The Impact of the Level of Digital Transformation on Financial Performance Differences: *Empirical Evidence from Saudi Commercial Banks*[1]

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ABSTRACT

This study aims to analyze the differences in financial performance among Saudi commercial banks according to the level of digital transformation implementation, considering the financial characteristics of each bank as additional explanatory variables. The digital transformation was measured through a merged index consisting of six sub-components: Growth of digital customer base, use of digital banking services, customer satisfaction with digital services, efficiency of digital operations, digital innovation, and compliance with cybersecurity standards. To facilitate the analysis, the level of digital transformation was categorized into three distinct levels: (Low, Medium, and High), based on the combined scores of the sub-components mentioned above. This classification allows for a more detailed comparison of financial performance between banks with different degrees of digital advancement.

The study relied on four key financial indicators: Return on Assets (ROA), Return on Equity (ROE), Earnings Per Share (EPS), and Cost to Income Ratio (C/I) to monitor the differences in financial performance between banks depending on their level of digital transformation. The study also addressed banks' financial characteristics such as capital adequacy ratio (CAR), liquidity coverage ratio (LCR), loan-to-deposit ratio (LDR), Loan Loss Coverage ratio (LLC), and Leverage ratio (LR) to analyze their role in explaining these differences.

The study relied on a quantitative approach, using data for Saudi banks listed on the financial market during the period from 2019 to 2023. The data was analyzed using analysis of variance (ANOVA) to detect differences, and regression analysis to identify the variables that explain the differences in performance.

The results showed that there were statistically significant differences in all financial performance indicators (ROA, ROE, EPS, C/I) attributable to the level of digital transformation, with higher digitized banks achieving better financial performance. Financial characteristics also proved to play an explanatory role in these differences, especially in ROE and C/I, while the relationship between the level of digital transformation and both ROA and EPS were not significantly affected by financial bank characteristics. These findings reflect the importance of understanding a bank's internal financial context when analyzing differences in the level of digital transformation outcomes and support the strategic orientation towards digital investment to enhance efficiency and profitability in the Saudi banking sector.

Keywords: *cost-to-income ratio (C/I), earnings per share (EPS), financial bank characteristics, financial performance, level of digital transformation, return on assets (ROA), return on equity (ROE).*

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1. INTRODUCTION

The global banking industry is undergoing an accelerated digital transformation that is reshaping the way financial services are delivered, enhancing operational efficiency and fostering innovation within the banking system. Digital transformation is powered by artificial intelligence (AI) technologies, including machine learning and big data analytics, to optimize financial processes and boost performance in banks. Digital transformation has gone beyond being a strategic choice to become a competitive necessity, driven by customer expectations and the challenges arising from the changing digital environment (Verhoef et al., 2021).

However, despite this expansion of the digital transformation applications in the banking sector, the relationship between the level of digital transformation and financial performance is still the subject of scientific and empirical debate. Studies have shown mixed results, with some indicating improved operational efficiency and profitability, while others found no significant impact, and some even warned of higher operational costs and risks associated with cyber compliance (Do et al., 2022; Herath & Gamlath, 2025; Porfírio et al., 2024).

This disparity in results raises fundamental questions: Does digital transformation necessarily lead to improved financial performance? Do the results of this performance differ depending on the level of digital transformation? How much influence do banks' internal financial characteristics have in explaining this discrepancy?

When looking at the Saudi experience, questions arise from the observation of discrepancies in the financial reports of banks despite their adoption of digital transformation initiatives. This raises the deeper question of whether these differences are solely attributable to the level of digital transformation, or whether the financial characteristics of each bank play an explanatory role.

Despite the existence of previous studies on the relationship between digital transformation and financial performance in digitally advanced banking environments, these studies did not adequately explain how different levels of digital transformation can reflect on financial performance in an emerging environment such as Saudi Arabia, which is witnessing major economic and legislative transformations under the “Saudi Vision 2030”. Hence, the study attempts to answer: Does the financial performance of Saudi banks differ according to the level of digital transformation, and what role do financial characteristics play in explaining this difference?

Accordingly, this study seeks to construct an explanatory model to analyze how variations in digital transformation levels while controlling for financial characteristics impact the financial performance of Saudi banks.

1.1 Research Problem and Questions

Despite the widespread adoption of digital technologies within the banking sector, the observed differences in financial performance among banks with seemingly similar levels of digital transformation continue to raise important questions. Why do some banks succeed in achieving tangible financial gains from their digital investments, while others fail to realize such improvements?

Previous research has mostly explored the overall relationship between digital transformation and financial performance, without adequately examining how varying levels of digital transformation contribute to performance differences. Moreover, the role of internal financial characteristics such as e.g., Capital Adequacy Ratio, Liquidity Coverage Ratio, Leverage Ratio, Loan-to-Deposit Ratio, and Loan Loss Coverage Ratio in explaining this relationship has received limited attention. These gaps are particularly relevant in the Saudi banking sector, which is undergoing major economic and structural transformations under Saudi Vision 2030. As such, findings from studies in digitally mature banking environments may not be fully generalizable to this emerging context.

This study, therefore, aims to explore how digital transformation levels affect financial performance across Saudi banks and to investigate the extent to which internal financial characteristics influence this relationship.

Accordingly, the study seeks to answer the following questions:

1. To what extent do differences in the levels of digital transformation explain the variation in financial performance among Saudi commercial banks?
2. What roles do internal financial characteristics (e.g., Capital Adequacy Ratio, Liquidity Coverage Ratio, Leverage Ratio, Loan-to-Deposit Ratio, and Loan Loss Coverage Ratio) play in explaining the relationship between digital transformation and financial performance?

1.2 Research Objectives

The study focuses on two main objectives:

1 .To analyze the impact of digital transformation levels on key financial performance indicators in Saudi commercial banks, explaining observed differences based on the degree of digital transformation adopted.

2. To examine how banks' internal financial characteristics (e.g., Capital Adequacy Ratio, Liquidity Coverage Ratio, Leverage Ratio, Loan-to-Deposit Ratio, and Loan Loss Coverage Ratio) influence or moderate the relationship between digital transformation and financial performance outcomes.

1.3 Importance of Research

The importance of this study stems from two main aspects:

First: Academic Significance

This study seeks to fill a knowledge gap in the scientific literature through a rigorous quantitative analysis of the impact of the level of digital transformation implementation on the financial performance of banks, relying on real data from the Saudi banking sector. This analysis is even more important given the wide variation in the results of previous studies on the relationship between digital transformation and financial results, as well as the different economic and organizational contexts in which they were conducted, which limits the possibility of generalizing their results to emerging environments such as Saudi Arabia.

The study also differs from many previous studies by not only proving the existence of a relationship between digital transformation and financial performance but also seeks to understand why this effect varies among banks by including banks' financial characteristics as an explanatory factor that may enhance or weaken the impact of digital transformation, which gives the study a deeper analytical dimension than traditional models. Given the critical role that digital transformation plays in enhancing operational efficiency and profitability in banks, understanding this effect in the Saudi context is a scientific necessity to understand the relationship in depth in a changing regulatory and economic environment.

Second: Applied relevance

This study provides a practical analytical framework that helps decision makers in Saudi banks to assess the feasibility of digital investments and maximize the return from them, by providing reliable quantitative evidence linking the level of digital transformation implementation and financial performance. The results contribute to rationalizing strategic decisions, increasing the efficiency of investment spending, and reducing reliance on ungrounded impressions, which may negatively affect performance. The results of this study are expected to support the efforts of regulators in Saudi Arabia by providing insights that may

help in developing policies for digital banking, achieving a balance between innovation and maintaining financial stability. These insights are particularly important considering the accelerated drive towards digital transformation within the framework of Saudi Vision 2030, and the future challenges that may be associated with it, such as transformation costs and cybersecurity risks, which requires more scientific understanding of the potential financial impacts of this transformation.

1.4 Research Limitations

a) The study is limited to Saudi banks that are listed on the Saudi Stock Exchange (Tadawul) and whose reports have detailed and clear information about digital transformation.

b) The study covers the time from 2019 to 2023, which is considered the period during which Saudi banks witnessed a significant development in the implementation of digital transformation in the Kingdom of Saudi Arabia.

c) This study is limited to analyzing the bank's financial characteristics, which include liquidity coverage ratio, capital adequacy, leverage ratio, Loan Loss Coverage Ratio, and loan-to-deposit ratio. This study does not include organizational factors or other variables that may affect risk management, which limits the scope of the research to financial indicators only.

2. LITERATURE REVIEW AND RESEARCH GAP

The concept of digital transformation in banking has progressed from simple automation to a comprehensive redesign of financial services, incorporating AI, data analytics, and advanced technologies (Dohotaru, Palta, Prisacaru, & Shin, 2025). Scholars define digital transformation as the integration of advanced tech. This transformation integrates technologies such as artificial intelligence, data analytics, cloud computing, and customer-centric platforms to enhance operational capabilities and competitiveness. It is defined as the strategic integration of advanced technologies aimed at improving banking efficiency, agility, and customer experience (Verhoef et al., 2021).

On the other hand, financial performance encompasses profitability, efficiency, and solvency indicators such as ROA, ROE, EPS, and C/I ratio (Berger & Bouwman, 2013). Understanding how these two domains interact is essential to evaluating digital investment outcomes.

The impact of digital transformation on the financial performance of banks has received increasing attention in academic literature over the last decade, as

banking organizations worldwide adopt digital technologies to enhance efficiency and improve service quality. However, researchers have not reached a consensus on the effects of this transformation, reflecting the complexity of the relationship between digital transformation and financial performance indicators.

Several studies indicate that digital transformation has positively contributed to improving operational efficiency, reducing costs, and enhancing customer satisfaction, which in turn has positively impacted banks' financial performance. For example, Lehenchuk, Zeytinoglu, Hrabchuk, Zhalinska, and Oleksich (2023) found that technological innovation contributes to enhancing the efficiency of banking operations and increasing shareholder returns.

Winasis, Riyanto, and Ariyanto (2020) reported that the use of artificial intelligence and machine learning helped reduce operational costs and increase customer satisfaction, leading to improved profitability. At the Asian level, Wu (2024) showed that Chinese banks have benefited from digital transformation to improve their operational performance, and Ashfaq, Nadeem, Qasim, Kamran, and Asim (2024) found similar results in the Pakistani banking sector. Similarly, Alrawashedh and Shubita (2024), in a study conducted in Jordan, found that digital transformation enhanced the customer experience and had a positive impact on financial performance.

On the other hand, some studies have shown a negative or limited impact of digital transformation, especially in the short term, as the cost of digital investment is a major factor in minimizing temporary returns. Shanti, Siregar, Zulbainarni, and Tony (2023) reported that digital transformation may lead to a temporary decrease in profitability due to high start-up costs. Rahmalia, Azman, and Bajuri (2024) found that digital transformation positively affected some indicators, such as the loan-to-deposit ratio (LDR), but did not have a clear impact on return on equity (ROE). Coryanata, Ramli, Puspita, and Halimatusyadiah (2023) showed that digital transformation in Indonesian banks may be associated with a lower return on investment (ROI), indicating that the effect is not always positive. Furthermore, some studies have emphasized that the impact of digital transformation varies depending on the characteristics of the bank itself. For example, Yang and Masron (2023) showed that banks that integrated financial inclusion into their digital strategies achieved better financial performance compared to banks that adopted digital transformation without modifying their organizational structure. Nguyen-Thi-Huong, Nguyen-Viet, Nguyen-Phuong, and Van Nguyen (2023), in a study conducted in Vietnam,

found that contingencies such as the COVID-19 pandemic may play a role in determining the effectiveness of digital transformation, making the impact vary across banks. Albinali and Ghosh (2023) found that the bank's internal structure, the level of acceptable risk, and management policies play a crucial role in converting digital investment into tangible returns. Aldosari (2018) also highlighted the differences between conventional and Islamic banks in Saudi Arabia in terms of their response to digital transformation during crises.

Yoon, Lee, and Oh (2023) showed that financial bank characteristics such as capital adequacy, previous levels of profitability, and cost structure directly affect the results of digital transformation. Rahman, Rahiman, Meero, and Amin (2023), in their study on Islamic banks, also confirmed that organizational culture and organizational maturity influence how digital transformation is leveraged to achieve improved financial performance.

In the Saudi context specifically, Ramady (2021) explained that the new policy environment under Saudi Vision 2030 provided support for digital transformation; however, banks' financial performance did not exhibit uniform improvement due to varying technological and financial capabilities. Similarly, Banerjee, Majumdar, and Albastaki (2022), in a regional study of the UAE, showed that the success of digital transformation varies depending on the extent to which a bank's corporate identity is digitally aligned. The Nigerian experience, as reported by Kolawole, Muritala, Akande, and Adekunle (2024), indicates that digital transformation does not necessarily lead to a direct improvement in financial performance, but rather depends on the bank's flexibility and ability to adapt to the new digital architecture.

Considering the above, the relationship between digital transformation and banks' financial performance remains a subject of debate. While some studies report a positive effect, others find negative or limited impacts. Moreover, the Saudi banking environment has not received sufficient academic attention, despite undergoing significant transformations under Saudi Vision 2030 and experiencing substantial disparities in digital adoption and financial capabilities.

Despite a growing body of research on digital transformation in global banking contexts, there remains a lack of empirical studies that capture the unique dynamics of the Saudi banking sector. This sector is currently undergoing regulatory changes under Vision 2030 and is characterized by varying levels of digital adoption and financial structures. Most existing studies either generalize findings from advanced economies or fail to consider internal financial

characteristics as explanatory variables in assessing the impact of digital transformation.

This study addresses this gap by constructing a composite digital transformation index to empirically test its effect on financial performance measures within the Saudi context. Accordingly, there is a pressing need for an analytical framework that combines precise measurement of digital transformation levels with an evaluation of bank-specific financial characteristics. This will help explain inter-bank differences in financial performance outcomes particularly in a context like Saudi Arabia, which is witnessing rapid digital acceleration in the absence of rigorous performance evaluation.

Therefore, this study contributes to bridging the existing research gap through a quantitative investigation of digital transformation levels in Saudi banks and their linkage to financial performance indicators. It also considers the role of internal bank financial characteristics as explanatory variables for the differential effects of digital transformation. Rather than simply asking whether digital transformation impacts financial performance, this research seeks to understand why similar digital strategies yield divergent outcomes across banks, depending on their financial structures and operational readiness. The study evaluates not only the existence of digital transformation but also its effectiveness and efficiency in delivering tangible financial value. These mixed findings highlight the need for context-specific analysis, particularly in emerging economies such as Saudi Arabia.

3. THEORETICAL FRAMEWORK AND HYPOTHESIS DEVELOPMENT

3.1 Digital Transformation in Saudi Banks under Vision 2030: Government Support, Challenges, and Recommendations

Saudi Arabia has launched several national programs to promote digital transformation across sectors. The most prominent among them is the National Transformation Program (NTP), which aims to enhance digital services in government institutions and encourages banks to adopt innovative digital solutions to improve operational efficiency and competitiveness. These initiatives align with Vision 2030, a strategic framework targeting economic and social transformation in the Kingdom, including the financial and banking sectors (Ministry of Communications and Information Technology [MCIT], 2022; Thompson & Quilliam, 2024).

The government has also restructured ministries and established specialized agencies to support digital transformation, helping banks adapt to emerging technologies and improve operational flexibility (Thompson & Quilliam, 2024). Digital transformation, driven by advanced technologies such as artificial intelligence (AI), big data, and blockchain, offers immense potential to transform banking operations and aligns with the goal of creating a knowledge-based economy under Vision 2030 (Muafa, Al-Obadi, Al-Saleem, Taweili, & Al-Amri, 2024).

In this context, the digital transformation of banks in Saudi Arabia has become one of the key pillars of the national strategy. It includes the development of regulatory frameworks, enhancement of digital infrastructure, and encouragement of financial technology innovation. These efforts contribute to financial stability, economic competitiveness, and the ability of the banking sector to meet emerging challenges. For instance, Saudi Arabia has adopted international regulatory approaches such as the UK's "Protection Approach" while ensuring compliance with Shariah principles in financial services (Hariri, 2023).

Additionally, the government has invested in high-speed internet infrastructure, cloud computing, and smart cities, all of which support large-scale digital transformation in the banking sector (Hashim, 2024). It also provides financial and regulatory support for digital entrepreneurship and FinTech development through targeted programs and incentives (Alrsheedi & Iskandar, 2025).

FinTech plays a critical role in enhancing customer experience, building loyalty, and ensuring long-term financial sustainability for banks (Aldaarmi, 2024). To support this ecosystem, the government has launched training and development programs aimed at enhancing the digital competencies of Saudi youth. Initiatives like *"Yenmi"* serve as successful models for preparing nationals to participate effectively in the digital economy (Jones & Punshi, 2024).

Despite these advancements, Saudi banks continue to face challenges in integrating digital tools into their core operations. Nevertheless, government support through infrastructure investment and national initiatives is a key enabler in helping banks overcome these challenges (Asem, Abdullah, Mohammad, & Ziyad, 2024). Banks are still required to proactively develop customer-centric innovations and balance regulatory guidance with operational flexibility to ensure sector stability and adaptability in the face of ongoing digital disruption.

However, banks must take proactive steps to develop and find innovative solutions in line with the needs of customers and market requirements to achieve a balance between government guidance and institutional flexibility, which enhances the stability of the banking sector and its ability to adapt to any changes, ***including the most important of these challenges:***

3.1.1 Technological challenges

Saudi banks face multiple technological challenges in the process of digital transformation, most importantly the increased cybersecurity risks due to the high reliance on digital platforms, which increases the likelihood of exposure to cyber-attacks and requires advanced security systems to protect data (Ononiwu et al., 2024).The integration of new digital systems with legacy systems causes technical complexities that negatively impact operational efficiency (Simuchimba & Mpundu, 2024). In addition, the lack of digital skills among employees is a major challenge that hinders the effective use of new technology (Ononiwu et al., 2024).

3.1.2 Cultural challenges

One of the most important cultural challenges facing banks is the staff's resistance to change, which hinders the rapid adoption of digital solutions and creates hesitation within organizations (Simuchimba & Mpundu, 2024). Some institutions also lack an organizational culture that supports innovation and flexibility, which weakens their ability to adapt to rapid digital transformations (Gong, 2024).

3.1.3 Organizational challenges

Organizational challenges are the difficulty of continuously complying with changing regulations, which adds an additional burden to digital transformation processes (Simuchimba & Mpundu, 2024). In addition, some studies have shown that there is ambiguity in the legal framework for protecting consumer rights in the digital environment, and poor coordination between different regulators, which negatively affects building trust with customers (Aljudaibi & Amuda, 2024).

Based on the identified challenges, the following strategies are proposed to strengthen digital transformation in Saudi banks:

***Technological solutions*:** Saudi banks can enhance their cybersecurity by adopting advanced technologies such as artificial intelligence for early detection of threats and implementing high security standards (Alotaibi, 2024).

Modernizing the technological infrastructure and replacing legacy systems with systems compatible with new digital solutions improves efficiency and reduces downtime (Al-Ansi, Garad, & Jaboob, 2024). To overcome the skills shortage, intensive training programs should be implemented to develop employees' digital capabilities in line with the requirements of the new phase (Na Ayudhya & Plangsorn, 2024).

Cultural solutions: Addressing cultural challenges in banking organizations requires the implementation of effective management strategies that engage employees and raise their awareness of the importance and benefits of digital transformation. Equally important is fostering a culture of innovation that encourages interaction with technology and embraces flexibility, thereby creating a work environment supportive of transformation (Ajayi-Nifise, Odeyemi, Mhlongo, Ibeh, Elufioye, & Falaiye, 2024).

Organizational solutions: Regulatory challenges require a periodic review of the legal framework in line with technological developments, and ensuring clarity of legislation related to customer protection in the digital environment (Aljudaibi & Amuda, 2024). It is also recommended to strengthen cooperation with FinTech companies to support innovation, improve operational efficiency, and develop new services that meet legal requirements (Miguel & Algarvio, 2019). In addition, global regulatory best practices, such as those adopted in the UK, can be adopted to provide a balance between regulatory compliance and innovation (Freij, 2020; Hariri, 2023).

3.2 Digital transformation, financial performance, and financial characteristics of banks

Incorporating financial characteristics into the study of the relationship between digital transformation and financial performance is essential to ensure the accuracy of the analysis and provide a comprehensive view of the factors affecting banks' performance. By considering these characteristics, it is possible to assess the extent to which digital transformation affects financial stability and efficiency of banking operations. In this context, five key financial characteristics have been identified that contribute to explaining the relationship between digital transformation and financial performance: Capital Adequacy Ratio (CAR), Liquidity Coverage Ratio (LCR), Leverage Ratio (LR), Loan-to-Deposit Ratio (LDR), and Loan Loss Coverage Ratio (LLC).

Based on recent literature on digital transformation and financial performance in the banking sector, banks' financial characteristics as explanatory variables in

analytical models are a necessary methodological measure to ensure the accuracy of estimates and to separate the true impact of digital transformation from institution-specific structural effects. Several studies have shown that variables such as capital adequacy, Liquidity Coverage Ratio, bank size, and Loan Loss Coverage Ratio are internal structural factors that can cause significant variation in financial performance outcomes, regardless of the level of digital transformation adoption (Do, Pham, Thalassinos, & Le, 2022; Porfírio, Felício, & Carrilho, 2024; Zhou, Zhang, & Tang, 2023).

Chen and Zhang (2024) emphasize that ignoring these characteristics leads to biased results due to the missing variables effect, while Nguyen-Thi-Huong et al. (2023) and Liu, Naveed, Mustafa, and Naveed (2024) used these variables to control bank-specific financial conditions, thus enhancing the reliability of the standard models' results. Hence, employing these characteristics as controllers within the model is an established research direction in contemporary empirical literature. It is important to distinguish between these financial characteristics and factors used as direct indicators of financial performance, such as return on assets (ROA) or cost-to-income ratio (C/I). While financial characteristics are used to measure the ability of banks to maintain financial stability and deal with risks, financial performance indicators are used to measure operational efficiency and profitability and thus represent outputs to be interpreted considering the level of digital transformation.

3.2.1 Capital Adequacy (CAR)

Capital adequacy ratio is a key indicator of banks' stability and ability to face financial risks, as it reflects the extent to which a bank has sufficient capital to protect depositors and comply with regulatory requirements. Studies show that banks with high capital adequacy ratios are better able to bear the costs of digital transformation, such as developing digital infrastructure and enhancing cybersecurity (Wanjiru, Jagongo, & Ndede, 2024). On the other hand, a higher ratio may reduce leverage, which may restrict the realization of high returns (Alnajjar & Othman, 2021). Therefore, the inclusion of this characteristic helps in assessing the impact of capital on digital transformation investments and achieving sustainable financial returns (Charisma, Bramasto, & Nisa, 2022).

3.2.2 Liquidity Coverage Ratio (LCR)

This ratio reflects the ability of banks to maintain sufficient liquid assets to cover their short-term liabilities, which is critical in the context of digital transformation, as digital investments may affect cash flow and liquidity needs.

The literature shows that adherence to LCR standards may contribute to operational efficiency and financial stability (Rajdeep & Patra, 2023). But may also lead to a lower net interest margin, which impacts profitability (Sidhu, Rastogi, Gupte, & Bhimavarapu, 2022). Digital transformation improves liquidity management and reduces liquidity gaps, which enhances the financial stability of banks (Shi & Wu, 2023). Therefore, the inclusion of LCR as a financial characteristic contributes to analyzing the impact of digital transformation on bank liquidity and stability.

3.2.3 Leverage (LR)

Leverage plays a pivotal role in determining banks' ability to finance digital transformation investments and its impact on financial performance. On the one hand, high leverage can enhance return on assets by financing digital transformation projects (Palupi, Al Furqon, Lestari, & Margaretha Leon, 2023). Evidence suggests that digital transformation contributes to revenue growth for banks with balanced funding policies, while public banks may face regulatory constraints that limit their benefit from digital transformation (Kidschun, Gandhi, & Hecklau, 2024). Thus, studying leverage enables understanding the impact of funding on the relationship between digital transformation and financial performance.

3.2.4 Loan-to-Deposit Ratio (LDR)

This ratio reflects a bank's ability to manage liquidity and convert deposits into productive loans. Digital transformation can increase the efficiency of lending operations, which improves the balance in LDR and contributes to increased profitability (Herath & Gamlath, 2025). However, over-reliance on lending without proper management may lead to increased risk, necessitating the inclusion of this ratio to understand the relationship between digital transformation and financial stability (Anggraini & Abidin, 2025; Aryasari & Usman, 2024).

3.2. 5 Loan Loss Coverage Ratio (LLC)

This ratio indicates the ability of banks to cope with irregular loan losses and is an important indicator for assessing credit risk. Digital transformation has been shown to improve the accuracy of credit assessment and reduce non-performing loans, which enhances this ratio and improves financial performance (Yang & Masron, 2023). However, implementing digital transformation without study may increase operational risk, highlighting the importance of LLC study to

understand the impact of digital transformation on financial sustainability (Wang & Wen, 2024).

3.3 Hypothesis Development

Despite the widespread adoption of digital transformation initiatives in the banking sector, questions remain as to whether the level of digital transformation is reflected in significant differences in financial performance between banks. Some studies have indicated a positive relationship between digital transformation and improved financial performance, while others have not been able to demonstrate a conclusive relationship. This discrepancy in results reflects that the impact of digital transformation is not only related to the presence of digital technologies but is also influenced by the degree of digital transformation within each bank, as well as its financial and organizational characteristics.

Some of the characteristics such as: Liquidity Coverage Ratio (LCR), Capital Adequacy Ratio (CAR), Leverage Ratio (LR), Loan Loss Coverage Ratio (LLC), and Loan-to-Deposit Ratio (LDR) are important explanatory variables in analyzing the extent to which banks benefit from digital transformation in improving their financial performance.

Since financial performance is measured across a set of key indicators, this study examines each indicator separately through a separate hypothesis, allowing for an accurate analysis of potential differences given the level of digital transformation and the circumstances of each bank.

Although there are many studies in international banking environments (e.g. China, Indonesia, Jordan, Malaysia), the specificity of the regulatory and economic environment in Saudi Arabia necessitates the need to verify the generalizability of these findings at the local level. Within the framework of Vision 2030, Saudi banks are adopting various digital strategies, making it necessary to analyze the differences in performance based on their levels of digital transformation.

In the Saudi context, where the degree of digital transformation among banks varies because of different resources and technical readiness, the importance of measuring the impact of these differences on financial performance increases, especially considering the strategic directions of Vision 2030.

Based on the above, the study aims to test whether there are statistically significant differences in financial performance among Saudi banks according to the levels of digital transformation, in addition to analyzing the impact of

financial and organizational characteristics in explaining these differences. The main hypothesis of the study can be formulated:

"There are statistically significant differences in financial performance among Saudi banks according to the level of digital transformation, considering their financial characteristics."

Based on recent literature and empirical evidence from previous studies, the following sub-hypotheses can be formulated:

3.3.1 Differences in ROA among Banks by Level of Digital Transformation

Return on assets (ROA) is one of the most important indicators of operational efficiency, as it reflects the bank's ability to convert its assets into profits. Studies such as Aryasari and Usman (2024) and Sezal, Yalçın, and Yenice (2024) have indicated that a high level of digital transformation contributes to improving the efficiency of operations, which reflects positively on ROA. On the other hand, other studies such Cuadros-Solas, Cubillas, and Salvador (2023) show that alternative digital finance models in some emerging markets have led to lower ROA due to operational risks and weak regulatory infrastructure. These findings emphasize that the impact of digital transformation on ROA is not static, but is influenced by factors such as the bank's size, asset structure, and level of financial development.

Accordingly, this study argues that return on assets (ROA) is a key indicator to measure the efficiency of banks in using their assets to generate profits, which should be affected by the level of digital transformation by improving operational efficiency and reducing costs. However, the potential impact of this transformation may differ from one bank to another depending on its financial characteristics (CAR, LCR, LR, LDR, LLC). Therefore, the study aims to test whether there is variation in the relationship between the level of digital transformation and ROA among Saudi banks.

Accordingly, the first sub-hypothesis can be formulated as follows:

H1: " *There is a statistically significant difference in the average return on assets (ROA) among Saudi banks according to the level of digital transformation, considering their financial characteristics*.".

3.3.2 Differences in ROE among Banks by Level of Digital Transformation

Return on Equity (ROE) is used as an indicator to measure a bank's ability to generate returns for shareholders. Studies such as Herath and Gamlath (2025)

and Pratiningsih and Wardhani (2024) have shown that banks with a high degree of digital transformation perform better in terms of ROE due to improved operational efficiency and increased non-traditional revenues. However, studies such as Rahmalia et al. (2024) and Putra (2022) suggest that this effect is not evident in undercapitalized banks, implying that a bank's financial characteristics are a critical variable in determining the magnitude of the differences. Given the disparity in resources and capabilities among Saudi banks, testing this relationship locally becomes particularly important.

Accordingly, this study argues that Return on Equity (ROE) is one of the core indicators to assess a bank's ability to generate returns to shareholders and is assumed to be affected by the level of digital transformation through improving operational performance and enhancing efficiency in resource allocation. However, this effect may differ between banks depending on their financial characteristics (CAR, LCR, LR, LDR, LLC). Therefore, the study aims to analyze the extent of variation in the relationship between the level of digital transformation and ROE in Saudi banks.

Accordingly, the second sub-hypothesis can be formulated as follows:

H2: *"There is a statistically significant difference in the return on equity (ROE) between banks according to the level of digital transformation, considering their financial characteristics"*.

3.3.3 Differences in EPS among Banks by Level of Digital Transformation

Earnings per share (EPS) are one of the key indicators that investors are interested in, as it reflects the share of net profit. Chen and Huang (2024) showed that banks that adopted advanced technologies such as artificial intelligence and data analysis recorded a significant increase in EPS as a result of improving efficiency and reducing costs. On the other hand, Nguyen-Thi-Huong et al. (2023) noted that some banks that implemented digital projects without completing the infrastructure or training staff did not benefit financially, resulting in a decrease in EPS. Testing this indicator in the Saudi context is even more important given the diversity of digital transformation strategies among Saudi banks and their differing abilities to realize immediate operational returns from digital transformation.

Accordingly, this study argues that earnings per share (EPS) are one of the most important market indicators that reflect a bank's financial performance from the perspective of shareholders, as it represents the share of net profit per share. Digital transformation is expected to improve EPS by enhancing operational

efficiency, increasing customer satisfaction, and expanding the base of digital services, which could lead to improved revenues and reduced costs. However, this effect may differ among banks according to their financial (CAR, LCR, LR, LDR, LLC). Therefore, the study aims to test whether the relationship between digital transformation and EPS differs among Saudi banks.

Accordingly, the third sub-hypothesis can be formulated as follows:

H3: *"There is a statistically significant difference in earnings per share (EPS) among Saudi banks according to the level of digital transformation, considering their financial characteristics".*

3.3.4 Differences in Cost-to-Income Ratios Among Banks by Level of Digital Transformation

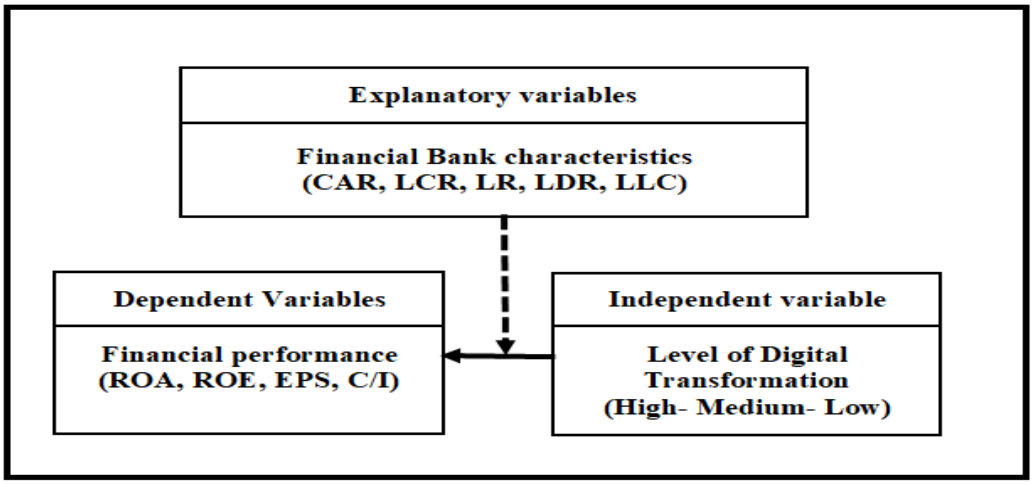
The cost-to-income (C/I) ratio is a critical measure of operational efficiency, reflecting the extent to which a bank can manage its operating expenses relative to its income. Empirical evidence by Ononiwu et al. (2024) suggests that banks which have advanced in their digital transformation efforts tend to achieve lower C/I ratios, indicating improved efficiency. Conversely, findings from Pratiningsih and Wardhani (2024), indicate that some institutions may initially experience an increase in this ratio due to substantial upfront costs associated with digital transformation, particularly infrastructure upgrades and employee training programs. Within the Saudi banking context, observed disparities in capital investment levels among banks underscore the importance of assessing expected variations in the C/I ratio relative to their degree of digital transformation.

Accordingly, this study argues that the cost-to-income ratio is an important indicator for measuring operational efficiency in banks, as it reflects the extent to which the bank can control costs compared to its operating revenues. Digital transformation should contribute to lowering this ratio by reducing operational expenses and improving the efficiency of banking services. However, this effect may differ between banks depending on their financial characteristics such as capital adequacy and liquidity. Thus, the study seeks to test whether the relationship between the level of digital transformation and the efficiency ratio varies according to the characteristics of Saudi banks.

Accordingly, the fourth sub-hypothesis can be formulated as follows:

H4: "*There is a statistically significant difference in the ratio of costs to income among Saudi banks according to the level of digital transformation considering their financial characteristics*".

The analytical model for examining differences in financial performance based on the level of digital transformation and banks' financial characteristics can be illustrated as follows:



Source: prepared the researchers

4. DATA AND METHODOLOGY

The study aims to provide empirical evidence from Saudi banks on the impact of the level of Digital Transformation on the differences in financial performance among these banks. Due to some limitations in the availability of full digital reports and consistent annual data over the study period. The study sample was selected to include six Saudi banks listed on the Saudi Stock Exchange (Tadawul), based on the availability of full annual financial statements for the period from 2019 to 2023, and the continuity of providing banking services during the study period. The financial data was extracted from the annual reports published on the banks' official websites, in addition to documented data from the Saudi Capital Market Authority website, annual reports issued by the Central Bank of Saudi Arabia, and Mubasher and Arqaam websites. The study relied on these data to test the hypotheses related to the existence of differences in financial performance among Saudi banks according to the level of digital transformation, taking financial characteristics as additional explanatory determinants.

To implement the study's methodological sequence, the study relied on a multi-stage quantitative analysis. In the first stage, a composite index including six measurable sub-indices related to operational, customer, and regulatory compliance dimensions was constructed to categorize banks into three categories in terms of the level of digital transformation: high, medium, and low. In the second stage, descriptive and inferential statistical analysis methods were used to analyze the differences in financial performance (ROA, ROE, EPS, and C/I) between the classified categories, including Two-Way ANOVA to test the existence of statistically significant differences between the levels of digital transformation, as well as regression models to determine the direction and strength of the effect. In the final stage, the banks' financial characteristics (CAR, LCR, LR, LDR, LLC) were incorporated into the regression models to assess the role of these characteristics as explanatory variables in the strength or weakness of the relationship between digital transformation and financial performance.

4.1 Study Variables and Measurement Methods

This study focuses on analyzing the differences in financial performance among Saudi banks according to the level of digital transformation. Accordingly, the study variables were categorized into three main groups: Independent variable, dependent variables, and financial characteristics. These variables are presented as follows:

- ***Independent variable:*** The independent variable in this study is the level of digital transformation, which was measured through a composite index built on a set of dimensions that reflect the scope and depth of the application of digital transformation within banks, Banks were then categorized into three main levels based on their Digital Transformation Composite Index score (high, medium, and low). The measurement tools and sub-indicators used in building this index are summarized in Table No. (1).

Table 1: Independent Variable - The level of Digital Transformation in Banks

Variable	Code	Measurement Method	The studies that addressed the measurement
Growth Rate of the Customer Base	GRB	Number of new accounts opened via digital channels / total number of accounts opened x 100	(Zhang & Li, 2025)
-Percentage of Customers Using Digital Banking Services	PCD	Number of customers using digital services / total number of customers x 100	(Tomar, 2024) (Swapna, Sandeep, & Rao, 2024)
Customer satisfaction level with digital services.	CSL	Calculated using customer surveys and then calculating the average satisfaction	(Tomar, 2024) (Mwakisoba & Meela, 2024)
Efficiency of digital operations	EDO	Total Digital . Transactions / Total Financial Transactions x 100	(Patisahussiwa & Abu Bakar Lahjie, 2024) (Liu et al., 2024)
Innovation in Digital Service Delivery	IDSD	Number of new digital products and services introduced / total products and services offered x 100	(Hoa, Anh, & Ha, 2024)
Compliance With Cybersecurity Standards	CCS	Number of standards adhered to / Total standards issued by the Saudi Central Bank (SAMA) x 100	(Onimisi Dawodu, Omotosho, Akindote, Adegbite, & Ewuga, 2023)

- ***Dependent Variables:*** Dependent variables represent key financial performance indicators, including Return on Assets (ROA), Return on Equity (ROE), Earnings Per Share (EPS), and Cost to Income Ratio (C/I). These indicators are used to monitor the differences in performance between banks during the study period. can be summarized according to Table No. (2)

Table 2: Methods For Measuring The Dependent Variable: Financial Performance

Variable	Code	Measurement method	The studies that addressed the measurement
Return on Assets	ROA	(Net Profit / Total Assets) x 100	(Bousrih, 2023) (Hutapea, 2024)
Return on Equity	ROE	(Net Profit / Total Shareholders' Equity) x 100.	(Barkóciová, Dolná, & Rudý, 2023)
Earnings Per Share	EPS	(Net Profit - Preferred Stock Dividends) / Number of Common Shares.	(Al Frijat & Elamer, 2025)
Cost to Income Ratio	C/I	(Total Operating Expenses / Total Income) x 100.	(Iatzaz Ul Hassan, Wu, & Gates, 2024)

- ***FINANCIAL CHARACTERISTICS:*** To more accurately explain differences in financial performance, the study includes a set of financial characteristics of each bank as explanatory variables. These characteristics include Liquidity coverage ratio, capital adequacy ratio, leverage ratio, loan-to-deposit ratio, and loan loss coverage ratio. These variables are used to determine the qualitative contribution of digital transformation in explaining variation in financial performance, while controlling other influential financial conditions. as shown in Table No. (3)

Table 3: Methods of Measuring Financial Characteristics

Variable	Code	Measurement method	The studies that addressed the measurement
Capital Adequacy Ratio	CAR	(Capital / Risk Weighted Assets) x 100	(Wanjiru et al., 2024)
Liquidity Coverage Ratio	LCR	(High-quality liquid assets / 30-day outgoing cash flows) x 100	(Hou & Yang, 2024)
Leverage Ratio	LR	(Total Assets / Shareholders' Equity) x 100	(Palupi et al., 2023)
Loan to Deposit Ratio -	LDR	(Total Loans / Total Deposits) x 100	(Herath & Gamlath, 2025)
Loan Loss Coverage Ratio	LLC	(Total Non-Performing Loans (NPLs) / Provision for Loan Losses) × 100	(Yang & Masron, 2023)

4.2 Statistical Methods Used in Analyzing Study Data

This study relied on a set of statistical methods using the Statistical Package for the Social Sciences (SPSS.25) program, in order to test the hypotheses related to the existence of differences in financial performance among Saudi banks according to the levels of digital transformation, as well as to examine the relationship between those levels and various financial performance indicators in the presence of a set of additional explanatory variables related to the financial characteristics of the banks. The statistical methods included the following:

- **Descriptive statistical analysis:** It was used to characterize the basic characteristics of the study variables in terms of minimum and maximum values, arithmetic means and standard deviations, which helps to form an initial perception of nature and distribution of the data.
- **Correlation analysis (Pearson correlation coefficient):** It was used to measure the strength and direction of the relationship between the study variables, and to explore the initial correlations between study variables.
- **Normal distribution tests:** To check the extent to which the distribution of the data converges with the normal distribution, supporting the validity of using inferential methods.
- **Variance Inflation Factor (VIF) test:** To check for multicollinearity among the explanatory variables and to ensure that each variable is independent of the other within the regression model.
- **Durbin-Watson test:** Used to detect the presence of autocorrelation between the estimation errors in the regression model, which enhances the reliability of the model and its suitability for analysis.
- **Two-Way ANOVA:** was used as a statistical tool to test the existence of statistically significant differences in financial performance indicators among Saudi banks, according to different levels of digital transformation and some specific financial characteristics. Banks were classified into three main categories based on the level of digital transformation (high, medium, and low), and the differences in their financial performance between these categories were analyzed. This type of analysis is suitable for assessing the overlapping impact of both the level of digital transformation and other financial variables on the variation in financial performance results. Previous studies have shown the effectiveness of this approach in analyzing financial performance in the banking sector, such as Ghosh and Sahu (2021), which used bivariate analysis of variance to measure differences in financial performance among banks based on multiple factors such as financial inclusion and regional characteristics. Similarly, Chen and Huang (2024) applied Two-Way ANOVA to examine the impact of digital innovation on banking efficiency in Asian markets. These studies validate the appropriateness of applying Two-Way ANOVA in this research context.
- **Simple and multiple linear regression analysis:** It was used to measure the impact of digital transformation levels as an independent composite indicator

on various financial performance indicators (ROA, ROE, EPS, C/I). While including banks' financial characteristics as additional explanatory variables. This analysis helps in explaining the differences between banks and determining the strength and direction of the relationship between the variables. This type of analysis is suitable for understanding the differences between banks and identifying the most influential factors in achieving financial performance. Previous studies have indicated the effectiveness of regression analysis in explaining bank performance, such as the study by Do et al. (2022), which used multiple regression models to analyze the relationship between digital transformation applications and the financial performance of banks in different economic contexts.

5. FINDINGS AND DISCUSSION

5.1 Descriptive Analysis of Study Variables

The purpose of the descriptive analysis is to present the nature and distribution of the sample, providing an indication of the characteristics of the study variables and the normality of the data, which in turn affects the reliability of the results. The outcomes of the descriptive analysis of the study variables are demonstrated in Table No. (4).

Table 4: Descriptive Analysis of Study Variables

Variables	Mean	Minimu	Maximum	Standard Deviation
GRB	72.32%	20.00%	99.00%	22.62%
PCD	67.87%	10.00%	98.50%	28.67%
CSL	72.18%	33.20%	99.00%	19.87%
EDO	99.37%	99.00%	100.00%	0.49%
IDSD	99.37%	99.00%	100.00%	0.49%
CCS	70.76%	36.00%	98.50%	16.45%
ROA	1.95%	0.63%	2.76%	0.45%
ROE	14.54%	7.20%	23.87%	4.57%
C/I	33.58%	26.10%	57.60%	5.89%
EPS	2.35%	2.02%	4.24%	1.23%
LCR	183.93%	118.52%	354.00%	50.13%
LR	13.2228%	11.03%	16.28%	1.59244%
LDR	81.87%	74.5%	89%	3.49%
LLC	161.62%	109%	306%	55.105%

Source: Statistical Analysis Results

From the descriptive data analysis, the following insights are evident: The results indicate that there is variation in the digital transformation among Saudi banks, with the mean values of most of the digital transformation indicators reflecting a generally advanced level at the sample level. This disparity supports the study's objective of testing whether differences in financial performance can be explained by different levels of digital transformation. Financial performance indicators and explanatory financial characteristics showed stability and operational efficiency in the banking sector, with notable differences between banks. These differences provide a basis for testing the study's hypotheses related to the relationship between the levels of digital transformation and the variation in financial performance among Saudi banks.

5.2 Tests for Normality of Data Distribution

To assess the normality of the data, the Kolmogorov-Smirnov test was conducted. The results indicated that some variables including EPS, Liquidity Coverage Ratio (LCR), Leverage Ratio, and Loan Loss Coverage Ratio (LLC), did not follow a normal distribution ($p < 0.05$). In response, a logarithmic transformation was applied to these non-normally distributed variables. Logarithmic transformation is a widely accepted method to correct skewness and approximate normality in positively skewed data, especially when preparing data for parametric statistical techniques such as regression and ANOVA. This approach is well-supported in literature, as it helps stabilize variance and enhance the reliability of inferential statistics (Lee, 2020; van Albada & Robinson, 2007). After transformation, the distribution of the variables conformed more closely to normality, thereby justifying the use of parametric tests with increased statistical validity. The results of the Kolmogorov-Smirnov test are shown in Table (5) after performing a logarithmic transformation of the variables:

Table 5: Presents the Results of the Kolmogorov-Smirnov

Variable	Kolmogorov-Smirnov Statistic	
	Value	P-value
GRB	0.196	0.460
PCD	0.224	0.801
CSL	0.115	.200*
EDO	0.406	0.771
IDSD	0.406	0.105
CCS	0.108	.200*
ROA	0.215	0.112
ROE	0.123	.200*
C/I	0.09	.200*

Variable	Kolmogorov-Smirnov Statistic	
	Value	P-value
EPS	0.098	.200*
CAR	0.096	.200*
LCR	0.187	0.890
LR	0.173	0.192
LDR	0.146	0.100
LLC	0.281	.200*

Source: Statistical Analysis Results

The Kolmogorov-Smirnov test results presented in Table 5, following the logarithmic transformation, indicate that the variables now conform to a normal distribution, as all p-values exceed the 0.05 threshold. This confirms the appropriateness of using parametric statistical techniques in subsequent analyses.

5.3 Collinearity Test and Autocorrelation Test

The results are presented in Table No. (6), as follows:

Table 6: Presents the Results of the Collinearity Test and the Autocorrelation Test

Variable	Toleance		(VIF)	
The level of digital transformation	0.408		2.453	
CAR	0.77		1.298	
LCR	0.715		1.398	
LR	0.364		2.750	
LDR	0.742		1.348	
LLC	0.659		1.517	
Durbin Watson Test	Model (1)	Model (2)	Model (3)	Model (4)
	ROA	ROE	EPS	C/I
	1.832	1.981	1.861	1.766

Source: Statistical Analysis Results

Based on the results of the linear interaction and autocorrelation tests, the following conclusions can be drawn:

- VIF (variance inflation factor): All values here are less than 10, indicating no significant multicollinearity issue.
- Tolerance value: Values are high (above 0.1), meaning there is no significant overlap between the independent variables.

- Durbin Watson Test values range between 1.766 and 1.981 across the four models, which is an acceptable value and indicates that there is no strong autocorrelation, which means that the model results are considered reliable in terms of the absence of undesirable effects due to autocorrelation between errors, which enhances the reliability of the model.

The results of the multicollinearity test, assessed through the Variance Inflation Factor (VIF) and tolerance values, indicate that all independent variables exhibit acceptable levels of independence (VIF < 10, Tolerance > 0.1). Furthermore, the Durbin-Watson statistics across all regression models range between 1.766 and 1.981, suggesting no significant autocorrelation. These diagnostic checks confirm the robustness and statistical reliability of the regression models used in the analysis.

5.4 Correlation Analysis Using Pearson's Correlation Coefficient

The study aims to present the Pearson correlation matrix to display the nature of the correlation relationships between the study variables. This helps to understand the strength and direction of the relationship between the variables, providing an initial insight into the form of these relationships. Positive values indicate a direct relationship, while negative values indicate an inverse relationship. The results are shown in Table No. (7).

Table 7: The Results of the Correlation Analysis

Variables	The level of digital transformation	ROA	ROE	C/I	EPS	LCR	LLC	LR	CAR	(LDR)
The level of digital	1									
ROA	0.666	1								
ROE	0.550*	0.826**	1							
C/I	-0.588	-0.759**	-0.677**	1						
EPS	0.768	0.754**	0.713**	-0.832**	1					
LCR	0.267	-0.372*	-0.274	0.213	-0.105	1				
LLC	0.456	0.602**	.638**	-0.265	0.267	-0.366*	1			
LR	-0.488	-0.218	-0.396*	0.104	-0.283	-0.004	-0.301	1		
CAR	-0.086	-0.365*	-0.374*	0.361	-0.18	-0.024	-0.195	0.391*	1	
LDR	-0.314	-0.146	-0.29	0.088	0.033	0.044	-0.422*	0.356	0.179	1

Source: Statistical Analysis Results

(*) indicates that the relationship is statistically significant at the 0.01 level (99% confidence).
(**) indicates that the relationship is statistically significant at the 0.05 level (95% confidence).

From the correlation analysis, the following insights are evident:

A. The relationship between digital transformation and financial performance:

- Return on Assets (ROA): There is a strong positive correlation (r = 0.666, p = 0.002) between levels of digital transformation and ROA, indicating that banks with a higher level of digital transformation achieve higher efficiency in the use of assets, which supports the hypothesis that differences in performance are associated with different levels of digital transformation.
- Return on Equity (ROE): There is a positive correlation (r = 0.550, p = 0.013), reflecting that banks that have reached higher levels of digital transformation achieve better returns to shareholders.
- Earnings per share (EPS): The results showed a strong positive correlation (r = 0.768, p = 0.005) between levels of digital transformation and EPS, supporting the hypothesis that digital transformation contributes to improving financial performance by increasing profitability and reducing costs.
- Operational efficiency (C/I ratio): A strong negative correlation (r = -0.588, p = 0.042) emerged, indicating that banks with a higher level of digital transformation achieve higher operational efficiency, as digital transformation contributes to reducing costs and increasing productivity.

B. The relationship between digital transformation and financial bank characteristics:

- Liquidity Coverage Ratio (LCR): The relationship was weakly positive (r = 0.267, p = 0.054), indicating that digital transformation may contribute to improving liquidity, although it is not the main factor.
- Loan Loss Coverage Ratio (LLC): The relationship was moderately positive (r = 0.456, p = 0.002), reflecting that digital transformation may contribute to improving risk management, especially through analytics and AI tools.
- Leverage ratio (LR): The relationship was moderately negative (r = -0.488, p = 0.000), suggesting that digital banks may rely less on debt financing because of enhanced internal operating efficiency.
- Capital Adequacy Ratio (CAR): The relationship was weakly negative (r = -0.086, p = 0.053), indicating that the impact of digital transformation on capital adequacy is limited.

- Loan to Deposit Ratio (LDR): The relationship showed a weak negative correlation (r=-0.314, p =0.041), which may indicate that digital transformation contributes to reducing the risks associated with lending operations compared to available deposits.

Overall, the results of the correlation analysis indicate that the levels of digital transformation play an important role in explaining the differences in financial performance among Saudi banks, where a higher level of digital transformation is associated with better financial and operational results, while its impact remains relatively limited on some aspects such as capital adequacy and liquidity.

6. RESULTS OF THE STATISTICAL HYPOTHESES TESTS

In its statistical approach, this study relies on Two-Way ANOVA as a first step to test whether there are statistically significant differences in financial performance indicators among Saudi banks according to different levels of digital transformation, in addition to the impact of the financial characteristics of these banks. This analysis is suitable for testing significant differences between banks according to two independent variables, which contributes to the verification of the hypotheses related to the impact of the level of digital transformation on financial performance. To explain these differences in more depth, linear regression and multiple regression analysis were used as complementary analytical tools, due to their ability to measure the relationship between the level of digital transformation as an independent composite indicator and various financial performance indicators as dependent outcomes. These statistical analyses also allow the inclusion of a range of financial characteristics of banks as additional explanatory variables, which enhances the understanding of the extent to which digital transformation contributes to explaining the variation in financial performance among banks. In this way, the study combines difference-in-differences and causality testing, which enhances the accuracy of the results and supports their generalizability within the Saudi banking context.

6.1 Results of the First Sub-Hypothesis Test

To test the hypothesis that there are statistically significant differences in the average return on assets (ROA) among Saudi banks depending on the levels of digital transformation taking into account their financial characteristics, analysis of variance was used to test the differences between groups, followed by multiple linear regression analysis to estimate the impact of digital transformation levels on ROA while controlling for explanatory variables thus enhancing the accuracy of the results and contributing to a deeper explanation of the differences.

Results summary

Table 8: Summary of Two-Way ANOVA and Regression Analysis Results for the First Sub-Hypothesis

Partial Eta Squared (η^2)	p-Value	t / F Value	Coefficient /Value	Source/Indicator	Variable /Analysis
0.61	0.004	—	—	Level of Digital Transformation (DT)	Two-Way ANOVA Analysis
0.553	0.032	—	—	Financial Bank characteristics	
0.556	0.017	—	—	Interaction (Digital Transformation × Financial Bank characteristics)	
—	0.194	—	—	Levene's Test for Equality of Variances	
—	—	—	0.606	R Squared	
—	—	—	0.51	Adjusted R Squared	
—	0.000	5.887	1.703	Constant (B_0)	Regression Analysis (Simple)
—	0.002	5.888	1.003	Digital Transformation (DT)	
—	—	—	0.378	R^2	
—	0.003	__	5.789	F Value	
—	0.314	1.030	2.604	Constant (B_0)	Regression Analysis (with Financial Characteristics)
—	0.010	5.941	1.148	Digital Transformation (DT)	
—	0.302	-1.056	0.002-	Liquidity Coverage Ratio (LCR)	
—	0.008	2.895	0.004	Loan Loss Coverage Ratio (LLC)	
—	0.010	1.035	0.002	Leverage Ratio (LR)	
—	0.101	-1.707	0.130-	Capital Adequacy Ratio (CAR)	
—	0.004	2.794	0.018	Loan-to-Deposit Ratio (LDR)	
—	—	—	0.778	R^2	
—	0.001	—	13.517	F Value	

Source: Statistical Analysis Results

First: Results of Two-Way ANOVA

This analysis was used to measure the impact of both the level of digital transformation and financial bank characteristics as independent factors, as well as their interaction, on return on assets (ROA). The results showed the following:

- The effect of the level of digital transformation: The probability value (Sig.) was equal to 0.004, which indicates that there are statistically significant differences in ROA between banks according to the levels of digital transformation. The partial eta squared value (η^2) = 0.61, indicating that 61% of the variance in ROA is attributable to different levels of digital transformation, which is a significant effect size.
- Effect of financial bank characteristics: There is also a significant effect (Sig. = 0.032) with η^2 = 0.553, which means that 55.3% of the variance in ROA can be explained by banks' explanatory characteristics such as liquidity, capital adequacy, etc.
- Interaction between the two factors: The interaction between the level of digital transformation and financial bank characteristics showed statistical significance (Sig. = 0.017), with an effect size of η^2 = 0.556, reflecting that the interactive effect between these two factors accounts for a significant proportion of the explanation of the differences in financial performance, i.e. the effect of one factor changes depending on the other.
- The accompanying hypothesis tests such as Levene's Test showed no significant differences in variance between groups (Sig. = 0.194), which enhances the reliability of the ANOVA results. This non-significant result supports the homogeneity of variances assumption, validating the use of Two-Way ANOVA.
- The value of the adjusted coefficient of determination (Adjusted R^2) was about 0.51, indicating that the model explains more than half of the variance in ROA even after adjusting for effects.

Second: Results of Simple and Multiple Linear Regression Analysis

Two models were applied: The first without introducing explanatory variables, and the second after introducing them. The objective of this analysis is to measure the direct impact of digital transformation levels on ROA while controlling explanatory variables.

In the baseline model (without explanatory variables):

- The digital transformation has a positive and statistically significant effect on ROA (B = 1.003, Sig. = 0.002).
- The R^2 = 0.378, which means that the basic model explains 37.5% of the variance in ROA.

In the extended model (with explanatory variables):

- The effect of digital transformation strengthened after controlling the bank's explanatory characteristics, as the coefficient became larger (B = 1.148) and more significant (Sig. = 0.010).
- The explanatory power of the model increased significantly, with R^2 = 0.778, indicating that 77.8% of the variance in ROA can be explained by the model.
- Among the explanatory variables, the loan loss coverage ratio (LLC) showed significant (B = 0.004, Sig. = 0.008), indicating that it plays an additional role in influencing ROA.

Conclusion: The results of both analyses confirm that the level of digital transformation is a significant factor in explaining the differences in ROA among Saudi banks. Incorporating explanatory characteristics into statistical models enhances the accuracy of the estimates and increases the explanatory power of the model, especially considering the presence of a significant interaction effect between financial bank characteristics and the level of digital transformation. This indicates that the impact of digital transformation on financial performance cannot be separated from the operational and financial context of the bank.

***Supporting Studies*:** The results of this study showed that there are significant differences in return on assets (ROA) among Saudi banks depending on the levels of digital transformation, which is consistent with what Aryasari and Usman (2024) indicated that banks with a high level of digital transformation have higher operational efficiency, which reflects positively on their ability to achieve profits from their assets. Sezal et al. (2024) also confirmed that there is a positive relationship between the level of digital transformation and financial performance indicators, especially under a stable regulatory environment and advanced technical infrastructure. On the contrary, Cuadros-Solas et al. (2023) pointed to mixed results in some emerging markets, where the return on assets of a number of banks declined because of high operational risks and weak regulatory structure, indicating that the impact of digital transformation is not typical, but is influenced by several internal and external factors. This is also supported by this study by highlighting the impact of banks' financial characteristics, such as capital adequacy and liquidity.

Based on the results obtained from the analysis of variance and regression, the first sub-hypothesis, which states that there is a significant difference in return on

assets (ROA) among Saudi banks with different levels of digital transformation considering the banks' explanatory characteristics, can be accepted. The results indicate that digital transformation has a statistically significant effect on ROA, and that this effect differs between banks according to their financial characteristics such as capital adequacy and liquidity level.

Based on these results, the regression model for the first sub-hypothesis can be expressed by the following equation:

$$ROA = 2.604 + 1.048 \times DT - 0.002 \times LCR + 0.004 \times LLC + 0.002 \times LR - 0.130 \times CAR + 0.018 \times LDR$$

6.2 Results of the Second Sub-Hypothesis Test

The hypothesis that there are statistically significant differences in the average return on equity (ROE) among Saudi banks according to the levels of digital transformation was tested through bivariate analysis of variance, followed by applying multiple linear regression analysis to measure the relationship between the levels of digital transformation and ROE, while controlling for relevant explanatory variables.

Results summary

Table 9: Summary of Two-Way ANOVA and Regression Analysis Results for the Second Sub-Hypothesis

Partial Eta Squared (η^2)	p-Value	t /F Value	Sig. Value Coefficient/ Value	Source/Indicator	Variable/ Analysis
0.651	0.011	—	—	Level of Digital Transformation (DT)	Two-Way ANOVA Analysis
0.533	0.04	—	—	Financial Bank characteristics	
0.667	0.041	—	—	Interaction (Digital Transformation × Financial Bank characteristics)	
—	0.302	—	—	Levene's Test for Equality of Variances	
—	—	—	0.611	R Squared	
—	—	—	0.586	Adjusted R Squared	
—	0.006	2.918	7.749	Constant (B_0)	Regression Analysis (Simple)
—	0.012	2.668	0.298	Digital Transformation (DT)	
—	—	—	0.232	R^2	

Partial Eta Squared (η^2)	p-Value	t /F Value	Sig. Value Coefficient/ Value	Source/Indicator	Variable/ Analysis
—	0.012	—	7.122	F Value	
—	0.589	0.548	12.804	Constant (B_0)	Regression Analysis (with Financial Characteristics)
—	0.003	2.937	0.491	Digital Transformation (DT)	
—	0.839	0.205	0.003	Liquidity Coverage Ratio (LCR)	
—	0.006	3.326	0.047	Loan Loss Coverage Ratio (LLC)	
—	0.519	0.655	0.428	Leverage Ratio (LR)	
—	0.068	-1.918	-1.348	Capital Adequacy Ratio (CAR)	
—	0.634	0.482	0.101	Loan-to-Deposit Ratio (LDR)	
—	—	—	0.667	R^2	
—	0.002	—	7.525	F Value	

Source: Statistical Analysis Results

First: Results of Two-Way ANOVA

This analysis was used to measure the impact of both the level of digital transformation and financial bank characteristics as independent factors, as well as their interaction, on return on equity (ROE). The results showed the following:

- The effect of the level of digital transformation: The probability value (Sig.) was 0.011, which indicates that there are statistically significant differences in ROE between banks according to the levels of digital transformation. The partial eta squared value (η^2) = 0.651, indicating that 65.1% of the variance in ROE is attributable to different levels of digital transformation, which is considered a strong effect size.
- Effect of financial bank characteristics: There was also a significant effect (Sig. = 0.04) with η^2 = 0.533, meaning that 53.3% of the variance in ROE can be explained by banks' financial characteristics such as capital adequacy, liquidity, and leverage ratios.
- Interaction between the two factors: The interaction between the level of digital transformation and financial bank characteristics also showed statistical significance (Sig. = 0.041), with an effect size of η^2 = 0.667. This indicates that the interaction between these two factors significantly explains the variance in

ROE, i.e., the effect of digital transformation on ROE changes depending on bank-specific characteristics.

- Levene's Test for Equality of Variances showed no significant differences in variance between groups (Sig. = 0.302), which enhances the reliability and validity of the ANOVA results. This non-significant result supports the homogeneity of variances assumption, validating the use of Two-Way ANOVA.
- The value of the adjusted coefficient of determination (Adjusted R^2) was 0.586, indicating that the model explains approximately 58.6% of the variance in ROE, even after accounting for adjusted effects.

Second: Results of Simple and Multiple Linear Regression Analysis

Two models were estimated: the first without introducing explanatory variables (baseline model), and the second with these variables included (extended model). This approach aims to assess the direct effect of digital transformation on ROE while accounting for key financial bank characteristics.

In the baseline model (without explanatory variables):

- The digital transformation has a positive and statistically significant effect on ROE (B = 0.298, Sig. = 0.012).
- The model explains 23.2% of the variance in ROE (R^2 = 0.232), with a statistically significant F-value = 7.122 (Sig. = 0.012).

In the extended model (with explanatory variables):

- The effect of digital transformation on ROE remained positive and became stronger (B = 0.491) and more significant (Sig. = 0.003) after controlling for bank-specific characteristics.
- The model's explanatory power increased notably, explaining 66.7% of the variance in ROE (R^2 = 0.667), with F-value = 7.525 (Sig. = 0.002).
- Among the control variables, the Loan Loss Coverage Ratio (LLC) showed a significant positive effect (B = 0.047, Sig. = 0.006), indicating its role in enhancing return on equity.
- Other variables, including LCR, LR, CAR, and LDR, did not show statistically significant effects at the 5% level, although CAR approached significance (Sig. = 0.068).

Conclusion: The results from both analyses confirm that the level of digital transformation plays a significant role in explaining variations in ROE among Saudi banks. Moreover, incorporating financial characteristics into the regression model significantly improves its explanatory power. The significant interaction between digital transformation and financial bank characteristics suggests that the impact of digital transformation on financial performance is conditional upon each bank's internal financial structure and operational conditions.

Supporting Studies: Equity (ROE) among Saudi banks based on their level of digital transformation, are consistent with the findings of previous studies. For example, banks with advanced digital infrastructure tend to achieve better ROE performance due to improved cost efficiency and increased income from digital channels (Herath & Gamlath, 2025). A similar positive relationship between digital transformation and ROE was confirmed, especially when supported by sound financial strategies and investment in technology (Pratiningsih & Wardhani, 2024). Conversely, the benefits of digital transformation on ROE are not uniformly realized across all banks, particularly those with weak capital structure or poor risk management (Putra, 2022; Rahmalia et al., 2024).

This reinforces the conclusion reached in this study that the impact of digital transformation on ROE is not homogeneous, but rather shaped by the bank's financial characteristics, such as capital adequacy, liquidity, and leverage factors that were explicitly controlled for in the analytical model. Accordingly, the second sub-hypothesis, which states that there is a statistically significant difference in the return on equity (ROE) among Saudi banks based on their level of digital transformation and financial characteristics, is supported. Based on these results, the regression model for the Second sub-hypothesis can be expressed by the following equation:

$$ROE=12.804+0.491\times DT+0.003\times LCR+0.047\times LLC+0.428\times LR-1.348\times CAR+0.101\times LDR$$

6.3 Results of the Third Sub-Hypothesis Test

To test the hypothesis that there are statistically significant differences in the average earnings per share (EPS) among Saudi banks depending on the levels of digital transformation, a bivariate analysis of variance and then a multiple linear regression analysis were conducted to estimate the impact of digital transformation on EPS, considering the effect of the banks' financial characteristics.

Results summary

Table 10: Summary of Two-Way ANOVA and Regression Analysis Results for the Third Sub-Hypothesis

Partial Eta Squared (η^2)	p-Value	t / F Value	Coefficient / Value	Source / Indicator	Variable / Analysis
0.564	0.002	—	—	Level of Digital Transformation (DT)	Two-Way ANOVA Analysis
0.576	0.45	—	—	Financial Bank characteristics	
0.483	0.09	—	—	Interaction (Digital Transformation × Financial Bank characteristics)	
—	0.188	—	—	Levene's Test for Equality of Variances	
—	—	—	0.471	R Squared	
—	—	—	0.20	Adjusted R Squared	
—	0.04	2.109	2.664	Constant (B_0)	Regression Analysis (Simple)
—	0.003	1.901	2.009	Digital Transformation (DT)	
—	—	—	0.228	R^2	
—	—	—	4.812	F Value	
—	0.009	-0.140	-1.216	Constant (B_0)	Regression Analysis (with Financial Characteristics)
—	0.009	2.120	0.211	Digital Transformation (DT)	
—	0.090	-0.127	-0.001	Liquidity Coverage Ratio (LCR)	
—	0.255	1.167	0.006	Loan Loss Coverage Ratio (LLC)	
—	0.004	-0.926	-0.225	Leverage Ratio (LR)	
—	0.778	-0.286	-0.075	Capital Adequacy Ratio (CAR)	
—	0.003	1.148	0.089	Loan to Deposit Ratio (LDR)	
—	—	—	0.471	R^2	
—	0.005	—	5.794	F Value	

Source: Statistical Analysis Results

First: Results of Two-Way ANOVA

This analysis was used to measure the impact of both the level of digital transformation and financial bank characteristics as independent factors, as well as their interaction, on earnings per share (EPS). The results showed the following:

- Effect of the level of digital transformation: The probability value (Sig.) was equal to 0.002, which indicates that there are statistically significant differences in EPS between banks according to the levels of digital transformation. The

partial eta squared value (η^2) = 0.564, indicating that 56.4% of the variance in EPS is attributable to different levels of digital transformation, which is a significant effect size.

- Effect of financial bank characteristics: The probability value (Sig.) was 0.055, indicating that there is no statistically significant effect of financial bank characteristics (such as liquidity, capital adequacy, etc.) on EPS. However, the effect size (η^2 = 0.576) is moderate, suggesting that while this factor does not have a significant effect, it still contributes to some extent to explaining the variance in EPS.
- Interaction between the two factors: The interaction between the level of digital transformation and financial bank characteristics showed no statistical significance (Sig. = 0.09), although the effect size (η^2 = 0.483) was moderate. This suggests that the interaction between the two factors does not significantly impact EPS, but the relationship is worth considering in further analysis.
- Levene's Test for Equality of Variances: Levene's test showed no significant differences in variance between groups (Sig. = 0.188), which enhances the reliability of the ANOVA results. This non-significant result supports the homogeneity of variances assumption, validating the use of Two-Way ANOVA.
- Adjusted R^2: The adjusted R^2 value was 0.2, indicating that there are limitations in generalizing the model beyond the sample, and a considerable portion of the variance in EPS remains unexplained.

Second: Results of Simple and Multiple Linear Regression Analysis

Two models were applied: The first without introducing explanatory variables, and the second after introducing them. The objective of this analysis is to measure the direct impact of digital transformation levels on EPS while controlling explanatory variables.

In the baseline model (without explanatory variables):

- The digital transformation had a positive and statistically significant effect on EPS (B = 2.009, Sig. = 0.003).
- The R^2 = 0.228, which means that the baseline model explains 22.8% of the variance in EPS.

In the extended model (with explanatory variables):

- The effect of digital transformation remained significant but slightly reduced (B = 0.211, Sig. = 0.009).
- The explanatory power of the model increased significantly, with $R^2 = 0.471$, indicating that 47.1% of the variance in EPS can be explained by the model.
- Among the explanatory variables, the Loan-to-Deposit Ratio (LDR) showed a positive and statistically significant effect (B = 0.089, Sig. = 0.003), indicating its role in influencing EPS.

Conclusion: The results of both analyses confirm that the level of digital transformation has a significant effect on EPS, with the variance in EPS being considerably explained by digital transformation (56.4%). However, financial bank characteristics, such as liquidity and capital adequacy, did not show significant effects, even though they contributed moderately to the model's explanatory power. The interaction between digital transformation and financial bank characteristics also did not significantly impact EPS, suggesting that the effect of digital transformation on financial performance is not dependent on the specific financial characteristics of the bank.

Supporting Studies: The results of this study, which showed significant differences in earnings per share (EPS) among Saudi banks with varying levels of digital transformation, are consistent with previous research. For instance, a study by Chen and Huang (2024) highlighted that banks adopting advanced technologies, such as artificial intelligence and data analytics, experienced a significant increase in EPS, owing to improved efficiency and reduced operational costs. Similarly, Nguyen-Thi-Huong et al. (2023) observed that some banks which implemented digital projects without fully completing their infrastructure or providing adequate staff training did not see a financial benefit, leading to a decline in EPS.

These findings underline the critical role of digital transformation level in improving EPS by enhancing operational efficiency, increasing customer satisfaction, and expanding the base of digital services. However, the effect may vary depending on the financial characteristics of each bank, such as capital adequacy, bank size, and liquidity. The diverse digital transformation strategies among Saudi banks, as well as their varying abilities to capitalize on digital investments, make this study particularly relevant in the context of the Saudi banking sector.

Accordingly, the third sub-hypothesis, which posits that there is a statistically significant difference in earnings per share (EPS) among Saudi banks based on their level of digital transformation, considering their financial characteristics, is supported by the literature. These results highlight the importance of investing in digital transformation to enhance earnings per share, if banks maintain a balanced and sound financial structure to support this transformation effectively.

Based on the analysis of variance and regression results, the third sub-hypothesis is confirmed, and the model for testing the relationship between digital transformation and EPS in Saudi banks can be represented as follows:

$$EPS=-1.216+0.211\times(DT)-0.001\times(LCR)+0.006\times(LLC)-0.225\times(LR)-0.075\times(CAR)+0.089\times(LDR)$$

6.4 Results of the fourth Sub-Hypothesis Test

The hypothesis that there are statistically significant differences in the cost-to-income (C/I) ratio among Saudi banks according to the levels of digital transformation was tested using bivariate analysis of variance, followed by multiple linear regression analysis to estimate the relationship between digital transformation and operational efficiency, while controlling for other financial explanatory variables.

Results summary

Table 11: Summary of Two-Way ANOVA and Regression Analysis Results for the fourth Sub-Hypothesis

Partial Eta Squared (η^2)	p-Value	t / F Value	Coefficient / Value	Source / Indicator	Variable / Analysis
0.438 -	—	—	0.047	Level of Digital Transformation (DT)	Two-Way ANOVA Analysis
0.372	—	—	0.045	Financial Bank characteristics	
0.38	—	—	0.036	Interaction (Digital Transformation × Characteristics)	
—	—	—	0.171	Levene's Test for Equality of Variances	
0.593	—	—	—	R Squared	
0.519	—	—	—	Adjusted R Squared	
—	0.000	9.282	35.287	Constant (B_0)	Regression Analysis (Simple)
—	0.006	-0.47	-0.249	Digital Transformation (DT)	

Partial Eta Squared (η^2)	p-Value	t / F Value	Coefficient / Value	Source / Indicator	Variable / Analysis
			0.278	R^2	
			3.221	F Value	
—	0.93	0.088	3.595	Constant (B_0)	Regression Analysis (with Financial Characteristics)
—	0.008	-0.287	-0.323	Digital Transformation (DT)	
—	0.541	0.621	0.016	Liquidity Coverage Ratio (LCR)	
—	0.005	0.770	0.019	Loan Loss Coverage Ratio (LLC)	
—	0.648	-0.463	-0.527	Leverage Ratio (LR)	
—	0.082	1.816	2.221	Capital Adequacy Ratio (CAR)	
—	0.009	0.171	0.062	Loan to Deposit Ratio (LDR)	
	—	—	0.593	R^2	
—	0.004	—	4.982	F Value	

Source: Statistical Analysis Results

First: Results of Two-Way ANOVA

The effects of digital transformation and independent financial bank characteristics, as well as their interaction, on the cost-to-income ratio were examined. The results showed the following:

- Effect of Digital Transformation Level: The p-value (Sig.) = 0.047, indicating statistically significant differences in the cost-to-income ratio between banks according to digital transformation levels. The partial eta squared value (η^2 = 0.438) indicates that 43.8% of the variance in the cost-to-income ratio can be attributed to the level of digital transformation, reflecting a significant impact.
- Effect of Financial bank characteristics: The p-value (Sig.) = 0.045, indicating that financial bank characteristics (such as liquidity, capital adequacy, etc.) have a significant effect on the cost-to-income ratio. The effect size (η^2 = 0.372) suggests a moderate effect, meaning that while financial bank characteristics have a notable impact, their contribution to explaining the variance remains moderate.
- The interaction between digital transformation and financial bank characteristics was statistically significant (Sig. = 0.036), indicating that this interaction contributes meaningfully to explaining the variance in the cost-to-income ratio. Although the effect size (partial eat squared = 0.38) is smaller

than the main effects of digital transformation and financial characteristics, it still reflects a moderate influence that should not be overlooked in the analysis.

- Levene's Test for Equality of Variances: Levene's test showed no statistically significant differences in variance between groups (Sig. = 0.171), supporting the reliability of the ANOVA results and confirming the assumption of equal variances. This non-significant result supports the homogeneity of variances assumption, validating the use of Two-Way ANOVA.
- Adjusted R^2: The adjusted R^2 value = 0.519, indicating that the model can explain only 51.9% of the variance in the cost-to-income ratio. After adjustment, the model's explanatory power decreased, suggesting limitations in generalizing the results beyond the sample.

Second: Results of Simple and Multiple Linear Regression Analysis

The regression analysis was conducted in two stages: the first without controlling for explanatory variables, and the second with them included. The goal of this analysis was to measure the direct impact of digital transformation levels on the cost-to-income ratio while controlling other explanatory variables.

In the baseline model (without explanatory variables):

- Digital transformation had a statistically significant negative effect on the cost-to-income ratio (B = -0.47, Sig. = 0.006), indicating that higher levels of digital transformation are associated with a reduction in the cost-to-income ratio.
- The R^2 = 0.278 means that digital transformation alone explains 27.8% of the variance in the cost-to-income ratio.

In the extended model (with explanatory variables):

After controlling for financial bank characteristics, the effect of digital transformation remained statistically significant but slightly reduced (B = -0.287, Sig. = 0.008), indicating that digital transformation still affects the cost-to-income ratio, but to a lesser degree after controlling for other factors.

The model's explanatory power remained high (R^2 = 0.593), and the F-test was statistically significant (F = 4.982, P-value = 0.004), indicating that the model as a whole is statistically significant.

- Among the Financial Variables: The Loan Loss Coverage Ratio (LLC) had a statistically significant positive effect (B = 0.77, Sig. = 0.005), indicating that an

increase in the loan loss coverage ratio is associated with an increase in the cost-to-income ratio.

- The Loan-to-Deposit Ratio (LDR) had a statistically significant positive effect (B = 0.171, Sig. = 0.009), indicating that an increase in LDR is associated with an increase in the cost-to-income ratio.
- The Capital Adequacy Ratio (CAR) had a marginally significant effect (B = 1.816, Sig. = 0.082).

Conclusion: The results of both the ANOVA and regression analyses confirm that both digital transformation levels and financial bank characteristics have a significant impact on the cost-to-income ratio in Saudi banks. Digital transformation showed a strong negative relationship with the cost-to-income ratio, suggesting that higher levels of digital transformation can improve operational efficiency. Financial bank characteristics, especially the loan loss coverage ratio and loan-to-deposit ratio, also affected operational efficiency, although their effects were more moderate. Additionally, the interaction between digital transformation and financial bank characteristics highlights the complex relationship between these factors in shaping bank performance.

Supporting Studies: The results of this study, which showed differences in the cost-to-income (C/I) ratio among Saudi banks with varying levels of digital transformation, are consistent with previous research. Studies such as Ononiwu et al. (2024) have shown that banks that adopted advanced digital transformation were able to reduce this ratio and achieve higher efficiency. In contrast, studies like Pratiningsih and Wardhani (2024) found that some banks faced temporary increases in this ratio due to the initial costs of digital transformation, such as infrastructure investment and staff training.

In the case of Saudi banks, disparities in capital expenditures highlight the need for a detailed examination of how digital transformation affects this ratio. While digital transformation can reduce operational costs in the long run, its impact varies among banks based on financial characteristics such as capital adequacy and liquidity.

Accordingly, the fourth sub-hypothesis, which posits that there is a statistically significant difference in the cost-to-income (C/I) ratio among Saudi banks based on their level of digital transformation, considering their financial characteristics, is supported by the literature. These findings emphasize that strategic digital

transformation initiatives can be an effective tool to enhance cost efficiency, particularly when supported by sound risk management and capital deployment.

Based on the analysis of variance and regression results, the fourth sub-hypothesis is confirmed, and the model for testing the relationship between digital transformation and the cost-to-income ratio in Saudi banks can be represented as follows:

$$C/I=3.595-0.323\times(DT)+0.016\times(LCR)+0.019\times(LLC)-0.527\times(LR)+2.221\times(CAR)+0.062\times(LDR)$$

7. CONCLUSION AND FUTURE RESEARCH DIRECTIONS

7.1 Conclusion

The study sought to analyze how varying levels of digital transformation affect the financial performance of Saudi commercial banks, using a composite index to classify banks according to their digital transformation and incorporating internal financial characteristics as explanatory variables. The four key performance indicators studied were Return on Assets (ROA), Return on Equity (ROE), Earnings per Share (EPS), and Cost-to-Income Ratio (C/I). The results confirmed that digital transformation is associated with significant improvements in financial performance, but the strength and direction of this effect varies across banks based on their financial structure as follows:

- ***Return on Assets (ROA):*** The analysis of variance revealed statistically significant differences in ROA between banks according to their level of digital transformation, with an effect size of 61%. Financial characteristics also had a significant impact, explaining 55.3% of the variance in ROA, while the interaction between digital transformation and these characteristics was statistically significant (η^2 = 0.556), indicating that the effect of digital transformation varies depending on banks' financial structures. Regression analysis confirmed that digital transformation has a positive and significant effect on ROA, both in the baseline model (R^2 = 0.375) and in the extended model with financial characteristics (R^2 = 0.778), showing that incorporating these explanatory variables substantially improves the model's explanatory power.
- ***Return on Equity (ROE):*** The results of the analysis of variance showed that there are significant differences in ROE according to the level of digital transformation, with an explained variance of 65.1%. The regression model confirmed the positive and significant impact of digital transformation on

ROE, with loan loss provisions (LLC) emerging as a significant financial factor. The interaction between digital transformation and financial bank characteristics was significant, indicating that the effect varies by financial characteristics.

- ***Earnings per share (EPS):*** The variance results revealed significant differences in EPS between banks according to the level of digital transformation, with an effect size of 56.4%. The regression results confirmed a positive and significant relationship between digital transformation and EPS, even after controlling financial variables, with the loan-to-deposit ratio (LDR) emerging as an influential factor. In contrast, the interaction between digital transformation and financial characteristics was not statistically significant, indicating that the effect of digital transformation on EPS is stable.
- ***Cost to Income Ratio (C/I):*** The results showed significant differences in C/I attributable to different levels of digital transformation, with an effect size of 43.8%, indicating that operational efficiency improves as the level of digital transformation increases. The regression model confirmed that the negative effect of digital transformation on C/I remained statistically significant even after controlling financial characteristics. Among these variables, the Loan Loss Coverage Ratio (LLC) and Loan-to-Deposit Ratio (LDR) showed significant positive effects, while the Capital Adequacy Ratio (CAR) had a marginal effect. The interaction between digital transformation and financial bank characteristics was also statistically significant, highlighting that the influence of digital transformation on operational efficiency is conditioned by banks' financial structures.

The results show that there are significant differences in the four financial performance indicators depending on the levels of digital transformation, which is reflected in enhancing profitability and operational efficiency. The financial characteristics of banks are additional explanatory variables that contribute to explaining the impact of digital transformation, especially in ROE and C/I, emphasizing the importance of incorporating the financial context of the bank when studying the results of digital transformation.

7.2 Future Research

- Studying the impact of digital transformation on the non-financial performance of banks, such as customer satisfaction, service quality, and efficiency of internal processes, to provide a comprehensive view of the impact of digital transformation beyond the traditional financial aspects.

- Analyze the role of digital transformation in enhancing banking sustainability and social responsibility, by examining the relationship between the expansion of digital solutions and banks' commitment to environmental, social and governance (ESG) dimensions.
- Exploring the impact of digital transformation on improving banking risk management, by examining how digital tools and analytical techniques can be used to predict and mitigate risks more effectively.

8. RECOMMENDATIONS

Considering the study's statistical findings, and based on the observed differences in financial performance among Saudi banks according to the levels of digital transformation, considering financial characteristics as explanatory variables, the study recommends the following:

- Enhancing the digital readiness of banks by developing technical infrastructure, providing qualified human competencies, and allocating sustainable budgets to invest in technology, as a prerequisite for ensuring the effectiveness of digital transformation and realizing its positive impact on financial performance.
- Focus on the internal organizational environment, by improving the management structure and decision-making methods within banks to ensure that digital strategies are aligned with the bank's financial goals and facilitate the digital transformation process through flexible and adaptable policies.
- Integrate digital transformation initiatives into banks' financial and operational plans to ensure that they are linked to clear and specific goals to increase efficiency, reduce costs, and achieve a return on digital investment.
- Address barriers to implementing digital transformation, such as weak culture of change, employee resistance, high initial costs, and lack of digital expertise, by:
  a. Designing ongoing training programs.
  b. Adopting gradual transformation plans.
  c. Allocating internal incentives to encourage interaction with new technologies.
- Developing supportive policies from regulatory and supervisory authorities, such as the Central Bank, to support digital transformation through:

a. Providing financial or tax incentives for digitally advanced banks.

b. Issuing flexible regulatory guidelines that promote digital innovation while protecting financial stability.

- Encourage banks to periodically assess the level of digital transformation using clear performance indicators; including readiness, utilization, financial impact, and operational flexibility, allowing for gap detection and continuous improvement.
- Establish performance measurement frameworks for digital transformation that combine readiness, utilization, financial impact, and operational efficiency, enabling continuous improvement and benchmarking across the sector.

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أثر مستوى التحول الرقمي على فروق الأداء المالي: دليل تجريبي من البنوك التجارية السعودية

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ملخص البحث باللغة العربية

سعت هذه الدراسة إلى تحليل الفروقات في الأداء المالي بين البنوك التجارية السعودية وفقًا لمستوى تنفيذ التحول الرقمي، مع مراعاة الخصائص المالية لكل بنك كعوامل تفسيرية إضافية. تم قياس مستوى التحول الرقمي من خلال مؤشر مركب يتكوّن من ست مكونات فرعية: نمو قاعدة العملاء الرقمية، استخدام الخدمات المصرفية الرقمية، رضا العملاء عن الخدمات الرقمية، كفاءة العمليات الرقمية، الابتكار الرقمي، والامتثال لمعايير الأمن السيبراني. ولتسهيل التحليل، تم تصنيف مستوى التحول الرقمي إلى ثلاثة مستويات: (منخفض، ومتوسط، ومرتفع)، بناءً نسب المؤشر المركب للمكونات الفرعية للتحول الرقمي. وقد اعتمدت الدراسة على أربعة مؤشرات مالية رئيسية: العائد على الأصول (ROA)، العائد على حقوق الملكية(ROE) ، ربحية السهم(EPS) ، ونسبة التكاليف إلى الدخل(C/I) ، وذلك لرصد الاختلافات في الأداء المالي بين البنوك تبعًا لتباين مستوى التحول الرقمي لديها. كما تناولت الدراسة خصائص البنوك المالية مثل نسبة كفاية رأس المال، نسبة تغطية السيولة، نسبة القروض إلى الودائع، نسبة تغطية القروض المتعثرة، والرافعة المالية، لتحليل دورها في تفسير هذه الفروقات.

اعتمدت الدراسة على منهج كمي، باستخدام بيانات للبنوك السعودية المدرجة في السوق المالية خلال الفترة من 2019 إلى 2023. تم تحليل البيانات باستخدام تحليل التباين (ANOVA) لرصد الفروقات، وتحليل الانحدار لتحديد المتغيرات الأكثر تفسيرًا للاختلافات في الأداء.

أظهرت النتائج وجود فروقات ذات دلالة إحصائية في جميع مؤشرات الأداء المالي ROA ، ROE، EPS، C/I تعزى لمستوى التحول الرقمي، حيث حققت البنوك الأعلى رقمية أداءً أفضل. كما أثبتت الخصائص المالية دورًا تفسيريًا في هذه الفروقات، لا سيما في مؤشري ROE وC/I، في حين ثبتت العلاقة بين التحول الرقمي وكل من ROA و EPS دون تأثر ملحوظ بالخصائص البنكية. تعكس هذه النتائج أهمية فهم السياق المالي الداخلي للبنك عند تحليل الاختلافات في نتائج التحول الرقمي، وتدعم التوجه الاستراتيجي نحو الاستثمار الرقمي لتعزيز الكفاءة والربحية في القطاع المصرفي السعودي.

الكلمات الدالة: فروق الأداء المالي، مستوى التحول الرقمي، العائد على الأصول(ROA)، العائد على حقوق الملكية(ROE)، ربحية السهم(EPS)، نسبة التكاليف إلى الدخل(C/I)

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