Tác động của chuyển đổi số đến mức độ chấp nhận rủi ro tại các ngân hàng thương mại Việt Nam: Vai trò điều tiết của sở hữu nhà nước

TÓM TẮT

Nghiên cứu này tập trung nghiên cứu về vai trò điều tiết của sở hữu nhà nước đến tác động của chuyển đổi số đến mức độ chấp nhận rủi ro tại các ngân hàng thương mại Việt Nam. Dữ liệu nghiên cứu được thu thập từ báo cáo tài chính đã kiểm toán của 27 ngân hàng thương mại Việt Nam và cơ sở dữ liệu của Ngân hàng Thế giới trong giai đoạn từ năm 2011 đến 2021. Kết quả ước lượng bằng phương pháp GMM hệ thống hai bước đã cung cấp thêm bằng chứng thực nghiệm về mối quan hệ ngược chiều giữa chuyển đổi số và mức độ chấp nhận rủi ro trong lĩnh vực ngân hàng, đồng thời chỉ ra rằng sở hữu nhà nước có thể xem là một yếu tố điều tiết quan trọng giúp ngân hàng ứng dụng chuyển đổi số trong việc giảm thiểu rủi ro. Kết quả nghiên cứu là cơ sở để đề xuất các hàm ý chính sách như: Các ngân hàng thương mại Việt Nam cần thúc đẩy chuyển đổi số để nâng cao khả năng kiểm soát rủi ro, cần phát triển khung quản trị rủi ro tích hợp công nghệ và nâng cao năng lực của nhân viên trong việc ứng dụng công nghệ số; cần tăng cường sự tham gia của Nhà nước vào quá trình chuyển đổi số của các ngân hàng và cân nhắc trong việc duy trì mức sở hữu Nhà nước hợp lý nhằm cân bằng giữa mục tiêu an toàn tài chính, ứng dụng công nghệ và giảm rủi ro hiệu quả hơn.

Từ khóa: *Cấu trúc sở hữu, chuyển đổi số, mức độ chấp nhận rủi ro, sở hữu nhà nước*

The impact of digital transformation on risk-taking in Vietnamese commercial banks: The moderating role of state ownership

ABSTRACT

This study focuses on the moderating role of state ownership on the impact of digital transformation on risk-taking in Vietnamese commercial banks. Research data is collected from audited financial statements of 27 Vietnamese commercial banks and the World Bank database for the period from 2011 to 2021. The estimation results using the two-step system GMM method have provided additional empirical evidence on the inverse relationship between digital transformation and risk-taking in the banking sector and, at the same time, indicated that state ownership can be considered an important moderating factor that helps banks apply digital transformation in minimizing risks. The research results are the basis for proposing policy implications such as: Vietnamese commercial banks need to promote digital transformation to improve risk control capabilities, develop a technology-integrated risk management framework, and improve staff capacity in applying digital technology; it is necessary to increase State participation in the banks' digital transformation process and consider maintaining a reasonable level of State ownership to balance the goals of financial safety, technology application and more effective risk reduction.

Keywords: *ownership structure, digital transformation, risk-taking, state ownership*

1. INTRODUCTION

In recent years, digital transformation has brought about significant changes across all sectors, leading to the rapid growth of Fintech, digital payments, high-tech online lending, and automated financial advisory services within the financial and banking industry. During the Covid-19 pandemic, the banking sector introduced various innovations to promote comprehensive digital transformation, enabling commercial banks to enhance operational efficiency by reducing information search costs (through the Internet), improving the quality and speed of information collection (via big data analytics), and employing cryptographic techniques to establish reliable governance mechanisms (such as Blockchain). These efforts have contributed to improving risk management capabilities, aiming for comprehensive financial stability within the banking system. However, technological advancements also present numerous challenges, particularly the rapid development of financial technologies and the potential risks faced by banks. Recent studies indicate that the adoption of digital technologies, or the digital transformation process, has influenced the risk-taking behaviors of commercial banks in diverse ways.

Digital transformation is understood as the utilization of digital connectivity and technological applications such as artificial intelligence (AI), digital data, and internet connections and networks, resulting in the disruption of the entire social structure in the creation, management, use, and distribution of resources.[1] Digital transformation represents a new development model that contributes to enhancing social labor productivity and national competitiveness, thereby generating higher-level services as well as new societal values and demands. Humans are not only consumers but also creators of unprecedented products and services, driving the transformation of value systems and socio-economic structures. In the financial and banking sector, digital transformation has revolutionized service delivery methods, particularly causing significant changes in payment services (both domestic and cross-border), lending ecosystems, asset management services, and insurance. The convenience and rapidity brought about by digital transformation pose a substantial challenge to traditional financial services that have long dominated the market.[2]

According to modern banking theory, the stability and profitability of banks are influenced by financial market crises or risks, the characteristics of borrowers and depositors, and any entities closely associated with the banks.[3] Such crisis situations or uncertainties are referred

to as the risk-taking, which reflects the risk tolerance of certain banks during crises. The banks' risk-taking depends on their corporate governance strategies, regulatory frameworks, and competitiveness.[4]

A review of the literature reveals inconsistencies in findings regarding the impact of digital transformation on the risk-taking of commercial banks. This impact can be positive,[3,5,6] negative,[7–9] or nonlinear.[10,11] The process of digital transformation and risk-taking of commercial banks can be influenced by various factors, including bank-specific characteristics and macroeconomic conditions. However, to date, no study has explored the moderating role of ownership structure, particularly state ownership, on the impact of digital transformation on the risk-taking of commercial banks.

This study seeks to clarify the direction of the impact of digital transformation on the risk-taking of 27 Vietnamese commercial banks during the period 2011–2021 while examining the moderating role of state ownership in the relationship between these two variables. To the best of the authors' knowledge, this research is pioneering in providing empirical evidence on the moderating role of state ownership in the impact of digital transformation on the risk-taking of Vietnamese commercial banks. The findings aim to offer a foundation for policy recommendations, serving as a reference for managers and policymakers in the context of increasingly vigorous digital transformation.

2. LITERATURE REVIEW

2.1. The impact of digital transformation on bank risk-taking

Digital transformation is defined as the application of modern technologies to enhance business operations, meet customer needs more effectively, and create new, more efficient business opportunities.[12] Within the banking sector, key technologies facilitating digital transformation include artificial intelligence (AI), big data, blockchain technology, and the Internet of Things (IoT).[13,14] The speed of digital transformation in banking can be influenced by factors such as the strategic role of management, the prevailing organizational culture, the rapid advancement of digital technologies, the digital skillset of employees, the formulation of digitalization strategies, and the overarching objective of optimizing customer satisfaction.[15,16]

When banks undergo digital transformation, it helps them improve service quality and enhance operational efficiency.[2] At the same time, digital transformation significantly changes the way banks interact with customers and manage their operations, including managing risk-taking behavior.[16] Risk-taking behavior in banks can be defined as the proactive acceptance of risks by banks to achieve higher profits.[9] According to the study by Hoque et al., the main types of risks faced by banks include credit risk, liquidity risk, and bankruptcy risk. Credit risk arises when borrowers are unable to meet their debt obligations on time, resulting in financial losses for the bank. Liquidity risk occurs when a bank is unable to meet short-term withdrawal requests from customers or is unable to provide short-term loans. Bankruptcy risk arises when a bank is unable to meet long-term debt obligations or experiences a significant decline in asset value.[8]

Thus far, many studies have been conducted to assess the impact of digital transformation on the risk acceptance behavior of banks, and the results of these studies are not consistent. Some studies suggest that digital transformation has altered the business model of banks and increased their risk-taking levels.[5] This can be explained by the continuous development of digital technologies, particularly financial technology, which has led to the establishment of market-driven interest rates, thereby changing the capital structure of commercial banks and increasing their debt servicing costs.[3] To cope with rising costs, banks often invest in higher-risk projects that yield higher returns. Furthermore, digital transformation facilitates easier access to financial resources, extending to areas that traditional financial institutions could not reach, such as underqualified loan applicants and small and microenterprises.[17] As a result, large amounts of capital are being redirected to online platforms, bypassing traditional financial institutions like commercial banks. This impacts the core profit-generating activities of commercial banks, especially lending activities.[6] Additionally, recurring payments such as electricity, water, gas, insurance, and capital, which are typically paid through banks, may be replaced by Fintech organizations, potentially affecting the revenue generated from providing these services.[18] Therefore, to offset these declining profits, banks may increase their involvement in high-risk investment activities.

In contrast to the above view, some other studies have shown that the process of digital

transformation may reduce the risk-taking behavior of commercial banks by improving the information asymmetry between customers and banks, reducing transaction costs, enhancing credit risk management, and increasing stability in operations.[7,8] The development of financial technology can help save or replace basic production factors such as capital, labor, and land, thereby reducing the operational costs of commercial banks. As a result, banks are forced to innovate their business models, offer online products and services, open new markets, attract more customers, and enhance business efficiency. When operational efficiency improves, banks tend to reduce high-risk acceptance behavior.[9] Additionally, when digital transformation occurs rapidly, it creates conditions for banks to accumulate net income and reduce the tendency to allocate capital to high-risk projects, thus promoting financial technology innovation and activity diversification while simultaneously reducing high-risk acceptance behavior. In terms of risk management, commercial banks can leverage digital technologies to improve efficiency, accuracy, timeliness, and stability in risk management activities, especially in identifying and assessing risks. Digital technologies help banks overcome time and space limitations, expand customer reach, and diversify data sources, thus effectively addressing issues such as information shortages and untimely updates. Furthermore, the application of artificial intelligence and big data can accelerate the intellectualization of risk assessment activities. The enhanced effectiveness of risk management will contribute to reducing high-risk acceptance behavior among bank managers.[9]

In addition to studies that indicate a linear relationship between digital transformation and the risk acceptance behavior of banks, some other studies have highlighted a non-linear U-shaped relationship between Fintech and the risk-taking behavior of banks.[10,11] Specifically, in the early stages, the development of Fintech threatens bank profits and increases their risk acceptance levels; however, as banks begin to collaborate with Fintech companies, this partnership drives technological upgrades, business innovation, and service optimization, which enhances bank stability and reduces risk acceptance behavior. In contrast, there is empirical research that points to the impact of internet finance on the risk acceptance behavior of banks in a U-shaped non-linear form.[19] The authors of this study argue that, in the early stages of internet finance development, commercial banks benefit from reduced management costs and lower levels of risk acceptance; however, as internet finance progresses, capital costs increase, exacerbating the risk-taking behavior of banks.

Studies on the impact of Fintech or digital transformation on the risk-taking behavior of commercial banks often employ various measurement methods to assess the level of digital transformation. These methods include measuring investment costs in technology;[2,20] conducting in-depth interviews and surveys;[21,22] using digital transformation indices from regulatory authorities;[8] and applying Principal Component Analysis (PCA).[3] However, the most commonly used method is "text analysis," which searches for keywords related to digitization in annual reports.[11,23]

Research on the impact of digital transformation on risk, particularly in relation to the risk-taking behavior of commercial banks in Vietnam, is still relatively sparse. Specifically, Hoque et al. used regression methods such as OLS, PCSE, and FGLS to examine the impact of digital transformation on three types of risks faced by commercial banks: credit risk, bankruptcy risk, and liquidity risk. This was based on the Vietnam ICT Index and a dataset from 26 commercial banks in Vietnam over the period 2013–2022. The results indicated that the digital transformation process contributes to reducing bank risks by enhancing risk management capabilities and reducing information asymmetry.[8] Meanwhile, Pham and Nguyen, through a survey of 192 experts working in 18 commercial banks listed on the Vietnamese stock market, demonstrated that digital transformation has a positive impact on the risk management practices of commercial banks (including the three types of risks: credit risk, liquidity risk, and information risk).[13]

2.2. The moderating role of state ownership in the relationship between digital transformation and bank-risk taking

State ownership in the banking sector refers to a form of ownership in which banks are wholly or partially owned by the government, granting the state significant control over the bank's management and operations.[24] State ownership can range from full ownership to partial ownership. This is one of the distinctive ownership structures of banks in many countries, particularly in developing nations, where the banking system plays a critical role in supporting macroeconomic objectives.[25] State ownership in banks is often measured by the percentage of equity held by the government or the number of

board members appointed by the government.[26] Some studies also assess state ownership based on the extent of government intervention in the decision-making processes of banks or the level of financial support provided by the government during emergencies.[27]

State ownership can play a crucial role in stabilizing the financial system, ensuring credit availability for priority sectors, and contributing to broader socio-economic development goals.[28] Banks with state ownership are often expected to prioritize financial stability over profitability, reducing systemic risks through more prudent policies. State ownership profoundly influences the risk-taking behavior of commercial banks.[29] Banks with state ownership generally exhibit lower risk tolerance compared to private banks, as their priorities focus on financial stability and adherence to government policies.[30]

Micco et al.,[31] highlighted that state-owned banks tend to limit high-risk lending and invest less in risky portfolios to avoid potential threats to the financial system. Moreover, due to strict government oversight and the emphasis on prudent governance, state-owned banks often implement more cautious policies in assessing and managing risks.[26] Additionally, government supervision creates an environment where state-owned banks can leverage digital transformation without facing the same pressures to accept risks as private banks.[23] As a result, state ownership may amplify the inverse relationship between digital transformation and risk-taking behavior, as state-owned banks typically prioritize maintaining safety and adhering to government regulations over maximizing profits.[24]

So far, to the best of the authors' knowledge, empirical evidence on the moderating role of state ownership in the relationship between digital transformation and the risk-taking behavior of commercial banks remains limited. Therefore, this study focuses on examining the moderating effect of state ownership on the relationship between digital transformation and the risk-taking levels of commercial banks in Vietnam to address this research gap.

3. METHODOLOGY

3.1. Research data

To clarify the moderating role of ownership structure in the relationship between digital transformation and bank risk-taking, this study employs an unbalanced panel dataset comprising bank-specific characteristics and macroeconomic data. Bank-specific data are obtained from the audited annual financial statements of Vietnamese commercial banks, while macroeconomic data are sourced from the open data repository of the World Bank.

Additionally, to measure the level of digital transformation, the study uses data from the Vietnam ICT Index, provided by the Ministry of Information and Communications. Due to the availability of the ICT Index, the study focuses on data from 27 commercial banks during the period from 2011 to 2021. The selected banks have continuous ICT Index data for at least five years and consistently published clear financial statements during the research period. After collection, the data are cleaned by removing outliers to ensure the reliability of the estimation results.

3.2. Research variables

3.2.1. Dependent variable

The bank risk-taking results from the decision-making process balancing potential risks and expected returns, and it is typically measured using the Z-score.[32–36] A higher Z-score indicates a lower level of risk acceptance.[37,38] The Z-score is calculated as follows:

$$\text{Z-score}_{it} = \frac{\text{ROA}_{it} + \text{Equity}_{it}/\text{Total Assets}_{it}}{\partial \text{ROA}_{it}}$$

Where i represents the bank, t represents the time period, ROA is the return on average assets, and ∂ROA is the standard deviation of ROA. To facilitate interpretation of the research findings, following previous studies, we use the natural logarithm of the inverse of the Z-score (denoted as Z).[37,39,40] A higher Z value implies a higher level of risk acceptance by the bank, and vice versa.

3.2.2. Independent variable

To measure digital transformation, Hoque et al.[8] utilized the ICT Development and Application Readiness Index (ICT Index), which is publicly released annually by Vietnam's Ministry of Information and Communications.[41] The Vietnam ICT Index is considered a comprehensive metric of digital transformation, consisting of four main components:

Technical Infrastructure*:* Includes server and workstation infrastructure, communication infrastructure, ATM and POS systems, information security and data protection solutions, and disaster prevention measures.

***Human Resources Infrastructure**:* Includes IT specialists and information security experts.

***Internal IT Applications in Banking**:* Includes the implementation of core banking systems, basic applications, and electronic payment systems.

***Online Banking Services**:* Includes websites, online banking platforms, and e-banking services.

Each of these components is standardized using the Z-score method, consistent with the calculation methodology used in the United Nations' E-Government Development Report.

3.2.3. Moderating variable

To clarify the moderating role of state ownership in the relationship between digital transformation and bank risk-taking, this study introduces a dummy variable for state ownership, denoted as *statedum*. This variable takes the value of 1 if the bank has state ownership and 0 otherwise.

Additionally, an interaction term between state ownership and digital transformation, denoted as *ICTstate*, is included in the model to address the identified research gap and further explore this moderating effect.

3.2.4. Control variables

To account for the factors influencing the dependent variable, the study incorporates both bank-specific characteristics and macroeconomic factors as control variables.

Bank-Specific Characteristics

***Bank size* (SIZE):** According to the "too big to fail" theory, larger banks are more likely to engage in higher-risk projects compared to smaller banks.[42] This tendency stems from their ability to maintain diversified portfolios, access advanced risk management tools, and handle complex financial products.[43] Conversely, smaller banks face stricter regulatory oversight and limited access to capital markets, which often results in lower risk-taking.[44] Thus, SIZE may exhibit either a positive or negative relationship with the dependent variable.

***Cost Efficiency* (CIR):** Cost efficiency, measured by the cost-to-income ratio (CIR), influences a bank's risk acceptance. Poor cost management can pressure banks to adopt riskier strategies to boost income and maintain financial stability.[45] Such strategies may include increased lending or investing in high-risk securities.[46] In contrast, banks with efficient cost management tend to adopt more conservative approaches to risky activities.[47] Therefore, CIR is expected to have a positive correlation with the dependent variable.

***Income Diversification* (DIV):** Income diversification is measured as the ratio of non-interest income to total net income. Banks often diversify income sources by shifting from traditional interest-based revenues to non-interest activities (e.g., fee-based services or investments). While diversification stabilizes revenue flows by reducing reliance on interest margins, it may also increase financial risk.[48] Dependence on non-interest income sources can drive banks to adopt riskier strategies due to market volatility and uncertainty.[49] Hence, DIV is anticipated to positively affect the dependent variable.

***Capital Adequacy Ratio* (CAR):** The capital adequacy ratio (CAR) is a key regulatory tool that sets minimum capital requirements to absorb potential losses. Banks with higher CARs face less financial pressure during crises and are more likely to engage in riskier activities due to their ample capital buffers.[50,51] Thus, CAR is expected to positively influence banks' risk-taking.

Macroeconomic Factors

***Inflation Rate* (INF):** High inflation reduces the real value of debts, encouraging banks to increase lending activities to preserve profit margins.[52] This expansion often leads to higher risk acceptance. Conversely, low inflation typically signals stable market conditions, prompting banks to adopt cautious risk strategies to maintain financial stability.[52] Therefore, INF may have either a positive or negative effect on the dependent variable.

***Economic Growth* (GDP):** Measured by GDP growth rate, economic growth has a dual effect on banks' risk behavior. In the short term, growth improves borrowers' creditworthiness and reduces default risks, leading to lower risk acceptance by bank.[53] However, sustained economic growth and increased competition may drive banks to seek higher returns by investing in riskier projects.[54] Consequently, GDP's relationship with the dependent variable may vary depending on the economic cycle and market conditions.

Table 1 provides a summary of the variables used in this study.

Table 1. Variable Description

Variable		Definition	Measurement
Dependent variable	Z	Bank risk-taking	$Ln[\partial ROA_{it}/(ROA_{it} + Equity_{it}/Total\ assets_{it})]$
Independent variable	ICT	Digital transformation	ICT
Moderating variable	statedum	State ownership	Equal to 1 if there is state ownership; equal to 0 if there is no state ownership.
	ICTstate	Interactive variable	ICT x statedum
Control variables	SIZE	Bank size	Ln(Total assets)
	CIR	Cost efficiency	Cost/Income
	DIV	Income diversification	Non-interest income/Total income
	CAR	Capital Adequacy ratio	(Tier 1 + Tier 2)/ Risk-weighted assets
	INF	Inflation	Annual inflation rate
	GDP	Economic growth	Annual GDP growth rate

3.3. Research Model

Research models in the field of banking and finance often face the issue of potential endogeneity.[55] Therefore, this study employs the Generalized Method of Moments (GMM) regression technique to ensure the reliability of the estimation results.[56,57] For panel data and small sample sizes, the two-step system GMM is considered an effective and reliable estimation method.[55] Additionally, we use the Sargan and Hansen tests to check the validity of the instruments used, and the Arellano-Bond (AR(1) and AR(2)) tests to examine the presence of autocorrelation.

With i representing the bank and t representing the time period (year), the estimation model is as follows:

$$Z_{i,t} = \beta_1 Z_{i,t-1} + \beta_2 ICT_{i,t} + \beta_3 statedum_{i,t} + \beta_4 ICTstate_{i,t} + \beta_5 Biến\ kiểm\ soát_{i,t} + e_{i,t}$$

The model aims to assess the relationships between digital transformation, state ownership, and risk-taking while accounting for potential endogeneity through the GMM estimation method.

3. REGRESSION RESULTS

Table 2 shows the descriptive statistics of the study sample, in which bank risk-taking, measured by the Z-score, ranges from 0.64 to 2.54 with a low standard deviation (0.48%); the mean value of the ICT index is 0.51 with a standard deviation of 0.11%. In addition, the Pearson correlation coefficient matrix shows that the phenomenon of multicollinearity among the explanatory variables is insignificant.

Source: Authors

Table 2. Descriptive statistics

Variables	Z	ICT	SIZE	CIR	DIV	CAR	INF	GDP
No. Obs.	290	223	290	290	290	256	297	297
Mean	1.58	0.51	4.94	51.85	15.64	12.24	4.28	6.39
Std. Dev.	0.48	0.11	1.18	9.27	9.11	2.14	2.67	0.73
Min	0.64	0.31	2.58	39.67	5.86	8.34	0.63	5.50
Max	2.54	0.74	7.47	63.83	33.84	15.2	9.09	7.46
Correlation matrix								
Z	1.000							
ICT	-0.138**	1.000						
SIZE	0.101*	0.320***	1.000					
CIR	0.015	-0.311***	-0.457***	1.000				
DIV	0.231***	0.058	0.360***	0.170***	1.000			
CAR	0.116*	-0.118	-0.482***	0.150**	-0.177***	1.000		

INF	-0.143**	-0.078	-0.266***	0.004	-0.059	0.199***	1.000	
GDP	0.111*	-0.275***	0.045	0.043	0.0008	-0.036	-0.387***	1.000

Source: Authors

*Note: ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively.*

Table 3 shows the estimation results using the two-step system GMM method. In general, the regression results show that in all models, the one-year lag variables of the Z indicator are positively correlated and statistically significant at the 1% level; the number of instruments is equal to the number of groups; the p-values of the Sargan and Hansen tests are higher than 0.05; the p-values of the AR(1) tests are less than 0.05 while the AR(2) tests are greater than 0.05. These figures show that the estimation results are consistent and there is no autocorrelation problem. Moreover, the direction of the impact of the explanatory variables is consistent in all models, demonstrating that the estimation results are consistent and reliable.

Table 3. Estimation results by two-step system GMM method

Models	**(1)**	**(2)**	**(3)**
Z_{t-1}	0.8071***	0.7292***	0.9380***
ICT	-0.1356***	-0.2495***	-0.2248***
SIZE	-0.0281***	0.0070	-0.0458***
CIR	0.0113***	0.0064***	0.0039**
DIV	0.0112***	-0.0006	0.0079**
CAR	0.0111***	0.0353***	0.0304***
INF	-0.0179***	0.0003	-0.0096**
GDP	-0.0421***	-0.0269***	-0.0286***
statedum		-0.0461***	-0.2461***
ICTstate			0.5478***
No. Groups	26	26	26
No. Instruments	26	26	26
Sargan test	0.154	0.066	0.308
Hansen test	0.304	0.293	0.345
AR(1)	0.018	0.025	0.023
AR(2)	0.951	0.617	0.592

Source: Authors

*Note: The table above shows the regression results of the impact of digital transformation on the bank risk-taking in Vietnam and the moderating role of ownership structure using the two-step system GMM estimation method. ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels.*

Regarding the impact of digital transformation on risk-taking, the results show that digital transformation has a negative impact on the risk-taking level of commercial banks, meaning that when banks promote digital transformation, the risk-taking behavior tends to decrease. This may be due to the fact that digital transformation helps banks improve their data management capabilities, increase transparency, and control risks through analytical tools and automated reporting systems. Digital technologies such as artificial intelligence, big data, and business process automation allow banks to assess risks in more detail and make safer decisions, limiting high-risk activities.[7–9]

Regarding the role of state ownership in the impact of digital transformation on risk-taking, the dummy variable *statedum* has a negative impact, and the interaction variable *ICTstate* has a positive impact on the dependent variable. This shows that banks with more state-owned capital tend to accept lower risks, and at the same time, state ownership has a positive moderating role, increasing the impact of digital transformation on banks' risk-taking behavior. That is, in banks with high state ownership, the stronger the digital transformation, the more the risk-taking level decreases. This can be explained by the fact that state-owned banks often prioritize financial safety and stability, so they are willing to invest more in technology to control risks and maintain stability for the national financial system.[23,30] In addition, strict supervision from the government and requirements for compliance

with risk management standards also make state-owned banks take full advantage of the benefits of digital transformation to minimize risks.

Regarding the control variables related to bank characteristics, bank size is negatively correlated with the dependent variable, which is due to the fact that large banks, thanks to their abundant financial and technological resources, are able to invest in advanced digital tools, which help integrate sophisticated risk management systems. In addition, they can allocate significant resources, both financial and human, to purchase and operate modern software systems. These systems support credit risk management by improving the accuracy and reliability of credit and investment decisions. Thanks to their ability to minimize errors and optimize processes, large banks tend to accept lower levels of risk than smaller banks, which are limited in resources and the ability to implement complex technological solutions. The remaining factors, including cost efficiency, income diversification, and minimum capital adequacy ratio, all have a positive impact on digital transformation, consistent with the expectations presented above. Regarding the control variables related to macroeconomic conditions, both inflation and economic growth have a negative correlation with the dependent variable. The reason is that during periods of high inflation or strong growth, banks often focus on maintaining financial stability instead of expanding risky business activities. This stems from the precautionary mentality against the risk of recession or financial crisis that may occur when the economic cycle changes. High inflation rates will increase nominal interest rates, increasing the cost of borrowing for borrowers. This can reduce credit demand and increase credit risk due to customers' declining ability to repay debts. In this context, banks tend to limit lending to high-risk investments to avoid bad debt. In addition, during periods of strong economic growth, businesses and individuals tend to have better financial capacity, reducing the risk of default. This leads to a safer credit environment, making it less necessary for banks to pursue risk-taking strategies to offset profits.

4. CONCLUSION

This study aims to examine the moderating role of state ownership in the impact of digital transformation on the risk-taking levels of 27 Vietnamese commercial banks from 2011 to 2021. The level of digital transformation is measured using the ICT Index, which is published annually by the Vietnamese Ministry of Information and Communications. The estimation results, obtained through the two-step System GMM method, not only provide empirical evidence of the inverse relationship between digital transformation and risk-taking in the banking sector but also reveal significant differences in this relationship between state-owned banks and private banks. State ownership emerges as a critical moderating factor that strengthens the effectiveness of digital transformation in mitigating risks.

Based on the study's findings, several managerial implications can be drawn:

First, commercial banks should accelerate digital transformation to improve their ability to manage risks. Bank managers should view digital transformation not only as a tool to enhance operational efficiency but also as a means to reduce risk-taking behavior. Banks should prioritize digital solutions such as automated risk analysis systems, artificial intelligence, and big data to support more comprehensive risk-based decision-making.

Second, banks need to design comprehensive risk management frameworks that integrate traditional tools with digital technologies. These frameworks should ensure that risk decisions are consistently monitored, transparently evaluated, and effectively implemented. Furthermore, they should be tailored to the level of state ownership, enabling banks to comply with safety requirements while leveraging digital transformation effectively.

Third, banks must invest in training and developing the competencies of their workforce, particularly in areas related to risk management and technology, in order to maximize the benefits of digital transformation. This ensures that employees can objectively assess risks and minimize errors in the decision-making process.

Fourth, for banks with high levels of state ownership, mechanisms to support digital transformation should be enhanced to optimize its impact on risk control. Regulatory authorities could consider policies that incentivize and provide technical assistance for state-owned banks to leverage technology, thereby strengthening financial safety and creating a more stable and efficient banking system.

Finally, policymakers should carefully determine the appropriate level of state ownership to balance the goals of banking stability with the flexibility and innovation required for effective digital transformation. An optimal level of state ownership can help align

financial safety objectives with the capacity to leverage technology to reduce risks effectively.

This study's sample size is limited and does not encompass all commercial banks operating in Vietnam. Future research should include a more comprehensive sample of Vietnamese commercial banks to enhance the reliability of findings. Additionally, future studies should explore the relationship between digital transformation and risk-taking in other developing economies to provide a broader and deeper perspective on this issue.

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