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How is the adoption of advances of ICT valued by the market through the Tobin's Q indicator? The case of Vietnamese commercial banks

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ABSTRACT

This study aims to examine the impact of information and communication technology (ICT) investment on the market-based performance of Vietnamese commercial banks. Using panel data from 26 banks over the period 2006–2022, the research adopts the system generalized method of moments (System-GMM) to address potential endogeneity and dynamic panel bias. ICT investment is measured through a composite ICT index, while performance is captured by Tobin's Q, a market-based indicator reflecting investor expectations. The findings reveal that ICT investment has a positive and significant effect on Tobin's Q, underscoring the strategic role of technology in enhancing a bank's market valuation. In addition to ICT, factors such as bank size, the loan-to-deposit ratio, the loan loss provision ratio, and macroeconomic conditions are also found to significantly influence Tobin's Q in ways consistent with prevailing banking practices and the economic context during the study period. The study concludes that ICT investment plays a strategic role in improving market-based performance and signaling future value to investors. These findings suggest that Vietnamese banks should adopt long-term, strategic ICT investment plans not only to enhance competitiveness but also to support broader goals of innovation and digital transformation in the banking sector, particularly in the context of Industry 4.0.

Contribution/Originality: This study offers a novel contribution by employing Tobin's Q to assess the impact of ICT investment on bank performance an approach underexplored in existing literature. Unlike prior studies relying on accounting metrics, it highlights market-based valuation, providing deeper insights into ICT-driven value creation in Vietnam's banking sector.

1. INTRODUCTION

Information and communication technology (ICT) has evolved significantly over the last few decades, shifting from basic communication tools like telegraphs to digital technologies such as cloud computing, AI-powered chatbots, and virtual assistants. This evolution has transformed the way people interact, learn, and conduct business, making ICT an essential part of modern society. Notably, advancements in ICT have profoundly transformed the banking sector by increasing operational efficiency, redefining customer interactions, and significantly promoting financial inclusion across diverse populations. Key applications of ICT in banking include online and mobile banking, automated teller machines, digital payment systems, customer relationship management, fraud detection and security,

and core banking solutions. The integration of ICT into banking has enabled the emergence of new markets, innovative products, and enhanced distribution channels, particularly through digital platforms (Rahman, Hamid, & Khan, 2015). Thus, significant efforts by many banks can be seen in keeping up with the trend of applying modern technologies to improve functionality, customer value, and overall quality of their financial services and products. This potentially generates substantial competitive advantages while simultaneously reducing labor and transportation costs, and ultimately enhancing the banks' overall profitability. From this perspective, digital transformation has brought banks many opportunities to access and provide services to diverse customer segments, promoting comprehensive financial development (Del Gaudio, Porzio, Sampagnaro, & Verdoliva, 2021).

Throughout the last two decades, commercial banks in Vietnam have also considerably increased their investment in ICT to modernize banking services and meet the evolving demands of customers. Almost all Vietnamese commercial banks have been developing their growth strategies based on Industry 4.0 technologies (Vu, 2024). For example, Techcombank has set a development strategy based on talent, digitization, and data (Vu, 2024). By late 2022, banks in Vietnam allocated approximately 618 million USD for investments in ICT (VietnamPlus, 2023). Investments have focused on building digital infrastructures, encompassing online transaction channels, mobile apps, and automatic teller machines. These investments aim to provide seamless and secure banking experiences, which in turn improve customer satisfaction and foster long-term retention while attracting new clients. Under this perspective, digital banking development is considered a strong "resource" of competition.

Despite the transformative effect of ICT adoption on the banking sector in Vietnam, commercial banks—especially smaller institutions—still face considerable challenges in effectively deploying and utilizing ICT-related technologies. These challenges certainly impede the fulfillment of the government's strategic objectives aimed at fostering innovation, creation, and digital transformation across the sector. First, implementing advanced ICT solutions, such as core banking systems, cybersecurity measures, and digital banking platforms, requires significant financial investment. Many banks, particularly smaller or regional banks, struggle to allocate sufficient funds for ICT adoption and maintenance (Nguyen & Vuong, 2022). Second, the proliferation of online transactions underscored the imperative need for robust cybersecurity measures. Vietnamese banks have reported challenges in preventing data breaches, phishing attacks, and other forms of cybercrime due to inadequate security infrastructure and limited expertise in handling advanced threats (Le, Nguyen, & Pham, 2020). For example, in 2021, several Vietnamese banks experienced phishing campaigns targeting online banking users, highlighting the need for stronger cybersecurity measures. Third, in rural and remote areas of Vietnam, limited ICT infrastructure and low digital literacy pose challenges to the widespread adoption of digital banking services. Many customers are unfamiliar with online banking platforms, leading to low usage rates and a continued reliance on traditional banking methods (Chong, Ooi, Lin, & Tan, 2020; Pham, 2022). Fourth, the rapid pace of ICT development has outpaced regulatory frameworks in Vietnam. For example, Dao, Pham, and Phan (2024) highlight that Vietnam's legal framework for data protection has been fragmented, lacking a unified approach to personal data protection. Dang and Pham (2021) view that Vietnam's legal framework lacks a clear definition and comprehensive regulations for emerging digital technologies applicable to the banking sector. These limitations in the legal framework create uncertainty for banks seeking to innovate, thereby slowing the process of digital transformation based on advancements in ICT. Fifth, investments in ICT require skilled professionals to manage, operate, and maintain cutting-edge digital initiatives. A lack of qualified IT personnel is seen as a critical obstacle for banks, which hinders the effective implementation and management of complex ICT systems (Pham, 2022; Pham, 2023). Continuous training and application development are essential but add to operational costs. Last but not least, many Vietnamese banks rely on outdated legacy systems, which are difficult to integrate with modern ICT solutions (Ha & Nguyen, 2022). Upgrading these systems is both time-consuming and expensive, leading to delays in adopting new technologies.

The challenges highlighted emphasize the need for banks to invest strategically in ICT, strengthen cybersecurity infrastructure, and improve customer awareness and workforce skills. However, significant initial costs and budget

constraints are major barriers preventing many banks from fully implementing such strategic investments. Additionally, the existing empirical evidence on the relationship between ICT investment and bank performance is inconclusive, with previous studies showing mixed results. This inconsistency diminishes the persuasive power of ICT investment as a definitive strategic decision. Furthermore, the effects of ICT investments are often not immediately visible within the same fiscal year, complicating investment decisions for banks. Therefore, this study aims to provide further empirical evidence on the impact of ICT investment by examining its relationship with Tobin's Q, a market-based performance indicator, in the banking sector. This area of research has been largely overlooked by prior studies. The evidence generated is intended to offer banks deeper insights to inform strategic ICT investment decisions, supporting the government's broader goal of fostering innovation, creation, and digital transformation in this critical sector of the economy. Additionally, based on the study's findings, recommendations will be provided to help bank managers develop effective policies to optimize operational costs and improve overall profitability. The remainder of this paper is organized as follows: Section 2 presents the theoretical framework and reviews empirical studies; Section 3 describes the research methodology and data sources; Section 4 discusses the empirical findings; and Section 5 concludes with some proposed recommendations.

2. THEORETICAL FRAMEWORK AND LITERATURE REVIEW

Two theories, transaction cost theory and resource-based view, serve as theoretical frameworks to elucidate the potential effect of ICT investment on the performance of banking institutions. The transaction cost theory indicates different costs arising when a firm delivers a service or a product to the market, such as costs of finding suitable partners, negotiation costs, contract signing costs, costs to ensure contract enforcement, costs for adjusting errors after contract signing, and dispute resolution costs (Coase, 1937). These transaction costs are typically divided into two main categories: operational and contractual. The adoption of ICT would support the collection, storage, selection, processing, and selective dissemination of data, thereby enhancing the quality of monitoring and supervising the partners' obligation performance, thus reducing transaction costs (Nooteboom, 1992). The adoption of ICT geared towards automating processes can help reduce labor costs significantly, thereby increasing the efficiency of business operations (Wiseman, 2008). For the banking sector, the adoption of ICT would create new products with new platforms of distribution, such as online, mobile, and Internet banking (Rahman et al., 2015), allowing customers to conduct transactions with banks from anywhere instead of visiting the bank in person, thus contributing to reducing transaction costs.

The resource-based theory posits that a firm's competitive advantage is derived from its access to strategic resources that are valuable, scarce, and not easily replicated or substituted by alternatives (Barney, 1991). Resources within a firm are typically sustained and shielded from competitive replication through a number of protective factors, including "time compression diseconomies," historically unique circumstances, deep integration within organizational routines, and the lack of understanding of cause-effect interactions between resources and performance outcomes (Barney, 1991). In terms of strategic management, the effectiveness of a firm's resources can be amplified through the integration of complementary existing assets, resulting in a unique resource configuration that is challenging for competitors to replicate or substitute (Bharadwaj, Bharadwaj, & Bendoly, 2007). In the era of digital transformation, ICT is gaining recognition as a synergistic resource that complements other existing assets within a firm to boost its overall value (Bharadwaj et al., 2007). Empirical findings by Melville, Kraemer, and Gurbaxani (2004) indicate that ICT resources, when combined with a firm's complementary assets, have a substantial influence on the efficiency of business processes. Accordingly, strengthening ICT capabilities serves as an indirect driver of enhanced organizational performance (Bharadwaj, 2000). Key components of ICT resources, including IT infrastructure, personnel, and software programs, collectively shape a firm's advanced ICT capability (Huang, Ou, Chen, & Lin, 2006). While each individual ICT resource has distinct and hard-to-replicate characteristics, many firms have

effectively combined them to achieve comprehensive ICT capabilities in their pursuit of sustainable competitive advantages.

Both theories, transaction cost theory and resource-based view, indicate that banks that succeed in developing superior ICT capabilities may achieve higher financial performance through reduced operational costs and/or increased revenues. Generally, empirical studies provide evidence for this perspective. Nolan (1994) and Bharadwaj (2000) document that ICT capabilities are a crucial factor differentiating a well-performing firm from one with lower profitability. Wu, Wang, and Wang (2017) show that advanced ICT capabilities helped businesses overcome the crisis and recover swiftly in the post-recession period. For the banking sector, several recent studies also provide evidence that investing in ICT significantly boosts bank profits. Del Gaudio et al. (2021) confirm that the benefits brought by ICT investment far outweigh the initial investment costs. Dadoukis, Fiaschetti, and Fusi (2021) report that banks that successfully leveraged IT systems demonstrated stronger recovery capabilities and experienced reduced levels of non-performing loans and default during the COVID-19 pandemic. Pierri and Timmer (2022) also yield similar results, emphasizing the importance of applying ICT systems for screening borrowers, thus helping build up the recovery ability of the banking system during crises. However, investing in information technology is an expensive process that requires considerable effort, time, and money at every stage (planning, analysis, design, development, implementation, and upgrading). Therefore, companies that do not manage well and take advantage of the benefits that IT brings will face the IT performance paradox (Brynjolfsson, 1993).

Recently, several studies have investigated the impact of ICT investment in the context of Vietnamese banks. These studies yield mixed findings about the impact of ICT investment, although the findings of a positive impact seem to outweigh the negative ones. Nguyen and Vuong (2022) present evidence that investments in each component of ICT positively influence bank profitability, as measured by book-based indicators of profitability. This is consistent with the results presented by Le and Pham (2022). Meanwhile, the finding by Cu, Tran, and Nguyen (2024) suggests that the adoption of ICT significantly reduces operational risks for banks, primarily through improving IT infrastructure and developing internal IT human resources, enhancing training, and increasing IT knowledge, capabilities, and skills for staff. However, Nguyen and Vuong (2022) indicate that investments in innovative ICT technologies negatively impact bank profitability, especially for banks of small size, as these technologies involve high costs while not generating immediate profitability in the short run. In the meantime, Le, Nguyen, and Pham (2023) found that the effect of ITC investment on bank profitability exhibits a U-shaped non-linear relationship. Accordingly, the positive impact occurs only after the measure of this type of investment in terms of ICT indices reaches beyond a certain threshold. Therefore, they recommend that Vietnamese banks strategically plan ITC investments at such a scale that enables them to fully capitalize on the advantages offered by technological advancements.

The mixed findings regarding Vietnamese banks may stem from the fact that investments in ICT require substantial financial resources and take time to yield expected benefits, while simultaneously exposing banks to risks such as data breaches, phishing attacks, and other cyber threats risks often exacerbated by inadequate security infrastructure and limited technical expertise. To contribute further empirical insight into the influence of ICT investment from the perspective of market valuation, this study investigates how ICT investment affects bank performance, which is measured by Tobin's Q indicator. This perspective remains underexplored in existing literature, although market value is a crucial source of information for top management to make investment and financing decisions. From this perspective, the study highlights that a firm's market value is fundamentally shaped by the expected cash flows generated from its assets, including those arising from ICT investments (Nolan, 1994), as well as the level of risk associated with these cash flows. Thus, Tobin's Q provides a more appropriate measure to understand how ICT investment affects banking performance, given the transparency of the investment and operational activities of commercial banks. By relying on market valuation, Tobin's Q avoids the limitations of conventional book financial performance measures, thereby offering a more nuanced and comprehensive picture of

the effectiveness of ICT investment. This study makes a novel contribution by highlighting the significant and positive influence of ICT investment on banking performance in Vietnam.

3. RESEARCH METHOD AND DATA

We follow the approach in building empirical models to shed light on the drivers of bank performance adopted in existing literature (Gupta, Raychaudhuri, & Haldar, 2018; Pierri & Timmer, 2022; Wang, Nguyen, Dang, & Trinh, 2021). These drivers are implied by a number of seminal theories, such as economies of scale, efficiency structure hypothesis (Berger, 1995), capital structure theory (Myers & Majluf, 1984), financial intermediation theory (Freixas & Rochet, 2008), and risk-return tradeoff theory (Stiglitz & Weiss, 1981). Accordingly, our estimation model for capturing the influence of ICT investment on banking performance in Vietnam is specified in Equation 1 as below.

$$Y_{it} = \alpha_0 + \alpha_1 ICT_{it} + \alpha_2 BANK_{it} + \alpha_3 MACRO_{it} + e_{it} \quad (1)$$

Where: α_1, α_2, and α_3 represent coefficients of independent variables; Y_{it} refers to the performance of commercial bank i in year t, which is measured by Tobin's Q indicator; ICT_{it} refers to the level of application and development of ICT, measured by the ICT index. $BANK_{it}$ refers to control variables specific to banks (including SIZE, representing bank size; ETA, representing the equity-to-asset ratio; LDR, representing the loan-to-deposit ratio; and LLP, representing the loan loss provision ratio). $MACRO_{it}$ denotes macro-environmental factors (including GDP index, representing the economic growth rate; and INF index, representing the inflation rate); and e_{it} represents the model error term.

To estimate Equation 1, we collected data from 35 commercial banks operating as of December 31, 2023, for the period 2006-2022. However, to align with the research model using Tobin's Q as a measure of market performance, we excluded those banks that are not listed on stock exchanges due to a lack of market capitalization data. Therefore, only 26 commercial banks met the conditions for this study. Furthermore, four banks were excluded from the sample by the selected estimation method because of the need to employ lagged values of explanatory variables. The data on control bank-specific variables were obtained from financial reports, management reports, and annual reports published on the official banks' websites. The data on macro-environmental factors were gathered from the General Statistics Office of Vietnam.

The data on the ICT index are collected from the Ministry of Information and Communications of Vietnam. The ICT composite index is based on four main components, including internal bank applications, technical infrastructure, human infrastructure, and online banking services. The ICT index reflects the level of readiness and investment in applying ICT by commercial banks.

Tobin's Q ratio serves as the dependent variable in the model, measuring bank performance, which replaces traditional accounting ratios such as ROA and ROE. There are various methods to calculate this market-based indicator of performance, but there is no significant difference among these methods, as indicated by Chung and Pruitt (1994). Therefore, we choose the calculation method proposed by Khanna and Palepu (1996) due to its simplicity and the availability of data from credible sources. Accordingly, Tobin's Q ratio is derived by dividing the total of a firm's market equity value and debt book value by the book value of its assets in year t. This measure of performance reflects the market's expectations regarding the value of banks, considering their reported investment and business activities, including investments in ICT.

The study focuses on the period from 2006 to 2022 for two primary reasons. First, although Vietnam's stock market was officially established in 2000, it was not until 2006 that the market experienced substantial growth. Importantly, from 2006 onward, commercial banks began actively listing on the stock market, thereby improving data transparency and providing a more comprehensive basis for market-based evaluations of bank performance. Second, selecting this period ensures the availability and consistency of critical datasets, particularly those related to market information and the ICT index. Additionally, this time span guarantees a sufficient number of observations, thereby enhancing the robustness and reliability of the empirical estimations.

Several standard methods can be employed to estimate Equation 1 using panel data, including pooled ordinary least squares (OLS), fixed effects model (FEM), and random effects model (REM). The OLS method operates based on several assumptions, such as independence, homoscedasticity, and normality of residuals. If these assumptions are violated, the estimation results may become unreliable. This method also requires the absence of multicollinearity, stipulating that the independent variables are not linearly correlated with one another. The FEM model considers that the unique, heterogeneous characteristics of each entity could bias the independent or dependent variables, thus needing to be controlled (Blackwell III, 2005). The REM model is appropriate when differences between entities are assumed to be random and uncorrelated with the independent or dependent variables. To determine the suitable estimation method, the following sequential tests are used: (i) the F-test to choose between the pooled OLS method and the Fixed Effects Model (FEM); (ii) the Breusch-Pagan Lagrangian multiplier test to select between the pooled OLS method and the Random Effects Model (REM); and (iii) the Hausman test to assess whether the FEM or the REM is appropriate. Once an estimation model is identified as relevant, issues such as heteroscedasticity and autocorrelation are checked within that model. If such issues are detected, they may be addressed using the feasible generalized least squares (FGLS) technique. However, if endogeneity is present in the data, the FGLS method may not be suitable. To test whether a variable is endogenous, the Durbin-Wu-Hausman test is applied. This test compares the instrumental variables (IV) estimator with the ordinary least squares (OLS) estimator, based on the principle that if the results are similar, the OLS estimator remains valid (failing to reject the null hypothesis H_0, indicating the variable is exogenous). If the estimates differ significantly, instrumental variables are necessary for the model (Ao, 2009).

For models exhibiting defects such as heteroscedasticity, autocorrelation, and endogeneity, the most appropriate estimation method to address these issues is the system generalized method of moments (System-GMM) (Roodman, 2009). First, the System-GMM method can address the issue of unobserved heterogeneity of cross-sectional units (Ogbonna, Ogbuabor, Eze, & Ugwuoke, 2021). Second, the System-GMM method corrects the estimation biases commonly found in static panel models (Baum, 2006). These biases arise from neglecting the impact of lagged values of the dependent variable and/or independent variables, resulting in inconsistent and inefficient estimates (Bond, 2002). Third, the System-GMM method also resolves endogeneity issues arising from the correlation between explanatory variables and residuals by incorporating lagged values of these explanatory variables as instruments within the model (Roodman, 2009). Fourth, Blundell and Bond (1998) confirm in their research the superiority of the System-GMM method in addressing heteroscedasticity in the model. Therefore, given the results of tests reported in Section 4, we adopt the System-GMM method to estimate Equation 1 using the Arellano-Bond, Sargan, and Hansen tests to control for the model's defects.

Table 1. Correlation coefficients and results of multi-collinearity tests.

Correlation matrix									**Results of multicollinearity tests**	
	Q	**ICT**	**ETA**	**SIZE**	**LDR**	**LLP**	**INF**	**GDP**	**VIF**	**1/VIF**
Q	1.000									
ICT	0.132	1.000							1.26	0.793
ETA	-0.007	0.079	1.000						1.25	0.798
SIZE	0.151	0.352	-0.115	1.000					1.67	0.599
LDR	-0.071	0.230	0.31 9	0.472	1.000				1.63	0.612
LLP	-0.057	0.020	0.059	-0.045	0.084	1.000			1.03	0.969
INF	0.102	0.158	-0.002	-0.130	-0.130	-0.050	1.000		1.10	0.909
GDP	-0.058	-0.125	-0.054	0.045	-0.127	-0.134	0.010	1.000	1.08	0.922
Mean VIF									1.29	

4. ESTIMATION RESULTS AND DISCUSSION

Table 1 presents the correlation coefficients among the variables and the results of multicollinearity tests. The correlation coefficients generally align with initial expectations based on the examined period and banking practices. Variables such as ICT, SIZE, and INF positively correlate with Tobin's Q, while LDR, LLP, and GDP negatively correlate with this performance indicator. Additionally, the correlation matrix can be used as a tool to detect signs of high correlation among variables. According to Hair (2006), multicollinearity exists when the absolute correlation between any two independent variables reaches 0.9 or above. Such a correlation indicates a high degree of linear association that could potentially distort the estimation of individual effects. However, Pallant (2020) suggests that 0.7 should be the threshold for multicollinearity among independent variables. Table 1 shows that the highest absolute correlation coefficient is 0.4724, which is much lower than 0.7. The results of multicollinearity tests using variance inflation factors (VIF) also indicate the absence of multicollinearity in the model, as the mean VIF value is 1.29, and the tolerance values (1/VIF) of the independent variables are all greater than 0.1. Therefore, there is no multicollinearity in the estimated model.

Table 2 presents the results of tests for selecting the suitable method or model used for estimating Equation 1. The outcomes of F-test and Breusch-Pagan test indicate that the FEM model and the REM model are more appropriate than the OLS method while the FEM model is preferred by the Hausman test.

Table 2. Results of tests for selecting the appropriate method or model for estimation.

Type of test	Objective of test	Null hypothesis	Test results	Method or model to be selected
F-Test	Selecting the appropriate model between the two options: Pooled OLS and FEM.	H_0: All the fixed effects are jointly zero or insignificant.	F (25, 125) = 5.62 Prob > F = 0.000	FEM
Breusch-Pagan Lagrangian multiplier	Selecting the appropriate model between the two options: Pooled OLS and FEM.	H_0: The random effects are insignificant.	Chibar2(01) = 54.13 Prob > chibar2 = 0.000	REM
Hausman	Selecting the appropriate model between the two options: FEM and REM.	H_0: Difference in coefficients is not systematic	Chi2(7) = 33.97 Prob > chi2 = 0.000	FEM

Table 3. Test results for the issues of heteroscedasticity and autocorrelation within the FEM model.

Type of test	Null hypothesis	Results	Interpretation
Wooldridge test for autocorrelation in panel data	There is an absence of first-order autocorrelation.	F (1, 21) = 3.723 Prob > F = 0.0673	The null is rejected.
Modified Wald test for groupwise heteroskedasticity	There is homoscedasticity (constant variance) of residuals.	Chi2 (26) = 115364.52 Prob > chi2 = 0.0000	The null is rejected.

Table 3 presents results of tests for detecting issues of heteroscedasticity and autocorrelation within the FEM model. The test outcomes indicate the presence of these issues in the FEM model. As discussed in section 3, to address these issues, the FGLS method would be employed. However, the outcomes of the Durbin-Wu-Hausman test suggest the endogeneity issue is present in the model with chi2(1) = 2.80644 and p = 0.0939. Thus, we adopt the System-GMM for estimating Equation 1.

Table 4. Results of estimation and robustness tests.

Variables	Coefficients	P-value	Expected	Estimation results reported in previous studies
ICT	0.12393	0.000	+	Dadoukis et al. (2021); Nguyen and Vuong (2022); Aguegboh, Agu, and Nnetu-Okolieuwa (2023); and Pierri and Timmer (2022)
ETA	-0.0509	0.476	+/-	Acharya, Hasan, and Saunders (2006); Berger, Hasan, and Zhou (2010), and Jouida (2018)
SIZE	0.0101	0.021	+	Jouida (2018); Le et al. (2023) and Gržeta, Žiković, and Tomas Žiković (2023)
LDR	-0.741	0.000	+/-	Alshatti (2015); Aguegboh et al. (2023); Tabari, Ahmadi, and Emami (2013); and Golin and Delhaise (2013)
LLP	-0.0207	0.000	-	Alhadab and Alsahawneh (2016) and Nguyen and Nguyen (2022)
INF	-0.0007	0.072	-	Barajas, Steiner, and Salazar (1999) and Beck, Levine, and Smith (2013)
GDP	-0.0031	0.000	+/-	Rajan (2006) and Beck et al. (2013)
_cons	0.7183	0.000	+	
Number of groups: 22				
Number of instruments: 19				
Arellano-Bond test for AR (1) in first differences: z=-1.65, Pr>z=0.100				
Arellano-Bond test for AR (2) in first differences: z = -1.36, Pr > z = 0.175				
Sargan test of overid. Restrictions: Chi2(10) = 113.22 Prob > chi2 = 0.212				
Hansen test of overid. Restrictions: Chi2(10) = 8.31 Prob > chi2 = 0.599				

Table 4 presents the results of the estimation of Equation 1 and robustness tests using the System-GMM method. The outcomes of the robustness tests, including Hansen, Sargan and Arellano-Bond, are reported at the end of Table 1. The results of both Hansen test and Sargan test support the null hypothesis – stating the instrumental variables are exogenous and uncorrelated with the empirical model's residuals - cannot be denied. The Arellano-Bond test outcomes reveal the absence of second-order serial correlation in the residuals of the empirical model. Therefore, the empirical model is appropriately specified and functions as expected within the analytical framework.

The estimation results presented in Table 4 indicate that the ICT index positively affects Vietnamese banks' performance, measured by Tobin's Q, at a significance level of 1 percent. This empirical evidence reaffirms that enhancing innovation and applying ITC systems in the organization and operation of banking systems help banks achieve significant benefits and meet market expectations. This is consistent with both domestic and international studies, such as Dadoukis et al. (2021), Nguyen and Vuong (2022), Le et al. (2023), and Vu, Tran, Nghiem, and Luong (2022). Since the bank's performance is measured by Tobin's Q, such estimation results suggest that the adoption of advances in ICT by banks is closely observed and evaluated by the stock market. The stock market reacts to investments in ICT by banks based on the expected future gains in efficiency and the potential for delivering new services. Commercial banks that effectively integrate technology into their operations often experience positive stock price reactions, as investors anticipate enhanced competitive advantages Koetter & Noth, 2013 and improved customer satisfaction with digital banking services Jorgenson & Vu, 2005, which drive revenue growth. Banks with higher ICT investments tend to have lower operational costs (Beccalli, 2007) while enhancing their ability to assess and manage risks (Pierri & Timmer, 2022). Thus, as reports on the annual ICT indices of Vietnamese commercial banks are timely available throughout the market, investors would adjust their expectations about the value of banks accordingly.

Regarding the control bank-specific variables, except for the variable ETA, its impact on banks' performance is insignificant. Other variables such as SIZE, LDR, and LLP all affect bank performance with P-values of 5%, 1%, and 1%, respectively. Accordingly, bank size (SIZE) has a positive impact on bank performance, while the loan-loss provision ratio (LLP) and the loan-to-deposit ratio (LDR) exhibit negative impacts. The positive impact of bank size on performance indicates that larger institutions are able to leverage economies of scale, thereby achieving higher

profitability than their smaller counterparts. This aligns with our initial expectations and previous studies (Gržeta et al., 2023; Le et al., 2023). The negative impact of the loan-loss provision ratio (LLP) suggests that the LLP ratio tends to diminish bank profitability. This outcome aligns with our prior expectations and is consistent with evidence reported in previous studies (Alhadab & Alsahawneh, 2016; Nguyen & Nguyen, 2022). Loan loss provisions are essentially costs set aside as buffers to cover potential loan defaults, thereby directly influencing banks' profitability and overall performance. The negative effect of the loan-to-deposit ratio (LDR) contradicts our expectations but aligns with lending practices during the surveyed period. This result reflects the accumulation of loan balances during years of excessive credit growth. Several violations by credit institutions were detected and addressed by the authorities during the study period, significantly reducing investor confidence. Consequently, a higher LDR ratio indicates poorer liquidity risk, raising concerns about the liquidity capacity of credit institutions and negatively impacting bank profitability in terms of Tobin's Q (Adegbite, Olayemi, & Adeniran, 2022; Golin & Delhaise, 2013; Tabari et al., 2013).

For macro control variables, both inflation (INF) and economic growth (GDP) have negative impacts on banks' performance, consistent with our expectations and findings documented in many previous studies (Criste & Lupu, 2014; Yanikkaya, Gumus, & Pabuccu, 2018). Indeed, rising inflation adversely influences the credit activities of banks as it increases interest costs, thus lowering net interest income and bank performance. The negative effect of growth reflects the fact that the favorable economic environment leads to increasingly intense and fierce competition in the banking sector, thus negatively affecting banks' profitability and performance.

5. CONCLUSION AND RECOMMENDATION

The adoption of advances in ICT has recently contributed to the transformation and modernization of the Vietnamese banking industry. However, several challenges and barriers remain for banks to effectively deploy and utilize new digital technologies. Notably, the biggest barriers for banks to stay aligned with this strategic transformation process are high initial costs and budget constraints. This study aims to offer further empirical evidence on the nexus between ICT investment and bank performance, thereby assisting banks in making well-informed decisions regarding ICT investment. We shed light on the effectiveness of ICT investment by Vietnamese banks through the behavior of Tobin's Q, a market-based financial efficiency indicator. The investment in ICT is assessed using the ICT index provided by Vietnam's Ministry of Information and Communication, which reflects the level of ICT application and investment of Vietnamese banks. This independent variable, together with a number of control variables, is embedded into an empirical model similar to those applied by studies on drivers of bank performance. To ensure the reliability of the estimates, the empirical model is estimated using the System-GMM. This econometric technique is well-suited for dynamic panel data analysis as it effectively addresses econometric issues such as heteroscedasticity, autocorrelation, and endogeneity. Moreover, it accounts for the effects of lagged explanatory variables, providing more consistent and efficient parameter estimates. The estimation results demonstrate a positive relationship between ICT investment and bank performance assessed by Tobin's Q. This indicates that ICT investment in the banking sector appears to be closely observed and evaluated by investors, while suggesting that enhancing investment in ICT is not just a temporary trend but a critical factor in improving performance and competitiveness for Vietnamese banks. The estimation results also reveal impacts of other bank-specific control variables, which are mostly consistent with our initial expectations and with the findings reported in similar empirical studies. Notably, the effect of the loan-to-deposit ratio is not as significantly positive as expected. However, this actually reflects the outcome of excessive credit growth during a number of years after Vietnam became a member of the WTO.

The empirical evidence provided in this study highlights the importance of adopting ICT in enhancing the performance of Vietnamese commercial banks. However, the adoption of ICT also presents challenges such as high costs, cybersecurity threats, regulatory complexities, and resistance to change by both employees and clients, as

discussed in the introduction of this article. To fully realize the potential of ICT in banking business, Vietnamese commercial banks should address these challenges. To a large extent, successful implementation of investment in ICT depends on strong leadership, investment in innovation, and regulatory adaptation. Given the limitations in Vietnam's current legal framework, it is imperative for Vietnam to create a conducive legal environment that promotes the integration of ICT in the banking sector, drives innovation, enhances financial inclusion, and ensures the stability and security of digital financial services. In such a legal environment, any adoption of advances in ICT by banks would be highly valued by investors, thereby strengthening investors' confidence in the effectiveness of investments in ICT by commercial banks.

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