



Article

Advancing Digital Transformation and Banking Services: An Examination of Opportunities and Challenges in the Digitalization Process

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Abstract: This article examines a theoretical and practical analysis of the digital transformation and digital banking services into the banking system, which is a key component of the economy. Despite the growing interest of academics and professionals in improving digital services in the banking industry, this comprehensive review offers a holistic understanding of Uzbek digital bank services' historical, current, and future trends. Existing reviews of digital technologies in banking have primarily focused on conceptual aspects, such as constructing theoretical frameworks or contextual elements; these reviews offer a limited and incomplete understanding of the entire field. To bridge this gap, this paper takes a different approach by conducting a comprehensive analysis of several articles published in Scopus-indexed journals from 2020 to 2025. The results show that digital banking in emerging countries is a growing research field that has driven the introduction of new information technologies. This study aims to conduct a scientific analysis of the processes of introducing digital banking services and digital technologies to improve the financial efficiency of banking activities and to identify their impact on income, expenses, risk management, and customer behavior. The article also allows for a more extensive exploration of the literature, providing a more robust and comprehensive overview of the concepts of digital transformation and technological adoption, which significantly impact the development of the banking industry, as well as presents statistical materials for analysis, conclusions, and recommendations.

Keywords: Digital transformation, digital technologies, digital banking services, financial stability, fintech, mobile banking, digital transformation, artificial intelligence, innovative, commercial banks.

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1. Introduction

In the era of the digital economy, which is a key element of the fourth industrial revolution, the rapid development of digital technologies is leading to the provision of services in a new format in all sectors, including the banking system, which is considered the backbone of the economy. It is worth noting that the effective organization of modern banking activities is inextricably linked to providing customers with fast and high-quality services and adapting to digital transformation processes in order to strengthen financial stability.

The integration of digital technology and financial innovation has led to the digital transformation of commercial banks. Digital transformation is widely acknowledged as a pivotal factor in reducing banks' marginal costs and enhancing the efficiency of bank performance. This transformation processes in the banking system can be seen in the form of the introduction of innovations such as online banking, mobile applications, digital

payment systems, financial advisors based on artificial intelligence, blockchain technologies and "open banking" platforms. These new technologies improve customer service quality and ensure banking operations' transparency, security, and speed.

However, the trajectory of these technological advancements has not been uniform but heterogeneous, with varied economic impacts that may be specific to each commercial bank or its regulatory environment [1]. As an example, while larger multinational banks quickly adopted technologies to improve operational efficiency and customer personalization, smaller regional banks often faced challenges due to limited resources and stricter regulatory constraints, resulting in slower adoption rates and different technological strategies [2].

As commercial banks face increasing pressure to innovate and compete with FinTechs, their ability to develop and deploy these dynamic capabilities, such as organisational learning, technological integration, and strategic flexibility, becomes crucial [3].

New business models have emerged driven by disruptive technologies that integrate physical and digital elements - such as big data, artificial intelligence (AI), cloud, and blockchain - marking the beginning of the Fourth Industrial Revolution, or Industry 4.0 (I4.0) [4]. This revolution aimed to offer more efficient, customised, and accessible services to customers, leading to increased competition in the banking sector [5].

Currently, several problems exist in the consistent implementation of digital transformation processes in our country's banking and financial system. In particular:

1. The low quality, quantity and level of integration of the existing database in banks reduces the effectiveness of the high-level use of digital banking services;
2. The level of digitization of operational processes through digital technologies in banks varies from bank to bank;
3. The qualifications of personnel are insufficient for the widespread implementation of these technologies;
4. Local methodologies for systems such as forecasting, customer segmentation, and fraud detection based on artificial intelligence technologies have not been developed for Uzbek banks.
5. There is insufficient experience in using artificial intelligence solutions for tasks such as analyzing the quality of the loan portfolio, detecting fraud, reducing operating costs, and analyzing income.

Based on the above, the objectives and the research contributions of this paper are as follows: to theoretically analyze the impact of digital technologies on banking activities and financial efficiency; to study existing international experience and scientific literature on assessing efficiency in banking systems with the introduction of digital technologies; To identify the level of integration of digital technologies in the banking system of Uzbekistan, existing problems and limitations; to analyze the digitalization processes in banks from a practical perspective and evaluate them using empirical (statistical/econometric) methods.

Literature review

In the modern world, digitalization is ubiquitous and the banking sector is no exception. Banks big and small alike are ramping up investments in digital projects to stay distinctive and meet as many of their customers' needs as they can. Digitalization leads to higher levels of customization and better client relationships. Furthermore, digital transformation alters the procedures of businesses and changes the way banks operate. Digital transformation contributes to the conventional customer-bank relationship. In particular, customers have the right to interact online with banks and other customers through a range of communication channels. Most significantly, digital technologies improve banks' operational efficiency by allowing them to serve several customers at once. Various methods have been employed to assess the impact of commercial banks' digital transformation, that have attracted significant scholarly attention. Moreover, the digital economy, digital technologies, and the theoretical and practical aspects of banks providing banking services to customers based on digital technologies have been described by a number of researchers as well as the number of scientific articles and dissertations on this topic has increased dramatically around the world.

Despite the large number of studies on the implementation of digital technologies and artificial intelligence in the banking system, most of them are focused on describing the general digitalization strategy or technological processes of banks. In addition, scientific approaches to the direct impact of the introduction of artificial intelligence on the financial efficiency of banking activities, criteria for assessing efficiency, and mechanisms for measuring economic results have not been sufficiently developed. Therefore, below we will examine the theoretical views of some researchers on this topic.

Industry 4.0 presents a value proposition where greater customer satisfaction can be achieved as production systems become smarter using internet of things (IoT), cyber-physical systems (CPS), cloud computing and Big Data [6].

According to Filotto, the global financial crisis of 2008 and the rise of FinTechs in the 2010s marked a shift towards prioritising internet access and smartphone use for digital services [7].

Throughout the 2010s, the banking sector underwent significant transformations with the emergence of I4.0 technologies and the introduction of 'Open Banking' regulation [8]. Concerning I4.0, its concept was introduced in Germany in 2011, referring to the fourth cycle of the Industrial Revolution2 [9]. The I4.0 technologies such as AI, big data, machine learning, blockchain, cybersecurity, cloud, and Internet of Things (IoT) possess the capacity to foster substantial innovation and competitive expansion while concurrently enhancing the sustainability of the existing industrial system [10].

Riikinen and Pihlajamaa emphasize that I4.0 technologies are rapidly reshaping the banking industry [11]. Indicators of this transformation include the reduction of physical branches in favour of digital service channels, as well as investments in employee training and partnerships with technology companies to accelerate the adoption of I4.0 technologies. By investing in intangible resources, such as strategic collaborations and cybersecurity training, for example, these banks can achieve a sustainable competitive advantage over competitors who do not have these resources [12].

The main mechanisms that assist in a successful digital technologies (DT) process, the literature indicates innovation and integration [13]. In the innovation mechanisms approach, DT encompasses novelty in both strategic and operational dimensions, involving activities such as formulating digital business strategies, mobilising and accelerating transformation at the strategic level, and exploring digital capabilities for the development of innovative products, processes, and business models, with a particular emphasis on human-machine interaction for sustainable synergies [14], [15].

Hanelt, Bohnsac and Marz, concluded that integration mechanisms play a pivotal role in aligning new elements with existing ones within an organisation during DT. This requires the formulation of a comprehensive strategy serving as the central concept for coordination, prioritisation, and implementation.

Digitalisation empowered by FinTech has improved the service efficiency and customer experience of inclusive finance, as well as other business income and bank performance. Banks must be cautious when analysing the risks and benefits afforded by internet platform flow-data, according to Keda Zhu and Lihong Guo [16].

Allen, Franklin, Xian Gu, and Julapa Jagtiani found that banks have developed strategies to boost business by adopting new technologies. Innovations in financial products and services, such as real-time payments, online lending, or financial services through mobile platforms, have experienced explosive growth. Furthermore, Rahi and others provide insights on internet-based e-banking that offers convenience to the user as an alternative channel, facilitating 24-hour service delivery anywhere through a digital banking website [17].

Kitsios, Fotis, Ioannis Giatsidis, and Maria Kamariotou concluded that digital transformation empowers new banking establishments to offer new service channels through technology platforms and points of service and enables them to reduce operating cost [18]. However, although the benefits of new information technologies bring opportunities, they also represent challenges for the banking business [19]. Digitization involves substantial costs. Therefore, it may not be financially viable or compromise the bank's stability due to increased technical and regulatory risk [20]. Managers should

systematically evaluate these investments because they could commit funds that can be used to finance other strategic activities.

According to Khattak, this digital transformation process will affect commercial banks internally and externally [21]. External digital transformation implies that non-banking firms can offer digital services such as traditional banking. Internal digital transformation relates to the adoption of advanced technologies. These technologies include artificial intelligence, blockchain, big data, cloud computing technology, etc. These technologies are driving innovation in the banking sector, to the extent that they offer opportunities to facilitate customer transactions, product customization, and security in service delivery

Koroleva and Kudryavtseva found a positive impact of digital banking features on the performance of Russian banks, using ROA as an endogenous variable [22]. Specifically, a positive and statistically significant relationship was evident when relating the number of users and online banking transactions to the performance variable. Scott showed a positive effect of the adoption of financial technologies such as SWIFT on banks' performance, measured in terms of profit margin [23]. However, some papers have found evidence that contrasts with these findings. Nguyen-Thi-Huong and others observed a negative impact of the digital transformation process on performance measures such as ROA and ROE. The authors explained this result as being due to the significant investment represented by technology adoption, the business results of which cannot be seen immediately [24].

2. Materials and Methods

It can be noted in this study that we carried out various studies using a systematic literature review method (SLR) and a quantitative research method. A review in accordance with universally recognized standards for practitioners and researchers enables the finding, evaluating, and integrating of existing studies. The SLR method is made up of three main phases: planning, execution, and reporting. In the planning process, specific research questions are formulated and the protocol established, along with the scope of the review. The execution phase consists of the development of a search strategy, inclusion and exclusion criteria and the assessment, coding, analysis and synthesis procedures. Finally, the reporting section is all about writing up the review and the dissemination of the findings

To resolve these research issues in the current work, we have also used the empirical analysis, which is based on the panel-series from units of data across 14 regions over 10 time periods (140 observations). The dependent variable is the growth in financial services and the independent variables are key indicators such as the measures of development of internet and mobile technology. Unobserved individual heterogeneity by units was adjusted for in the fixed-effects regression. The model was estimated using a within estimator. Statistical significance was assessed at the 1%, 5%, and 10% levels; multicollinearity was examined in the estimation process.

To achieve its goals, this study suggests using publications and citations to analyze the performance of authors, institutions, countries and journals. Another unique approach used in this study is known as Statistical Comparison.

We started by conducting a methodical keyword search of the literature on digital bank technologies. We extracted data from the Scopus index database as Scopus has a larger journal than any other service that conducts data mining. As a result, this study made use of this database to mine data for analysis. To identify digital banking impact articles, we used the keyword methodology outlined by scholars who have recently conducted reviews of DBT. The keywords and search terms used in these databases were developed based on the research question and these terms included essential concepts such as 'commercial bank,' 'digital bank services,' 'fintech,' 'digitalization,' 'digital technologies' and 'digital transformation.

3. Results

Commercial banks in the Republic of Uzbekistan are actively implementing digital transformation processes today. The work carried out by banks in such innovative areas

as proprietary mobile applications, remote identification systems, and the automation of banking services using artificial intelligence is intensifying competition in the national financial market and contributing to an improvement in the investment climate. Digital technologies also contribute to expanding financial inclusion, increasing the accessibility of banking services for the population, and strengthening the stability of the financial system.

The development of digital and internet technologies in our country has led to the growth of financial services. As a result of increased internet coverage in Uzbekistan, financial technologies are developing harmoniously. It should be noted that the role of digital technologies in the provision of financial services by banks and other financial institutions is growing.

Today, the role of Internet technologies in the emergence and provision of digital banking services is becoming increasingly significant. The share of digital services in the global non-banking market amounted to US\$143 billion, and by 2025, this figure is expected to reach US\$210 billion [25]. In general, we can observe how traditional banking services are being replaced by digital financial services.

Notably, in recent years, with the development of mobile communication services and the increase in the number of mobile devices per person in Uzbekistan, there has been a growing trend towards the use of financial technologies through these devices. It should be noted that the development of online banking services is highly attractive, saving people time and money. The development of financial technologies, as well as the coverage of a single Internet network, contribute to improving the quality and quantity of services provided to customers through artificial intelligence (Table 1).

Table 1. Analysis of the impact of internet technology factors on the growth of financial services Fixed-effects model

services Fixed-effects model							
Fixed-effects (within) regression		Number of obs		140	Number of groups		14
R-squared:		Obs per group:			Group variable:		region
Within = 0.0918		min		10	F(4,122)		3.08
Between = 0.0022		avg		10.0	Prob > F		0.0186
Overall = 0.0040		max		10	corr(u_i, Xb)		-
							0.9646
Growth of financial services	Coefficient	Std. err.	t	P>t	[95% conf. interval]		
Number of subscribers connected to the Internet, individuals per 100 population	.0681578	.2147232	0.32	0.751	-.35690	.49322	
The population's provision with telephones, per 100 people	-	1.090993	-1.94	0.055	-4.2743	.04514	
Number of subscriber radio stations connected to the mobile communication system, individuals per 100 population	-	.2233396	-0.27	0.790	-.50176	.38248	
Number of subscribers connected to the Internet,	0	(omitted)					

individuals per 100 population						
Number of subscribers connected to the Internet, per 100 inhabitants (by region)	-	.21701 54	-1.13	0.262	-.67407	.18512
_cons	153.6159	12.772 05	12.03	0.000	128.33	178.89
sigma_u	18.25824 5					
sigma_e	14.12968 2					
rho	.6254340 8	(fraction of variance due to u_i)				
F test that all u_i=0: F(13, 122) = 0.77			Prob > F = 0.6884			

Table 1 shows the results of fixed-effects linear regressions on internet technology factors and financial services growth. A model with 140 observations in 14 subgroups with 10 observations per group has a balanced panel.

The R-squared of the explanatory variables explains 0.40% of the total variance (overall $R^2 = 0.0040$) as the model grows. The within R^2 (0.0918) is the value indicating that within groups, approximately 9.18% of the variation over time is the result of being included; meanwhile the between R^2 (0.0022) is also quite low, suggesting very low explanatory capability between groups. The F-statistic ($F = 0.77$) and $\text{Prob} > F = 0.6884$ reveals no statistical significance in the overall model. The combined independent variables are unlikely to provide a meaningful explanatory effect on financial services growth, which is therefore unrepresentative. Among the explanatory variables:

1. The proportion of Internet users per 100 population shows a positive but statistically insignificant effect ($p = 0.751$), indicating that its direct impact on financial services growth is weak.
2. The number of mobile subscriber stations per 100 population has a negative coefficient (-2.1146) and is marginally significant at the 10% level ($p = 0.055$), suggesting a weak inverse relationship.
3. The number of Internet users per 1000 population shows a negative and insignificant effect ($p = 0.790$).
4. One Internet-related variable is omitted due to multicollinearity, indicating a strong correlation with other regressors.
5. The amount of Internet users per 100 population (household level) has a negative but insignificant impact ($p = 0.262$).
6. The constant term is highly significant ($p = 0.000$), implying the presence of strong baseline factors influencing financial services growth beyond the included digital indicators.
7. In the constant rho coefficient (0.6254), a considerable proportion of 62.5% is accounted over due to unobserved group effects, thus justifying use of fixed impact-based model.

Based on the above considerations, we analyze the panel data, adding the factor of years, and as a result we obtain the data presented in Table 2

Table 2. Analysis of panel data on the impact of Internet technology factors on the growth of financial services. Random effects model.

Fixed-effects regression	(within)	Number of obs	140	Number of groups	14
R-squared: Within = 0.6841		Obs per group: min	10	Group variable: Wald chi2(4)	region 1531.42

Between		=	avg	10.0	Prob > chi2	0.0000	
0.1669							
Overall = 0.6710			max	10	corr(u_i, Xb)	0	(assumed)
Growth in financial services	Coefficient	Std. err.	t	P>t	[95% conf. interval]		
The number of subscribers connected to the Internet	-.0616249	.1029664	-0.60	0.550	-.26343	.1401855	
Provision of the population with telephone devices	-.8658545	.2505734	-3.46	0.001	-1.3569	.374739	
Number of subscriber radio stations connected to the mobile communication system	.102588	.0858157	1.20	0.232	-.06560	.2707838	
Number of subscribers connected to the Internet	.1015888	.0642597	1.58	0.114	-.02435	.2275356	
Years							
2016	-6.333395	1.955958	-3.24	0.001	-10.167	2.49978	
2017	-5.721121	2.516486	-2.27	0.023	-10.6533	.788898	
2018	3.4094	2.839061	1.20	0.230	-2.15505	8.97385	
2019	28.19696	4.24162	6.65	0.000	19.88354	36.51038	
2020	-3.545645	4.037914	-0.88	0.380	-11.4598	4.36852	
2021	-5.87295	4.288688	-1.37	0.171	-14.2786	2.53274	
2022	-5.508896	5.887537	-0.94	0.349	-17.0482	6.030465	
2023	-13.88206	5.576442	-2.49	0.013	-24.8116	2.95243	
2024	-18.72113	4.587978	-4.08	0.000	-27.7134	9.72886	
_cons	126.1693	2.877351	43.85	0.000	120.5298	131.8088	
sigma_u	0						
sigma_e	8.6357945						
rho	0						(fraction of variance due to u_i)

Table 2 shows that the model is statistically significant. Specifically, $\chi^2(13)$ Wald = 1531.42 and Prob > χ^2 = 0.0000 indicate that the model is statistically significant. In addition, the intra-criterion coefficient (R^2) (0.6841) indicates that 68% of the changes over

time are well explained by the model. The total coefficient (R^2) (0.6710) indicates a high level of explanation by the model. Based on the data presented in Table 2, we were able to draw the following scientific conclusions:

1. First, Internet coverage did not affect the growth of financial services. The increase in the number of mobile radio stations also indicates no impact.
2. Second, it is clear that the penetration of telephony among the population does not correspond to the growth in the volume of financial services. In other words, it should be noted that the relationship between them is inversely proportional.
3. Third, the growth in the number of subscribers connected to the Internet, although small, is statistically significant. This indicates a positive effect of connecting to the Internet from a mobile device.
4. Fourth, it should be noted that there was strong growth in 2019. In 2023–2024, there is a negative trend. In other years, there is no statistically significant correlation. From this point of view, it should be noted that coordinated reforms do not proceed evenly across regions in different years.

4. Discussion

The results of the fixed-effects regression analysis show that the chosen internet technology indicators have a negligible and statistically weak effect on the financial services growth during the period studied here. Digital infrastructure is generally perceived as a significant facilitator of the financial sector's development, however the results of the current study indicate that this direct influence is low in the context analyzed. The low values of the overall and between R-squared support the conclusion that differences across regions are not sufficiently interpreted by the included internet-related variables. Simultaneously, the within R-squared indicates that digitalization factors account for a relatively small portion of time-based shifts in financial services growth. This indicates that macroeconomic, institutional or financial characteristics may have a more significant implication on financial services dynamics.

The number of mobile subscriber stations per 100 population shows only a weak negative association with financial services growth and is only marginally significant at the 10% level among the explanatory variables. This unforeseen inverse relationship might suggest that expanding mobile communication by itself does not necessarily lead to more financial service development, particularly if digital financial services do not exist well enough in the mobile ecosystem.

Other indicators (share of Internet users and number of Internet subscribers) showed statistically insignificant influences, indicating that internet access is not sufficient to increase financial services development if you don't also consider financial literacy, regulatory support, digital payment infrastructure, and confidence in digital platforms.

Because of multicollinearity, one of the internet-related variables was excluded, thus showing how tightly digitalization indicators were interrelated and indicating that future research would be better off using composite digital development indices rather than the highly correlated individual variables.

The high value of the rho coefficient indicates that a large portion of our financial services growth variance has to do with unobserved regional factors. This demonstrates that structural, institutional and regional characteristics which continue to lie outside the current model's scope but are still very effective at driving financial sector performance really matter.

Overall, the findings reveal that while internet technologies constitute a basic groundwork for financial digitalization, but that their unique impact from there on alone is not enough to guarantee sustainable growth of financial services. Hence, policymakers should not just concentrate on developing digital infrastructure, but rather strengthening digital financial services, improving financial inclusion, enhancing regulatory frameworks, and increasing digital and financial literacy among the population.

Our findings also show that although digital banking services are growing globally, the trend has varying degrees of success across regions. Figure 1 gives a graphic representation of regional differences in adoption rates of digital banking services in 2025. Base on this we will conclude these (Figure 1):

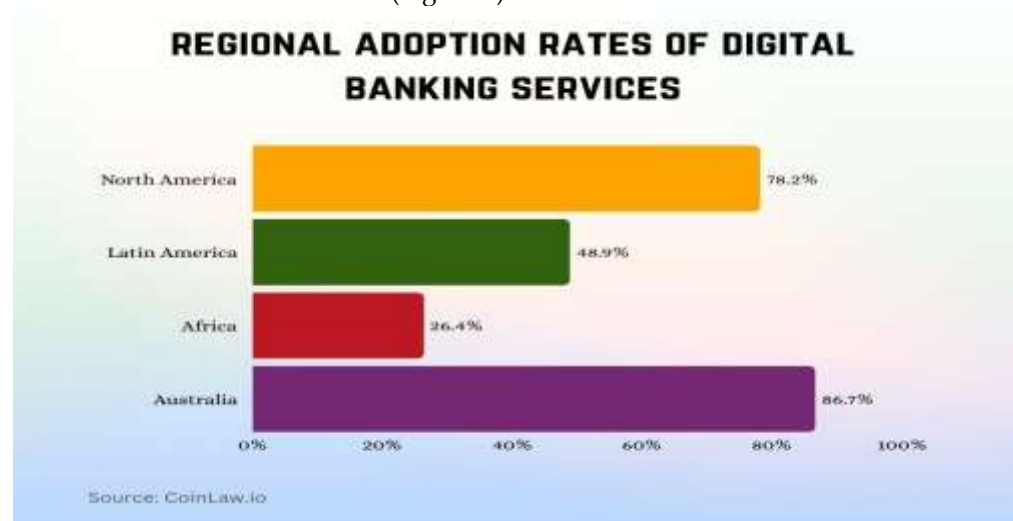


Figure 1. The adoption rate of digital banking services across different regions (2025)

1. North America leads the way in digital banking, with 78.2% of U.S. adults using some form of digital financial service in 2025 as a result of modern mobile platforms, real-time payments, and fintech partnerships.
2. In Latin America, digital banking usage continues to soar, with 48.9% of Brazilians now using digital banks as their primary financial service, supported by mobile-first platforms, rising fintech investments, and cashless initiatives. Africa is quickly catching up countries including Kenya, Nigeria, and South Africa held 26.4% of the continent's digital banking users in 2025, aided by the widespread use of mobile wallets, neobanks, and financial inclusion programs.
3. In the Middle East, digital banking adoption increased 28.1% in 2025, led by UAE and Saudi Arabia owing in part to national digital agendas, Sharia-compliant fintechs, and seamless onboarding experiences
4. Australia remains one of the world's leading digital banking adopters, with 86.7% of the population using digital banking services in 2025, buoyed by competition from neobanks, strong cybersecurity standards, and the normalization of contactless payments.

5. Conclusion

In conclusion, the improvement of digital banking technologies is becoming increasingly important in the banking and financial sector in order to provide quick and convenient services as well as increase competitiveness. By analyzing the above situation, it indicates that the enhancement of banking digital services would achieve a gain in financial efficiency, broaden the user base, secure cybersecurity, and achieve financial inclusion. The country's banking system is required to study the advanced experiences of foreign banks and adapt them to our own requirements and environment in this respect. Therefore, this study emphasizes the significant growth and significance of digital banking in emerging countries and highlights its important role in advancing technological innovations within the financial sector. These key aspects of digital revolutionisation in the banking industry are very relevant in the context of recent literature review. This article adds value in providing insights and statistics which support the continued investment in digital banking solutions as one of the factors that allow banks to remain major

contributors to the modernisation and competitiveness of banking systems in emerging economies.

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