(0.000)			
EXPENSE	-0.350*	-0.325*	-0.413*	0.151	1.000	
	(0.000)	(0.001)	(0.000)	(0.118)		
LLR	0.394*	0.308*	0.292*	0.013	-0.360*	1.000
	(0.000)	(0.001)	(0.002)	(0.893)	(0.000)	

**** p<0.01, ** p<0.05, * p<0.1*

Variables	(NIIR)	(TECHINVEST)	(SIZE)	(CAPITAL)	(EXPENSE)	(LLR)
NIIR	1.000					
TECHINVEST	0.311*	1.000				
	(0.001)					
SIZE	0.212*	0.657*	1.000			
	(0.028)	(0.000)				
CAPITAL	-0.193*	-0.282*	-0.590*	1.000		
	(0.045)	(0.003)	(0.000)			
EXPENSE	0.037	-0.325*	-0.413*	0.151	1.000	
	(0.700)	(0.001)	(0.000)	(0.118)		
LLR	-0.045	0.308*	0.292*	0.013	-0.360*	1.000
	(0.641)	(0.001)	(0.002)	(0.893)	(0.000)	

**** p<0.01, ** p<0.05, * p<0.1*

Variables	(NII)	(TECHINVEST)	(SIZE)	(CAPITAL)	(EXPENSE)	(LLR)
NII	1.000					
TECHINVEST	0.727*	1.000				
	(0.000)					
SIZE	0.876*	0.657*	1.000			
	(0.000)	(0.000)				
CAPITAL	-0.319*	-0.282*	-0.590*	1.000		
	(0.001)	(0.003)	(0.000)			
EXPENSE	-0.480*	-0.325*	-0.413*	0.151	1.000	
	(0.000)	(0.001)	(0.000)	(0.118)		
LLR	0.394*	0.308*	0.292*	0.013	-0.360*	1.000
	(0.000)	(0.001)	(0.002)	(0.893)	(0.000)	

*** p<0.01, ** p<0.05, * p<0.1

4. How Does the Technology Investments Effect on Banking Performance?

4.1. Main Findings

We perform multivariate analyses to investigate how technology investments affect bank marginal gains after controlling other control variables. Our main baseline model is as follows:

$$Y_{it} = \alpha + TECHINVEST_{it} + Z_{it} + \theta_t + \varepsilon_{it} \quad (1)$$

Where, Y_{it} is the measure of marginal returns of bank i at time t including NIM, NIIR and NII respectively. Additionally, we use the natural logarithm of TECHINVEST as the key explanatory proxy in our investigation. We also use alternative of this proxy in our robustness tests. Z_{it} is the vector of control variables as described above. We include time-fixed effects, θ_t, to control for the macroeconomic conditions, common across banks. ε_{it} is the error term.

Table 3 delineates our main results, which are performed by using ordinary least squares (OLS) regressions from Model (1) to Model (4) and fixed-effects estimator in Model (5). First, we start with a reduced model (Model (1)) where we conduct only our variable of interests (TECHINVEST). We present our baseline model in Model (2) where we include our control variables. In both models, the coefficients on our primary explanatory variable, TECHINVEST, are positive and statistically significant at the 1% and 10% level in Model (1) and Model (2) respectively. For example, in our baseline model (Model (2)), one standard deviation increase of TECHINVEST, holding all other equal, results to an increase of NIM of 0.22 bps (i.e. the coefficient of TECHINVEST, 0.00148, times the standard deviation of TECHINVEST, 1.466). Although the results suggest an economically modest, the positive relationship between TECHINVEST and NIM considers that NIM would be higher in banks that engage more in technology spendings.

In Model (3), we add the dummy variable, STATE, that equals one if the commercial bank is owned by the state and equals 0 otherwise, to examine the possible impact of State-owned commercial banks on our finding. The result is almost unchanged in comparison with Model (2). Although STATE negatively affects NIM, but its coefficient is statistically insignificant. In addition, macroeconomic conditions may play a certain role in fostering more innovation in different countries. Therefore, we also continue to add some macroeconomic variables such as GDP and IFLR to Model (2) to estimate the effects of macroeconomic factors in Model (4). Accordingly, this estimation produces similar result to the previous finding. Next, in Model (5), we include time fixed-effects to take into account the possible effects of time on the result, and we still reach similar finding.

In the next stage, we re-estimate our finding by using NIIR and NII as independent variables in Model (6)-(10) and in Model (11)-(15) respectively. We find that while these investments effect on NIM is insignificant, the magnitude of that on NIIR and NII is relatively more significant. Moreover, the coefficients on our key variable, TECHINVEST, in all these models are positive and statistically significant at the 1% level. This means that the expansion into technology spendings has profoundly enhanced the non-interest incomes of banks.

Table 3: Baseline Multivariate Analysis

This table below depicts regression estimates of the main relation between the marginal gains and technical investment in which the dependent variables include NIM, NIIR and NII correspondingly. All variables are winsorized at the 1% and 99% levels. The asterisks ***, **, * denote significance at the 1%, 5%, and 10% level respectively. The sample period spans from 2011 to 2019.

	(1)	(2)	(3)	(4)	(5)
Y=NIM	**Reduced model**	**Baseline model**	**Additional Dummy variable**	**Additional Macro variables**	**Adding the time fixed-effects**
TECHINVEST	**0.00166*** **	**0.00148***	**0.00133***	**0.00132***	**0.00135***
	(0.000584)	(0.000747)	(0.000751)	(0.000738)	(0.000745)
SIZE		-0.000613	0.000695	0.000530	0.000336
		(0.00109)	(0.00154)	(0.00101)	(0.000956)
CAPITAL		0.102***	0.109***	0.111***	0.108***
		(0.0281)	(0.0276)	(0.0268)	(0.0270)
EXPENSE		-0.0115***	-0.0113***	-0.00984**	-0.0115**
		(0.00366)	(0.00364)	(0.00413)	(0.00514)
LLR		0.0342***	0.0335***	0.0202*	0.0247*
		(0.0106)	(0.0108)	(0.0116)	(0.0126)
GRGDP				0.0459	
				(0.155)	
IFLR				0.0510***	
				(0.0153)	
STATE			-0.00361		
			(0.00247)		
Constant	-0.0101	0.0133	-0.0259	-0.0283	-0.00842
	(0.0142)	(0.0309)	(0.0437)	(0.0340)	(0.0282)
Observations	107	107	107	107	107
R-squared	0.069	0.350	0.364	0.406	0.431

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

	(6)	(7)	(8)	(9)	(10)
Y=NIIR	**Reduced model**	**Baseline model**	**Additional Dummy variable**	**Additional Macro variables**	**Adding the time fixed-effects**
TECHINVEST	**0.0372*** **	**0.0466*** **	**0.0367*** **	**0.0485*** **	**0.0501*** **
	(0.00825)	(0.0127)	(0.0119)	(0.0127)	(0.0137)
SIZE		-0.00396	0.0815**	-0.00461	0.00324
		(0.0205)	(0.0343)	(0.0249)	(0.0307)
CAPITAL		-0.648	-0.217	-0.525	-0.258
		(0.592)	(0.561)	(0.575)	(0.691)
EXPENSE		0.138*	0.148**	0.187**	0.283
		(0.0706)	(0.0680)	(0.0918)	(0.185)
LLR		-0.298	-0.344	-0.257	-0.190
		(0.584)	(0.513)	(0.665)	(0.644)
GRGDP				4.395	
				(3.095)	
IFLR				0.200	
				(0.304)	
STATE			-0.236***		
			(0.0559)		
Constant	-0.697***	-0.823	-3.385***	-1.173	-1.227
	(0.190)	(0.777)	(1.176)	(0.976)	(1.177)
Observations	107	107	107	107	107
R-squared	0.097	0.160	0.329	0.176	0.205

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

	(11)	(12)	(13)	(14)	(15)
Y=NII	**Reduced model**	**Baseline model**	**Additional Dummy variable**	**Additional Macro variables**	**Adding the time fixed-effects**
TECHINVEST	**0.876*** **	**0.260*** **	**0.209*** **	**0.257*** **	**0.264*** **
	(0.0849)	(0.0563)	(0.0532)	(0.0556)	(0.0563)
SIZE		1.255***	1.646***	1.288***	1.201***
		(0.0848)	(0.111)	(0.0923)	(0.0999)
CAPITAL		9.168***	10.23***	9.479***	8.376***
		(2.758)	(2.841)	(2.721)	(2.814)
EXPENSE		-0.818***	-0.733***	-0.688**	-1.446***
		(0.307)	(0.253)	(0.341)	(0.491)
LLR		4.072*	4.139**	3.757	3.369
		(2.242)	(1.861)	(2.426)	(2.611)
GRGDP				8.319	
				(11.46)	
IFLR				1.717	
				(1.248)	
STATE			-1.035***		
			(0.184)		
Constant	5.782***	-20.97***	-32.51***	-22.71***	-18.78***
	(2.108)	(2.782)	(3.499)	(3.280)	(3.545)
Observations	104	104	104	104	104
R-squared	0.528	0.866	0.900	0.868	0.880

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

4.2. Alternative Measure and Robustness Tests

In Table 4, we continue to re-conduct our findings depicted in Table 3 with the different estimation methods. According to Beccalli (2007), banks have to need some certain times to grasp the basic principles of new technology and adopt these rapid changes in their business operations. Thus, following the author, our independent variable, TECHINVEST, is lagged of one period in Panel A. Accordingly, we use NIM as the dependent variable from Model (1) to Model (4) besides NIIR and NII are the stand-alone variables in Model (5)-(8) and in Model (9)-(12) correspondingly. The results show that TECHINVEST has positive effects on NIM however its coefficients are statistically insignificant. Meanwhile, we find the consistent result with our previous finding when using NII and NIIR as the dependent variable in the remainder models.

In Panel B, we re-estimate our baseline model with alternative measure for TECHINVEST. Following Uddin, Ali and Hassan (2020), we use the ratio of total technological expenditures over total non-interest operating expenses (TECHRATE), which is considered as relative measure of TECHINVEST. The result in Model (1) illustrates that TECHRATE has positive effect on NIM but its coefficients are statistically insignificant. Meanwhile, TECHRATE effects profoundly on NIIR and NII with the significant level of 10% in Model (2)-(3).

In brief, our evidence continues to show that investing into technology will improve banking performance, especially non-interest incomes.

Table 4: Alternative measure and robustness tests
These tables below depict regression estimates of the main relation between the marginal gains and technical investment in which the panel A presents the primary explanation variable lagged of one year, besides we also re-estimate our baseline model by using TECHRATE as alternative measure of TECHINVEST in the panel B. All variables are winsorized at the 1% and 99% levels. The asterisks ***, **, * denote significance at the 1%, 5%, and 10% level respectively. The sample period spans from 2011 to 2019.

Panel A: The independent variable, TECHINVEST, is lagged of one period.

	(1)	(2)	(3)	(4)
Y=NIM	**Baseline model**	**Additional Dummy variable**	**Additional Macro variables**	**Adding the time fixed-effects**
L.TECHINVEST	0.00137	0.00110	0.00128	0.00127
	(0.000848)	(0.000821)	(0.000866)	(0.000892)
SIZE	0.000481	0.00280*	0.000533	0.000279
	(0.00103)	(0.00146)	(0.00101)	(0.00105)
CAPITAL	0.135***	0.144***	0.132***	0.128***
	(0.0269)	(0.0258)	(0.0280)	(0.0285)

EXPENSE	-0.00863**	-0.00748*	-0.00939**	-0.0127**
	(0.00384)	(0.00393)	(0.00420)	(0.00528)
LLR	0.0242**	0.0228*	0.0272**	0.0229*
	(0.0118)	(0.0127)	(0.0128)	(0.0132)
GRGDP			-0.224	
			(0.194)	
IFLR			-0.0528	
			(0.0564)	
STATE		-0.00601**		
		(0.00236)		
Constant	-0.0253	-0.0954**	-0.00761	-0.0132
	(0.0287)	(0.0415)	(0.0326)	(0.0289)
Observations	95	95	95	95
R-squared	0.333	0.374	0.341	0.351

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

	(5)	(6)	(7)	(8)
Y=NIIR	**Baseline model**	**Additional Dummy variable**	**Additional Macro variables**	**Adding the time fixed-effects**
L.TECHINVEST	**0.0456*** **	**0.0332** **	**0.0499*** **	**0.0516** **
	(0.0171)	(0.0139)	(0.0182)	(0.0196)
SIZE	-0.00231	0.105***	-0.00601	0.00264
	(0.0208)	(0.0384)	(0.0220)	(0.0293)
CAPITAL	-0.703	-0.292	-0.584	-0.311
	(0.678)	(0.618)	(0.637)	(0.744)
EXPENSE	0.0680	0.121*	0.106	0.215
	(0.0677)	(0.0676)	(0.0848)	(0.187)
LLR	-0.495	-0.562	-0.562	-0.452
	(0.665)	(0.569)	(0.734)	(0.685)
GRGDP			8.679	
			(5.270)	
IFLR			1.729	
			(1.256)	
STATE		-0.279***		
		(0.0652)		
Constant	-0.812	-4.064***	-1.447	-1.239
	(0.902)	(1.422)	(1.071)	(1.236)
Observations	95	95	95	95
R-squared	0.140	0.343	0.166	0.193

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

	(9)	(10)	(11)	(12)
Y=NII	**Baseline model**	**Additional Dummy variable**	**Additional Macro variables**	**Adding the time fixed-effects**
L.TECHINVEST	**0.205*** **	**0.171*** **	**0.213*** **	**0.202** **
	(0.0671)	(0.0539)	(0.0721)	(0.0777)
SIZE	1.359***	1.867***	1.350***	1.271***
	(0.100)	(0.133)	(0.100)	(0.111)
CAPITAL	9.295***	9.657***	9.378***	8.457**
	(3.485)	(2.972)	(3.520)	(3.561)
EXPENSE	-0.831**	-0.555**	-0.760*	-1.580***
	(0.354)	(0.263)	(0.407)	(0.569)
LLR	3.418	3.207*	3.505	2.819
	(2.164)	(1.688)	(2.371)	(2.548)
GRGDP			8.910	
			(18.08)	

IFLR			0.752	
			(5.534)	
STATE		-1.334***		
		(0.202)		
Constant	-23.12***	-38.96***	-23.64***	-19.99***
	(3.269)	(4.235)	(3.668)	(3.849)
Observations	92	92	92	92
R-squared	0.853	0.903	0.853	0.864

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Panel B: Alternative measure of technical investment

	Y=NIM	Y=NIIR	Y=NII
	(1)	(2)	(3)
	Baseline model	Baseline model	Baseline model
TECHRATE	0.00690	**1.904***	**8.183***
	(0.0515)	(0.992)	(4.616)
SIZE	0.000795	0.0438*	1.515***
	(0.000869)	(0.0244)	(0.0886)
CAPITAL	0.113***	-0.399	10.41***
	(0.0293)	(0.551)	(2.796)
EXPENSE	-0.00991**	0.0982	-0.836**
	(0.00390)	(0.0651)	(0.337)
LLR	0.0374***	-0.270	4.193*
	(0.0108)	(0.597)	(2.235)
Constant	0.00102	-1.300	-23.47***
	(0.0313)	(0.855)	(3.141)
Observations	108	108	104
R-squared	0.304	0.100	0.846

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

4.3. GMM Regressions

To ensure our finding, we use the dynamic system GMM by adding the lag dependent variable to the baseline model. This, in turn, helps us to address potentially corrects endogeneity, heteroscedasticity, and autocorrelation issues as well as correlations between all independent variables (Arellano & Bond, 1991; Blundell & Bond, 1998). Indeed, as Arellano and Honoré (2001) noted, OLS method might inadequately tackle biased estimates. The results are described in Table 5.

In Model (1), we re-estimate our baseline model by GMM method with NIM as the stand-alone variable. The result shows that TECHINVEST has the positive effect on NIM at a significance of 1% but the degree is negligible. In the same manner, we use respectively NIIR and NII as the independent variables in Model (2) and Model (3). Our results indicate that TECHINVEST has a relatively considerable positive effect on NIIR and NII. In short, the evidence proves our previous finding that TECHINVEST is associated with the attainment of bank gains.

Table 5: Approaching GMM regression

The table below depicts regression estimates of the main relation between the marginal gains and technical investment in which we use a dynamic panel of system GMM that includes correspondingly the independent variables (NIM, NIIR, NII) as a lag variable in these GMM models. All variables are winsorized at the 1% and 99% levels. The asterisks ***, **, * denote significance at the 1%, 5%, and 10% level respectively. The sample period spans from 2011 to 2019.

	Y=NIM	Y=NIIR	Y=NII
	(1)	(2)	(3)
	Baseline model	Baseline model	Baseline model
L.NIM	0.287**		
	(0.129)		
L.NIIR		0.126	
		(0.101)	
L.NII			-0.104
			(0.139)

TECHINVEST	**0.000875*** **	**0.0285*** **	**0.154***
	(0.000214)	(0.00962)	(0.0887)
SIZE	0.000639	-0.0314	1.697***
	(0.000678)	(0.0208)	(0.278)
CAPITAL	0.0940***	-1.343*	28.38
	(0.0203)	(0.785)	(19.11)
EXPENSE	-0.00794***	0.0535*	-0.369*
	(0.00173)	(0.0325)	(0.201)
LLR	0.00436	-0.0846	0.209
	(0.00767)	(0.240)	(2.505)
Constant	-0.0250	0.580	-31.97***
	(0.0208)	(0.696)	(8.372)
AB test AR(2)	0.179	0.156	0.262
Wald chi2	19563.1	257.48	301141.08
Prob > chi2	0.0000	0.0000	0.0000
Observations	95	95	89
Number of BANK	12	12	12

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

4.5. The Effects of Bank Size

In this section, we continue to re-conduct the baseline model according to different bank sizes. We divide our sample into two groups (large and small banks) based on the median value of total assets. Accordingly, large and small banks are the banks that have total assets above and below median value respectively. The results are depicted in Table 6. From Model (1) to Model (6), we use TECHINVEST as the key explanatory variables while from Model (7) to Model (12), TECHRATE is performed as alternative measure. Generally, TECHINVEST has positive effects on NIM, NIIR and NII in all models, however this impact is solely statistically significant at the 5% level in Model (5) where we use NIIR and small banks. Meanwhile, Model (7)-(12) also show the similar results except for Model (8) where TECHRATE affects remarkably on NIIR in small banks. In general, our evidence supports the view that small banks have more incentives to become innovators compared to large banks.

Table 6: The effects of bank size
The table reports regression estimates of the main relation between the marginal gains and technical investment. Accordingly, we divide our sample into two groups (large and small banks) based on the median value of total assets. All variables are winsorized at the 1% and 99% levels. The asterisks ***, **, * denote significance at the 1%, 5%, and 10% level respectively. The sample period spans from 2011 to 2019.

	Large banks			**Small banks**		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
	Y=NIM	**Y=NIIR**	**Y=NII**	**Y=NIM**	**Y=NIIR**	**Y=NII**
TECHINVEST	0.00160	0.0221	0.186	0.000883	**0.0255** **	0.175
	(0.00115)	(0.0268)	(0.121)	(0.000964)	(0.00885)	(0.0968)
SIZE	-0.00295	-0.0615	0.690***	0.00269	0.0488	1.833***
	(0.00237)	(0.0496)	(0.152)	(0.00484)	(0.0279)	(0.203)
CAPITAL	0.151**	0.579	6.452*	0.0543	-0.0229	13.95***
	(0.0646)	(1.064)	(2.886)	(0.0946)	(0.804)	(2.575)
EXPENSE	-0.0209	1.259	-0.808	-0.00451	-0.0335	-1.521**
	(0.0121)	(0.678)	(2.014)	(0.00982)	(0.119)	(0.519)
LLR	0.0241	-1.588	-2.918	0.0362*	0.0906	4.556*
	(0.0249)	(1.170)	(3.324)	(0.0186)	(0.321)	(2.100)
Constant	0.0979	1.162	0.156	-0.0707	-1.976*	-37.38***
	(0.0820)	(1.945)	(6.518)	(0.163)	(0.982)	(5.917)
Observations	55	55	55	52	52	49
R-squared	0.606	0.715	0.667	0.526	0.527	0.923

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

	Large banks			Small banks		
	(7)	(8)	(9)	(10)	(11)	(12)
	Y=NIM	Y=NIIR	Y=NII	Y=NIM	Y=NIIR	Y=NII
TECHRATE	0.111	-0.958	3.506	0.00296	**1.276***	4.997
	(0.0803)	(1.980)	(9.993)	(0.0343)	(0.578)	(3.379)
SIZE	-0.00179	-0.0369	0.858***	0.00318	0.0760**	2.006***
	(0.00241)	(0.0601)	(0.240)	(0.00489)	(0.0320)	(0.202)
CAPITAL	0.162**	1.053	8.917*	0.0483	-0.0306	12.84**
	(0.0667)	(1.126)	(3.978)	(0.0936)	(0.866)	(3.884)
EXPENSE	-0.0199*	1.344	-0.421	-0.00333	-0.0612	-1.620**
	(0.00952)	(0.735)	(2.336)	(0.00992)	(0.119)	(0.535)
LLR	0.0217	-1.474	-2.639	0.0370	0.128	4.823**
	(0.0209)	(1.293)	(3.903)	(0.0205)	(0.320)	(1.949)
Constant	0.0960	0.824	-1.247	-0.0654	-2.258*	-38.72***
	(0.0833)	(2.169)	(8.444)	(0.164)	(1.126)	(6.958)
Observations	55	55	55	53	53	49
R-squared	0.595	0.708	0.616	0.491	0.523	0.915

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

5. Does the Technology Investments Impact on Bank Stability?

To deal with the concerns that increasingly investing into technology may lead banks to face at the risk of instability, we use Z-score as the proxy of bank stability. The results are described in Table 7.

From Model (1) to Model (3), we use TECHINVEST as the primary explanatory variable. We respectively re-conduct our baseline model, adding macroeconomic variables and time fixed-effects. These models illustrate that although TECHINVEST has positive impacts on Z-score, all coefficients are statistically insignificant. Similarly, we re-estimate by using TECHRATE as the alternative measure. The results in Model (4)-(5) are similar to that in Model (1)-(3). Thus, we do not find the empirical evidence supporting the view that spending on technology may lead banks to face higher risks of instability.

Table 7: Banking stability and technical investment

The table reports regression results of the relation between the banking stability and technical investment. All variables are winsorized at the 1% and 99% levels. The asterisks ***, **, * denote significance at the 1%, 5%, and 10% level respectively. The sample period spans from 2011 to 2019.

	TECHINVEST			TECHRATE	
	(1)	(2)	(3)	(4)	(5)
Y=ZSCORE	Baseline model	Additional Macro variables	Adding the time fixed-effects	Baseline model	Adding the time fixed-effects
TECHINVEST	0.0796	0.208	0.130		
	(0.426)	(0.441)	(0.446)		
TECHRATE				-9.438	-6.767
				(21.72)	(22.84)
SIZE	0.499	0.103	0.134	0.555	0.250
	(1.098)	(1.090)	(1.127)	(1.109)	(1.097)
CAPITAL	40.21	42.54	40.64	40.89	41.45
	(50.55)	(50.70)	(48.79)	(51.12)	(49.09)
EXPENSE	-4.996***	-3.499**	-4.372	-4.829***	-4.269
	(1.534)	(1.669)	(3.179)	(1.523)	(3.173)
LLR	-37.34**	-31.12	-30.13	-36.77**	-29.96
	(18.42)	(18.91)	(19.67)	(18.35)	(19.65)
GRGDP		165.3*			
		(95.74)			
IFLR		-8.278			
		(9.197)			
Constant	-16.08	-16.92	-5.872	-15.97	-6.492
	(39.25)	(42.36)	(39.48)	(40.12)	(39.79)
Observations	107	107	107	108	108
R-squared	0.136	0.167	0.246	0.136	0.246

Robust standard errors in parentheses
*** p<0.01, **p<0.05, * p<0.1

6. Conclusions

This paper is carried out to discover the impact of technological development and digitalization on banking operation by examining the relationship between increasingly investment into distribution information and communication technologies of banks and baking performance based on the landscape of an emerging country. We find that spending on technology will improve significantly banking performance, especially non-interest incomes. Our main finding remains almost unchanged when performing a battery of robustness tests. Additionally, our empirical evidence does not support fears in expanding investments into technology may lead banks to be more instability and thus, we advocate investment strategy into technology of banks. Overall, our main results suggest that expanding investments into technology yields a significantly positive effect on efficient business of banks, particularly non-interest revenue, and thus support the bright side of technological development and digital transformation, at least in Vietnamese context. At the same time, our study can be viewed as complementary to the innovation-growth hypothesis as well as to the recent findings of Uddin, Mollah, and Ali (2020), who discover that the technology spendings have positive linear effects on banking stability but depending on the level of technological advancement in each country and alarm that banks will increase risk when enlarging technological investment. Again, we believe that our study is useful for academics, regulators and policymakers, especially in Vietnam and in countries that have similar financial structure.

Regardless of having certain efforts, the study still remains certain drawbacks that future research might fill these vital gaps. One of them, for instance, finding an optimal threshold of investing into distribution information and communication technologies of banks, even though this work may be really too challenge, is one of the most important dimensions. We hope our study will pay the way for investigations in coming time to perform this issue.

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