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IMPACT OF DIGITAL TECHNOLOGY INVESTMENT ON BANK PERFORMANCE IN VIETNAM

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ABSTRACT

This study examines the impact of digital technology investment on the performance of Vietnamese commercial banks, drawing on the productivity paradox theory proposed by Solow (1987), which suggests that technological progress may not immediately generate productivity gains. Panel data from 22 listed banks covering 2018-2023 were collected from disclosed statements. The Generalized Least Squares method was employed to estimate both contemporaneous and lagged effects of digital technology investment, with analysis spanning the pre-pandemic and COVID-19 periods. Results reveal that digital technology investment has a negative effect on bank performance in both periods, reflecting a paradoxical outcome where rising digital expenditures coincide with declining profitability. Evidence also suggests lagged effects, indicating that the benefits of digital adoption may materialize only in the longer term. The study enriches the literature by extending the productivity paradox debate to Vietnam, an emerging market undergoing rapid and policy-driven digitalization, while challenging the assumption that digital transformation consistently improves performance. Banks should enhance workforce digital skills, and policymakers should promote broader digital literacy to enable the sector to fully harness the transformative potential of technology for sustainable growth.

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1. Introduction

The relationship between technology investment and firm performance has long been debated in academic literature. While the dominant perspective posits that technological advancements enhance efficiency and competitiveness, empirical evidence often paints a more complex picture. Solow (1987) observed the "productivity paradox" a phenomenon revealing a disconnect between substantial information technology expenditures and measurable productivity gains, particularly evident in the banking sector, where increased technology spending has not always translated into improved performance (Harris, 2001; Shu & Strassmann, 2005). Subsequent research has reinforced this paradoxical view. Beccalli (2007), in an analysis of 737 European banks, reported a "profitability paradox," whereby outsourcing technology functions improved profitability and efficiency, yet in-house investments yielded negative effects. Similarly, Gupta et al. (2018) found evidence of the paradox in Indian banks, while Campanella et al. (2017) demonstrated that technological innovations in planning and credit risk systems enhanced competencies but did not necessarily boost profitability. These studies suggest that the impact of technology investment on banking performance is heterogeneous, context-dependent, and far from universally positive.

More recent studies have shifted toward digital technology investment, yet findings continue to diverge across settings. Annor et al. (2024) in Ghana and Theiri and Hadoussa (2024) in Tunisia provide evidence that digital technology investment enhances bank profitability and stability, though the mechanisms differ. Ghana highlighted the moderating role of digital technology diffusion and financial development, whereas Tunisia underscored the importance of targeted investments in payment systems, digital channels, and cybersecurity. Al-Amarneh et al. (2023), focusing on Jordan, show that digital technology spending improves both profitability and cost efficiency, particularly in smaller and less leveraged banks. In contrast, Tran et al. (2023), analyzing 11 developing economies including Vietnam, reveal that digital transactions strengthen deposit and lending revenues but also expose vulnerabilities related to cybersecurity and regulatory frameworks. Collectively, these studies indicate a generally positive association between digital technology investment and bank performance, yet the magnitude and nature of the impact vary according to country conditions, banking structures, and whether the emphasis lies on firm-level investment or system-wide adoption.

For Vietnam, a rapidly developing economy, the banking sector plays a pivotal role in sustaining growth and financial inclusion. In recent years, Vietnamese commercial banks have accelerated digital transformation in response to the Fourth Industrial Revolution. According to FiinResearch (2020, 2021), 93% of banks have launched digital initiatives, ranging from electronic Know-Your-Customer solutions to the deployment of artificial intelligence and machine learning in service delivery and risk management. Despite these advancements, the tangible performance outcomes of digital technology investments remain largely unverified. Furthermore, the COVID-19 pandemic further intensified this uncertainty. While it catalyzed the rapid adoption of digital banking services, questions persist regarding whether these investments translate into measurable efficiency gains or simply echo the productivity paradox observed in other contexts.

Against this backdrop, a critical research gap emerges. Although the literature on developed and some emerging economies has provided valuable insights into the mixed outcomes

of digital technology investment, empirical evidence from Vietnam remains scarce. Specifically, little is known about whether digital technology investment in Vietnamese commercial banks delivers concrete improvements in profitability and efficiency, or whether it reflects the paradoxical patterns seen elsewhere. Addressing this gap is essential not only for advancing academic discourse on digital technology investment and financial performance but also for guiding managerial and policy implications in Vietnam, a rapidly evolving banking sector.

2. Theoretical framework

2.1. Productivity Paradox Theory

The productivity paradox, first introduced by Robert Solow in 1987, posits a discrepancy between substantial information technology investments and observed productivity growth. This paradox has been extensively studied across various sectors, including banking, which is characterized by significant information technology expenditure.

Despite heavy technology investment aimed at efficiency and effectiveness gains, banks often encounter counterintuitive results. This phenomenon, known as the productivity paradox, suggests a potential negative correlation between increased information technology investment and short-term productivity. Studies by Beccalli (2007) and Del Gaudio et al. (2021) and others corroborate this negative relationship in specific cases. Several factors contribute to this paradox. Firstly, poor management and employee resistance to change, as highlighted by Dos Santos and Sussman (2000), can hinder the realization of technology investment benefits. Secondly, Harris (2001) emphasizes the importance of realistic goals and technology investment expertise in avoiding project failures. Thirdly, the time lag between technology investment and tangible returns, coupled with mismanagement, can delay or negate productivity gains (Gupta et al., 2018). Despite these challenges, intense competitive pressures drive banks to maintain their digital technology investment. Elsaid (2021), Glushchenko et al. (2019), and others underscore the imperative of continued technology investment to avoid falling behind in the digital landscape.

2.2. Effect Mechanism

Digital Technology Investment and Bank Performance

Technology investment has become a critical driver of competitiveness in banking, though its impact on performance remains debated. Historically, banks have been significant investors in technology, ranging from core systems to advanced analytics, seeking to enhance efficiency, improve customer experience, and generate new revenue streams (Devlin, 1995; Ho & Mallick, 2010). Yet, expected productivity gains often fall short (Ekata, 2012; Triplett, 1999). This paradox arises because while automation streamlines routine tasks, complex and regulated services still require human judgment (Hajli et al., 2015; Martin-Oliver & Salas-Fumas, 2011). Competitive pressures also force banks to invest simply to maintain parity, rather than to boost productivity (Demertzis & Claeys, 2021).

Measuring productivity further complicates this issue. Traditional metrics like labor productivity fail to capture the value of information technology, as digital technology investments both reduce staffing needs and enable new services that are difficult to quantify (Brynjolfsson & Hitt, 1998; Fox, 2012). Moreover, technology benefits often emerge only after significant time lags and upfront costs (Stratopoulos & Dehning, 2000; Sun & Guo, 2022).

Despite these challenges, information technology remains essential, underpinning innovations such as mobile banking, online lending, and personalized advisory services (Ghosh, 2021; Gomber et al., 2018). Recent evidence reinforces this view. Citterio et al. (2024) show that digital technology investment and network efficiency improve bank profitability in EU, with COVID-19 amplifying the effect, though diminishing returns and delays persist. At the organizational level, Porfírio et al. (2024) highlight the importance of employee skills, flexibility, and stakeholder trust, while Alqararah et al. (2025) demonstrate that digital capabilities, technological, strategic, and competitive positioning, strengthen performance in Jordanian banks. Similarly, Humeedat (2025) finds that non-financial size indicators, such as branch networks, drive digital technology investment, mediated by operational efficiency.

Overall, the literature indicates that digital technology enhances performance only when supported by strategic alignment, organizational readiness, and human capital development. Overcoming the banking productivity paradox requires careful project selection, process optimization, and clear digital strategies that balance technological investment with structural and cultural adaptability.

COVID-19 and the Productivity Paradox in Banking

The COVID-19 pandemic accelerated digital transformation across industries, including banking (Fu & Mishra, 2022; Haapio et al., 2021). While emphasizing the need for technological advancements, it highlighted the industry's longstanding productivity paradox (Degorce & Monnet, 2021; Demertzis & Claeys, 2021).

The pandemic necessitated a rapid shift to remote work and digital channels. Banks invested heavily in technology for business continuity, enhanced customer experiences, and social distancing compliance (Nguyen-Thi-Huong et al., 2023; Pham et al., 2023). Anticipated productivity gains, however, proved elusive.

The pandemic exacerbated the existing banking productivity paradox. Challenges included integrating new technologies into existing operations, hindered by legacy systems and organizational inertia (Bao & Huang, 2021). The pandemic-induced stress and uncertainty impacted employee morale and productivity, compounded by remote work management difficulties.

A surge in digital transactions overwhelmed existing information technology infrastructure, leading to system failures, slow response times, and increased costs (Dicuonzo et al., 2021; Minh Sang, 2022). While banks expanded capacity, addressing these issues took time, delaying productivity improvements.

The pandemic also presented productivity opportunities. Reduced office overheads, optimized branch networks, and efficient customer onboarding through digital channels contributed to gains (Vargo et al., 2021). However, increased cybersecurity risks, staff training needs, and remote team management challenges offset these benefits. While the pandemic accelerated digital channel adoption, fundamental business models or process transformations were less evident (Kwan et al., 2023).

The COVID-19 pandemic amplified the banking industry's productivity paradox. Realizing technology's full potential requires addressing various challenges. Strategic technology adoption, employee training, process optimization, and a culture of innovation are essential to unlocking digital transformation's true value.

3. Methodology

3.1. Proposed model

To examine the impact of digital technology investment on bank performance, we incorporate a digital technology investment variable into the model of bank performance determinants (Chhaidar et al., 2022; Kriebel & Debener, 2020). The lagged bank performance variables were excluded to avoid potential multicollinearity and dynamic endogeneity, which could bias the coefficient estimates and complicate model interpretation. Moreover, the model focuses on capturing the contemporaneous effects of digital technology investment and control variables on bank performance rather than assessing the persistence of profitability over time.

$$pe_{it} = \alpha + \delta_1 * di_{it} + \gamma * ba_{it} + \theta * ma_t + \varepsilon_{it} \quad (1)$$

Where, pe_{it}, di_{it}, and ba_{it} are performance, digital technology investment, and characteristic variables of bank i at time t, respectively. ma_t is macroeconomic condition at time t. ε_{it} is error term, capturing bank-specific effects that may vary across banks and over time.

Following Bashayreh and Wadi (2021), Kriebel and Debener (2020) and Pham et al. (2021), we consider the possibility of a lagged effect, meaning the impact of digital technology investment might not be immediate. To account for this, the model incorporates the following formulation for the lagged effect of digital technology on bank performance:

$$pe_{it} = \alpha + \delta_1 * di_{i,t-1} + \gamma * ba_{it} + \theta * ma_t + \varepsilon_{it} \quad (2)$$

In our study, a one-year lag was selected for two main reasons. First, the banking sector typically realizes the effects of digital technology investments within a relatively short horizon, as system upgrades, customer-facing platforms, and operational technologies are deployed and reflected in performance indicators within the subsequent fiscal year. Extending the lag to two or three years would not only reduce the number of available observations, thereby limiting the robustness and efficiency of the estimations, but could also obscure the immediate impact of technology adoption by conflating it with broader macroeconomic or regulatory changes over longer periods. Second, given the panel structure of our data, applying longer lags significantly decreases degrees of freedom and exacerbates potential estimation biases. Therefore, the one-year lag provides the most appropriate balance between capturing the delayed effects of investment and preserving sufficient statistical power for meaningful inference.

As previously mentioned, the COVID-19 pandemic may have negatively impacted the relationship between digital technology investment and bank performance. To explore this possibility, we propose the following models:

$$pe_{it} = \alpha + \delta_2 * di_{it} * co_t + \delta_3 * di_{it} * (1 - co_t) + \gamma * ba_{it} + \theta * ma_t + \varepsilon_{it} \quad (3)$$

$$pe_{it} = \alpha + \delta_4 * di_{i,t-1} * co_t + \delta_5 * di_{i,t-1} * (1 - co_t) + \gamma * ba_{it} + \theta * ma_t + \varepsilon_{it} \quad (4)$$

Where, co_t is the COVID-19 pandemic at time t.

Equation (3) decomposes the effect of digital technology investment into two distinct coefficients to capture potential differences between COVID-19 and non-COVID-19 periods. Specifically, when $co_t = 1$ (during the COVID-19 period), the effect of digital investment on bank performance is represented by δ_2, since $di_{it} * co_t = di_{it}$ and $di_{it} * (1 - co_t) = 0$. Conversely, when $co_t = 0$ (during the non-COVID-19 period), the effect is represented by δ_2, as $di_{it} * co_t = 0$ and $di_{it} * (1 - co_t) = di_{it}$. A similar interpretation applies to Equation (4), where the analysis focuses on the lagged effect of digital technology investment.

This modeling strategy is a widely adopted econometric technique for investigating heterogeneous treatment effects or differential impacts of an explanatory variable under distinct regimes. In this context, it allows us to explicitly estimate and compare the effect of digital technology investment on bank performance in the periods of COVID-19 and non-COVID-19.

3.2. Variable measurement

Digital technology investment variable

Drawing on prior studies by Bagna et al. (2021), Ho and Mallick (2010), and Shu and Strassmann (2005) and disclosed statements by Vietnamese commercial banks, we find that digital technology investment in this sector primarily focuses on software acquisition, encompassing both routine system upgrades and potentially disruptive technologies. Given the limited availability of detailed expenditure breakdowns for broader categories of digital transformation, software investment serves as a practical and consistent proxy for overall digital technology investment across banks.

To operationalize this proxy, we extract software investment data from each bank's disclosed financial statements. Before analysis, the raw data were cleaned by removing duplicate records; ensuring consistency in currency units; and cross-checking reported values with multiple disclosure sources (e.g., annual reports, financial statement, and investor presentations) to resolve any discrepancies.

Two measures are then constructed. First, the ratio of software investment to total assets (SOFT1) captures the scale of technology investment relative to the bank's asset base, thereby reflecting its strategic magnitude. Second, the ratio of software investment to total expenses (SOFT2) indicates the proportion of operational spending allocated to software acquisition and upgrades, thereby reflecting its operational intensity. Together, these measures provide a more nuanced basis for examining the relationship between digital technology investment and bank performance.

Bank performance variable

In line with Kriebel and Debener (2020) and Shanmugam and Nigam (2020), this study uses bank profitability as a proxy for bank performance. Profitability will be measured using two commonly employed and well-regarded metrics: return on assets (ROA) and return on equity (ROE).

Control variables

Based on Kriebel and Debener (2020) and Shanmugam and Nigam (2020), this study incorporates control variables that capture both bank-specific characteristics and macroeconomic conditions to ensure robust estimations of bank performance determinants. Seven bank-level controls are included the ratio of non-performing loans to total debt (NPL), the logarithm of total assets (SIZE), the logarithm of years since bank establishment (AGE), the ratio of customer loans to total assets (LOAN), the ratio of customer deposits to total assets (DEPO), the loan-to-deposit ratio (LODE), and the liability-to-asset ratio (LEV). These variables reflect differences in size, funding structure, leverage, and credit risk, which are widely documented to influence profitability (Berger & DeYoung, 1997; Menicucci & Paolucci, 2016; Phan et al., 2020). At the macroeconomic level, only the annual inflation rate (INF), measured by the Consumer Price Index from the World Bank, is included as it directly affects lending margins, funding costs, and asset valuations (Batten & Vo, 2019; Phan et al., 2020). Other macroeconomic factors, such as GDP growth, exchange rate volatility, and interbank rates, are excluded due to data limitations and concerns about multicollinearity.

Table 1. Variable definitions

Variable and denotation			Measurement
Dependent variable			
Bank performane	*pe*	ROA	return on asset
		ROE	return on equity
Explanatory variable			
Digital technology investment	*di*	SOFT1	ratio of software investment to total assets
		SOFT2	ratio of software investment to total expenses
Control variable			
Bank charateristic	*ba*	NPL	ratio of non-performing loan on total debt
		SIZE	logarithm of total asset
		AGE	logarithm of years since bank launch
		LOAN	ratio of loan for customer on total asset
		DEPO	ratio of deposit from customer on total asset
		LODE	ratio of loan on deposit
		LEV	ratio of liability on total asset
Macroeconomic	*ma*	INF	Inflation (Definition and Measurement by World Bank)
COVID-19	*co*	COV	= 1 if the years of 2021, 2022, 2023; = 0 if the year of 2018, 2019, 2020

Considering that the timeframe encompasses the peak of the COVID-19 pandemic, the COVID-19 variable is included in the investigation. This aims to test the hypothesis regarding the moderating role of the COVID-19 pandemic on the relationship between digital technology investment and bank performance.

The COVID-19 pandemic started globally in early 2020, but its major social and economic impacts in Vietnam began with social distancing measures in late 2021 (Dong & Truong, 2024). For this study, we consider the pre-Covid period up to 2020 and code it as "0" in the data. We aimed to capture the most recent data possible, including information from 2023. According to Vietnamese authorities, the COVID-19 pandemic officially ended in Vietnam on October 20, 2023 (according to Ministry of Health of Vietnam), so we classify 2023 as part of the COVID-19 impacted period and code it as "1" in the data.

3.3. Data analysis

There were several ways to employ the regression model for the strongly balanced panel, such as Pooled, Fixed-effects (FE), Random-effects (RE), Generalized least squares (GLS), and Generalized method of moments (GMM) (Hansen, 1982). The pooled method treats the sample as cross-sectional data and thus was not suitable for the characteristics of panel data. The GMM method requires distinguishing between endogenous and exogenous variables in the model (Wooldridge, 2001). However, the proposed model consisted only of endogenous variables, lacking exogenous variables (such as the inflation variable). Since the inflation variable was evaluated as unsuitable for the GMM method, we argue that the GMM method was not appropriate. We preferred the FE, RE, and GLS methods to achieve the objectives.

The data analysis process was conducted as follows. *Firstly*, the descriptive statistics were analyzed to illustrate the characteristics of the variables in this study. *Secondly*, a multicollinearity test was employed to confirm the models for the following steps. If the model exhibited multicollinearity, the proposed model would be modified. *Thirdly*, the FE and RE methods were applied to estimate the effect of the independent variables on the dependent variable. Then, the Hausman test was used to choose the appropriate estimation between the results of FE and RE (Hansen, 1982). After that, heteroskedasticity and autocorrelation issues in the model were checked. If the estimation results from FE or RE showed that the models exhibited heteroskedasticity and/or autocorrelation, the GLS method was used to address these issues (Gujarati & Porter, 2009).

3.4. Data collection

This study analyzes a balanced panel of 22 listed commercial banks in Vietnam during the period 2018–2023, using audited financial statements and annual reports obtained from official disclosures. The banks are identified by their trading codes on the stock exchange: ABB, ACB, BAB, BID, BVB, EIB, HDV, KLB, LPB, MBB, MSB, NSB, NVB, OCB, SGB, SHB, SSB, STB, TCB, TPB, VIB, and VPB. The sample selection is based on data availability and consistency, as only these banks provide complete and comparable financial information for the entire study period. Although there are more than 40 commercial banks currently operating in Vietnam, the selected sample is considered highly representative of the sector due to its significant contribution to total assets, lending, and deposits. The study period beginning in 2018 is chosen to capture key developments, including digital transformation initiatives and the impacts of the COVID-19 pandemic. Inflation data are obtained from the World Bank and used as a proxy for the macroeconomic environment. Overall, the dataset provides a robust and reliable foundation for assessing the impact of digital technology investment on bank performance.

4. Research results

4.1. Descriptive statistics

We begin by analyzing descriptive statistics to understand the key characteristics of our variables (Table 2). The average ROA and ROE (0.0149305 and 0.1653711, respectively) fall within the expected range for the banking industry during this period. However, the National Citizen Commercial Joint Stock Bank (NVB) exhibited negative ROA and ROE in 2023 (-0.0069249 and -0.1308267, respectively). This aligns with reports of operational challenges faced by NVB a few years ago, which led to special monitoring by the State Bank of Vietnam. Consequently, their 2023 income report reflects a loss *(see Appendix 1 online)*.

The average SOFT1 ratio (0.0020175) indicates that commercial banks invest a tiny portion of their total assets (around 0.2%) in digital technology (through software). This can be attributed to the nature of commercial banks, where a large portion of assets are allocated toward credit activities. However, the higher average SOFT2 ratio (0.0892352) suggests that software investment accounts for approximately 8.92% of total expenses. This highlights a preference for digital technology investment within operational costs. While the average expense for software might seem high based on our knowledge, it could reflect the banking industry's growing interest in technological innovation.

In line with existing publications on the determinants of bank performance in Vietnam, the characteristics of our variables closely correspond to factors identified in reports on the Vietnamese economy and banking industry outlook for the sample period.

4.2. Multicollinearity test

Second, we calculate a correlation matrix to assess the relationships between variables. This will help us identify potential multicollinearity issues that could affect the robustness of our models. Appendix 2 *(see Appendix 2 online)* shows that two pairs of variables exhibit correlation coefficients exceeding 0.8: ROA and ROE, and SOFT2 and SOFT1. While high correlations can be problematic, it's important to consider the context here. ROA and ROE are frequently used dependent variables in bank performance studies, and they naturally capture overlapping aspects of profitability. Similarly, SOFT1 and SOFT2 likely have a high correlation because they both measure software investment. However, to mitigate potential multicollinearity concerns, we will explore adjustments to the proposed model as detailed in the following tables.

4.3. Effect of digital technology *investment on bank performance*

To address potential panel data issues, we employed FE and RE models to estimate the impact of digital technology investment on bank performance. The Hausman test was then conducted to select the most appropriate model between FE and RE (Hansen, 1982). However, due to space limitations, we will only present the results from the GLS estimation, which corrects for heteroskedasticity and autocorrelation identified in the initial models.

Table 2. Effect of digital technology investment on bank performance

Panel 2.1. Effect of SOFT1 on bank performance

	ROA	z	ROE	z
SOFT1	-0.769794**	-20.02	-150.63247***	-2.99
NPL	-0.0034167	-00.86	-0.0127655	-0.24
SIZE	0.0050245***	10.02	0.0504203***	9.24
AGE	-0.0066402***	-30.92	-0.0471477**	-2.36
LOAN	0.0037159	0.17	0.2639666	0.92
DEPO	-0.026881	-10.33	-0.4801659*	-1.82
LODE	-0.0032797	-00.22	-0.1830287	-1.01
LEV	-0.1806154***	-9.03	-0.3476352*	-1.95
INF	-0.0454972	-1.29	-0.7906872*	-1.67
Constant	0.1261389***	5.13	0.046794	0.20
N	132		132	
Wald Chi2	279.96***		157.07***	

Panel 2.2. Effect of SOFT2 on bank performance

	ROA	z	ROE	z
SOFT2	-0.0167415**	-1.99	-0.3722078***	-4.08
NPL	-0.003885	-1.03	-0.0349675	-0.69
SIZE	0.0047996***	9.44	0.0502319***	10.03
AGE	-0.0063749***	-3.70	-0.046347**	-2.38
LOAN	0.0043963	0.20	0.2602655	0.92

DEPO	-0.0273907	-1.37	-0.5042195*	-1.95
LODE	-0.0039444	-0.27	-0.1955014	-1.10
LEV	-0.1776948***	-9.01	-0.2678132*	-1.79
INF	-0.0480824	-1.38	-0.8081127	-1.72
Constant	0.1276375***	5.13	0.0094669	0.04
N	132		132	
Wald Chi2	279.92***		184.98***	

Note: **, **, and *** indicate significance levels at 10%, 5%, and 1%, respectively.*

Table 2 indicates that all estimation models are statistically significant at the 1% level, suggesting that the explanatory variables collectively explain variations in bank profitability, as measured by ROA and ROE. Among the bank-specific control variables, SIZE exhibits a positive and significant relationship with profitability, implying that larger banks in Vietnam tend to achieve higher returns. This finding aligns with the economies of scale hypothesis, where bigger banks can exploit cost efficiencies, diversify income sources, and leverage stronger market power to enhance profitability (Athanasoglou et al., 2008; Pham et al., 2021). Conversely, AGE shows a negative and significant effect, suggesting that older banks are less profitable. One possible explanation is organizational rigidity and higher operational costs that limit their capacity to adapt to changing financial and technological environments (Pasiouras & Kosmidou, 2007). The results also indicate that LEV is negatively associated with profitability, supporting prior evidence that excessive leverage increases financial risk and interest burdens, thereby reducing returns (Athanasoglou et al., 2008; Berger & DeYoung, 1997). Additionally, DEPO has a significant negative impact on ROE, implying that a higher reliance on deposits may increase funding costs and limit earnings efficiency (Ghosh, 2021; Menicucci & Paolucci, 2016). Interestingly, NPL and INF are not statistically significant in the Vietnamese context. The insignificance of NPL may be attributed to banks' effective risk management practices and government-backed restructuring policies that mitigate credit risks (Al-Matari, 2021). Similarly, the effect of inflation may be offset by interest rate adjustments, which allow banks to reprice loans accordingly, reducing its direct impact on profitability. These results highlight the dominant role of bank size, leverage, and funding structures in explaining profitability, while credit quality and inflation play less critical roles in the observed period.

This study focuses on how investments in digital technologies (represented by SOFT1 and SOFT2) affect bank profitability. Interestingly, the results across all four models show that the coefficients for these digital technology investment variables are significantly negative. In simpler terms, banks that invested more in digital technologies relative to assets and expenses (SOFT1 and SOFT2) saw a decrease in profitability (ROA and ROE) at statistically significant levels (5% and 1%, respectively). This supports the hypothesis that digital technology investments during this period might have hurt bank profitability. We argue this could be because banks were still in the early stages of adopting these technologies, and the initial costs outweighed the potential benefits.

4.4. Lagged effect of digital technology investment on bank performance

We previously described how we modeled the impact of digital technology investment on bank profitability. In this section, we'll take

a more rigorous approach by considering the lagged effect, meaning we'll examine if the impact of investments appears after some time. The results of this analysis are shown in Table 3.

Table 3. Lagged effect of digital technology investment on bank performance

Panel 3.1. Lagged effect of SOFT1 on bank performance				
	ROA	**z**	**ROE**	**z**
SOFT1 (t-1)	-0.7158289**	-2.00	-19.20173***	-3.31
NPL	-0.0065876	-1.54	-0.0505224	-0.91
SIZE	0.0053138***	11.46	0.0467975***	8.31
AGE	-0.0069493***	-4.10	-0.0535907**	-2.53
LOAN	0.0085887	0.41	0.3410128	1.14
DEPO	-0.0364322*	-1.84	-0.5797403**	-2.06
LODE	-0.0081557	-0.55	-0.2479095	-1.31
LEV	-0.1735367***	-9.31	-0.3076468	-1.63
INF	-0.0404433	-0.93	-0.7425429	-1.45
Constant	0.1230323***	5.22	0.1900714	0.72
N	110		110	
Wald Chi2	346.00***		141.32***	

Panel 3.2. Lagged effect of the ratio of software investment to total expense				
	ROA	**z**	**ROE**	**z**
SOFT2 (t-1)	-0.0129575	-1.43	-0.4198236***	-3.72
NPL	-0.0058481	-1.38	-0.0315152	-0.54
SIZE	0.0050083***	10.44	0.0465914***	8.78
AGE	-0.0071692***	-4.18	-0.0549623***	-2.65
LOAN	0.0082408	0.38	0.375679	1.28
DEPO	-0.0340753	-1.64	-0.615651**	-2.22
LODE	-0.006555	-0.42	-0.2672344	-1.40
LEV	-0.1690183***	-8.85	-0.2441135	-1.42
INF	-0.0512758	-1.31	-0.7490215	-1.49
Constant	0.1225871***	5.04	0.1583996	0.63
N	110		110	
Wald Chi2	308.73***		163.14***	

Note: **, **, and *** indicate significance levels at 10%, 5%, and 1%, respectively.*

Looking at Table 2, we see results similar to those in Table 3. Factors like SIZE, AGE, and LEV continue to significantly influence profitability. Importantly, the lagged effect of digital technology investments (from Table 3) is also negative, which confirms what we observed earlier (in Table 3). This means that even when we consider the delayed impact of these investments, they are still associated with a decrease in bank profitability.

4.5. Role of COVID-19 Pandemic

The next step is to examine the effect of digital technology investments on bank performance, separated into the pre-COVID-19 period and the COVID-19 pandemic. The estimation results are shown in Appendix 3 *(see Appendix 3 online)*. The estimation results reveal a consistent negative impact of digital technology investment on ROE at a very high level of significance (1%) in both periods - before and during the COVID-19 pandemic. However, the negative effect on ROA was only significant during the COVID-19 period itself.

4.6. Discussion

This study presents a counterintuitive finding. Despite rising digital investment, the Vietnamese banking sector has witnessed declining profitability, reflecting a persistent form of the productivity paradox. Several factors underpin this outcome. First, limited digital capabilities and insufficient workforce readiness impede the effective integration of new technologies. Earlier studies suggest that weak managerial practices further exacerbate these constraints (Dos Santos & Sussman, 2000; Harris, 2001). Second, low levels of financial and digital literacy among the broader population restrict customer adoption of digital banking services. Recent evidence from Vietnam confirms that digital literacy is a decisive factor in enabling successful banking transformation (Ngo et al., 2024; M. H. Nguyen et al., 2023). Together, these limitations generate diminishing returns on digital technology investment.

The delayed realization of digital benefits compounds the paradox. Digital transformation typically requires restructuring legacy systems, organizational adaptation, and workforce upskilling, all of which generate transitional costs and short-term productivity losses (M. H. Nguyen et al., 2023). Moreover, the institutional and regulatory environment in emerging markets often slows the diffusion of innovation (T. P. Nguyen & Dang, 2018). Evidence from developed economies suggests that profitability gains are possible. Citterio et al. (2024) find that digital technology investments enhance EU bank profitability, but only after lags and contingent on organizational capabilities. Similarly, Porfírio et al. (2024) emphasize that organizational readiness including encompassing skills, flexibility, and cultural alignment, shapes digital transformation outcomes.

Cross-national evidence from developing contexts reveals important structural variation. Alqararah et al. (2025) report that in Jordan, strong institutional alignment and strategic positioning amplify the benefits of digital transformation, while Humeedat (2025) shows that bank size and structural factors such as branch networks condition digital technology investment effectiveness more than financial size alone. These findings suggest that the Vietnamese experience is not entirely unique. Other developing countries with weaker institutional frameworks, limited human capital, or fragmented banking systems may also encounter similar paradoxical outcomes. However, contexts with stronger regulatory support, higher digital literacy, or better integration of strategy and technology may be better positioned to translate digital spending into performance gains.

The COVID-19 pandemic further intensified Vietnam's paradox. Social distancing accelerated digital adoption, boosting transaction volumes (Berger & Demirgüç-Kunt, 2021). Yet profitability lagged behind, as banks relied on fee-free services to attract users (Chi & Tan, 2021). Emergency-driven investments often lacked strategic alignment, thereby undermining long-term efficiency. Such patterns were also observed in other developing markets, where crisis-induced digitization delivered short-term adoption gains but limited financial returns, reinforcing the argument that context-specific capabilities are critical for sustainable benefits.

In conclusion, while digital technology investment is indispensable for the long-term growth of banking, Vietnam's experience highlights that investments alone do not guarantee profitability. The evidence suggests that similar challenges are likely to surface in other developing economies where digital literacy, institutional readiness, and managerial capacity remain limited. Overcoming the paradox requires complementary investments in human capital, governance, and regulatory infrastructure, as well as business models that link digital adoption to sustainable revenue. These insights resonate with cross-country findings by Citterio et al. (2024), Humeedat (2025), and Porfírio et al. (2024), underscoring that digital technology investment is not merely a technological shift but a long-term strategic process whose success hinges on organizational readiness and contextual fit.

5. Conclusion

This study challenges the conventional wisdom that digital technology investment invariably drives increased profitability in the banking sector. By examining the Vietnamese banking industry from 2018 to 2023, we found evidence supporting the productivity paradox, where higher digital technology investment is associated with lower bank performance. This counterintuitive finding underscores the complexity of leveraging digital transformation for improved outcomes.

To fully realize the potential of digital technology, the Vietnamese banking industry must address several key challenges. Banks should prioritize enhancing their workforce's digital literacy to maximize the return on technology investments. Simultaneously, the government can play a pivotal role by fostering a digitally literate population through targeted programs. Such initiatives are essential not only for the banking sector but for the overall success of Vietnam's digital transformation. By acknowledging the complexities and addressing the underlying issues, the Vietnamese banking industry can harness the power of digital technology to achieve sustainable growth and improved performance.

This study makes several academic contributions to the literature on digital technology investment and bank performance. *First*, it extends the longstanding debate on the productivity paradox by providing novel evidence from Vietnam, an emerging market where digital transformation in banking is both accelerated and policy-driven. *Second*, by uncovering a paradoxical outcome where escalating digital technology expenditures coincide with declining profitability, the study challenges the prevailing assumption that digital technology investment automatically enhances performance. *Third*, it underscores the importance of lagged effects, suggesting that the benefits of digital technology investment may materialize only in the long run, thus contributing to theoretical refinement in evaluating technology-performance linkages. Collectively, these contributions enrich comparative banking research and inform strategies for digital technology investment in emerging economies.

The study has certain limitations, pointing to future research avenues. *Firstly*, digital technology investment can influence multiple aspects of bank performance, including profitability, customer satisfaction, and competitiveness. Therefore, a comprehensive evaluation is needed. We suggest assessing bank performance from various perspectives including customer, financial, internal processes, and innovation, using the Balanced Scorecard framework. *Secondly*, the effectiveness of digital technology investment depends not only on the bank's adoption but also on customer and client behavior. Future research should incorporate a measure of customer technology adoption into models analyzing bank performance. This would emphasize the role of customers in mediating the impact of digital technology investment on bank outcomes.

Based on the findings, policymakers should strengthen the digital transformation ecosystem by enhancing digital literacy, promoting workforce upskilling, and improving institutional readiness to maximize the returns on technology investments. Given that bank size, leverage, and funding structures significantly influence profitability, regulatory frameworks should encourage sustainable capital management, reduce overreliance on deposits, and support larger banks in leveraging economies of scale. Moreover, the moderating effect of COVID-19 highlights that crisis-driven digital adoption boosted transaction volumes but did not immediately improve profitability due to fee-free services and misaligned investments. Therefore, adaptive policies integrating technological innovation, strategic alignment, and risk management are essential to overcome Vietnam's productivity paradox and enable banks to convert digital spending into sustainable performance gains and long-term competitiveness in the financial sector.

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