

Analysis of Digitalisation Impact on Bank Risk Management Methods and Marketing Policy of Banks

Gulnaz ABDUKADYROVA

*Department of Banking Activity and Securities Market, Musa Ryskulbekov Kyrgyz Economic
University, Bishkek 720033, Kyrgyz Republic*

E-mail: gulnaz__abduk@outlook.com

Zhyldyz ALYMBAEVA*

*Department of Banking Activity and Securities Market, Musa Ryskulbekov Kyrgyz Economic
University, Bishkek 720033, Kyrgyz Republic*

E-mail: alym.zhyldyz@gmail.com

Adilia TABYSHOVA

*Department of Banking Activity and Securities Market, Musa Ryskulbekov Kyrgyz Economic
University, Bishkek 720033, Kyrgyz Republic*

E-mail: tabyshova.a@hotmail.com

Asmat ORUNTAYEVA

*Department of Economics and International Economic Relations, Musa Ryskulbekov Kyrgyz Economic
University, Bishkek 720033, Kyrgyz Republic*

E-mail: asmatorun@outlook.com

Bigali AIZAT AZBERGEN KYZY

*Department of Economics and International Economic Relations, Musa Ryskulbekov Kyrgyz Economic
University, Bishkek 720033, Kyrgyz Republic*

E-mail: bigali-aizat@hotmail.com

Abstract The study aims to analyse transformational changes in banking risk management and marketing policy of banks caused by digitalisation. The study addressed examples of successful digital technology implementation in the banking sector around the world and conducted a comparative analysis of the current situation in Kyrgyz banking. The study addresses the process of digital transformation of the banking sector, with a focus on Kyrgyzstan. Digital transformation involves the integration of technologies such as artificial intelligence, big data and blockchain into all aspects of banking operations, leading to significant changes in their functioning and customer experience. The study analysed automating processes, improvement of customer service, enhancement of transaction security and creation of new business models. The study included examples of successful digitalisation in banks around the

Received July 2, 2025, accepted March 12, 2026

*Corresponding author

world, such as the use of artificial intelligence to automate and analyse data, which helps to predict risks and improve customer experience. Based on the analysis, recommendations for banks in Kyrgyzstan were proposed, including investments in IT infrastructure, literacy programmes and enhanced cybersecurity. The results show that digitalisation can significantly increase the accessibility and quality of banking services, improving the overall standard of living of the population.

Keywords internet of things; big data; artificial intelligence; financial services; customer behaviour

1 Introduction

Digitalisation has become a crucial driver of transformation in the banking sector, reshaping internal operations, customer interactions, risk management, and marketing strategies. The relevance of studying this phenomenon stems from its ability to enhance operational efficiency and flexibility, enabling banks to respond promptly to market changes and evolving customer needs. Modern financial technologies, including fintech solutions, offer new tools for predicting and mitigating risks, which is particularly important in volatile economic conditions and highly competitive markets. At the same time, the expansion of digital channels for customer engagement necessitates a reassessment of traditional marketing approaches, focusing on personalised services and digital user experiences. The implementation of digital transformation requires substantial investments in infrastructure, employee training, and organisational culture, while simultaneously addressing emerging cybersecurity and data protection challenges. Key aspects of digitalisation include the adoption of artificial intelligence, big data analytics, and blockchain to streamline operations, improve service quality, and develop innovative business models. In parallel, risk management benefits from advanced analytical tools for forecasting and minimising potential threats, and credit decision processes can be automated to increase accuracy and speed. Marketing policies are increasingly data-driven, leveraging digital channels and analytics to segment audiences, tailor offers, and strengthen long-term customer relationships, highlighting the importance of comprehensive research into the impact of digitalisation on banking performance and strategy. The banking sector in Kyrgyzstan presents a unique context due to its limited digital infrastructure and the ongoing transition from traditional to technology-driven operations. Research on the impact of digitalisation in this market remains scarce, leaving gaps in understanding how modern financial technologies can enhance efficiency, risk management, and customer engagement. These characteristics make Kyrgyzstan a relevant case for studying the adaptation and implementation of digital banking solutions in emerging economies.

Analysing the work of various researchers, several results can be identified. Cucari et al.^[1] studied the impact of blockchain technologies on banking operations and highlighted that the introduction of this technology helped to increase transparency and reduce operational risks. Rodrigues et al.^[2] addressed cybersecurity issues in the banking sector and proposed comprehensive measures to protect customer data from cyberattacks. In the study by Hoque et al.^[3], the authors investigated the impact of digital transformation on risk-taking behaviour in Vietnamese commercial banks. In particular, they demonstrated that banks with higher levels of

digital adoption had significantly lower exposure to financial risks, indicating that digitalisation contributed to stability and more prudent risk management.

In the research by Mansour^[4], the author examined the effects of digital finance adoption on the risk profiles of commercial banks. In particular, it was found that broader digital finance implementation reduced risky lending practices and enhanced banks' resilience, highlighting the importance of digital tools in mitigating operational risks. In Huynh^[5], the study focused on how digital transformation influenced banks' liquidity creation in a bank-based market. In particular, it was shown that banks with advanced digital systems were able to generate greater liquidity through improved asset and liability management, supporting more efficient financial operations. In the work by Koldovskiy and Rekunen^[6], the authors analysed the role of digitalisation, transparency, and social responsibility in driving financial innovation within banking systems. In particular, they revealed that digital initiatives not only streamlined operational processes but also enhanced trust and institutional credibility, fostering innovative financial practices. In Pratama^[7], the research explored strategic approaches for advancing digital banking and creating a roadmap for operational excellence. In particular, it was demonstrated that integrating technological enablers, digital risk frameworks, and innovation strategies enabled banks to improve service quality, strengthen resilience, and better respond to evolving fintech landscapes.

Thus, studies by various authors confirm the importance of digitalisation for banking risk management and marketing policy. The adoption of technologies such as blockchain, artificial intelligence and big data is helping to increase the efficiency of operations, reduce risks and improve customer experience. Particular attention is devoted to cybersecurity issues and changing the organisational culture of banks. However, such topics as the impact of digitalisation on the resilience of banks in economic crises, the effectiveness of specific fintech solutions for managing operational risks, and the impact of digitalisation on the corporate culture of banks in different regions of the world remain insufficiently researched. The study aims to comprehensively examine the impact of digitalisation on bank risk management methods and marketing policies to develop recommendations for banks to successfully adapt to the new environment. The research hypothesis was that the implementation of digital technologies in the banking sector significantly improves risk management, customer interaction, and operational efficiency in Kyrgyzstan.

2 Materials and Methods

The main elements of the study include the study of examples of successful implementation of digital technologies in the banking sector around the world and a comparative analysis of the current situation in the banking sector of Kyrgyzstan. This made it possible to identify the main trends and technologies used in the banking sector for digitalisation, as well as to identify the key problems and challenges faced by banks in the process of implementing digital technologies.

The study included a comparative analysis of the current situation in the banking sector of Kyrgyzstan. For this purpose, data on the key performance indicators of the national bank-

ing sector, as well as information on digital initiatives implemented by Kyrgyz banks, were collected. The study analysed data from the national banking sector of Kyrgyzstan between 2019 and 2023, focusing on banks that actively implemented digital initiatives, such as Aiyl Bank^[8] and Bank “Kyrgyzstan”^[9]. Inclusion criteria were based on the availability of complete performance indicators (income, expenses, assets, liabilities, and capital) and documented use of analytical tools for credit risk assessment, while transparent procedures involved collecting official statistics from the National Statistical Committee of the Kyrgyz Republic^[10] and verified bank reports to ensure consistency and comparability of the data. Banks were compared using several key criteria, including their ability to manage risks through AI, big data, and blockchain technologies, the effectiveness of customer service and personalisation, market and product coverage, profitability, asset and deposit growth, operational efficiency, and the capacity to maintain a sound loan portfolio and balanced financial position.

The study included the collection and analysis of data on examples of successful implementation of digital technologies in the banking sector of different countries. The leading banks in the world, such as Bank of America^[11] and HSBC^[12], which actively use artificial intelligence, big data, and blockchain technologies, were studied. Other banks, such as DBS Bank^[13] and UBS Bank^[14], which are applying innovative solutions to improve their services and risk management, are also studied. Bank of America’s analysis Erica, a virtual financial assistant who uses AI to provide personalised financial advice and warnings about potential risks. Particular attention was devoted to machine learning technologies in analysing network traffic and preventing DDoS (Distributed Denial of Service) and other types of cyberattacks. This analysis identified best practices and approaches that can be applied in the banking sector of Kyrgyzstan. These banks were chosen as they exemplify global best practices in digital transformation, using AI, big data, and blockchain to enhance operations, customer services, and risk management, providing models that can be adapted to the Kyrgyz banking sector. The study compared international practices with the Kyrgyz context and highlighted specific recommendations for adapting digital strategies to local conditions. This approach enabled the identification of transferable methods and context-sensitive adjustments for effective implementation.

In the study, a structured interview was conducted among employees of the banking sector in Kyrgyzstan to identify features of digital technology implementation, risk management practices, and the impact of digitalisation on bank efficiency. The sample included 30 respondents from Aiyl Bank, Bank Kyrgyzstan encompassing staff from IT, risk management, and marketing departments. Inclusion criteria were: direct experience with digital technologies and participation in digital projects for more than one year, while exclusion criteria included lack of practical experience in digitalisation or tenure of less than one year. During the interviews, all ethical requirements were strictly observed in accordance with the principles of the Declaration of Helsinki^[15]. Participants provided informed consent, and their confidentiality and rights were fully respected throughout the study. The interview consisted of 10 structured questions, addressing topics such as the use of AI, big data, digital channels, credit risk assessment, changes

in internal control, and the effectiveness of implemented digital solutions.

Q1. How well are digital technologies integrated in your department?

Q2. How much has the implementation of AI or analytical systems improved risk management?

Q3. How effectively does the bank use big data to assess customers' creditworthiness?

Q4. How significantly has digitalisation affected internal control processes?

Q5. How systematically is the effectiveness of new digital solutions evaluated?

Q6. How much has digitalisation increased the speed of transaction processing?

Q7. How positively have digital channels influenced customer interaction?

Q8. How challenging was the implementation of new technologies?

Q9. How adequately are staff trained on new digital tools?

Q10. How important are the results of implementing digital technologies in your department?

For evaluation, the interview data were analysed quantitatively. Oral responses were coded into thematic categories, followed by a quantitative assessment of the frequency of key terms such as "AI", "big data", "digital channels", and "risks", which allowed identification of the most significant digitalisation factors. Since the interviews were structured, respondents' answers were rated on a scale from 1 to 5, where 1 indicated a "very low" level and 5 indicated a "very high" level of satisfaction or agreement with the statement. Additionally, descriptive statistical methods were applied, including the calculation of frequencies, percentages, and mean values to assess the prevalence of digital tool usage in banks, along with the pearson correlation coefficient to determine the relationship between digital technology adoption and the effectiveness of risk management.

Based on the data collected, the state of digitalisation in the Kyrgyz banking sector was analysed. At the same time, the challenges of digital technologies in the banking sector and their impact on the quality of life of the population were identified. The results of the study were used to develop recommendations for further development of digital transformation in the banking sector.

3 Results

Digital transformation is the process of integrating digital technologies into all aspects of a bank's operations, leading to fundamental changes in the way it operates and interacts with customers. The main elements of digital transformation include the use of AI to automate processes and improve customer service, big data analysis to make more informed decisions and personalise services, the introduction of blockchain technologies to increase the security and transparency of transactions, and the development of digital communication channels such as mobile Apps and online banking to provide convenient and round-the-clock access to banking services^[16]. Digital transformation aims to increase efficiency, reduce costs and create innovative business models that can adapt to rapidly changing market conditions. Big data is another important element of the modern banking industry. Big data analysis allows banks to better understand customer

behaviour and preferences, which helps to personalise services and improve their quality. Banks use data to develop more accurate risk assessment models, which enables more informed lending and investment decision-making^[17]. In addition, big data analysis helps to detect fraud and prevent cyberattack. Blockchain is a distributed ledger technology that provides a high level of security and transparency of transactions. In the banking sector, blockchain is used to create secure and efficient systems for data exchange, international payments and digital asset management. Blockchain technology can significantly reduce transaction costs and speed up transaction processing, which is especially important for international financial transactions^[18]. Blockchain technologies provide a high level of security and transparency of transactions, which reduces operational and transactional risks. The use of a distributed ledger allows banks to track all transactions in real-time, preventing fraud and reducing the risks associated with errors and misuse. With the ever-increasing threat of cyberattack, digitalisation is helping to strengthen banks' security systems, including multi-factor authentication, data encryption and real-time monitoring of network traffic^[19]. Cybersecurity and data protection are critical aspects of the digitalisation of the banking sector. The introduction of digital technologies and the increase in the volume of data processed are creating new security threats, such as cyber-attacks, phishing and data breaches. To protect their systems, banks use multi-layered security measures, including data encryption, two-factor authentication, and firewalls^[20]. Particular attention is devoted to monitoring and anomaly detection, which enables quick identification and response to suspicious activity, thus preventing attacks.

In Kyrgyzstan, despite more limited resources than developed countries, banks are actively working to improve risk management using available technologies and methods. An example of such work is Aiy Bank^[8], which has implemented a data analytics system to assess credit risks and monitor the financial condition of borrowers. This system is based on the collection and analysis of various data, including financial statements, payment history and economic indicators of clients. Using this data, the bank can create detailed profiles of borrowers and assess their creditworthiness. This assessment can be used to predict the probability of loan defaults with greater accuracy and take preventive measures to minimise risks. In the event of changes in the economic situation, the system allows for prompt adaptation of credit terms and risk management strategies, which significantly reduces default rates. Aiy Bank also uses analytical tools to monitor the status of borrowers in real-time. This identifies potential problems, such as a deterioration in the client's financial position or delays in payments, in a timely manner, so thus appropriate actions can be taken. For instance, the bank can offer a loan restructuring or develop an individual debt repayment plan, which helps to reduce the level of overdue debt and improve the bank's financial performance.

Bank Kyrgyzstan^[9] focuses on improving internal control and audit, which is an important aspect of operational risk management. Internal control includes regular reviews of financial transactions, compliance with regulations and procedures, and monitoring of employee performance. The bank has implemented an internal audit system that enables timely detection and

prevention of financial mismanagement and errors in operations. This is achieved through regular audits and analysis of internal processes. In addition, Bank Kyrgyzstan has implemented automated systems for document management and regulatory compliance. These systems help reduce the likelihood of errors and increase transparency of operations. In case of violations or inconsistencies, the bank can quickly take corrective measures and minimise potential losses. This internal control policy contributes to the overall stability of the bank and strengthens customer confidence.

However, the implementation of digital tools in Kyrgyz banks also carries inherent risks. Limited technological infrastructure, unstable internet connections, and insufficient staff training can compromise the accuracy and reliability of risk assessments. Additionally, reliance on automated systems may reduce the ability of employees to detect unusual patterns or non-quantifiable risks, while data privacy and cybersecurity concerns create potential vulnerabilities. Misinterpretation of analytics outputs or incomplete data can lead to inappropriate credit decisions, and over-dependence on technology may diminish the role of human judgment in critical financial evaluations. Therefore, while digitalisation enhances risk management capabilities, it requires careful oversight, continuous staff development, and robust security measures to mitigate associated risks. Digital risks in banking encompass a growing set of challenges linked to the adoption of modern technologies, where traditional operational and credit risks are joined by systemic vulnerabilities inherent to digital systems. As reliance on information technologies (IT) infrastructure deepens through automated processes, cloud computing, mobile channels, and large-scale data processing, banks face heightened exposure to cyber threats such as phishing, malware, ransomware, and unauthorized access, which can lead to financial losses and undermine customer trust. A comprehensive review of cybersecurity threats in digital banking shows that institutions are particularly susceptible to these attacks as digital services expand, with advanced, AI-driven threats increasingly able to bypass conventional security measures and cause significant disruption and reputational harm, highlighting the need for robust, multi-layered protection strategies^[21].

Changes in risk profiles are also evident as digitalisation shifts risk from traditional domains to IT-centric and data-centric domains, requiring banks to rethink their risk frameworks and mitigation approaches. Cybersecurity risks now play a central role in overall risk governance, demanding proactive measures such as multi-factor authentication, encryption, network monitoring, and behavioural analytics to defend against sophisticated attacks, while compliance with international standards like International Organization for Standardization (ISO)/International Electrotechnical Commission (IEC) 27001 enhances resilience and stakeholder trust. Research into banking cybersecurity emphasises that the increasing complexity of digital systems including the proliferation of vulnerable access points and expansion of data volumes significantly raises the likelihood of successful cyberattacks unless countered by advanced technologies like SIEM (Security Information and Event Management) and User and Entity Behavior Analytics (UEBA), along with organisational responses such as incident response planning and employee

training^[22].

The banking context in Kyrgyzstan is unique due to its transitional economic structure, a relatively small and dispersed market, and the coexistence of traditional and modern banking practices. The aforementioned banks operate with limited digital infrastructure, resulting in uneven access to online services between urban and rural regions. The regulatory environment is developing, which creates variability in how innovations are adopted and implemented. Operational processes often combine manual and digital elements, making workflow efficiency dependent on both human and technological factors. Customer interactions are influenced by varying levels of digital literacy and trust in technology, which shapes the adoption of online banking and mobile platforms. These characteristics create a distinctive environment where digitalisation must be tailored to local economic, social, and technological conditions, balancing innovation with practical constraints to ensure effective implementation and service delivery. In summary, despite limited resources, banks in Kyrgyzstan are taking significant steps to improve risk management by using data analytics systems and strengthening internal controls. These measures allow banks not only to minimise financial losses but also to adapt to changing market conditions, ensuring stability and sustainable development. Table 1 shows the performance indicators of the banking sector in Kyrgyzstan.

Table 1 Performance indicators of the banking sector of Kyrgyzstan from 2019 to 2023, billion KGS

	2019	2020	2021	2022	2023
Income	43.3	32.6	36.0	92.6	107.4
Expenses	34.5	30.0	32.0	57.8	68.6
Balanced financial result	8.7	2.6	4.0	34.7	38.7
Assets	438.1	288.7	358.0	877.2	1058.8
Commitments	364.8	242.4	314.6	740.6	881.6
Capital	73.3	102.7	120.0	136.6	177.2
Including share capital	25.9	35.4	42.2	47.0	63.5

Source: compiled by the authors based on National Statistical Committee of the Kyrgyz Republic^[10].

Analysis of the Kyrgyz banking sector data from 2019 to 2023 demonstrates a clear causal relationship between key financial indicators and bank performance. Growth in capital, particularly share capital, created conditions for the expansion of loan and investment assets, which directly contributed to increased bank revenues and improved balanced financial results. Rising revenues combined with controlled increases in expenses supported profitability growth, reflecting the effect of efficient resource management. At the same time, the expansion of assets and liabilities influenced the scale of banking operations and their ability to generate financial outcomes, confirming that capital and asset growth are key determinants of financial stability and operational efficiency in the Kyrgyz banking sector. The growth in assets and income is partic-

ularly notable, reflecting the recovery and development of the banking sector after the economic turmoil caused by the pandemic. Improvements in capital and shareholders' equity ratios also point to the strengthening of banks' financial strength.

With the rapid digitalisation of the financial sector, banks around the world are actively implementing advanced technologies to manage risks and improve their financial stability. The examples of leading banks in the US and UK demonstrate how innovative approaches help not only minimise risks but also improve the quality of customer service. Bank of America^[11] is a pioneer in the use of artificial intelligence and machine learning to analyse big data and predict risk. These technologies allow the bank to more accurately assess the creditworthiness of borrowers and predict the likelihood of defaults. For instance, machine learning algorithms analyse customers' financial history, behaviour and market conditions to create accurate forecasts and recommendations.

One of the most prominent examples of AI is the Erica project, a virtual financial assistant that provides clients with personalised financial management advice and warns them of potential risks. Erica analyses customer transactions and helps clients avoid debt by offering optimal financial solutions. This helps to reduce the level of overdue debts and increase customer loyalty. Another example is a risk forecasting system that uses AI to analyse market data and identify potential financial threats. Bank of America actively employs this data to manage investment portfolios, minimising risk and increasing returns. This enables the bank to respond promptly to changes in market conditions and protect the interests of clients and investors.

British bank HSBC (Hongkong and Shanghai Banking Corporation)^[12] is also a leader in the use of modern technologies for risk management, especially in the field of cybersecurity. In the face of growing threats of cyber-attacks, the bank has developed a comprehensive data protection system, including multi-level authentication, data encryption and continuous monitoring of network traffic. One of the key elements of this system is multi-factor authentication, which includes the use of one-time passwords, biometric authentication and other security methods. This makes access to banking systems much more difficult for hackers and ensures a high level of security for customer data. HSBC also uses systems to monitor and analyse network traffic in real-time. These systems help detect anomalous activity and suspicious transactions, which facilitates a quick response to potential threats. For instance, the use of machine learning technologies to analyse network traffic helps to detect and prevent DDoS and other types of cyberattacks. HSBC is also actively investing in cybersecurity training for its employees. Regular training and educational programmes help to raise awareness of modern threats and security methods among employees, which reduces the likelihood of human error and data leaks.

Other countries also have successful examples of using technology for risk management. For instance, Singapore's DBS Bank^[13] is actively using blockchain to increase the transparency and security of transactions. The use of blockchain allows the bank to track all transactions in real-time and minimise fraud risks. Swiss UBS Bank^[14] has developed a market risk forecasting system based on big data and AI analysis. This system allows the bank to predict changes

in financial markets and make informed investment decisions, which significantly reduces the risk of losses. Table 2 illustrates the comparison of digital technology implementation and risk management practices among four leading international banks Bank of America, HSBC, DBS Bank, and UBS and highlights practical lessons for adaptation in Kyrgyz banks.

Table 2 Comparison of digital technology implementation and risk management practices in leading international banks and lessons for Kyrgyz banks

Bank/Country	Used Technologies	Key Risks Addressed	Risk Management Approaches	Lessons/Adaptation for Kyrgyz Banks
Bank of America (USA)	AI virtual assistant (Erica), big data analytics, blockchain, ML for network monitoring	Credit risk, fraud, cyberattacks, operational risk	AI flags suspicious transactions; blockchain secures transactions; ML detects threats	Adopt AI for alerts and warnings; gradual ML for cyber threats; blockchain for secure transactions
HSBC (UK)	AI for compliance, big data analytics, cloud platforms	Regulatory compliance, credit and market risk, cyber threats	Predictive credit scoring; AI compliance monitoring; automated alerts	Implement predictive scoring; adopt cloud with local data protection
DBS Bank (Singapore)	Digital wallets, mobile apps, AI chatbots, blockchain	Operational risk, cybersecurity, customer service risk	AI chatbots reduce error; blockchain for secure payments	Develop mobile apps and AI support; enhance efficiency and security
UBS (Switzerland)	AI advisory, big data for risk assessment, cybersecurity tools	Market risk, investment risk, cyberattacks	Algorithmic assessment; AI monitoring; cyber threat detection	Introduce AI risk assessment for investments; strengthen cybersecurity

Source: Compiled by the author based on Bank of America^[11], HSBC^[12], DBS Bank^[13], UBS Bank^[14].

Based on the analysis of leading international banks, several practices can be introduced to enhance the digital capabilities and risk management of Kyrgyz banks. The adoption of AI-driven tools, such as virtual assistants and predictive analytics, can improve credit assessment, detect potential fraud, and provide personalised customer alerts. Big data analytics can be used to monitor market trends and customer behavior, supporting more informed decision-making. Blockchain technology offers opportunities to secure transactions and increase transparency, particularly in cross-border payments. Machine learning applications can strengthen cybersecurity by detecting unusual network activity and preventing cyberattacks. Additionally, the implementation of mobile banking platforms and AI-powered customer support can enhance

operational efficiency and service quality. For successful adaptation, these technologies should be introduced gradually, accompanied by staff training, development of regulatory-compliant procedures, and investment in robust IT infrastructure. Emphasis should be placed on risk management practices that integrate technology, staff competence, and institutional processes, ensuring that the benefits of digitalisation are realised while mitigating potential operational, credit, and cyber risks.

The successful use of AI, big data, and blockchain in leading global banks can be adapted to the Kyrgyz banking sector to enhance operational efficiency, risk management, and customer service. For example, implementing AI-based virtual assistants similar to Erica could provide clients with personalised financial advice, monitor transactions, and alert customers to potential risks, thereby reducing overdue debts and improving loyalty. Banks in Kyrgyzstan could also adopt AI-driven risk forecasting systems to analyse market trends and anticipate financial threats, supporting more informed decision-making and better portfolio management. Additionally, introducing blockchain for transaction tracking would increase transparency and reduce fraud risk, while multi-layered cybersecurity measures, including encryption, multi-factor authentication, and real-time monitoring, could protect sensitive data from cyber threats. Leveraging big data analytics would allow banks to personalise marketing, develop targeted financial products, and respond quickly to customer needs. Overall, integrating these digital practices would create more flexible, efficient, and resilient banking models in Kyrgyzstan, aligning with global trends in financial sector digitalisation.

Digitalisation has fundamentally changed banks' approach to marketing policy, offering new tools and channels for customer interaction. In the face of growing competition and rising consumer expectations, banks are reviewing their marketing strategies to effectively capitalise on the opportunities offered by digital technologies. One of the key changes in banks' marketing policies in the context of digitalisation is the personalisation of marketing efforts. With big data and analytical tools, banks can collect and analyse information about their customers' behaviour and preferences^[23]. This can be used to create targeted marketing campaigns that account for the individual needs and preferences of each client. For instance, customers can receive personalised offers for loans, deposits or investment products based on their financial behaviour and life circumstances.

With the proliferation of the internet of things and mobile technologies, banks are actively using digital channels to promote their products and services. Social media, email, mobile Apps and websites are becoming the main tools for customer interaction. This allows banks not only to reduce marketing costs but also to respond quickly to changes in consumer preferences and market conditions^[24]. For instance, banks can run advertising campaigns on social media using precise targeting to attract new audiences and increase brand awareness. The overall level of digital technology adoption, staff preparedness, and organisational readiness in banks directly influences the effectiveness of risk management, customer interaction, and operational efficiency. Higher integration of advanced technologies such as AI, analytics, and automated sys-

tems is generally associated with improved decision-making, faster transaction processing, and more responsive customer services. Conversely, limitations in training, resource allocation, or technological infrastructure can constrain the benefits of digitalisation and create challenges for consistent implementation. Assessing the relationships between these factors provides insights into the interdependencies that shape digital banking outcomes and helps identify areas where targeted interventions may enhance performance. Table 3 presents the results of the Pearson correlation analysis based on the responses of 30 participants regarding the implementation of digital technologies in banks.

Table 3 Interview responses on digital banking implementation ($n = 30$)

Question	Mean	Standard Deviation	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Q1	4.1	0.7	1	0.62	0.58	0.41	0.45	0.50	0.53	0.36	0.47	0.51
Q2	3.8	0.8	0.62	1	0.66	0.49	0.55	0.61	0.59	0.44	0.52	0.57
Q3	4.0	0.9	0.58	0.66	1	0.52	0.60	0.63	0.61	0.42	0.50	0.56
Q4	3.5	0.6	0.41	0.49	0.52	1	0.47	0.51	0.45	0.33	0.41	0.44
Q5	3.9	0.7	0.45	0.55	0.60	0.47	1	0.57	0.52	0.39	0.50	0.53
Q6	3.7	0.8	0.50	0.61	0.63	0.51	0.57	1	0.58	0.43	0.49	0.55
Q7	3.8	0.7	0.53	0.59	0.61	0.45	0.52	0.58	1	0.40	0.46	0.50
Q8	2.9	0.9	0.36	0.44	0.42	0.33	0.39	0.43	0.40	1	0.38	0.41
Q9	4.0	0.8	0.47	0.52	0.50	0.41	0.50	0.49	0.46	0.38	1	0.54
Q10	4.2	0.6	0.51	0.57	0.56	0.44	0.53	0.55	0.50	0.41	0.54	1

Note: Responses from 30 participants were scored on a 1–5 Likert scale for each of the ten structured interview questions, and Pearson correlation coefficients were calculated to measure the strength and direction of relationships between answers, providing a quantitative assessment of interdependencies among respondents' perceptions.

Source: compiled by the author based on Pearson correlation analysis.

A regression analysis was conducted on the interview responses to examine the relationships between digital banking implementation factors, using the mean scores and standard deviations from Table 3. The analysis revealed that questions related to AI and analytics implementation (Q1–Q3) had relatively high mean values (4.0–4.1) and strong positive correlations with each other (ranging from 0.58 to 0.66), indicating that respondents who reported higher adoption of AI also perceived greater improvements in risk management and credit assessment. Questions on internal control and efficiency (Q4–Q6) showed moderate means (3.5–3.9) and correlations (0.47–0.63), suggesting a consistent but slightly weaker relationship between these factors and overall digital banking effectiveness. Questions on staff training and challenges (Q8) had the lowest mean (2.9) and weaker correlations (0.33–0.44), highlighting that perceived barriers and lack of training were less strongly associated with other aspects of digital banking implementation. Overall, the regression analysis indicates that adoption of advanced technologies is a significant predictor of improvements in risk management, customer interaction, and operational efficiency,

while training and implementation challenges contribute less directly to these outcomes.

The development of digital banking in Kyrgyzstan is influenced by a combination of institutional, regulatory, technological, and socio-economic factors, each playing a critical role in shaping the scope and effectiveness of digital transformation. From an institutional standpoint, the structure and governance of banks, including decision-making hierarchies and the presence of skilled IT and risk management personnel, are essential for the successful adoption and maintenance of digital banking solutions. Institutions with clear strategic priorities and sufficient human capital are better positioned to implement complex digital technologies and ensure ongoing operational reliability. Regulatory conditions also play a crucial role, encompassing banking supervision, licensing procedures, compliance requirements, and legal frameworks for fintech integration, which together establish the parameters for digital innovation and protect consumer interests while promoting a secure financial environment^[25–27].

Technological conditions form the foundation for practical digital banking operations, including high-speed internet access, robust IT infrastructure, reliable cybersecurity systems, and the integration of advanced tools such as artificial intelligence, blockchain, and big data analytics. These technologies enable banks to automate processes, improve customer experience, enhance risk management, and offer innovative financial products. Socio-economic conditions further influence adoption, encompassing factors such as the level of financial literacy, income distribution, urbanisation, and customer readiness to adopt digital financial services. High demand for online banking services and widespread mobile connectivity encourage banks to invest in digital platforms and tailor services to meet the needs of diverse customer segments^[28,29]. Together, these four dimensions create a complex, interdependent framework that determines the pace, scope, and effectiveness of digital banking transformation in Kyrgyzstan, highlighting both the opportunities for innovation and the constraints imposed by institutional, regulatory, technological, and socio-economic realities.

The banking sector in Kyrgyzstan has experienced considerable growth in recent years, with income rising from 43.3 billion KGS (Kyrgyz Som) in 2019 to 107.4 billion KGS in 2023, reflecting the expanding scope of banking operations. This increase in income has allowed banks to invest more heavily in digital platforms, mobile applications, and online services, which in turn creates opportunities for greater customer engagement and personalised financial solutions. At the same time, expenses grew from 34.5 billion KGS to 68.6 billion KGS^[30], indicating that resources are being allocated not only to operational needs but also to technological upgrades, staff training, and the integration of AI and big data systems. Such investments set the stage for improved service efficiency, faster transaction processing, and enhanced risk management capabilities.

The balanced financial result, increasing from 8.7 billion KGS to 38.7 billion KGS, demonstrates that profitability gains provide banks with the stability to explore innovative financial products and implement loyalty and educational programmes for clients. Rising assets, from 438.1 billion KGS to 1,058.8 billion KGS, support the expansion of lending operations, enabling banks to extend credit to underserved regions and develop financial inclusion initiatives.

Growing commitments, which increased from 364.8 billion KGS to 881.6 billion KGS, indicate greater client engagement and demand for banking services, highlighting the need for scalable digital solutions that ensure seamless omnichannel experiences. The expansion of capital, from 73.3 billion KGS to 177.2 billion KGS, provides banks with the capacity to absorb operational and technological risks, while higher share capital, from 25.9 billion KGS to 63.5 billion KGS, underpins long-term investments in cybersecurity, blockchain technologies, and automated risk assessment tools^[31].

As a result, these financial indicators directly drive strategic perspectives: The growth in income and assets encourages further investment in mobile banking, virtual customer support, and AI-driven credit scoring, which improve accessibility and reduce transaction times. Increasing commitments and balanced financial results create the opportunity to launch interactive financial literacy programmes, gamified educational tools, and client engagement initiatives, particularly targeting rural and underserved populations. The strengthened capital base allows banks to experiment with innovative services, expand digital infrastructure, and adopt advanced data analytics for personalised offerings, all of which contribute to long-term competitiveness and resilience^[32–34]. Collectively, the combination of rising financial metrics and digital adoption fosters a more inclusive, efficient, and innovative banking sector, capable of meeting the evolving needs of Kyrgyz customers while supporting sustainable economic development. In addition, digital technologies contribute to improving financial literacy by providing educational resources and advice online. Banks and other financial institutions are developing and offering online courses, webinars, articles, and videos to help people better understand financial products, manage their budgets, and plan^[35,36]. For instance, banks can offer interactive budgeting tools or calculators for planning savings and investments, helping users make more informed financial decisions.

The digitalisation of the banking sector in Kyrgyzstan represents an important stage in the development of the national financial system but also involves several problems and challenges. One of the main obstacles to the digitalisation of the banking sector in Kyrgyzstan is the lack of infrastructure. Rural and remote areas of the country often lack stable internet and access to modern technology, which limits the opportunities for the introduction of digital financial services. This factor significantly slows down the process of digital transformation and limits the availability of banking services for a significant part of the population^[37,38]. The second important obstacle is the low level of financial and digital literacy of the population. Many citizens, especially in rural areas, lack the knowledge and skills to use digital financial products and services. This creates additional barriers to the spread of digital technologies and requires banks to conduct large-scale educational programmes. The third obstacle is the lack of investment in the development of digital technologies. Banks face limited financial resources, which makes it difficult to modernise their IT infrastructure and implement new digital solutions. In addition, the high costs of cyber security and data protection are also becoming a significant financial burden for banks^[39,40].

Despite existing challenges, the digitalisation of the banking sector in Kyrgyzstan has significant potential to improve the financial system and the quality of life of the population. To successfully adapt to digital change, Kyrgyz banks should focus on several key areas. It is necessary to invest in the development of IT infrastructure and ensure access to modern technologies in both urban and rural areas. This may include expanding internet access networks and modernising banking systems. Banks should be actively engaged in improving the financial and digital literacy of the population. This can be done through educational programmes, webinars and awareness campaigns to help citizens better understand and use digital financial products and services. Banks should also address cybersecurity and data protection. In the context of digitalisation, ensuring the security of financial transactions and the confidentiality of customer data is becoming a priority. This requires the implementation of modern security measures, regular updates of security systems and training for employees. In conditions of limited resources, it is advisable to implement innovations that require minimal financial or technical investment while significantly improving the efficiency and quality of banking services. The use of artificial intelligence can automate routine processes such as transaction processing, fraud detection, and preliminary credit risk assessment. Big data analytics enables better risk management and personalized customer offerings without extensive infrastructure changes. Mobile and online platforms provide access to financial services in remote areas, reducing the need for physical branches. Blockchain technology can enhance transparency and security of transactions with relatively low additional resource requirements. Educational programs for staff and customers increase digital and financial literacy, improving the effective use of existing digital tools and overall bank performance.

The research hypothesis assumed that introducing digital technologies into the banking sector supported the enhancement of risk management, customer interaction, and operational efficiency in Kyrgyzstan. The collected data generally supported this hypothesis, as survey responses and operational indicators indicated improvements in internal risk monitoring, faster transaction processing, and more responsive digital customer channels. However, the reliability of these findings requires careful consideration. Data were primarily self-reported by bank employees, introducing potential response bias, and variations in technology adoption across departments may have influenced perceptions of effectiveness. Additionally, external factors such as regulatory changes, macroeconomic conditions, or concurrent training programs may provide alternative explanations for observed improvements. Limitations include the relatively small sample of banks and departments, which reduces generalizability, and the absence of longitudinal tracking to measure long-term effects. To address these concerns, robustness checks were conducted by comparing responses across different roles and departments, and sensitivity analyses examined whether extreme responses disproportionately affected mean scores. Despite these measures, potential bias and confounding factors remain, suggesting that while the hypothesis is tentatively confirmed, findings should be interpreted with caution, and further studies incorporating objective performance metrics and broader samples are necessary to strengthen evidence for

causal relationships.

4 Discussion

The results of the study show that the digital transformation of the banking sector in Kyrgyzstan is substantial in modernising and improving the efficiency of financial services. The introduction of advanced technologies such as AI, big data, blockchain and digital communication channels is having a significant impact on banks' operations, customer interactions and risk management. Analysis of the Kyrgyz banking sector from 2019 to 2023 revealed that growth in share capital and overall capital directly influenced the expansion of loan and investment portfolios. This, in turn, contributed to higher revenues and improved financial stability across banks.

The key element of digital transformation is the use of AI. It automates routine tasks, such as transaction processing and record keeping, freeing up employees to perform more complex tasks. AI also analyses huge amounts of data to predict market trends and assess the creditworthiness of customers. AI-powered virtual assistants and chatbots provide round-the-clock customer support, improving customer experience. Zouari and Abdelhedi^[41] addressed the impact of digital transformation on customer satisfaction in the banking sector. The focus is on the use of AI to personalise services. Payne et al.^[42], in turn, determined that the introduction of chatbots and virtual assistants significantly increases customer satisfaction by providing round-the-clock support and quick responses to queries. The study corresponds with current findings on the use of AI to improve customer experience. However, the authors focus on customer satisfaction, while the current study also covers other aspects such as risk management and internal efficiency.

Rising revenues coupled with controlled expense growth supported profitability increases, indicating effective resource management. This demonstrates the importance of balancing income and expenditures for operational efficiency. Big data analytics is becoming an important tool for understanding customer behaviour and preferences, which helps to personalise services and improve their quality. Banks are using data to develop more accurate risk assessment models, which allows them to make informed lending and investment decisions. In addition, big data analytics helps to detect fraud and prevent cyber-attacks. Hasan et al.^[43] investigated the use of big data in banks to improve credit risk assessment. The results show that big data analysis allows banks to predict risks more accurately and reduce loan defaults. The author's findings are fully consistent with the conclusions of the current study on the role of big data in credit risk assessment. Both studies confirm that data analytics can help improve risk assessment models and make more informed lending decisions.

The analysis of leading international banks revealed that the active implementation of artificial intelligence, big data, blockchain, and machine learning significantly enhanced risk management, improves customer interaction, and optimizes operational processes. It was found that gradual technology adoption, combined with staff training and proper oversight, was key for the successful adaptation of these practices in the context of Kyrgyz banks. Blockchain technolo-

gies provide a high level of security and transparency of transactions. In the banking sector, blockchain is used to create reliable and efficient systems for data exchange, international payments and digital asset management. This technology can significantly reduce transaction costs and speed up processing, which is especially important for international financial transactions. Chang et al.^[44] studied the impact of blockchain technologies on the security of transactions in banks. They determined that blockchain significantly reduced the risk of fraud and increases the transparency of transactions, especially in international payments. Dicuonzo et al.^[45] emphasised that the decentralised nature of the blockchain allowed all transactions to be tracked in real-time, making them more secure and less susceptible to interference. The current results also confirm that blockchain increases the security and transparency of transactions. However, the authors focus exclusively on international payments, while the current study looks at blockchain in a broader context.

In addition, cloud computing and the internet of things are important technologies that provide a flexible and scalable infrastructure for data storage and processing. Biometric technology is also widely used in the banking industry, providing a high level of security for customer identification and transactions. Li et al.^[46] studied the adoption of cloud technologies in banks. Their study shows that cloud solutions help banks reduce IT infrastructure costs and provide flexibility in data processing. Vinoth et al.^[47] noted that the use of cloud technologies allowed banks to scale faster and adapt to changing market conditions. Their research also highlights that the adoption of cloud-based solutions helps banks improve their operational efficiency and reduce the cost of maintaining their IT infrastructure. The current study also highlights the importance of cloud computing in providing flexibility and scalability to banking infrastructure. At the same time, there is no emphasis on cost reduction.

Digitalisation has a significant impact on banks' business models, making them more customer-centric and innovative. Traditional banks are forced to adapt to compete with fintech companies and digital banks offering convenient and affordable services. Digital marketing and big data analytics allow banks to personalise customer interactions and offer targeted financial products. This improves engagement, increases revenues, and strengthens customer relationships. Implementing omni-channel strategies allow for a seamless customer experience across all digital and physical channels. Personalisation is becoming a key element of banks' marketing strategy to meet the unique needs of each customer. Tanwar et al.^[48] conducted a study on the use of biometric technologies in various banks. They determined that biometrics significantly improved transaction security and reduced the risk of fraud. Their work discusses in detail various biometric identification methods, such as fingerprints, face recognition and iris scanning. The current results also confirm that biometrics play an important role in improving security. However, the authors describe this technology in more detail, while the current study describes it superficially.

In Kyrgyzstan, banks are actively working to improve risk management using available technologies and methods, despite limited resources. Aiyl Bank^[8], which has implemented a data analytics system to assess credit risks and monitor the financial condition of borrowers, is a

notable example. This system allows for a more accurate prediction of the probability of loan default and the adoption of preventive measures to minimise risks. Another example is Bank Kyrgyzstan^[9], which focuses on improving internal control and audit. The introduction of automated document management and compliance monitoring systems helps to reduce the likelihood of errors and increase transparency. Zephaniah et al.^[49] addressed the impact of digitalisation on the marketing strategy of banks in Spain. They determined that digital channels, such as social media and mobile Apps, have become the main tools for promoting banking services and interacting with customers. The authors emphasise that the use of customer behavioural data allows banks to create personalised marketing campaigns, which increases their effectiveness. The current study also highlights the importance of digital channels for customer engagement. However, the authors focus more on marketing strategies, whereas the current work looks at digitalisation in a broader context, including risk management and internal efficiency. Implementation of virtual assistants and AI-based risk forecasting in Kyrgyz banks could reduce overdue debts, improve customer loyalty, and support informed portfolio management. These measures highlight the direct benefits of adopting advanced digital tools.

Digitalisation also has a significant impact on the quality of life by improving access to and affordability of financial services. It allows people to manage their finances more efficiently through mobile Apps and internet banking, reduces transaction costs and speeds up financial transactions. Khatoon et al.^[50] conducted a study on the impact of the digital transformation of the banking sector on the quality of life of the population. Their study highlights how access to digital banking services contributes to financial inclusion and regional economic development. The author's research emphasises the importance of digital transformation for improving the quality of life of the population, which partially coincides with current findings on the impact of digitalisation on the banking sector. Both studies recognise the importance of digital technologies in expanding access to financial services and making them more affordable. Despite challenges such as limited infrastructure, low digital literacy, and constrained financial resources, Kyrgyz banks can implement low-cost innovations like AI, mobile platforms, and blockchain. These solutions enhance efficiency, transparency, and accessibility of banking services, particularly in rural areas.

Overall, the digital transformation of the banking sector is having a significant impact on efficiency, flexibility and customer focus. Studies have shown that the world's leading banks are actively implementing advanced technologies such as artificial intelligence, big data and blockchain to automate processes, improve customer service and manage risks. The transition to digital technologies in the banking sector has a significant impact on the quality of life of the population. Firstly, improved accessibility to banking services through mobile and online platforms reduces time and financial costs for customers, especially in remote and rural areas. Secondly, the introduction of innovative technologies such as artificial intelligence and big data allows banks to offer more personalised and relevant financial products and services, which helps customers better manage their finances. In addition, enhanced transaction security and reduced

risks of financial fraud contribute to building trust in banking institutions. Taken together, all these factors lead to an improvement in the economic well-being of the population, increased financial literacy and more active participation in the country's economic life.

5 Conclusion

The hypothesis was confirmed, as the analysis of interview responses showed strong positive correlations between the adoption of digital technologies and improvements in risk management, customer interaction, and operational efficiency. Participants consistently reported that AI, big data, and digital communication tools enhanced decision-making and service quality. These findings indicate that digitalisation has a measurable and beneficial impact on the performance of banks in Kyrgyzstan. The study of the digitisation of the banking sector in the Kyrgyz Republic provides important insights into how modern technology can transform the financial industry. The key elements of digital transformation, such as AI, big data and blockchain, play a key role in improving operational processes and customer experience. The use of AI to automate routine tasks, big data analytics to personalise services, and the introduction of blockchain to improve transaction security are all contributing to more efficient and flexible banking models.

The study highlights that digitalisation is transforming the banking sector in Kyrgyzstan by making banks more flexible, efficient, and customer-focused. Key technologies, including AI, big data, and blockchain, improve operational processes, personalise services, and enhance transaction security. Kyrgyz banks are actively using data analytics for risk management and financial stability, with examples like Aiyl Bank and Bank Kyrgyzstan successfully implementing credit risk assessment systems. The study of leading international banks demonstrates that advanced digital technologies, including AI, big data, blockchain, and machine learning, play a critical role in enhancing risk management, operational efficiency, and customer engagement. Effective implementation relies on the integration of technology with staff training, robust IT infrastructure, and regulatory compliance. These findings suggest that Kyrgyz banks can gradually adapt similar digital tools and risk management practices, tailoring them to local conditions and institutional capacities to achieve comparable improvements.

Thus, the study confirms that digitalisation is central to the transformation of the banking sector, making it more flexible, efficient and customer focused. The introduction of modern technologies, such as AI, big data and blockchain, allows banks to improve operational processes, enhance customer service and create innovative business models that can adapt to rapidly changing market conditions. One of the limitations of the study is that it focused on only four countries and their banks, which may limit the generalisability of the findings and the ability to draw conclusions applicable to the broader global banking sector. In the future, it would be advisable to conduct more in-depth research using an expanded set of data and analysis of global best practices to develop more effective strategies for the digital transformation of banks in the region.

References

- [1] Cucari N, Lagasio V, Lia G, et al. The impact of blockchain in banking processes: The Interbank Spunta case study. *Technology Analysis & Strategic Management*, 2022, 34(2): 138–150.
- [2] Rodrigues A R D, Ferreira F A F, Teixeira F J C S N, et al. Artificial intelligence, digital transformation and cybersecurity in the banking sector: A multi-stakeholder cognition-driven framework. *Research in International Business and Finance*, 2022, 60: 101616.
- [3] Hoque A, Le D T, Le T. Does digital transformation reduce bank's risk-taking? Evidence from Vietnamese commercial banks. *Journal of Open Innovation: Technology, Market, and Complexity*, 2024, 10(2): 100260.
- [4] Mansour N. Digital finance and commercial banks' risk. *International Journal of E-Business Research*, 2024, 20(1): 1–22.
- [5] Huynh J. Digital transformation and bank liquidity creation: Evidence from a bank-based market. *SAGE Open*, 2025, 15(4): 1–20.
- [6] Koldovskiy A, Rekunen I. Driving financial innovations: The role of digitisation, transparency, and social responsibility in banking systems. *Innovation and Sustainability*, 2025, 5(1): 31–43.
- [7] Pratama K J. Advancing futuristic digital banking: Strategic enhancement and a roadmap for excellence. *Journal of Central Banking Law and Institutions*, 2025, 4(1): 113–140.
- [8] Aiy Bank. Statement of Changes in Equity as at 31 July 2024. 2024. <https://ab.kg/guarddog/laravel-filemanager/files/shares/07-2024-kapital-russ.pdf>.
- [9] Bank “Kyrgyzstan”. Statement of Financial Position as at 31 August 2024. <https://mbank.kg/media/about/finance/>.
- [10] National Statistical Committee of the Kyrgyz Republic. Key performance indicators of the enterprises of the financial sector of the economy of the Kyrgyz Republic. 2024. <https://stat.gov.kg/ru/publications/osnovnye-pokazateli-deyatelnosti-predpriyatij-finansovogo-sektora-ekonomiki-kyrgyzskoj-respubliki/>.
- [11] Bank of America. How to harness the potential – And reduce the risks – Of AI. 2024. <https://business.bofa.com/en-us/content/cyber-security-journal/how-to-use-ai-in-business-responsibly.html>.
- [12] HSBC. Humans + Machines = An ethical AI future. 2024. <https://www.hsbc.com/news-and-views/views/hsbc-views/humans-machines-an-ethical-ai-future>.
- [13] DBS Bank. Why treasury innovation is helping drive the digital economy? 2024. <https://www.dbs.com.sg/corporate/insights/treasuryprism/digitaltransformation/global/role-of-corporate-treasury-innovation-in-digital-economy>.
- [14] UBS Bank. UBS's Second-Quarter 2024 Results. 2024. <https://www.ubs.com/global/en/media/display-page-ndp/en-20240814-2q24-quarterly-result.html?caasID=CAAS-ActivityStream>.
- [15] World Medical Association. World Medical Association Declaration of Helsinki: Ethical principles for medical research involving human subjects. 2013. <https://www.wma.net/policies-post/wma-declaration-of-helsinki-ethical-principles-for-medical-research-involving-human-subjects/>.
- [16] Kitsios F, Giatsidis I, Kamariotou M. Digital transformation and strategy in the banking sector: Evaluating the acceptance rate of e-services. *Journal of Open Innovation: Technology, Market, and Complexity*, 2021, 7(3): 204.

- [17] Hung J-L, He W, Shen J. Big data analytics for supply chain relationship in banking. *Industrial Marketing Management*, 2020, 86: 144–153.
- [18] Garg P, Gupta B, Chauhan A K, et al. Measuring the perceived benefits of implementing blockchain technology in the banking sector. *Technological Forecasting and Social Change*, 2021, 163: 120407.
- [19] Leo M, Sharma S, Maddulety K. Machine learning in banking risk management: A literature review. *Risks*, 2019, 7(1): 29.
- [20] Ghelani D, Hua T K, Koduru S K R. Cyber security threats, vulnerabilities, and security solutions models in banking. *Authorea*, 2022, 1–9.
- [21] Waliullah M, Hossain George Z, Hasan M T, et al. Assessing the influence of cybersecurity threats and risks on the adoption and growth of digital banking: A systematic literature review. *American Journal of Advanced Technology and Engineering Solutions*, 2025, 1(1): 226–257.
- [22] Fernandes Biao P. SecureBank: A financially-aware zero trust architecture for high-assurance banking systems. *arXiv Preprint arXiv: 2512.23124*, 2025. <https://arxiv.org/abs/2512.23124>.
- [23] Darma G S, Noviana I P T. Exploring digital marketing strategies during the new normal era in enhancing the use of digital payment. *Journal of Logic*, 2020, 4(3): 2257–2262.
- [24] Niemand T, Rigtering J P C, Kallmünzer A, et al. Digitalization in the financial industry: A contingency approach of entrepreneurial orientation and strategic vision on digitalization. *European Management Journal*, 2021, 39(3): 317–326.
- [25] National Bank and IFC discuss digital finance development in Kyrgyzstan. *Kabar*. 2025. <https://en.kabar.kg/news/national-bank-and-ifc-discuss-digital-finance-development-in-kyrgyzstan/>.
- [26] Yudina S, Razumova H, Lysa O, et al. Optimizing financial management and administration in infrastructure projects for economic recovery. *International Journal of Accounting and Economics Studies*, 2025, 12(2): 337–346.
- [27] Dalke A, Svyatov S, Ruziyeva E, et al. Criteria for identification and regulation of systemically important banks. *Accounting, Economics and Law: A Convivium*, 2025. DOI: 10.1515/ael-2024-0070. <https://www.degruyterbrill.com/document/doi/10.1515/ael-2024-0070/html>
- [28] Cui X. Digital transformation of commercial banks in Kyrgyzstan driven by artificial intelligence: Efficiency, risk and policy response. *Insights of Economics System*, 2025, 1(2): 1–8.
- [29] Kolodiziev O, Krupka M, Shulga N, et al. The level of digital transformation affecting the competitiveness of banks. *Banks and Bank Systems*, 2021, 16(1): 81–91.
- [30] National Statistical Committee of the Kyrgyz Republic. Key indicators of banking sector activity in Kyrgyzstan. 2023. <https://www.stat.gov.kg/ru/news/cifry-fakty-den-bankovskogo-rabotnika-kyrgyzstana>.
- [31] National Bank of the Kyrgyz Republic. Annual report 2023: Banking sector performance and financial stability. 2024. <https://www.nbkr.kg/DOC/28062024/000000000062630.pdf>.
- [32] Issayeva A, Niyazbekova S, Semenov A, et al. Digital technologies and the integration of a green economy: legal peculiarities and electronic transactions. *Reliability Theory and Applications*, 2024, 19: 1088–1096.
- [33] Hasanov R I, Vasa L, Guliyeva S, et al. Assessing the impact of oil prices and inflation on bank deposits in Azerbaijan. *Banks and Bank Systems*, 2025, 20(1): 11–22.
- [34] Vazov R, Shvachych G, Moroz B, et al. Development features and principles of blockchain tech-

- nologies and real options as the main components of the digital economy. *Lecture Notes on Data Engineering and Communications Technologies*, 2022, 126: 57–74.
- [35] Kanungo R P, Gupta S. Financial inclusion through digitalisation of services for well-being. *Technological Forecasting and Social Change*, 2021, 167: 120721.
 - [36] Kerimkulov S, Teleuova S, Tazhbenova G, et al. Measuring chaotic and cyclic fluctuations of cass freight index: expenditures. *Actual Problems of Economics*, 2015, 171(9): 434–445.
 - [37] Kovalchuk S, Morokhova V, Bondarenko O, et al. Creative economy and value creation through marketing analytics: New approaches and opportunities. *Pakistan Journal of Life and Social Sciences*, 2024, 22(2): 9812–9824.
 - [38] Oklander M, Oklander T, Pedko I, et al. Development of the subsystem of forecasting for the system of marketing information management at an industrial enterprise. *Eastern European Journal of Enterprise Technologies*, 2017, 5(3–89): 39–51.
 - [39] Dahan E, Aviv I, Kiperberg M, et al. Trust domain extensions guest fuzzing framework for security vulnerability detection. *Mathematics*, 2025, 13(11): 1879.
 - [40] Joseph O, Dahan E, Aviv I, et al. Requirements engineering for integrating quantum key distribution with blockchain systems. *2025 IEEE 33rd International Requirements Engineering Conference Workshops (REW)*, 1–5 September, 2025. Valencia: IEEE, 2025, (375–382).
 - [41] Zouari G, Abdelhedi M. Customer satisfaction in the digital era: Evidence from Islamic banking. *Journal of Innovation and Entrepreneurship*, 2021, 10: 9.
 - [42] Manser Payne E H, Dahl A J, Peltier J. Digital servitization value co-creation framework for AI services: A research agenda for digital transformation in financial service ecosystems. *Journal of Research in Interactive Marketing*, 2021, 15(2): 200–222.
 - [43] Hasan M M, Popp J, Oláh J. Current landscape and influence of big data on finance. *Journal of Big Data*, 2020, 7: 21.
 - [44] Chang V, Baudier P, Zhang H, et al. How Blockchain can impact financial services – The overview, challenges and recommendations from expert interviewees. *Technological Forecasting and Social Change*, 2020, 158: 120166.
 - [45] Dicuonzo G, Donofrio F, Fusco A, et al. Blockchain technology: Opportunities and challenges for small and large banks during COVID-19. *International Journal of Innovation and Technology Management*, 2021, 18(4): 2140001.
 - [46] Li F, Lu H, Hou M, et al. Customer satisfaction with bank services: The role of cloud services, security, e-learning and service quality. *Technology in Society*, 2021, 64: 101487.
 - [47] Vinoth S, Vemula H L, Haralayya B, et al. Application of cloud computing in banking and e-commerce and related security threats. *Materials Today: Proceedings*, 2022, 51: 2172–2175.
 - [48] Tanwar S, Tyagi S, Kumar N, et al. Ethical, legal, and social implications of biometric technologies. Obaidat M, Traore I, Woungang I. Eds. *Biometric-based Physical and Cybersecurity Systems*. Springer: Cham, 2019: 535–569.
 - [49] Zephaniah C O, Ogba I-E, Izogo E E. Examining the effect of customers' perception of bank marketing communication on customer loyalty. *Scientific African*, 2020, 8: e00383.
 - [50] Khatoun S, Zhengliang X, Hussain H. The mediating effect of customer satisfaction on the relationship between electronic banking service quality and customer purchase intention: Evidence from the Qatar banking sector. *Sage Open*, 2020, 10(2): 1–12.