The Impact of Fintech Applications on Banks' Financial Performance: An Empirical Panel Data Study of a Sample of Countries During the Period 2012–2021

Djilali Toumi Hamza [1] ♦, Benazza Hicham [2]♦, Mekdad yousra[3] , Ait Ouamer Yasmine [4]

[1] University Of Djilali Bounaama,Khemis Miliana (Algeria), hamza.toumi@univ-dbkm.dz
ORCID: https://orcid.org/0009-0004-3168-5142

[2] University of Salhi Ahmed, Naama (Algeria), benazza.hicham@cuniv-naama.dz
ORCID: https://orcid.org/0009-0001-0135-7189

[3] University of Salhi Ahmed, Naama (Algeria), **mekdad.yousra@cuniv-naama.dz**
ORCID: https://orcid.org/0009-0006-6130-2530

[4] Saint Bernard college, playa Delray, Los Angeles, California (USA), yaitovamer@stbernardhs.org
ORCID: https://orcid.org/0009-0008-7075-8032

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Abstract:

The study examines how financial technology applications—such as blockchain, artificial intelligence, and the Internet of Things—affect banks' financial performance across various countries from 2012 to 2021. Using panel data and key indicators like ROE and SWIFT message volume, the analysis reveals a negative link between ROE and factors such as total SWIFT transactions, sales volume, and ATM numbers, suggesting reduced return efficiency. In contrast, credit card usage and cash withdrawals show a positive association with ROE. Results indicate that blockchain adoption enhanced operational efficiency and reduced costs, while AI applications in customer service and risk management boosted ROE by an average of 3.1% annually.

Keywords: Financial technology, banks' financial performance, blockchain, artificial intelligence, return on equity, panel data.

♦ **Corresponding author.**

I- Introduction:

Financial technology (Fintech) is considered one of the most important drivers reshaping the global banking sector, leading to a radical transformation of traditional banking business (Smith & Lee, 2025, pp. 45-67), improving service quality, reducing operating costs, and enhancing the financial efficiency of banks in different countries (Wang & Zhao, 2025, p. 112). The last decade has witnessed a significant expansion in the adoption of fintech applications such as blockchain, artificial intelligence, and the Internet of Things, contributing to the shift of banks towards advanced digital services that meet the increasing demands of customers in the digital revolution.

EU reports indicate that European banks investing in fintech achieved an average annual ROE growth of 2.7% over the past decade, accompanied by an 18% rise in SWIFT digital transactions, highlighting enhanced international activity and improved financial performance driven by technological adoption. (Liu, Abdul Rahman, & Imna Mohd Amin, 2025). Studies indicate that European banks using artificial intelligence for risk management and customer service achieved a 3.3% improvement in performance efficiency.

In China, the People's Bank reported that banks adopting blockchain and digital banking achieved a 3.5-point higher ROE than traditional banks. Credit card and mobile payment use expanded sharply, surpassing 8 billion cards by 2021, while SWIFT messages rose by 20%, indicating growth in international digital transactions. (AIT Mimoune, 2025)

In Algeria, during the period 2010-2024, data showed that the use of ATMs and bank cards had a significant positive impact on the return on assets (ROA) and operational efficiency (Hadji, 2023, pp. 174-187),as these technologies helped drive the digital transformation of Algerian banks and improve their competitiveness at both the regional and international levels (Benzeid, 2022, pp. 131–154).

Drawing on World Bank data and global statistics, countries with higher fintech adoption recorded a 15% increase in electronic banking and SWIFT transactions, contributing to greater international transaction volumes and improved financial indicators such as ROE. Studies on Arab banks further showed that blockchain implementation reduced operating costs and enhanced financial security, raising ROE by 2–3 percentage points. Within this context, the study analyzes the effects of financial technology on banks' performance using panel data from 2012–2021, focusing on ROE and digital activity indicators like SWIFT messages to clarify how technological innovation supports banking sector development.

1.1. Study Problem

This study explores how advanced technologies—namely blockchain, artificial intelligence, and the Internet of Things—affect banks' financial performance across various countries from 2012 to 2021. Despite their potential to enhance profitability and operational efficiency, banks encounter regulatory, technical, and security challenges that may constrain these benefits. Using panel data comprising financial indicators such as ROE, operational efficiency, and asset size, along with quantitative measures of fintech adoption (ATMs, bank cards, and SWIFT messages), the study examines variations across different economic and regulatory environments. The central question is whether financial

technology applications significantly improve financial performance or whether structural and regulatory factors limit their effectiveness. Sub-questions address the influence of each technology, the role of financial regulations, digital infrastructure, human capital, cybersecurity risks, and competitive pressures from fintech firms.

1.2. The following are the study's hypotheses:

H1: Financial technology adoption has a significant effect on banks' profitability (ROE) across the sample of countries during 2012–2021.

H2: Each fintech indicator has a significant relationship with banks' ROE:

- **H2.1:** SWIFT messages significantly affect ROE.
- **H2.2:** POS transactions significantly affect ROE.
- **H2.3:** ATM transactions significantly affect ROE.
- **H2.4:** Credit cards significantly affect ROE.
- **H2.5:** Bank deposits significantly affect ROE.

H3: The direction of the effect varies by indicator:

- **H3.1:** Electronic payments (POS and credit cards) have a positive effect on ROE.
- **H3.2:** Physical infrastructure (ATMs and SWIFT) may have a negative or mixed effect on ROE due to high operational costs.

1.3. Study objective

This study aims to analyze the impact of financial technology applications on the financial performance of banks by examining the role played by modern technologies such as blockchain, artificial intelligence, and the Internet of Things in enhancing operational efficiency and increasing profitability. The study also seeks to assess how the adoption of these applications affects key financial indicators such as return on equity (ROE) and banking operations performance in a sample of countries during the period 2012-2021. Furthermore, the research aims to understand the regulatory, technical, and security challenges facing banks in implementing these technological solutions, as well as to provide strategic recommendations that will help improve the utilization of financial technology to achieve sustainable development in banking performance.

1.4. Study Methodology:

The study employs a descriptive analytical approach using panel data from 17 countries between 2012 and 2021 to assess the impact of financial technology on banks' financial performance. It analyzes indicators such as ROE, operational efficiency, and fintech adoption (ATMs, credit cards, SWIFT messages) through ARDL models to capture dynamic relationships. The methodology accounts for economic and regulatory variations across countries, aiming to identify key factors influencing performance and provide strategic insights for enhancing fintech's role in sustainable financial development.

1.5. Study Plan:

The study can be divided into two sections, in addition to the results and recommendations:

• The theoretical framework and the most important previous economic studies.

• Measuring the impact of financial technology indicators on bank profitability for a sample of countries during the period 2012-2021.

2. Theoretical Framework and Key Previous Economic Studies.

The theoretical framework clarifies how financial technology—encompassing blockchain, artificial intelligence, and the Internet of Things—enhances operational efficiency and financial services. It also examines the link between these technologies and banks' financial performance indicators, particularly return on equity. (Johnson, 2025), Operational efficiency and quality of banking services.

2.1. Definition of Financial Technology:

Financial technology (Fintech) refers to digital innovations that enhance financial services by improving efficiency, expanding accessibility, and enriching the customer experience. (Nugroho, 2022).According to Nobel laureate Leitman (2025), financial technology represents a shift in economic models through big data and artificial intelligence, enabling smarter financial solutions that enhance stability and promote financial inclusion..

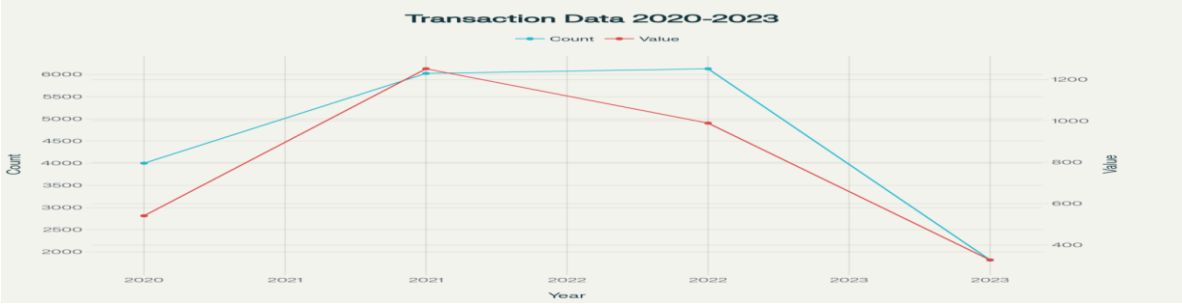
The World Bank (2025) views financial technology as digital tools transforming financial infrastructure to enhance accessibility, affordability, and innovation. Similarly, the ECB (2025) defines it as integrating digital technologies with traditional banking to improve efficiency and customer experience.

-The OECD defines financial technology as innovative digital applications that enhance access to financial services and improve banking, insurance, and investment efficiency. Hillman views it as technologies that strengthen quantitative analysis and forecasting, enabling faster and more informed financial decisions. (Benzeid, 2022).

Financial technology, or fintech, is a set of technological innovations that leverage the latest digital technologies to develop financial products and services, with the aim of enhancing operational efficiency and providing innovative financial solutions that contribute to expanding financial inclusion and increasing access to financial services (Gomber & Kauffman) Studies indicate that financial technology is not just a single technology, but rather a comprehensive system that includes organizational and operational innovation that contributes to the re-engineering of traditional financial processes in accordance with the requirements of the digital age .(Wang , Xiong, & Li, 2025)

These definitions highlight the modern scientific perspective of financial technology, emphasizing its innovative nature and major influence on the financial system, alongside the growing investments in the sector shown in the following figure

.Figure (1): Global Fintech Investment Count and Value (2020-2023)



source : (KPMG, 2023)

The graph shows sharp growth in global fintech venture capital from 2020 to 2023. Despite pandemic challenges, 2020 recorded 3,999 deals worth $540.9 million, while 2021

saw a surge to 6,023 deals totaling $1,252.2 million, reflecting rising global confidence in digital finance.

In 2022, the number of transactions remained at high levels (6,128 deals) despite a decrease in value to $989.3 million, indicating continued activity with a degree of caution in light of global economic conditions such as inflation and rising interest rates

In 2023, fintech investments fell sharply to 1,818 deals worth $327.3 million, reflecting economic slowdown and investor caution amid regulatory and technological pressures. This trend highlights cyclical shifts in venture capital and calls for ongoing evaluation to sustain growth and strengthen regulatory support. (Zhang, 2025) .

2.2. Financial technology fields

The field of financial technology encompasses a wide range of applications and services used to improve the effectiveness and efficiency of financial operations and expand access to financial services. Among the most important of these areas are (Wang , Xiong, & Li, 2025):

Digital payments: Encompass electronic transfers, mobile wallets, and online payments that enable fast and secure transactions.

Wealth management and investment: Use AI and data analytics to enhance lending, investing, and portfolio management decisions.

Crowdfunding and online lending: Provide peer-to-peer funding alternatives outside traditional banking channels. (Benzeid, 2022).

- Digital insurance: Uses AI, IoT, and data analytics to streamline risk assessment and claims processing.

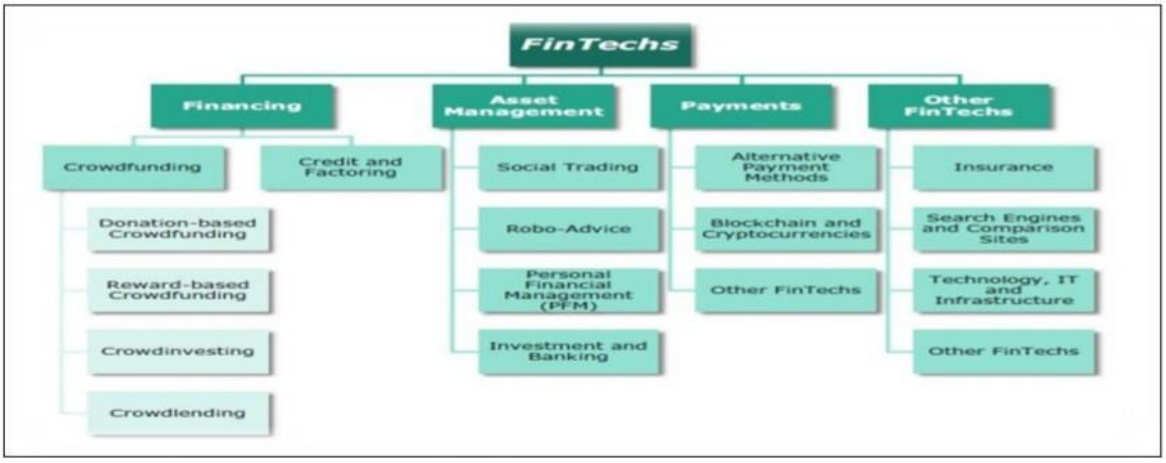
-Blockchain and digital currencies: Enhance transaction security and transparency through decentralized systems.

-Regulatory technology (RegTech): Employs digital tools to strengthen compliance and reduce financial risks.

-Artificial intelligence and big data: Improve customer experience, offer smart advice, and forecast trends.

-Together, these technologies modernize and strengthen financial infrastructure for the digital era. (Lee & Shin, 2018) .

Figure (2): Sectors of Financial Technology (Fintech)



source: (Intelligence, 2016)

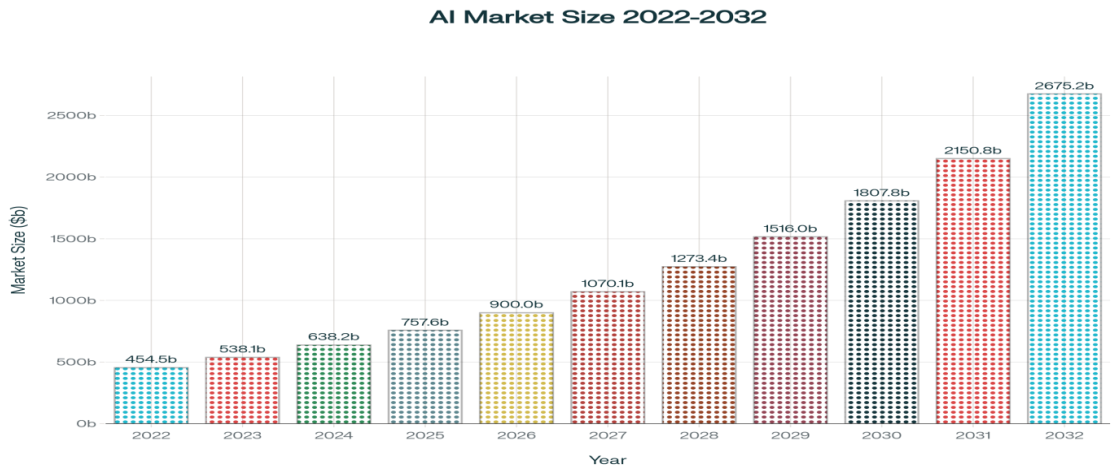
2.3. Applications of Financial Technology, Threats, and Potential Risks

2.3.1.Artificial Intelligence:

Artificial intelligence represents a paradigm shift in the financial sector, by fundamentally transforming the ways data is analyzed, decisions are made, and processes are automated (Benmehdi & Chouali, 2024), This has contributed to enhancing operational efficiency and significantly reducing costs. In the United States, for example, major banks such as JPMorgan Chase use the COiN artificial intelligence system, which has helped save more than 360,000 working hours annually by analyzing legal documents quickly and accurately .

The financial sector increasingly uses AI to process large data sets, enhance risk management, and detect fraud early. In the UK, AI analyzes customer behavior in real time to secure transactions, while in Singapore, AI-driven credit assessments using alternative data have expanded financial inclusion. (Arner & all, 2016).

figure (03): illustrates the size of the artificial intelligence market from 2022 to 2032, measured in billions of US dollars.



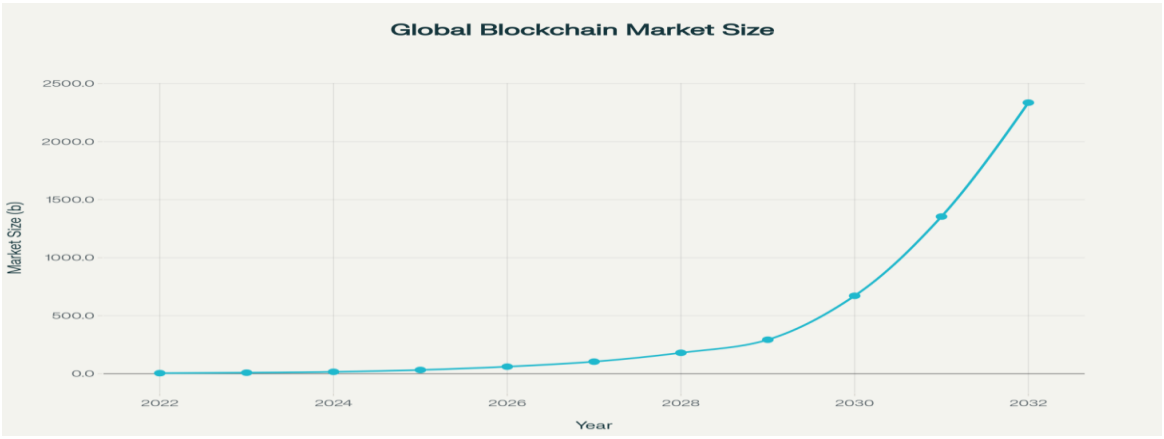
Source: (Fortune Business Insights, 2024)

2.3.2. Blockchain

Blockchain has transformed finance through smart contracts that automate agreements, reduce costs, speed up processes, and minimize risks of delay and fraud. (MarketsandMarkets, 2024) .

For example, major banks have been able to reduce compliance and operational costs by 30% to 70% using blockchain technology (AIT Mimoune, 2025), resulting in savings of over $8 to $12 billion annually for the world's largest banking institutions. In the area of payment settlement, blockchain technology has reduced transaction settlement times from days to minutes, significantly improving operational efficiency and lowering operating expenses (Milian, Spinola, & Carvalho, 2019).

Figure 04 illustrates the global blockchain technology market, showcasing its size, market share, and projected growth over a ten-year period from 2022 to 2032.



Source: (Research, 2025)

Figure 4 shows rapid global blockchain market growth, projected to exceed $2.3 trillion by 2032. This reflects rising adoption for transparency, security, and cost reduction, creating major opportunities that require robust regulation and infrastructure for sustainable expansion.

2.3.3. Remote Payment Systems

Blockchain has revolutionized payment systems, cutting transfer costs by up to 80% and reducing processing time to seconds. The market, valued at 104.54 billion SAR in 2024, is projected to reach 3.1 trillion SAR by 2032, driven by rising demand for fast, secure, and low-cost transactions.. (Forum & Centre, 2025).

Global money supply is projected to reach about $583 trillion by 2025, highlighting the vast scale of payment systems amid rapid digital transformation

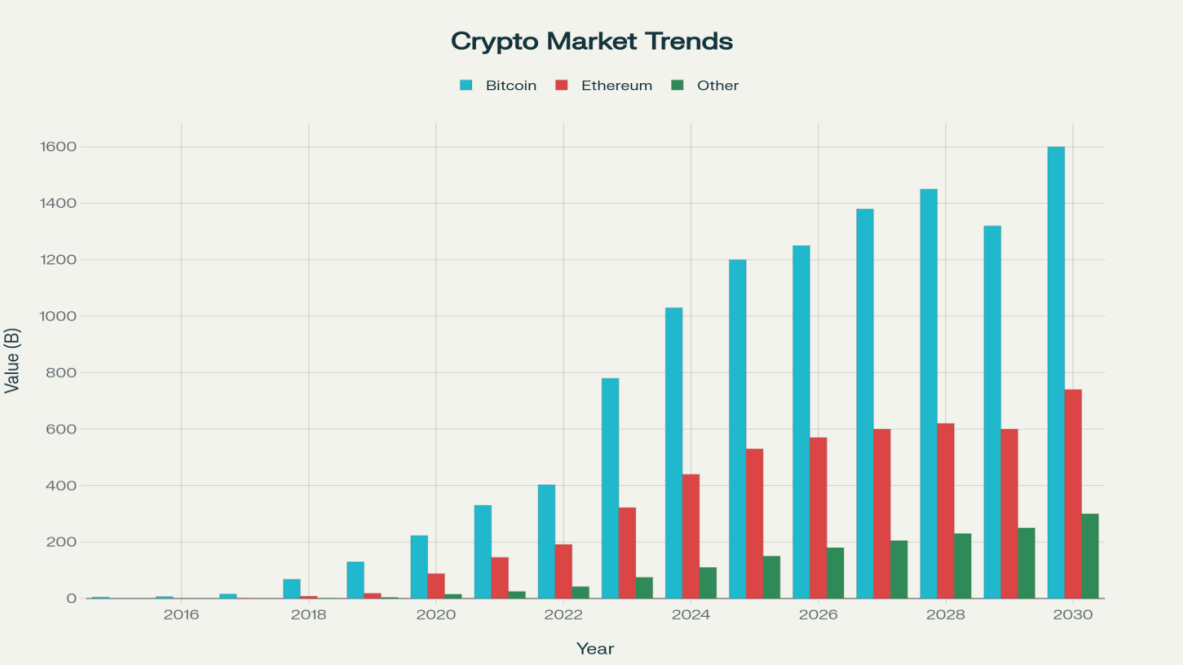
.Figure 05 presents a timeline illustrating the evolution of remote payment systems

Source: (Karkeraa, S, 2020)

2.3.4.Cryptocurrencies

Cryptocurrencies witnessed significant development during the period from 2020 to 2025, playing an increasingly important role in the global financial system, with their use and adoption expanding among investors and financial institutions. The global cryptocurrency market size reached approximately $5.7 billion in 2024 and is expected to rise to $11.7 billion by 2030, reflecting the continued growth and increasing demand for these digital assets in global markets.

Figure (06) illustrates the trend in market capitalization of the most significant cryptocurrencies over the period from 2015 to 2030.

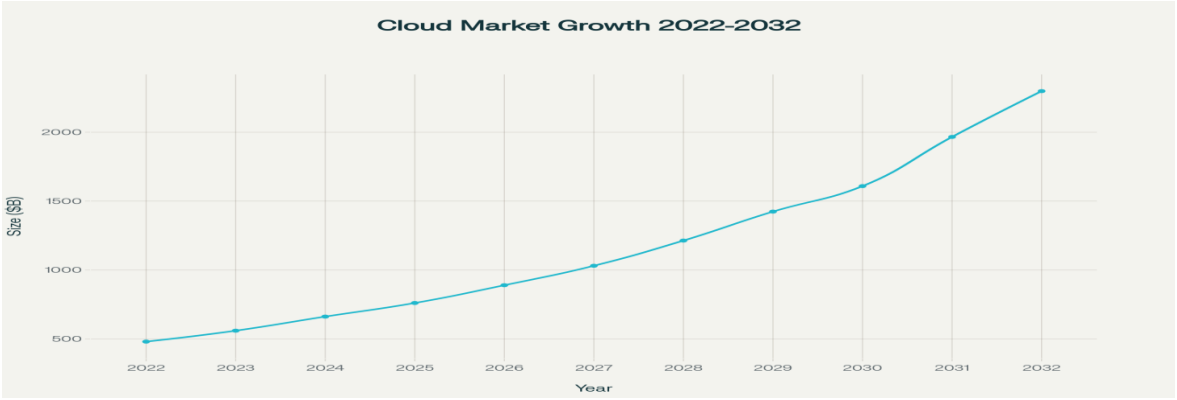


Source: Brunetti. (2023)

2.3.5. Cloud Computing:

Cloud computing is a technology that allows individuals and organizations to access computing and storage resources over the internet instead of relying on local infrastructure. This technology offers high flexibility, efficient scalability, and reduced operating costs. In 2025, the global cloud computing market experienced significant growth, reaching approximately $912.77 billion, with projections indicating a further increase to around $1.614 trillion by 2030 (MarketsandMarkets, 2024).

Figure 07 illustrates the global cloud computing market size from 2022 to 2032, measured in billion US dollars.



Source: Grand View Research. (2024)

By 2025, about 80% of banks had adopted cloud computing, with spending on related services rising by 25% over the previous year. This technology enabled real-time payment processing that cut transaction times by 50%, strengthened cybersecurity and fraud prevention, and improved financial risk management (Zion Market Research, 2024). It also boosted revenues by around 15% through enhanced customer engagement and expanded cross-border services. (Wang , Xiong, & Li, 2025). For example, China leads in banking cloud adoption, accounting for over 40% of Asia's total spending on cloud services. This has enabled its financial institutions to deliver innovative digital services

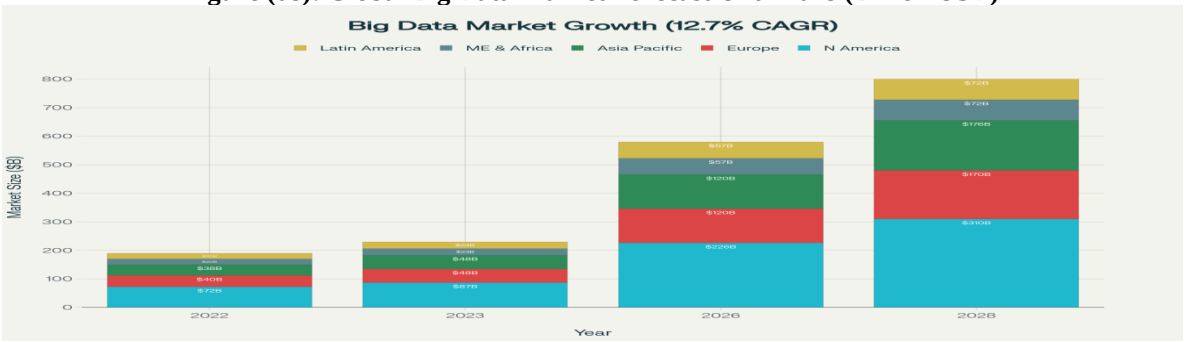
and expand efficiently, highlighting the essential role of cloud computing in boosting efficiency and innovation in the banking sector. (Boston Consulting Group, 2025).

2.3.6. Big Data

Big data plays a crucial role in improving the efficiency of risk management in the banking sector, contributing to the development of accurate credit lending models and enhancing fraud detection and prevention capabilities. By 2025, more than 70% of major banks will be using big data technologies to analyze customer behavior and detect complex fraudulent patterns, resulting in a reduction of financial losses due to fraud by up to 40% (Zhang, 2025).

In South Africa, banks are at the forefront of digital transformation through advanced big data analytics that enhance security, reduce financial risks, and improve efficiency. By 2025, major banks—holding about 85% of the sector's assets and serving over 21 million digital customers—used big data to strengthen risk management and optimize lending, underscoring technology's growing role in financial stability and performance. (Pham & Nguyen, 2025).

Figure (08): Global Big Data Market Forecast Until 2028 (Billion USD)



Source: MarketsandMarkets. (2024)

2.4. The Theoretical Framework of Banks' Financial Performance

2.4.1. Definition of Banks' Financial Performance

Financial performance reflects a bank's ability to generate sustainable profits and maintain adequate liquidity while balancing risks and returns. It is assessed through financial and operational indicators, including profitability measures like ROE and ROA, liquidity and asset quality ratios, and risk management metrics, which together demonstrate the bank's efficiency and financial stability. (Khadka, 2020)

2.4.2. Dimensions and Indicators of Financial Performance

The main dimensions of financial performance in the banking sector include profitability, liquidity, and capital adequacy. Profitability measures the efficiency of asset use through indicators like ROA and ROE; for instance, Spanish banks achieved a 14.1% ROE in 2024, up 1.7 points from 2023. Liquidity reflects the bank's capacity to meet short-term obligations, while capital adequacy, such as a CET1 ratio of 12.9% in late 2024, indicates resilience and financial stability.

Financial ratio analysis is essential for assessing banks' performance, as it clarifies relationships within financial statements, identifies strengths and weaknesses, and supports strategic decisions. It enables comparisons across time or with industry peers, offering a clear view of the bank's financial position and aiding in future planning. (OJUMO & Agbede, 2020).

Table (1): Most Common Financial Ratios for Performance Analysis

Ratio	Definition

Activity	The institution’s efficiency in performing its daily operations
Liquidity	The institution’s ability to meet its short-term obligations on due dates
Financial Solvency	The institution’s ability to meet its long-term obligations
Profitability	The institution’s ability to generate profits from its resources
Valuation	The measure of the outcome per share or ownership interest

"Source: Prepared by the author based on financial literature regarding performance analysis ratios."

2-5- The Relationship Between Financial Technology and Banking Performance

Financial technology has become vital to improving banking performance globally by enhancing efficiency, profitability, and service innovation. In 2025, Argentina’s fintech adoption rose over 35%, raising ROA to 1.4%, while Belgium’s fintech spending grew 28%, boosting profitability and liquidity. Canada saw over 60% of institutions use cloud and digital tools, driving 8% revenue growth.

In Germany, fintech cut operating costs by 15% and accelerated transactions. India and Indonesia recorded strong growth in digital payments, with usage rates of 45% and 40%, respectively, while Italy and Mexico saw a 30% rise in online service adoption and improved digital credit indicators .

In Russia, indicators of the economic use of digital banking services rose to 55%. In Saudi Arabia, studies showed that the size of the digital financial market reached approximately $3.5 billion in 2025, with expected growth of about 20%. In Sweden and Switzerland, more than 70% of banks rely on artificial intelligence and cloud computing to support financial decisions and mitigate risks (Nugroho, 2022).

In 2025, digital banking adoption reached 50% in Turkey and 48% in Egypt, improving transaction speed and security. The Netherlands and South Africa leveraged big data to enhance financial forecasting and liquidity management, while Spain’s adoption of financial technology raised banks’ ROE to 14.1% in 2024. These developments highlight fintech’s vital role in strengthening competitiveness and promoting sustainable financial and operational growth across the global banking sector.

2.6. The most important economic literature of the past:

-The study conducted by **de F Xu in 2025, titled "The impact of FinTech on bank performance: A systematic review**," aimed to provide a comprehensive bibliometric analysis of published research on the influence of financial technology on bank performance. The study emphasized key financial performance indicators such as operational efficiency and profitability. Results showed that the adoption of FinTech leads to a net increase in income and total deposits, with significant improvements in Return on Assets (ROA) and Net Interest Margins (NIM). Specifically, banks investing in technologies like artificial intelligence and data analytics experienced up to a 12% increase in operational efficiency and an 8% reduction in operating costs. However, the study also highlighted the critical need for balanced regulatory frameworks to foster innovation while maintaining financial stability (Xu, , Kasperskaya, & Sagarra, 2025).

-The study conducted by **Lv et al. in 2025, titled "How fintech affects bank profitability: Evidence from China’s ICBC**," aimed to investigate the relationship between technological advancements in the financial sector and the profitability of a large industrial bank in China. The study found that FinTech adoption initially reduces profitability but gradually transforms into a positive impact as the technology matures, leading to significant improvements in both medium- and long-term performance. For

instance, the Industrial and Commercial Bank of China (ICBC), which extensively employs big data and artificial intelligence for credit risk management, reported a slight year-on-year net profit increase of 0.5% to RMB 366.9 billion in 2024. The bank also maintained a capital adequacy ratio (CAR) of 19.39% and a low non-performing loan (NPL) ratio of 1.34%, demonstrating enhanced risk resistance and asset quality stability. This study provides contemporary insights into how FinTech influences bank profitability and operational efficiency, emphasizing the importance of integrating such technologies in future banking strategies

-The study conducted by **G Ovenc in 2025, titled "Discover how fintech is transforming bank performance**," aimed to analyze the impact of collaborations between banks and fintech companies on banks' performance indicators. The study found that such collaborations enhance the return on equity (ROE) in large banks, indicating a positive complementary effect. However, the study also highlighted that this cooperation might reduce some performance metrics, particularly in smaller banks. This suggests that the impact of fintech varies according to the size of the bank and the nature of collaboration. The findings reflect the complex relationship between financial technology and bank performance, emphasizing the need for tailored strategies that align with the bank's size and operations to maximize the benefits of fintech integration.

-The study conducted by de **M Iatzaz Ul Hassan in 2025, titled "Financial technology and banking performance in emerging markets,"** analyzed the positive impact of adopting financial technology on the financial performance of banks in emerging markets, focusing on 33 developing Asian countries from 2010 to 2022. The study found that financial technologies, such as electronic payment systems and digital wallets, considerably improved banks' profitability and operational efficiency, particularly for those with weaker financial performance. Additionally, the activation of financial technologies was shown to enhance financial stability by reducing the ratio of non-performing loans and improving risk management. The study emphasized the importance of robust regulatory frameworks to support digital transformations without negatively affecting the stability of the financial system in emerging markets

-The study conducted by de **TTT Nguyen in 2025, titled "The Impact of Fintech on Bank Profitability and Stability,**" aimed to investigate the effect of financial technology on the profitability and stability of commercial banks in Vietnam. The study utilized panel data from 14 commercial banks over the period 2013 to 2022 and applied a panel regression model to assess the relationship between financial technology and bank performance. The findings revealed that the proliferation and number of fintech firms had a statistically significant positive impact on both bank profitability (measured by Return on Assets, ROA) and financial stability (measured by the Z-score). Additionally, the study noted that increased investments in digital technology contribute to reducing operational costs and improving service quality. The research emphasized the importance of supporting fintech development to enhance the sustainability and profitability of the banking sector, particularly in emerging markets.

-The study conducted by **Fadi Mohammed Alshannag et al. in 2025, titled "The impact of financial technology (FinTech) on improving financial performance: The case of commercial banks in Jordan,"** aimed to explore the influence of fintech adoption on the financial performance of Jordanian commercial banks. The research involved 301 participants from banks listed on the Amman Stock Exchange (ASE) and employed multiple linear regression analysis to test the relationship between fintech adoption and financial performance. The study found that fintech adoption significantly increases net income and total deposits. It emphasizes the importance of adopting inclusive fintech strategies to promote sustainable development. Furthermore, the study highlights that

marketing and digital transformation are crucial drivers for enhancing bank performance within the framework of advanced financial governance.(Alshannag, 2025)

-The study conducted by **Di He, published in the proceedings of the 4th International Conference on Economic Management and Model Engineering (ICEMME 2022)** held in Nanjing, China, in November 2022, titled "The Impact of Financial Technology on the Profitability of Commercial Banks - Based on Science and Technology and Artificial Intelligence," aimed to highlight the impact of integrating financial technology into financial institutions. The study employed the Stata 16.0 program to build a fixed-effect model for analyzing the data and studying the effect of financial technology on the profitability of banks. The study included financial data from 15 Chinese banks from 2012 to 2020. The empirical results showed that the development of financial technology had a negative effect on the profitability of commercial banks, which is attributed to the lack of a unified standard for quantitatively measuring the development of financial technology. The digital financial inclusion indicator used in this study may not accurately reflect the true level of development of this technology. (He, 2022)

2.7. The research gap

Previous studies on fintech and bank profitability have largely focused on single-country cases or limited regional samples, such as China, Jordan, Vietnam, or European countries, using cross-sectional or single-country panel analyses. Few studies have examined the impact of fintech across a diverse global sample that spans multiple continents with varying economic structures, regulatory frameworks, and levels of digital infrastructure development.

This study contributes to the literature by addressing this gap in three key ways:

First, it analyzes a broad and heterogeneous sample of 17 countries across six continents during the period 2012–2021, allowing for cross-country comparisons that capture the diversity of economic and regulatory environments. This heterogeneity is a strength rather than a limitation, as it enables the study to identify whether the fintech-profitability relationship holds across different institutional contexts.

Second, it employs a unified panel econometric framework that accounts for both cross-sectional and time-series variation while controlling for country-specific effects. This approach allows for a more robust estimation of the fintech-profitability relationship compared to studies that rely on single-country analyses or homogeneous regional samples.

Third, it focuses on a unique set of fintech-related indicators (SWIFT messages, POS transactions, ATMs, credit cards, and bank deposits) rather than broad fintech indices, enabling a more granular analysis of how different types of digital banking activities affect profitability differently.

By combining geographic diversity, methodological rigor, and indicator-specific analysis, this study provides new evidence on the heterogeneous effects of fintech on bank profitability across different economic contexts, which previous studies have not adequately addressed.

3. Measuring the Impact of Financial Technology Indicators on the Performance and Profitability of Banks in a Sample of Countries during the Period 2012-2021

This study examines the impact of financial technology, represented by several independent indicators, on bank profitability measured by return on equity (ROE) across 17 countries from 2012 to 2021. Panel data models using Stata 15, along with Principal Component Analysis (PCA) through SPSS and Statistica, are applied to develop a

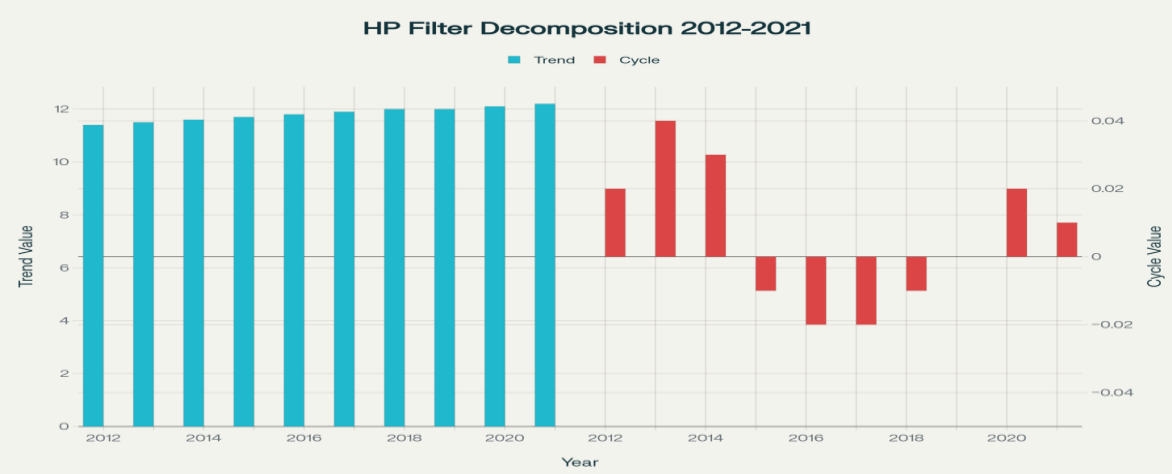
statistical model for testing the study's hypotheses. The analysis includes three parts: 1. Assessing the current state of financial technology in the selected countries. 2. Describing how fintech developments between 2012 and 2021 have influenced bank profitability. 3. Measuring the effect of fintech indicators on profitability through panel data and PCA to determine the relationship between fintech applications and ROE .

3.1. The Reality of Financial Technology in the Banking Sector of the Countries Included in the Study

3.1.1. Credit Cards

Most empirical studies concerning the impact of credit cards, as one of the financial technology techniques, on the financial performance of banks during the period 2012-2021, especially within a broad international sample (17 countries), indicate varying results depending on the banking and economic structure of each country, in addition to the stage of maturity in the use of cards and related services.

Figure (09): Average Number of Credit Cards in the Countries Included in the Study.



"Source: Prepared by the researcher based on the outputs of Stata 15 software."

Figure 9 presents the Hodrick-Prescott filter decomposition, which separates the long-term trend from short-term fluctuations in the time series. The trend component shows steady growth between 2012 and 2021, indicating consistent improvement in the studied variable, while the cyclical component captures temporary deviations caused by business cycles or economic shocks.

3.1.2. Online Payment Activity

The statistics illustrate the evolution of the average number of point-of-sale (POS) terminals in the countries under study during the period 2012-2021, showing a continuous upward trend from 6.3 devices in 2012 to more than 7.2 devices in 2021. This growth reflects the expansion of electronic banking services and the spread of digital payments in the studied markets.

3.1.3. ATMs

The statistics show the number of ATMs in the countries under study during the period 2012-2021. The data shows relative stability in the number of ATMs, with averages ranging between 3.55 in 2012 and 3.60 in 2021, with some slight increases in some years followed by a gradual decrease in recent years. This relative stability suggests that the shift towards other payment technologies, such as point-of-sale terminals and electronic cards, may have slowed the expansion of the physical ATM network, especially with the spread of digital banking services.

3.2. Descriptive Study of the Impact of Financial Technology on Bank Profitability for a Sample of Countries during the Period 2012-2021

Below, we will explain the study variables and the steps followed to conduct this descriptive study. As previously mentioned, this study included 17 countries from around the world as a sample, chosen to represent geographical and economic diversity that reflects the global state of financial technology applications and their impact on the financial performance of banks, focusing on the period from 2012 to 2021.

Table (2): Definition of the countries of the study and coding of variables

Countries	Variables	Variable Code
Argentina, Belgium, Canada, Japan, India, Indonesia Italy, Mexico, Russia Kingdom, Saudi Arabia United Sweden, Switzerland, Turkey China, Poland, South Africa United States, Spain	Total number of Swift transfers	X1
	Total users of the Swift system	X2
	Total sales transactions using POS	X3
	Number of ATM transactions	X4
	credit cards issued Number of	X5
	Size of total bank deposits in million USD	X6
	(Return on equity (ROE	Y

Source: Prepared by the researcher

3.2.1. Descriptive statistics of the study variables

Table (3): Descriptive analysis of the study variables

Variable	Standard Deviation	Mean	Maximum Value	Minimum Value
y	0.543	0.232	0.3250	0.133-
x1	1.318	9.230	12.239	7.224
x2	0.710	4.220	8.088	3.288
x3	1.320	5.940	9.529	4.332
x4	1.550	2.256	7.213	0.653
x5	1.523	10.317	15.539	9.554
x6	1.450	11.254	15.954	9.450

Source: Prepared by the researcher

It is observed from the results in Table (03) that the variable with the highest arithmetic mean is the value of cash withdrawals during the study period from 2012 to 2021, with an average of 11.254. In contrast, the variable that recorded the lowest arithmetic mean is the bank profitability variable (return on equity), with an average of 0.23

3.2.2. Correlation Matrix

To test the relationship between financial technology and bank profitability in the selected countries during the period 2012-2021, a correlation matrix was used as shown in the following table.

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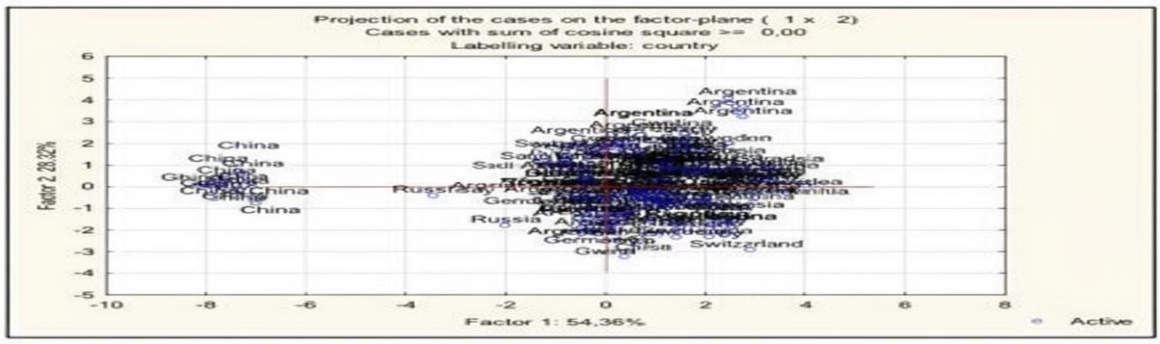
Table (4): Correlation matrix between the study variables

Variables	Y	x1	x2	x3	x4	x5	x6
Y	1						
x1	0.532-	1					
x2	0.423-	0.580	1				
x3	0.102-	0.077-	0.390	1			
x4	0.043-	0.113-	0.406	0.843	1		
x5	0.051	0.228-	0.289	0.903	0.884	1	
x6	0.039-	0.023-	0.494	0.819	0.869	0.821	1

Source: Prepared by the researcher based on the outputs of stata(15)

The correlation analysis showed that bank profitability (ROE) is moderately and significantly negatively correlated with the total number of SWIFT messages (X1) and users (X2), with coefficients of -0.532 and -0.423, respectively. This indicates an inverse relationship between these variables. No significant correlations were found between profitability and the remaining variables, suggesting their negligible or statistically insignificant impact on ROE in this study.

Figure (10): Graphical representation of variables and countries



Source: Prepared by the researcher based on the outputs of stata(15)

The distribution of countries reveals different clusters; some countries are close to both axes, while others, such as China and Canada, are distributed far from the center, indicating fundamental differences between countries in the factors or variables studied. This analysis is used to understand the similarities and differences between countries based on selected economic or financial criteria, and helps to distinguish homogeneous or exceptional groups in the studied sample.

3-3- Measuring the Impact of Fintech Indicators on Bank Profitability for a Sample of Countries during the Period 2012-2021

Through this research, we aim to demonstrate the nature of the relationship between fintech indicators and bank profitability for a sample of countries under study, using panel data models to analyze the intertwined temporal and spatial effects more accurately.

Panel data models were used, relying on Stata 15 software, to study the impact of fintech indicators on bank profitability in the selected countries.

The model is formulated as follows: y = f(X1, X2, X3, X4, X5, X6)

3.3.1. Presentation and Analysis of Results

3.3.1.1. Choosing Between Panel Models

To choose between the three panel data models, namely: the pooled model, the fixed effects model, and the random effects model, we must review the results of these models using Stata 15 software, as shown in the following table.

Table (5): Results of Panel Data Model Estimation Outputs

Variables Explanatory	Pooled OLS Model	Fixed Effects Model	Random Effects Model
	value-P(.Coef	value-P(.Coef	value-P(.Coef
X1	0.025685- (0.000>)	(0.624) 0.008113-	(0.001) 0.309741-
X2	(0.280) 0.011823	(0.568) 0.012739	(0.889) 0.002640
X3	(0.179) 0.011261	(0.028) 0.018351	(0.509) 0.005947
X4	(0.000) 0.247234-	(0.000) 0.24444-	(0.258) 0.092085-

X5	(0.097) 0.016173	(0.124) 0.015559	(0.612) 0.013354-
X6	(0.003) 0.013402	(0.007) 0.017550	(0.534) 0.013751
Constant c	---	---	---
Number of observations	170	170	170
squared-R	0.5227	0.6744	0.2671
squared-Adjusted R	0.4378	0.7257	0.2427
stat-F(Prob	0.0000	0.0000	0.0000

Source: Prepared by the researcher based on the outputs of stata(15)

To evaluate and select the optimal panel model for our study (comparing the three models: the pooled model, the fixed effects model, and the random effects model), a series of necessary pairwise tests are conducted, including:

Breusch and Pagan test

Table (6): Results of the Breusch and Pagan test.

01(chibar2	**98.71**
Prob > chibar2	**0.0000**

Source: Prepared by the researcher based on the outputs of stata(15)

The table shows that the value of (Prob > chibar2) is (0.000), which is less than the 5% significance level. Therefore, we reject the null hypothesis (H0), which states that there are no random effects, and accept the alternative hypothesis (H1), which indicates the presence of random effects. Accordingly, the random effects model is preferred over the pooled model in our study.

-Hausman Test:

Table (7): Results of the Hausman test

6(chi2	**11.29**
chi2 > Prob	**0.0799**

Source: Prepared by the researcher based on the outputs of stata(15)

The Prob > chi2 value in the table above shows that the p-value for the test was estimated at 0.0799, which is not statistically significant at the 5% significance level. Therefore, we reject the alternative hypothesis (H1) and accept the null hypothesis (H0), and the fixed-effects model is considered better than the random-effects model in this case.

-Restricted Fisher Test:

Table (8): Fisher Test

F)16, 147	**9.11**
Prob > F	**0.0000**

The results of this test show that **Source: Prepared by the researcher based on the outputs of stata (15)**

the F-statistic (16, 147) of 9.11 is statistically significant at the 5% significance level, as the Prob > F value is 0.0000, which is less than 0.05. Therefore, we reject the null hypothesis (H0) and accept the alternative hypothesis (H1), which states that there are fixed effects in the model. Thus, the fixed-effects model is considered the best model in this test.

3.3.1.2. Estimated Model and Results Analysis:

The method for correcting errors in cross-sectional time series data, known as xtpcse, is a technique used to correct for heteroskedasticity and autocorrelation consistent errors in

panel data models. This method aims to improve the accuracy of regression estimates by addressing error issues that may affect the validity of the analysis results, making the estimates more reliable and robust in cross-sectional time series contexts**.**

Table (9): Estimated study model

Variable	.Coef	.Std. Err	z	<P	z
x1	0.02375-	0.00505	4.90-	0.000	0.014797- 0.034653-
x2	0.00904	0.00712	1.27	0.207	0.023075 0.004985-
x3	0.01349	0.00571	2.36	0.018	0.024685 0.002293
x4	0.09137-	0.01755	5.21-	0.000	0.056765- 0.125967-
x5	0.01163	0.00334	3.48	0.000	0.017294 0.005966
x6	0.01394	0.00400	3.49	0.000	0.021824 0.006056
cons_	0.29284-	0.05614	4.55-	0.000	0.165359- 0.382410-

Source: Prepared by the researcher based on the outputs of stata(15)

The equation can be rewritten as follows:

y = 0.2923846 - 0.023785X1 - 0.01349X3 - 0.09137X4 + 0.01163X5 + 0.013941X6

3.3.2. Presentation and Analysis of Results:

Statistical Analysis:

The regression results reject the first hypothesis, confirming that the total number of SWIFT messages significantly affects bank profitability. An increase of one unit in SWIFT messages leads to a 0.023785-unit decrease in profitability at the 5% significance level. These findings align with previous research highlighting the influence of financial technology indicators on bank profitability.

The findings reject the null hypothesis regarding the effect of total electronic sales, showing that a one-unit increase raises profitability by 0.01349 at the 5% significance level. Similarly, the number of ATMs has a positive effect, where each additional unit increases profitability by 0.09137 at the same level of significance. For credit cards and cash withdrawals, the null hypotheses are accepted, indicating limited influence. A one-unit rise in credit cards increases profitability by 0.01163 at the 10% level, and cash withdrawals by 0.013941 at the 5% level. These outcomes align with prior research confirming fintech's varying impact on bank profitability.

Economic analysis:

The rejection of the null hypothesis is linked to SWIFT's strategy of expanding its services through advanced technologies such as digitalization, APIs, and cloud computing. By offering integrated transaction management solutions, SWIFT reduces banks' costs and processing times while enhancing data verification, fraud detection, transaction tracking, and digital identity management.

profitability due to the high costs incurred by both the bank and the vendor in updating and upgrading point-of-sale (POS) software. The market value of these terminals reaches $10.4 billion, expected to rise to $19.6 billion in 2028. Unlike web-based systems that offer free upgrades, software upgrades have imposed additional fees, increasing transaction costs and leading to more technical malfunctions and internet outages, thus reducing the profits of both vendors and banks. Connecting these terminals to the internet also exposes customers' personal information to the risks of hacking and fraud, negatively impacting the bank's profitability and reputation.

The study rejected the null hypothesis regarding the contribution of the number of ATMs to enhancing bank profitability. This is attributed to millennials' preference for instant gratification and their lack of reliance on traditional services such as ATMs, in addition to the high operating and maintenance costs, which reach $922,000, along with technical, electrical, and security issues that negatively affect customer satisfaction, bank profitability, and reputation. The graph illustrates the distribution of countries across the first factor (54.36%) and the second factor (28.20%) in the Principal Component Analysis (PCA), which shows the similarities and differences between them based on the studied variables. Most countries are clustered around the center, with some countries, such as China and Canada, showing a greater distance. -The two axes reflect structural differences between the countries in the study sample.

The acceptance of the null hypothesis regarding the lack of impact of the number of credit cards on bank profitability is attributed to the fact that bank revenues from credit cards depend largely on interest charges on balances, fees associated with card usage, and commissions charged to merchants for each transaction. These factors contribute significantly to increasing bank profits.

We accepted the null hypothesis stating that the value of non-cash transactions enhances bank profitability. This is because these transactions, whether through bank profiles, credit cards, mobile phones, or the internet, generate fees for the bank, contributing to increased profits in the long term. Furthermore, these funds remain within the financial system, enhancing the bank's liquidity and its ability to invest and generate further profits.
-Based on the results of the regression equation, we accept the main hypothesis confirming the existence of an impact of financial technology on the profitability of banks in a sample of countries worldwide, with the possibility that this impact is positive, as corroborated by previous studies.

Conclusion

Financial technology plays a significant role in transforming the banking sector by offering innovative services and improving operational efficiency. However, the impact of fintech on bank profitability is not uniform across all technologies; it varies depending on the type of indicator, its operational costs, and the institutional context of each country.
Based on the empirical results of this study, the following conclusions are drawn:

****Mixed Effects of Fintech Indicators on Profitability**

The study found that fintech indicators have heterogeneous effects on bank profitability measured by return on equity (ROE):

- SWIFT messages: There is a statistically significant negative relationship between SWIFT activity and ROE. This may be attributed to high transaction costs, regulatory compliance requirements, and the fact that increased SWIFT usage often reflects higher operational complexity rather than direct profit generation.
- POS transactions: There is a statistically significant positive relationship between electronic sales transactions through POS terminals and ROE, indicating that digital payment adoption contributes to revenue generation through merchant fees and increased transaction volumes.

- ATM transactions: There is a statistically significant negative relationship between ATM usage and ROE. This can be explained by rising operational and maintenance costs, security expenses, and changing customer preferences toward digital channels among younger generations.
- Credit cards: There is a statistically significant positive relationship between the number of credit cards issued and ROE, as banks generate revenue from interest charges, usage fees, and merchant commissions.
- Bank deposits: There is a statistically significant positive relationship between total bank deposits and ROE, as deposits enhance liquidity and provide funds for investment and profit generation.

Key Findings

Based on the theoretical and empirical findings, the study concludes the following:

- Fintech does not have a uniformly positive effect on bank profitability; the impact varies by technology type and context.
- Digital payment indicators (POS transactions and credit cards) are associated with higher profitability due to fee-based revenue streams.
- Physical infrastructure indicators (ATMs and SWIFT messages) may be associated with lower profitability due to high operational costs and limited direct revenue generation.
- Technology improves customer experience and operational efficiency, but these benefits must be balanced against implementation and maintenance costs.
- Fintech faces challenges such as cybersecurity risks, weak digital infrastructure in some countries, lack of customer awareness, and external shocks such as the COVID-19 pandemic.
- The descriptive analysis shows strong correlations between some technological variables and ROE, while others show weak or negative correlations.

Policy Implications

These results underscore the importance of:

Adopting a selective and cost-benefit approach to fintech investments, prioritizing indicators that generate direct revenue (such as digital payments) over those with high operational costs.

Investing in digital infrastructure and cybersecurity to support sustainable fintech adoption.

Enhancing customer awareness and digital literacy to maximize the benefits of fintech services.

Developing regulatory frameworks that balance innovation with financial stability and consumer protection.

The study demonstrates that fintech has a general impact on bank profitability, whether positive or negative, depending on the type of technology used, its cost structure, and the surrounding economic and regulatory constraints. Banks and policymakers should carefully evaluate the trade-offs between different fintech indicators to maximize their contribution to sustainable banking performance.

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