**DIGITAL TRANSFORMATION AND BANK PERFORMANCE:**

**A STUDY OF VIETNAMESE LISTED COMMERCIAL BANKS**

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**Abstract**

This study is to determine the dynamics of digital transformation as a strategic choice of banks on their performance under constant changes of technology, notably financial technologies and relatively stable market conditions such as macroeconomic policies, legal framework and industry structure. A sample of 23 Listed Commercial Banks in Vietnam was used based on the availability of ICT readiness index as a measure for the banks’ initial stages to prepare for digital transformation journey. Using binary values of 0 and 1 from texts of the annual reports, the banks' decision to implement digital transformation is being measured from 2017 through 2022. The findings show positive relations between ICT and Digital Transformation with Return on Assets. On the other hand, it is suggested that non-linear relationships of ICT, DA, and ROA need to be thoroughly investigated which in turn might set some lights diverse results coming from using DEA methods. At the firm level, Vietnamese banks might want to focus on either organizational level for better management and strategic decisions regarding digital transformation. At sector level, policies are needed to encourage the banks to innovatively employed new technologies while directing these technologies to achieve their business objectives in order to adapt and thrive in the digital age.

**Keywords**: Digital transformation, ICT readiness index, Bank performance, Bank efficiency, Commercial banks.

**1. Introduction**

Since the first banks were born, their business model has always been associated with the use of technology. The latest waves of technological development allow banks to continuously employ more technological resources in their quest for profit. On the other hand, competition has been a key driving force to make banks relentlessly find new ways to produce higher performance. Over the past few years, banks have been extensively engaged with ICT technologies in different forms as a strategic journey to transform themselves into more agile and service-oriented organizations to better serve their diverse customers. Traditional research on bank performance has been taking technology into account as a source of efficiency. Berger and Mester (1997) used three methods to assess banks’ efficiency including cost, profit and alternative profit efficiency. However, their treatment of technology was somewhat exogenous as three measures of bank efficiency were tested in accordance with changes in environment including technology, regulation and market condition. Large number of studies on bank performance have been employed various data envelopment analysis (DEA) methods but the results were often different and difficult to make meaningful managerial decisions as well as conclusive policy suggestions (Eskelinen, 2017). The reasons for this were either that technology innovation was considered exogenously Paradi and Zhu (2013) or that unspecified technology that shape banks’ production possibility frontier was assumed to apply to all banks (Yue, 1992) or that the method of DEA was only able to assess linear relationships between banks’ inputs and outputs of homogenous branch units (Thanassoulis,1999).

Since banks have been ever willing to adopt financial technologies to either improve or innovate their core business activities including payment services, fund mobilizations, credit and lending as well as cross-industry services such as insurance services and investment management (Barroso and Laborda, 2022). The adoption of financial technologies by banks, however, must go through a process called digital transformation. It is necessary to distinguish digital transformation from two related terms which are digitization and digitalization. In many cases of both academic research and industry practice, they are used interchangeably to present a process in which banks implement at different levels and scopes digital related projects. For a business organization, digitization is a process converting data from analog to digital form, and digitalization is the one that partly changes an existing business model to provide more and enhanced business value, while digital transformation is the process that wholly creates a new digital business model from traditional one (O'Leary, 2022).

There are a growing number of studies that have focused on the relationship between digital transformation and organization performance. Bumann and Peter (2016) undertook a comparative analysis of several digital transformation models and frameworks and found that the most common dimensions that digital transformation brings in an organization are strategy, organization, corporate culture, technology and people (customers/employees). Xuanli and Wang (2023) decomposed digital transformation into three dimensions which are strategy transformation, business transformation and management transformation. As for banks, empirical analysis on the impact of digital transformation on bank’s performance of Xiang and Jiang (2023) is typically interesting. They specifically focused on digitalization (or digitization as interchangeable term) as an important source of improvement in the bank’s performance. Of a sample size of 117 Chinese commercial banks for the period from 2014 to 2021, they found the non-linear dynamic relationship between digitization and bank performance in which the former not only inhibits but also facilitates the latter.

The purpose of this paper is to investigate non-linear relationships between digital transformation and bank performance with Vietnamese listed commercial banks. ECB (2010) pointed out that the traditional bank’s performance measurement might not be providing a complete picture of bank. Instead, they argued that a bank’s performance should be defined as “*the capacity to generate sustainable proﬁtability*”. The paper argues that while digitization and digitalization only help the banks at operational and management level digital transformation is the process taking place at all levels of the society and organization and having impact on not only the on technology and business aspects of the organization but also on culture. To achieve sustainable profitability banks might consider the fact that financial technologies that they want to employ are embodied with innovation. At a strategic level a bank must work to bring innovation to its organizational culture, which is largely involved in its human resources, it can experience exponential growth through higher competitive capacities.

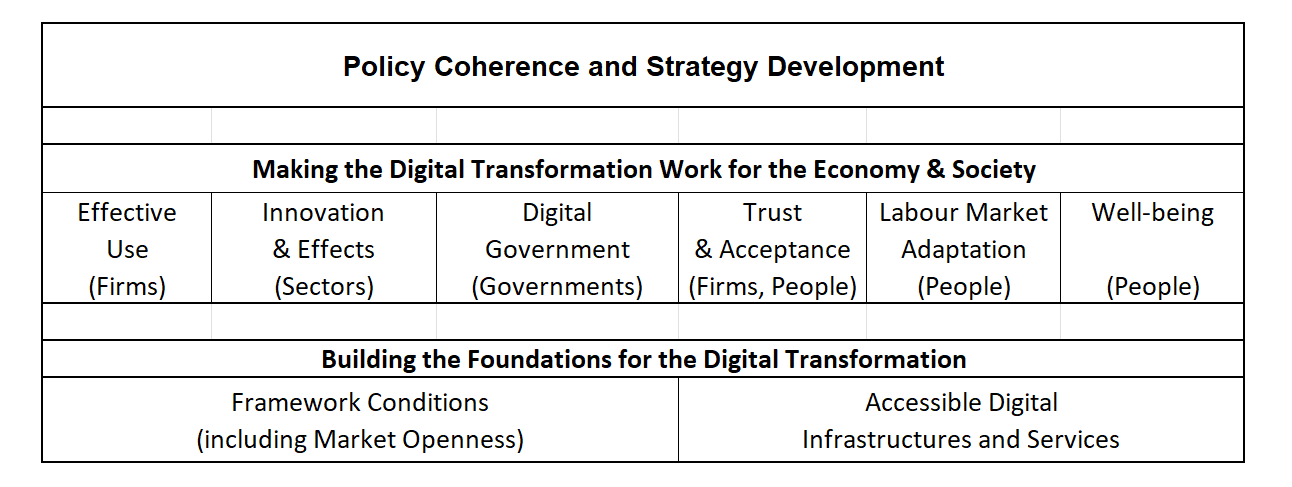
The paper is organized as follows. The next part is to explain a digital transformation framework from national to bank level in which Vietnam and Vietnamese banking sector might partly or fully follow. Come next is presentation of regression model with testing methods. Empirical results and discussion of management and policy implications are discussed in the following part before the paper concludes.

**2. A digital transformation framework for banks in Vietnam**

Since digital transformation is posing challenges to nearly every aspect of the economy and society, a comprehensive response from the government must take into account a wide range of policy agenda. To develop a whole-of-government approach to policymaking, governments must reach across traditional policy silos and different levels of government. While many policies must be considered, the figure below helps to distinguish some key building blocks.

**Figure 1:** OECD’s proposal of preliminary an integrated policy framework

for making the digital transformation work for growth and well-being



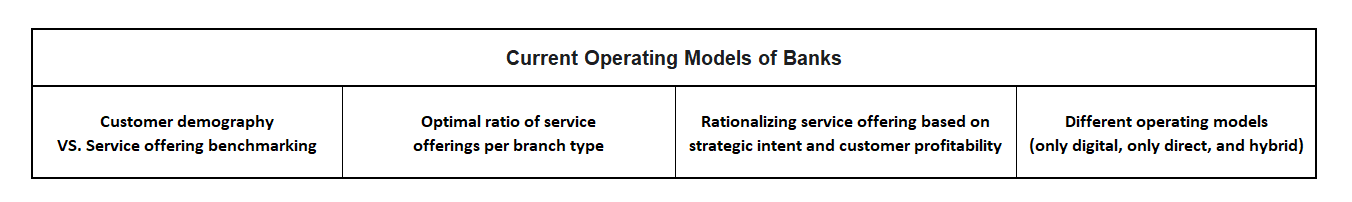
*Source: Reproduced from OECD (2017)*

According to the OECD, a nation can establish the three key building blocks including: “*First*, building the foundations for the digital transformation, including policies that impact the overall enabling environment (including market openness) for digital transformation as well as policies that promote grassroots access to digital infrastructure and services. *Second*, it is requires that making the digital transformation work for the economy and society. This content focuses on policies that enable people, businesses, and governments to effectively use digital technology, as well as policies that promote the activity of digital technology in specific conditioning and policy areas. Additionally, it comprises measures that utilize digital tools to enhance wellbeing, such as granting more equitable access to public services. It also carries policies that promote trust and acceptance, as well as policies that can help all parties, including citizens, workers, and consumers, adapt to digital transformation. And *third*, policy coherence and strategic development, including coordination between ministries and other agencies at all levels of government, as well as the active participation of all key stakeholders in the process of policy development to ensure that all policies are mutually corroborate and aligned with a coherent and unified strategy. In addition, collective action will be needed in several sectors to seize opportunities and meet the changing challenges of the digital economy.”

As pointed out in the above preliminary policy framework for the digital transformation elements, it is important to note that the specific implications of the digital transformation may vary across sectors within one country. Influenced by factors such as economic development, technological progress, trade specialization, and institutional characteristics, each country, including Vietnam, should tailor its policy responses to its unique circumstances and capabilities. In June 2020, Vietnamese government announced Decision No. 749/QĐ-TTg to approve *The National Agenda for Digital Transformation until 2025 with Orientation until 2030*. The agenda directs Vietnamese banks to embrace financial technologies to build digital and innovative banking business models, enriching financial ecosystem and meeting requirements of *The National Strategy for Financial Inclusion until 2025 with Orientation until 2030*.Although digital transformation had been envisaged by numerous commercial banks, implementation of it among banks at the strategic level has not been always obvious. Vietnamese commercial banks undertook a long and painful restructuring program directed by the State Bank of Vietnam in early 2010s after which universal banking models and customer-centric approaches have gradually emerged. The banks therefore would strategically shift to a new banking business model that relies on innovative measures as well as digital means to compete in the marketplace. And working with business consulting firms, big technology companies, and fintech firms through either buy or build models is the ways to achieve objectives.

At the sector level, Vietnamese commercial banks have been undertaking a transition from traditional banking business models to digital one which in turns helps them to realized shifts to more retail banking services as well as to more sources of income from services as compared to traditional interest rate one. The two models are illustrated in figure 2 and figure 3.

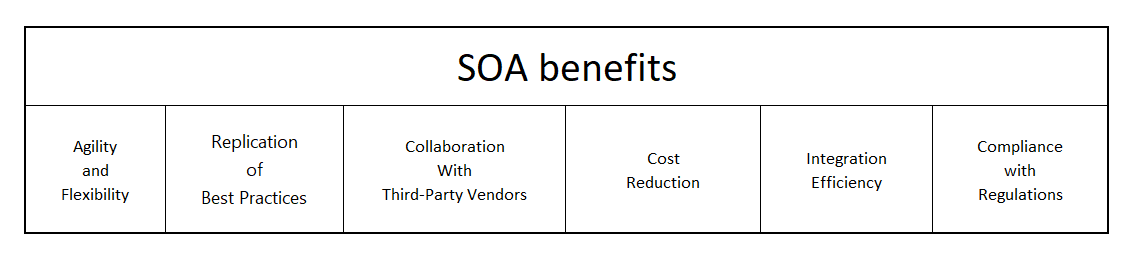
**Figure 2**: The current or traditional operating model of banks



*Source: Reproduced from Capgemini Financial Services Analysis, 2015*

The current operating or traditional model of banks faces several limitations. Firstly, traditional banks often struggle with outdated legacy systems and technology infrastructure, hindering their ability to provide seamless digital banking experiences. Secondly, the branch-centric model may lead to higher operational costs and inefficiencies, as physical branches require significant investment and maintenance. Thirdly, the lack of personalized customer experiences and tailored offerings can lead to decreased customer satisfaction and reduced loyalty. Additionally, the regulatory environment poses challenges, as banks need to navigate complex compliance requirements that can slow down innovation and hinder flexibility. Lastly, the emergence of fintech firms and digital disruptors has increased competition, requiring banks to adapt quickly to stay relevant in the market.

**Figure 3**: Service Oriented Architecture benefits for banks



*Source: Reproduced from Capgemini Financial Services Analysis, 2015*

From the traditional model, through digitization, digitalization and especially digital transformation, banks can shift to the service-oriented business model that is mainly based on digital technologies. According to Capgemini (2015), service-oriented architecture (SOA) is a design framework for integrating applications that connects business objectives to the IT infrastructure. It aligns IT capabilities with organizational goals and provides a technically adaptable infrastructure to swiftly respond to necessary changes. SOA offers flexibility through automation of infrastructure and essential tools, resulting in reduced integration costs and efficient coordination. SOA guarantees the seamless integration of various IT systems within a bank without incurring additional time or cost requirements. A well-crafted and executed SOA allows banks to undertake multiple smaller integration projects with less capital investment, as opposed to the high investment associated with the traditional legacy overhaul of IT architecture.

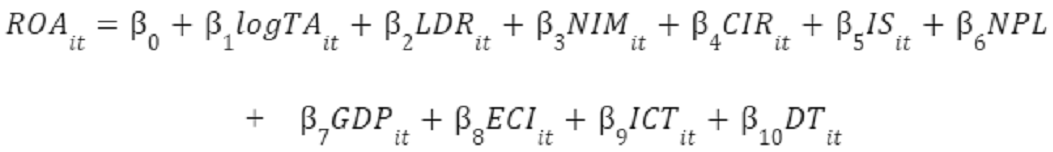
The benefits of introducing SOA strategy are multiples. First, SOA gives banks the capacity to respond swiftly and effectively to shifting market circumstances in constantly changing sectors. Second, replication of best practices and enhancement of development processes are made possible by the creation of standardized services. Third, collaboration with third-party vendors will be facilitated by standardized application programming interfaces. Fourth, banks can improve their back-office performance while reducing IT maintenance costs by switching to a common standard. Fifth, the highest level of efficiency is guaranteed by the use of widely accepted standards for interoperability between IT systems. And sixth, core banking systems with standardized SOA directly address banks' concerns about compliance and regulation. Given this practical benefits framework, banks would be able to synchronize its three domains including business, technology and innovation into one feasible and tractable digital strategy. In May 2021, the State Bank of Vietnam approved *the* *Plan for digital transformation in banking sector until 2025 with Orientation until 2030*. Data collected from Vietnamese listed commercial banks’ annual reports has proved that all observed banks have already taken a journey to digital transformation as

**3. Methodology and results discussion:**

## **3.1 Model**

The research on the impact of digital transformation on banking operations is still conflicting. Using a sample of 737 European banks from 1995 to 2000, Beccalli (2009) found no statistically significant link between digital transformation and bank performance. Beccalli's findings were recently confirmed by Xin and Choudhary (2019). Their data, in particular, suggest that increased IT spending does not always translate into increased revenue. Valverde et al. (2020), on the other hand, show that bank IT investment has a positive impact on end users and increases their use of financial services, not just productivity. The study of 13 Vietnamese commercial banks by Do et al. (2022) found that the digital transformation variable has a positive impact with a significant level of 1% and that digital transformation positively affects the performance of Vietnamese commercial banks. In terms of goals and concepts, digital transformation uses digital technology to create new business models and add value to the organization. However, not every company that uses digital transformation achieves the desired results. Although businesses are enthusiastic about sales activities, successful implementation is a critical issue that must be addressed in order to achieve accurate results (Kane et al., 2015). Many businesses will benefit from significantly lower operating costs due to issues with switching costs, workforce, and time (Zhai et al., 2022). Furthermore, the article on the impact of digital transformation on bank performance in Vietnam from 2015 to 2021 found that digital transformation, via return on assets and return on equity, has a negative impact on bank performance (Nguyen et al. 2022). In contrast, El-Chaarani and Abiad (2018) discovered that the impact of technological innovation on the performance of Lebanese banks is critical for bankers, investors, and even customers. Regarding the ICT index, Aguegboh et al. (2022) found that ICT has a large impact on bank performance in the short term; in the long term, these investments become very beneficial to improve bank performance.

To investigate the influence of digital transformation on bank performance, the researchers formulated the following empirical model for estimation.



To emphasize the important of technology-related impacts on the performance of banks, we have selected three groups of independent variables. Annual rate of growth (GDP) and logarithm of “stock” exchange capitalization index (ECI) are control variables, representing macroeconomic conditions. Traditional bank performance variables are logarithm of banks’ total assets (TA), banks’ loans to deposits ratio (LDR), banks’ net interest margin (NIM), banks’ cost to income ratio (CIR), banks’ income structure (IS), and banks’ non-performing loan (NPL) that helps to capture on different aspects such as operational efficiency, risk profile and income. Banks’ digitization and digitalization are measured by ICT, a compounding index published annually by the Ministry of Information and Communications. This provides interesting information of how far a bank has implemented digitization and digitalization in its organization. On the other hand, digital transformation (DT) shows a shift banks’ strategy for them to officially start the journey. It has value 0 if observed years do not have phrase “digital transformation” in the annual report while equals 1 otherwise. Finally, return on assets (ROA) is a measure of the banks’ performance.

**3.2 Data and estimation**

Turning our attention to the sample utilized in our research, our rigorous selection process initially identified 23 Vietnamese listed commercial banks as potential candidates from the broader population. It's noteworthy that we excluded several banks due to missing data during the stipulated research period, which spanned from 2017 to 2022. Consequently, our final dataset consisted of 22 out of the original 30 Vietnamese listed commercial banks, yielding a total of 138 bank-year observations for our analysis. This meticulous selection process ensured the integrity and reliability of our research findings. The selection of sample was made available when we could explore deeper in the banks’ activities on digitization and digitalization. The independent variable ICT presented in the "*Report on Readiness Index for Vietnam's ICT Application and Development*," is a critical annual publication by the National Steering Committee for Information Technology and the Ministry of Information and Communications. This index serves as a pivotal indicator, offering insights into the technological readiness and infrastructure in Vietnam with regard to the processes of digitization and digitalization. The ICT Index comprises four sub-categories including Technical Infrastructure Index, Human Resources Infrastructure Index, Internal Banking Applications Index, and Online Banking Services Index. These sub-indices collectively evaluate and reflect Vietnamese banks’ state of readiness and development in the field of information and communication technology.

In order to select the most suitable regression model for our dataset, a series of tests were conducted to compare the effectiveness of three models: Pooled Ordinary Least Squares (OLS), Fixed Effect Model (FEM), and Random Effect Model (REM). When comparing OLS to FEM, we utilized an F test to determine that the FEM model was more appropriate. Similarly, when comparing OLS to REM, we employed the Breusch and Pagan Lagrangian multiplier test for random effects, yielding the result that the REM model was more efficient than OLS. Finally, to compare FEM and REM models, the Hausman test was applied, leading to the selection of the most suitable model, which was REM.

After selecting the most suitable model, it is necessary to examine whether that model exhibits any flaws or deficiencies through a series of tests, including the Wooldridge test for autocorrelation in panel data and the Breusch and Pagan Lagrangian multiplier test for random effects.The results show that there exists both autocorrelation and heteroscedasticity in the selected model. In that case, it's advisable to address these issues using a method called Feasible Generalized Least Squares (FGLS) regression.

**3.3 Regression results and discussion**

Tables 1 to 3 in the below shows key results from the regression. The overall result is interesting when two traditional and one control variables do not support the expected relationship between Vietnamese listed commercial banks in this sample. On the other hand, two technology-related variables confirm our hypotheses. The ICT's mean value of 0.5167 reflects the average technological readiness across the observed banks, providing an overview of the nation's overall digital infrastructure and development status. The mean value of DT is 0.4928, and it falls within the binary range of 0 and 1. This mean value suggests that, on average, approximately half of the Vietnamese listed commercial banks in our study have implemented a strategic plan for digital transformation, while the other half have not.

**Table 1: Descriptive statistics of variables**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **ROA** | **logTA** | **LDR** | **NIM** | **CIR** | **IS** | **NPL** | **GDP** | **ECI** | **ICT** | **DT** |
| Mean | 0.0123 | 5.2905 | 0.7375 | .03351 | 0.4723 | .08620 | 0.0162 | 0.0574 | 11.526 | 0.5182 | 0.4928 |
| Median | 0.0095 | 5.253 | 0.7448 | 0.0303 | 0.4594 | 0.0748 | 0.0154 | 0.0692 | 15.27 | 0.5167 | 0 |
| Min | 0.0008 | 4.3091 | 0.4441 | .0060 | 0.2271 | 0.0029 | 0 .0050 | 0.0258 | 0 | 0.2527 | 0 |
| Max | 0.0370 | 6.3264 | 1.1233 | .0930 | 0.8745 | 0.3200 | 0.0459 | 0.0802 | 15.763 | 0.7762 | 1 |

For ICT index with the coefficient 0.0041364, we would like to point out that having a well-prepared technical infrastructure, skilled workforce, and internal applications or online services can expedite the digital transformation process, thereby increasing ROA. In a study conducted by Nguyen (2021), which utilized tabular data spanning from 2007 to 2019 for 20 commercial banks listed on the Vietnamese stock market, a comparable outcome was achieved. The research revealed that allocating resources to information technology investments can significantly transform a bank's operational model, leading to enhanced efficiency. Banks possessing substantial financial resources tend to take a proactive approach in intensifying their digital transformation efforts, consequently boosting their overall performance.

### **Table 2: Cross-sectional time-series FGLS regression**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Cross-sectional time-series FGLS regression** | | | | | |
| Chi-square = | | | 1192.84 | | |
| Prob > chi-square = | | | 0.0000 | | |
| ROA | Coefficient | Std. err. | | z | P > |z| |
| logTA | .0004299 | .0006746 | | 0.64 | 0.524 |
| LDR | .0070025 | .0018723 | | 3.74 | 0.000 |
| NIM | .2352651 | .0218531 | | 10.77 | 0.000 |
| CIR | -.0125442 | .0016352 | | -7.67 | 0.000 |
| IS | .0250167 | .0041112 | | 6.09 | 0.000 |
| NPL | -.0274415 | .0172627 | | -1.59 | 0.112 |
| GDP | .0144281 | .0047599 | | 3.03 | 0.002 |
| ECI | -.0000118 | .0000235 | | -0.50 | 0.617 |
| ICT | .0041364 | .0015103 | | 2.74 | 0.006 |
| DT | .0008428 | .0002587 | | 3.26 | 0.001 |
| Cons | -.0028606 | .0044921 | | -0.64 | 0.524 |

As for the impact of digital transformation on bank performance, the coefficient is 0.0008428 means that investing in and implementing digital transformation can yield benefits by optimizing production processes, effectively managing assets, improving customer experiences, and even creating new products and services. All of these factors can lead to an increase in ROA through enhanced productivity and business efficiency. This result is somewhat compatible with the findings of Xuanli and Wang (2023). In their research, they found that the positive effect of digital transformation in banks on ROA in the following year is minor, indicating that the direct improvement of a bank's overall performance through digital transformation is limited.

**Table 3: Summary of conclusions regarding the hypotheses set**

|  |  |  |  |
| --- | --- | --- | --- |
| **ROA** | **Expected** | **Result** | **Significant level** |
| logTA | + | Insignificant | Insignificant |
| LDR | + | + | 1% |
| NIM | + | + | 1% |
| CIR | - | - | 1% |
| IS | + | + | 1% |
| NPL | - | Insignificant | Insignificant |
| GDP | + | + | 1% |
| ECI | + | Insignificant | Insignificant |
| ICT | + | + | 1% |
| DT | + | + | 1% |

Large difference in the coefficient values of ICT and DT also suggests that carefully planned and well organized digital transformation process needs to be accompanied with better in-advance preparations of technological capabilities related to digitization and digitalization by the Vietnamese banks in to enhance efficiency in their various operational, business, legal aspects. Although we intended ICT to present digitization and digitalization at operational level while DT to show strategic level, the overall combined effect of them is far from providing a satisfactory explanation of Vietnamese banks’ behavior related to technology applications. The sample of the selected banks here might provide some important implications. First, it is necessary to continue to explore the non-linear relationship between ICT and DT and of course between DT and performance of banks. Second, lower value of DT coefficient, as an aggregation level of the announced strategy, might not fully expose all internal issues that a bank is having or dealing with. One thing deserves attention is that how the bank’s strategic vision and current’s governance framework is able to cope with changes in technology and competition. Third, dynamic market conditions and the current banking sector’s legal factors perhaps will need to thoroughly be taken into account to assess overall sector performance to provide better policy implications.

It is also interesting to note that three variables LDR, NIM and IS approve the trends happing in the Vietnam banking sector today that they want to shift the businesses to retail-oriented customers and non-interest rates income. Applied technologies with SOA directions also signify mindset changes among the banks towards a more modern banking business model. When banks want to survive or thrive in the today’s fiercely competitive market, they must be able to leverage new technologies, making the business model more agile and adaptive with changes. The efficiency is not only coming from cost reduction measures but is also generated from new services and innovative business models.

**4. Conclusion**

This paper is an attempt to investigate the technological progress and technology applications in the Vietnamese listed commercial banks in the emergence of financial technologies. The relationship between two layers of the on-going processes in banks, namely digitization and digitalization to present operational level as well at digital transformation to present strategic level, and the banks’ performance were incorporated in a model to measure banks’ efficiency. The model also takes into account traditional variables of various studies which are extensively relied on DEA methods. The results of the regressed model show positive relationships between ICT and DT of the observed banks. Although the significance and impact of these two variables on the observed bank’s performance measure are at different levels, it is important to note that the non-linear relationships need to be explored deeper in order to provide management and policy recommendations.

**References:**

1. Aguegboh E. S., Agu C. V. and. V. I. Nnetu-Okolieuwa (2022) *ICT and Bank Performance in Sub-Saharan Africa: A Dynamic Panel Analysis*, Information Technology for Development, Volume 29, 2023 - Issue 2-3
2. Barroso M. and J. Laborda (2022) *Digital transformation and the emergence of the Fintech sector: Systematic literature review*, Digital Business 2, 100028.
3. Beccalli E. (2009). *Does It Investment Improve Bank Performance? Evidence from Europe*,Journal of Banking & Finance*.* 31. 2205-2230.
4. Berger A. N. and L. J. Mester (1997) *Inside the black box: What explains difference in the efficiencies of financial institutions?* Journal of Banking &Finance 21, 895-947
5. Bumann, J.and M. K. Peter (2016) *Action Fields of Digital Transformation—A Review and Comparative Analysis of Digital Transformation Maturity Models and Frameworks,* Innovation und Unternehmertum, Band 2, Edition Gesowip.
6. Capgemini *(2015) Report of Financial Services Analysis*, https://www.capgemini.com/
7. Do T. D., Pham H. A. T., Thalassinos E. I., Le H. A. (2022) *The Impact of Digital Transformation on Performance: Evidence from Vietnamese Commercial Banks*, Journal of Risk and Financial Management, 15(1):21. <https://doi.org/10.3390/jrfm15010021>
8. ECB (2010) *Beyond ROE – How to measure bank performance*, Appendix to the report on EU banking structure, September.
9. El-Chaarani H. and Z. Abiad (2018) *The impact of technological innovation on bank performance*, Journal of Internet Banking & Commerce, 23(3), 1-33.
10. Eskelinen J. (2017) *Comparison of variable selection techniques for data envelopment analysis in a retail bank*, European Journal of Operational Research 259, 778–788
11. Government Decision No. 749 (2020) *The National Agenda for Digital Transformation until 2025 with Orientation until 2030*, https://thuvienphapluat.vn/van-ban/Cong-nghe-thong-tin/Quyet-dinh-749-QD-TTg-2020-phe-duyet-Chuong-trinh-Chuyen-doi-so-quoc-gia-444136.aspx
12. Kane G., Palmer, D., Phillips A. and Kiron, D. (2015) *Is Your Business Ready for a Digital Future?* MIT Sloan Management Review, 56. 37-44.
13. Nguyen T. (2021) *ICT and Bank Performance: Empirical Evidence from Vietnam*, Journal of Contemporary Issues in Business and Government, 27. 4149-4153. 10.47750/cibg.2021.27.02.433.
14. Nguyen T. H. L., Nguyen V. H., Nguyen P. A. and D. Nguyen (2023) *How does digital transformation impact bank performance?* Cogent Economics & Finance, 11. 10.1080/23322039.2023.2217582.
15. OECD (2017) *Going Digital: Making the Transformation Work for Growth and Well-Being*, Meeting of the OECD Council at Ministerial Level, Paris, 7-8 June, www.oecd.org
16. O'Leary D. E. (2022) *Digitization, Digitalization and Digital Transformation in Accounting, Electronic Commerce and Supply Chains* (December 19), USC Marshall School of Business Research Paper Sponsored by iORB, No. Forthcoming, Available at SSRN: <https://ssrn.com/abstract=4307305> or [http://dx.doi.org/10.2139/ssrn.4307305](https://dx.doi.org/10.2139/ssrn.4307305)
17. Paradi J. C. and H. Zhu (2013) *A survey on bank branch efﬁciency and performance research with data envelopment analysis*, Omega, 41, 61–79
18. Thanassoulis E. (1999) *Data Envelopment Analysis and Its Use in Banking*, Interfaces, Vol. 29, No. 3 (May - Jun.), pp. 1-13
19. SBV Decision 810 (2021) *Approval of “Plan for digital transformation in banking sector until 2025 with Orientation until 2030*, <https://thuvienphapluat.vn/van-ban/Tien-te-Ngan-hang/Quyet-dinh-810-QD-NHNN-2021-phe-duyet-Ke-hoach-Chuyen-doi-so-nganh-Ngan-hang-den-2025-474917.aspx>
20. Valverde S., Cuadros-Solas, P. & Rodriguez-Fernandez, F. (2020) *The Effect of Banks' IT Investments on the Digitalization of their Customers*, Global Policy. 11. 9-17. 10.1111/1758-5899.12749.
21. Xiang X. and,L. Jiang (2023) Digitalization and commercial bank performance: A test of heterogeneity from Chinese commercial banks, Finance Research Letters 58, 104303
22. Xin M. and V. Choudhary (2019) *IT Investment under Competition: The Role of Implementation Failure*, Management Science, 65: 1909–25
23. Xuanli X. and S. Wang (2023) *Digital transformation of commercial banks in China: Measurement, progress and impact*, China Economic Quarterly International 3, 35–45
24. Yue P. (1992) *Data Envelopment Analysis and Commercial Bank Performance: A Primer with Applications to Missouri Banks*, Federal Reserve Bank of St. Louis Review, Issue Jan., pages 31-45.
25. Zhai X. and R. H. Nehm (2023) *AI and formative assessment: The train has left the station,* Journal of Research in Science Teaching, 60(6), 1390–1398. <https://doi.org/10.1002/tea.21885>