

The financial sectors of Ghana and Kazakhstan: Comparative analysis of artificial intelligence adoption and implications

Tijani Forgor Alhassan¹, Gaukhar Kalkabayeva², Anar Kurmanalina²

¹ *Moscow Polytechnic University (Russia)* ² *Karaganda Buketov University (Kazakhstan)*

Corresponding author: Tijani Forgor Alhassan (atijaniforgor@yahoo.com)

Academic editor: Kapoguzov E. | Received 27 February 2025 | Accepted 5 May 2025 | Published 11 March 2026

Citation: Alhassan, T.F., Kalkabayeva, G., & Kurmanalina, A. (2026). The financial sectors of Ghana and Kazakhstan: Comparative analysis of artificial intelligence adoption and implications. *BRICS Journal of Economics*, 7(1), 155–175. <https://doi.org/10.3897/brics-econ.7.e151598>

Abstract

The adoption and integration of artificial intelligence (AI) in Ghana's and Kazakhstan's financial sectors signifies a transformative change, driven by technological advancement and pursuit of greater efficiency, improved risk management and enhanced customer experience. The study provides a comparative analysis of AI adoption in developing countries, focusing on key areas such as banking, investment management, legal compliance and financial inclusion. AI adoption is gradually gaining attention in Ghana, where fintech start-ups and traditional banks are using AI for mobile banking, fraud detection, and credit scoring. However, challenges such as poor infrastructure, data security concerns and lack of a skilled workforce impede the widespread implementation of AI and its full realization. In contrast, Kazakhstan has made significant progress in adopting AI, driven by government initiatives, robust digital infrastructure, and growing fintech ecosystem. Financial institutions in Kazakhstan use AI for algorithmic trading, regulatory compliance and customer service automation, positioning the country as a regional leader in fintech innovation. Despite differences in the countries' approaches to adopting AI, both economies face similar challenges, such as algorithmic bias, regulatory uncertainty and capacity-building needs. The present paper explains why tailored growth strategies are needed to address these issues. It highlights the importance of investment, public-private partnerships and legal frameworks in upskilling professionals and creating technological infrastructure. The two countries should develop roadmaps for

AI-tailored growth policies in their financial sectors to ensure their effective adoption and implementation for financial development.

Keywords

AI-powered innovations, AI-driven solutions, AI-based tools, Economic transformation, Economic potential, Financial inclusion, Financial sector, Fintech.

JEL: A10, E42, G41, O33.

Introduction

The rapid development of artificial intelligence (AI) has led to a fundamental transformation of the global financial landscape. Many countries are experiencing significant changes in their financial sectors as a result of this development (Rose Innes & Andrieu, 2022). This transformation is particularly notable in economies such as those of Ghana and Kazakhstan. According to the Adrian (2024), the adoption of AI technologies in these countries presents unique opportunities and specific challenges to their financial ecosystems.

Ghana, one of the major economies in West Africa, has made substantial progress in its financial technology sector. According to estimates from the Bank of Ghana (2023), the value of mobile money transactions in 2023 reached approximately \$80 billion. Similarly, Kazakhstan, a leading economy in Central Asia, has witnessed significant development in the adoption of digital banking. The Organization Economic Cooperation and Development (2023) estimates that over 73% of the Kazakhstani population actively use digital financial services. The intersection of these advancements with AI technologies presents a compelling case for comparative studies.

Both economies' financial industries are at a pivotal stage where the adoption of AI could help overcome the limitations of conventional banking infrastructure. Recent research has shown that AI technologies in developing markets can reduce operational costs by over 22% and raise financial inclusion by up to 35% (International Monetary Fund, 2024a). However, contextual variations between Ghana and Kazakhstan, ranging from regulatory policies to technological infrastructure, have led to differing adoption patterns and outcomes (Asian Development Bank, 2021).

This comparative analysis of two distinct economies aims to examine their similar developmental aspirations and different approaches to financial innovation. For example, Ghana is focused on mobile money activities (a type of mobile banking that does not require an internet connection) and microfinance innovations (Coffie & Hongjiang, 2023), while Kazakhstan has demonstrated a strong commitment to blockchain technology and the development of central bank digital currencies (International Monetary Fund, 2024b). These parallel yet oppositely directed

approaches provide useful insights into the adaptability of AI in various emerging market contexts.

Although the financial sectors of Ghana and Kazakhstan differ in their economic, cultural and geographical characteristics, as illustrated in Table 1, the two countries have similar trajectories in their pursuit of economic modernisation and technological progress. Both countries are developing economies with promising financial markets, and the adoption of AI-driven technologies in their financial sectors reflects a wider global trend toward digital transformation. Artificial intelligence has emerged as a keystone of innovation in finance, helping institutions improve efficiency, enhance customer experience and manage risk effectively. However, the pace and extent to which AI-based innovations are adopted differs significantly between countries, influenced by factors such as infrastructure, regulatory frameworks and economic priorities. This paper presents a comparative analysis of the adoption of artificial intelligence in the financial sectors of Kazakhstan and Ghana. It explores the drivers, challenges, and implications of this technological and economic transformation.

Ghana is a country located in West Africa with a rapidly growing economy. It has made significant progress in using innovation and technology to transform its economy, particularly in the financial sector. It is known for its mobile money services, which have revolutionized financial inclusion by providing millions of unbanked residents with access to financial and banking services (Aker & Mbiti, 2010). The interoperability of mobile money services offered by telecommunications operators and banks has promoted digital innovation in the country's financial sector, particularly with regard to cashless transactions. Recently, financial institutions in Ghana have begun integrating AI-based solutions, such as chatbots, fraud detection systems and algorithms for credit scoring to streamline transactions and improve customer services and experience. According to the Bank of Ghana (2021), the central bank has developed guidelines and regulatory sandboxes to promote innovation while safeguarding customer protection. Despite this technological progress, challenges remain in relation to technological infrastructure, the shortage of skilled AI personnel, and data privacy.

Kazakhstan is a country in Central Asia with abundant natural resources and a growing economy. It has focused on digital transformation as part of its wider economic transformation strategy. The financial sector in Kazakhstan has seen a rapid increase in the adoption of artificial intelligence (AI), driven by government initiatives such as the Digital Kazakhstan programme and the development of the Astana International Financial Centre (AIFC) fintech innovation hub (AIFC, 2020). Similar to Ghana, banks and financial institutions in Kazakhstan have adopted AI-driven tools for risk management, investment analysis and customer service, establishing the country as a regional leader in financial technology. However, Kazakhstan faces challenges related to data privacy, ethics, regulatory harmonization, infrastructure and the need to upskill the workforce to fully realize the potential of AI adoption.

Adopting AI in the financial sectors of these countries has far-reaching implications for socioeconomic development, financial inclusion and regulatory supervision. AI-

powered technologies have the capacity to improve access to financial services, lower transactional costs and mitigate associated risks. However, the rapid integration of AI-driven innovations raises concerns regarding data security, algorithmic bias and potential job displacement. Furthermore, as the regulatory sandboxes in both countries are evolving, it is necessary to strike a balance between promoting innovation and protecting consumer rights.

Table 1. Comparing Ghana and Kazakhstan in terms of population, credit-to-GDP ratio and GDP per capita growth

Year	Credit to GDP (%)		Population		GDP per capita growth (%)	
	Ghana	Kazakhstan	Ghana	Kazakhstan	Ghana	Kazakhstan
2015	17.93	37.73	28,696,068	18,084,169	-0.21	-0.30
2016	17.44	33.03	29,356,742	18,363,600	1.05	-0.44
2017	16.10	29.19	30,008,354	18,651,931	5.78	2.49
2018	13.71	25.93	30,637,585	18,932,727	4.02	2.56
2019	13.94	24.27	31,258,945	19,209,555	4.39	2.99
2020	13.06	25.64	31,887,809	19,482,117	-1.47	-3.86
2021	13.05	26.01	32,518,665	19,743,603	3.04	2.92
2022	13.29	25.02	33,149,152	20,034,609	1.84	1.70
2023	9.96	25.97	33,787,914	20,330,104	1.00	3.57

Source: Authors' construct using data from the (World Bank, 2025)

Kazakhstan maintained a higher and more stable credit-to-GDP ratio, peaking at 37.73% and stabilising at 25-26% post-2020. In contrast, Ghana's ratio declined sharply from 17.93% in 2015 to 9.96% in 2023, indicating potential problems in the credit market. Ghana's population is growing rapidly, which could put a strain on its resources. Between 2015 and 2023, Ghana's population grew from 28.7 million to 33.8 million. Kazakhstan's population is growing slowly. It grew from 18.1 million in 2015 to 20.3 million in 2023. Ghana experienced more volatile growth, peaking at 5.78% in 2017 before slowing to 1.0% in 2023. In contrast, Kazakhstan demonstrated resilience and recorded 3.57% GDP per capita growth in 2023, showing recovery from pandemic shocks. Thus, Kazakhstan outperforms Ghana in terms of financial stability, post-pandemic recovery and economic resilience, while Ghana faces challenges regarding access to credit and erratic growth. Kazakhstan's successes may be attributed to its pragmatic and comprehensive approach to adopting and using various strategies to boost technology and AI adoption in different industries, including the financial sector.

This comparative analysis explores the following major questions: What are the main factors influencing the adoption of AI in the financial sectors of these economies?

How do regulatory conditions in both economies influence the pace and scope of AI integration? What are the main benefits and challenges, including the regulatory impact, in each country? What socio-economic implications does AI-driven innovation present for Ghana and Kazakhstan?

This paper aims to enhance understanding of the opportunities and challenges associated with adopting AI in developing economies and to provide policy recommendations for governments, financial organizations and stakeholders. It expands the understanding of how AI-driven technologies could be leveraged in diverse emerging market contexts, thereby highlighting the importance of AI technologies in the financial sectors of developing economies. Given that financial systems of different countries are becoming increasingly interconnected, the experiences of Ghana and Kazakhstan can provide fresh insights for other developing nations (Bell & Hidary, 2024).

Literature review

Artificial intelligence (AI) has transformed the financial landscape, changing the way financial transactions are carried out, markets are operated, and risks are managed. The theoretical framework of AI in financial services represents a paradigm shift in the way that banking and financial organizations operate, particularly in developing economies (World Bank, 2025). According to a McKinsey & Company report (2023) on global banking, AI-driven technologies are projected to generate \$200–300 billion annually in emerging market banking sectors. The concept underlying the adoption of AI-driven innovations in finance encompasses machine learning, natural language processing and predictive analytics. These innovations are fundamentally transforming conventional banking models (Pattnaik et al., 2023).

AI-driven innovations have significantly improved customer experience, operational efficiency, and decision-making processes in the banking sector. Major elements of the AI-powered tool concept include fraud detection systems, credit scoring, chatbots, and personalized financial and investment advice. Davenport and Ronanki (2018) reveal that AI-based chatbots such as Erica (Bank of America) and Eno (Capital One) have enhanced customer engagement by providing 24/7 support and personalized recommendations. Fraud remains one of the biggest problems in the financial sector, but it is now widely mitigated using machine learning algorithms that can detect fraudulent activities in real time. Ngai et al. (2011) demonstrate how Mastercard uses AI to analyse operational patterns and detect anomalies. AI-powered tools, particularly those based on neural networks, have enhanced the precision of credit scoring by employing non-traditional data sources, such as social media activity and use of mobile phones (Lessmann et al., 2015), when determining the credit score of customers.

AI-powered innovations are also used to manage investments; they transform investment management through algorithmic trading, portfolio optimisation and

predictive analytics. AI-based trading algorithms analyse vast amounts of market data in order to execute trades at the most opportune moments. Biais et al. (2015) argue that these tools are used by high-frequency trading companies, such as Renaissance Technologies, to gain a competitive edge. Some banking platforms have adopted various Robo-advisors in their activities. For example, D'Acunto et al. (2019) state that companies such as Betterment and Wealthfront use AI-powered robo-advisers to provide automated, low-cost investment recommendations based on customer preferences and risk tolerance. Meanwhile, Chen et al. (2019) have demonstrated that AI-driven models can be used to predict market trends and asset prices based on historical data, news sentiment analysis, and macroeconomic factors.

In risk management, AI-driven technologies are used to assess related risks and develop mitigation approaches. AI has enhanced the methods of assessing and mitigating risks by providing more precise modelling and real-time monitoring. According to Barboza et al. (2017), AI-powered techniques such as deep learning have improved the accuracy of credit risk models by identifying complex, non-linear relationships in data. Also, transactional risks are managed with the help of AI-based models, which are used to monitor operational processes to detect potential risks, e.g. system failures or breaches of compliance. AI tools can be used to simulate market scenarios and predict potential losses in adverse conditions. This can help with stress testing and capital distribution Kou et al. (2014).

One major policy in the financial industry is ensuring regulatory compliance when providing financial services, both domestically and internationally. AI-powered innovations can be used to modernize compliance processes by automating tasks like know-your-customer (KYC) verification, anti-money laundering (AML), and others. Sironi (2021) explains how AI-powered systems analyze operational patterns in order to detect suspicious transactions and reduce false positives. Similarly, Arner et al. (2016) demonstrate how AI models verify client identities using facial recognition and document analysis. This has led to reductions in both onboarding time and costs. Deloitte (2020) also shows that natural language processing (NLP) tools can extract vital information from unstructured data in order to generate regulatory reports.

AI-powered innovations have transformed financial markets by improving liquidity, price discovery, and market productivity. AI algorithmic tools provide liquidity by consistently quoting bid and ask prices, thereby reducing bid-ask spreads (Hendershott & Riordan, 2013). According to Loughran and McDonald (2016), AI tools are effective in analysing new articles, social media activity and earnings calls to measure market sentiment and predict price levels. Gomber et al. (2017) also support this view. AI-based systems facilitate smart order routing, optimising trade execution by routing orders to the most favourable locations based on real-time market conditions.

Despite its numerous advantages, the adoption of AI in the financial sector faces difficulties related to data privacy, regulatory uncertainty, and algorithmic bias. For

example, Zarsky (2016) points out that using personal information in AI tools raises privacy and data security concerns. Mehrabi et al. (2021) also warn that AI-powered models can perpetuate biases arising from the data training processes, which may result in unfair credit scoring or hiring decisions. The Financial Stability Board (FSB, 2024) indicates in its 2024 report that the absence of clear and consistent regulatory guidelines for AI in finance poses threats to compliance and accountability.

Theoretical foundation of artificial intelligence in finance

AI encompasses a wide variety of technologies, including machine learning, natural language processing and robotic process automation. These elements enable systems to perform tasks that would traditionally require human intelligence (Russell & Norvig, 2020). Some of the most in-demand AI applications in the financial sector include fraud detection, investment analysis, credit scoring and customer service automation (Arner et al., 2015). The adoption of AI-powered technologies is based on their ability to increase efficiency, improve decision-making processes, and cut costs. However, Zetsche et al. (2020) raise concerns regarding data privacy, regulatory compliance and algorithmic bias associated with AI integration.

Developing countries face unique challenges and opportunities when it comes to adopting AI-driven instruments, owing to their varying levels of infrastructure, regulatory policies, and economic development strategies. According to a report by the World Economic Forum (2021), the adoption of AI in developing countries is impeded by various factors, such as limited access to data, low numbers of skilled professionals and inadequate funding for research and development. Despite these challenges, Ghana and Kazakhstan have made significant progress in using AI to streamline their economies, particularly in the financial sector.

In recent years, the financial sector in Ghana has undergone digital transformation, driven by the expansion and proliferation of mobile money services and financial technology (fintech) innovations. The successful expansion of mobile money services, along with the development of interoperability between banks and mobile money platforms, demonstrates technology's capacity to improve financial inclusion, particularly in remote areas (Aker & Mbiti, 2010). According to the Bank of Ghana (2021), financial institutions in the country have started to implement other AI-powered applications, such as chatbots and systems for fraud detection and credit scoring. While these innovations have improved transaction efficiency and customer engagement, issues relating to data privacy and inadequate infrastructure persist (Asongu & Nwachukwu, 2018).

The regulatory environment in Ghana has also evolved to encourage the adoption of AI. This is evident in the introduction of regulatory sandboxes (Bank of Ghana, 2021), which encourage innovation and consumer protection. However, Agyekum et al. (2017) argue that the lack of a comprehensive policy framework for data protection and cybersecurity continues to hinder the widespread adoption of AI-driven innovation in the financial sector.

In contrast, Kazakhstan has focused on digital transformation as part of its economic diversification. The development of the Astana International Financial Centre (AIFC) has been a key step in this drive, and the country has since positioned itself as a regional hub for fintech innovation. This has attracted investment and talent from across the Central Asia. The country's Digital Kazakhstan programme, overseen by the Ministry of Digital Development, has also accelerated the adoption of AI by promoting research and development, and encouraging the acquisition of digital skills. However, data security concerns, lack of skilled professionals and insufficient regulatory harmonisation are still the major obstacles to the full adoption of AI and realisation of its potential in the financial sector (Kapsalyamova, 2025).

Although both Ghana and Kazakhstan have made significant progress in adopting AI in their financial sectors, the extent and pace of this adoption varies owing to different contextual factors. Ghana's adoption of AI is based on the use of mobile money and financial inclusion, which has led to improved access to financial services, particularly among unbanked citizens (Asongu & Nwachukwu, 2018). Kazakhstan, on the other hand, emphasizes the diversification of its economy, as well as retaining its position as a regional leader in fintech. This has promoted the development and deployment of more sophisticated AI-powered applications, such as algorithmic trading and predictive analytics.

The regulatory environment in both economies plays a crucial role in the adoption of AI. Although the introduction of regulatory sandboxes to promote innovation and the establishment of robust regulatory policies, such as the AIFC in Ghana and Kazakhstan, are important and necessary, they have not resolved issues related to data security, cybersecurity (Agyekum et al., 2017) and regulatory harmonisation and enforcement (Kapsalyamova, 2025).

The adoption of AI in the financial sectors of both countries has far-reaching implications for socioeconomic development, financial inclusion and regulatory supervision. It has the potential to improve access to financial services, mitigate risks and reduce transaction costs (Arner et al., 2015) but the rapid pace of AI development and integration has raises concerns about data privacy, the displacement of traditional workforces and algorithmic bias (Zetzsche et al., 2020).

Theoretical and conceptual framework of AI adoption in the financial sector

The adoption of AI-powered solutions in the financial sector is supported by numerous theoretical works that describe the processes, drivers and outcomes of technological innovation. Examples include diffusion innovation theory (Rogers, 2003), the technology-organization-environment (TOE) theory (Tornatzky & Fleischer, 1990) and institutional theory (Meyer & Rowan, 1977).

Fig. 1 presents Roger's (2003) Diffusion of Innovations theory, which provides a foundation for understanding how new technological models and applications, such as AI-powered solutions, are adopted and diffused in communities.

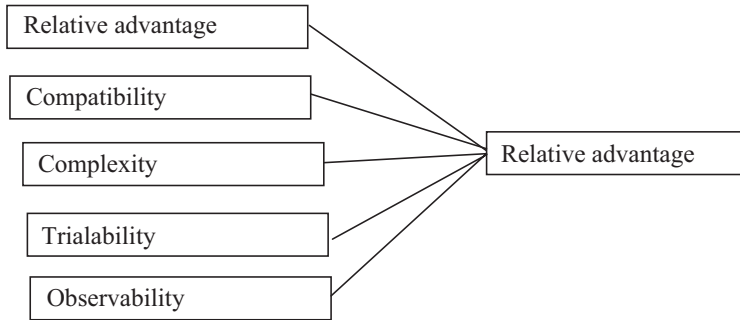


Figure 1. The Diffusion Innovation Theory. *Source:* Aygül et al. (2015).

According to this theory, the adoption of innovations is determined by the relative benefits obtained, compatibility, trialability, complexity and observability. In the case of AI-powered applications in the financial sector, these factors help to explain why some institutions and countries adopted AI earlier than others. For example, the potential of AI-driven solutions to enhance efficiency and reduce costs could encourage their adoption, while the perceived complexity or incompatibility with existing systems could hinder it. Thus, the early adoption of AI in Ghana's financial sector is evident in customer-facing applications such as chatbots: Leo and Kukua, developed by United Bank of Africa (UBA) and Fidelity Bank respectively, implemented to improve customer service, followed a bottom-up pattern driven by private sector initiatives. In Kazakhstan's financial sector, the adoption of AI exhibits a top-down diffusion model involving active government participation through the Generative Nation concept.

The Technology-Organisation-Environment (TOE) framework, developed by Tornatzky and Fleischer (1990), identifies three contexts that facilitate the adoption of technological innovations: technological, environmental, and organizational, as illustrated in diagram 2. In the financial sector, the technological context relates to the availability of AI tools and infrastructure. The organizational context includes elements such as firm size, resources, and leadership. The environmental context encompasses market competition, regulatory frameworks, and customer expectations. The TOE theory is useful for analyzing the adoption of AI in Ghana and Kazakhstan, as it outlines the interplay between technological potential, organizational readiness and external environmental conditions.

Ghana faces a variety of challenges, ranging from technological constraints, such as limited digital infrastructure, to varying levels of readiness, such as limited technical capacity among adopters, and limited specific AI policies, which create uncertainty for financial institutions (Quaye et al., 2024). Meanwhile, Kazakhstan is investing heavily in technological infrastructure such as supercomputing and 5G networks, actively developing governance frameworks, and coordinating organizational transformation with state initiatives such as the International AI Centre in Astana and financial institutions (Geneva Internet Platform digWatch, 2025).

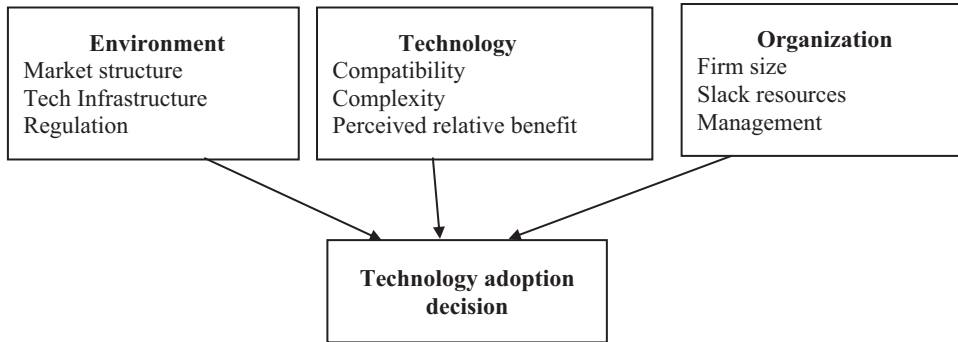


Figure 2. The framework of Technology-Organisation-Environment (TOE). *Source:* (Yong, 2023).

The institutional theory by Meyer and Rowan (1977) highlights the importance of regulatory policies, norms, and cultural expectations in forming organizational behavior (Scott, 2014). In the context of adopting AI, institutional theory explains how regulatory frameworks, societal attitudes and industry standards influence its adoption and integration into the financial sector. For example, the development of regulatory sandboxes in Ghana and the establishment of the Astana International Financial Centre (AIFC) in Kazakhstan demonstrate the influence of institutional factors on the adoption of AI. While Kazakhstan is proactively establishing comprehensive governance frameworks, such as the AI Law and standards for AI content labelling in financial services, Ghana currently lacks strong regulatory policies specifically for AI in finance.

The conceptual framework for this paper integrates the DOI theory, TOE framework, and institutional theory to analyze the adoption of AI in the financial sectors of Ghana and Kazakhstan, showing how technological, organizational, and environmental factors are intertwined and collectively determine the pace, extent and outcomes of the adoption of AI in the financial sector. The framework also includes the socio-economic implications of AI adoption, particularly with regard to financial inclusion, employment, and regulatory oversight.

Although Ghana and Kazakhstan have made significant strides in adopting and integrating AI-powered solutions to achieve their respective economic agendas, the pace and extent of this adoption varies. Among the obstacles that prevent the two countries from realising the AI full potential in their financial sectors are inadequate infrastructure, absence of a comprehensive regulatory framework on data privacy, and insufficiently skilled workforce

Ghana and Kazakhstan are located in different regions, both economically and geographically (West Africa and Central Asia, respectively), and have varying levels of socioeconomic development, regulatory policies, and infrastructure. By comparing these two economies, the paper aims to contribute to a wider understanding of how regional contexts could influence the adoption of AI in the financial sector. Ghana and Kazakhstan were selected for this comparative analysis due to their similar contexts

and challenges, and regional representation. The study applies this framework to explore AI application in the countries' regulatory environment and its broader implications for economic growth and financial inclusion in both countries.

Methodology and analysis

This paper employs a comparative approach in order to achieve in-depth understanding of the impact of AI-powered technologies on the financial sectors of Ghana and Kazakhstan. The analysis is carried out in accordance with the theoretical and conceptual framework of AI implementation in the financial sector; it involves private sector initiatives, major technologies, infrastructure, regulatory frameworks, and market dynamics (Table 2). This methodology is adopted to determine the degree and extent of the efforts and progress made by each of the countries.

From the table above it is clear that both Ghana and Kazakhstan have made great progress in using AI and digitalization for their economic development. Despite the differences in the initiatives, infrastructure, technologies and regulations employed to achieve their economic development agendas, they are reaping similar benefits.

Ghana's financial sector has made a digital breakthrough: according to the Bank of Ghana (2024) mobile money penetration is at 84% of the overall adult population. Ghana's fintech ecosystem has had an annual growth of about 15% since 2020, with AI-based innovative solutions playing a significant role in this development. The introduction of AI-powered chatbot by the Ghana Commercial Bank (GCB) has minimized the time of customer service response by over 60% (Mhlanga, 2024).

As concerns regulatory frameworks and innovations, Asante and Akowuah (2023) point out that AI-powered financial products were tested with the help of Bank of Ghana's Regulatory Sandbox. Innovative solutions were then introduced in credit scoring and fraud detection. It has been estimated that about 45% of licensed fintech companies in Ghana use AI-driven technologies in their activities.

The financial sector of Kazakhstan has shown notable advancement in digital transformation, and Astana International Financial Centre (AIFC) has become the hub for fintech innovation (National Bank of Kazakhstan, 2023). Between 2020 and 2023 about \$500 million has been invested in the country's banking sector to promote AI-powered technologies. The results of a survey conducted by the National Bank of Kazakhstan (2024a) show that 31% of financial market participants - including second-tier banks, microfinance organizations, insurance companies, and securities market participants - use AI in their operations. Among them, second-tier banks are the most active in adopting AI, with a usage rate of 60%.

Kazakh banks have been early adopters of AI technologies in Central Asia. According to Business and Finance Consulting (2024), these technologies helped Kaspi bank in its credit scoring by processing more than 1 million applications monthly. Furthermore, AI implementation in anti-money laundering systems enhanced detection capacity by 35% (Hall, 2024).

Table 2. Digital and AI adoption in Ghana and Kazakhstan

	Components	Ghana	Kazakhstan
AI initiatives		AI-enabled Mobile money platforms for fraud detection (MTN Mobile Money, 2023); Credit scoring algorithms employed by 67% of commercial banks (Bank of Ghana, 2024); Chatbot adoption rate of 45% among big banks (Krijnsen et al., 2024)	Risk assessment systems utilizing AI in 78% of banks (National Bank of Kazakhstan, 2024a); Automated lending platforms in 82% of financial institutions (Deloitte Kazakhstan, 2022); Blockchain integration with AI for payment systems (AIFC, 2020)
	Technologies such as Machine learning and market prediction models (algorithms)	Accuracy rate credit scoring models 85% (Mhlanga, 2024)	89% (Suleimenov, 2021)
	Infrastructure	KYC verification (implementation rate) 56% (MTN Mobile Money, 2023)	73% (Madiyev, 2024)
Regulatory frameworks	Technical infrastructure	4G coverage (78%), data centers (12) (Boladale, 2023)	5G implementation (35%), data centers (23) (National Bank of Kazakhstan, 2024a)
	Digital literacy	62% digital literacy rate	78% digital literacy rate
	Internet penetration	67% (ITU, 2024)	81.9% (World Bank, 2024)
Market dynamics	Financial regulation	Cybersecurity Act 2020, Payment Systems Act	Digital Kazakhstan 2025, Financial Market Regulation Act
	AI governance	National AI policy (draft stage)	AI development strategy 2025
	Data protection laws	Data protection act 2012	Personal data protection law 2020
Investment landscape	Banking sector	23 commercial banks, 85% AI adoption rate (MTN Mobile Money, 2023)	22 banks, 92% AI adoption rate (National Bank of Kazakhstan, 2024a)
	Mobile money/ FinTech	17.5 million active users (International Monetary Fund, 2024a)	12.3 million digital wallet users (National Bank of Kazakhstan, 2024a)
	Investment landscape	\$125M fintech investment (2023) (Bank of Ghana, 2024)	\$198M fintech investment (2023) (National Bank of Kazakhstan, 2024b)

Source: Constructed by authors

Results and discussion

Digitalization and the adoption of AI have provided considerable economic benefits by increasing financial inclusion (African Banker, 2023) and reducing operational and processing costs. For instance, Deloitte (2023) integrated AI in its operations and thus reduced its operational expenses through automation of routine tasks and improvement in decision-making process. In Ghana, the introduction of AI-driven chatbots and automated customer services systems led to an over 20% reduction in the labor costs (Krijnsen et al., 2023). In a similar way, Kazakhstan's banks used AI-based systems to reduce their processing costs by about 15% (National Bank of Kazakhstan, 2024a).

AI technologies have improved financial inclusion in developing countries by offering access to digital financial services to the population groups that were previously underserved by conventional banking systems (World Bank, 2020). The number of users of digital banking services in Kazakhstan, particularly in remote communities, rose by over 25% according to the Hall (2024). MTN Mobile Money (2023) reported that the integration of AI on mobile money platforms led to increased access to financial services in rural areas by 30%. AI-based technologies have also encouraged competition among financial institutions, which is beneficial to the financial sector as it makes it more vibrant and up to date. According to McKinsey & Company (2023), the development of AI improved market competitiveness, helping financial organizations to develop and offer personalized products and services to their clients. Grzybowski et al. (2023) in their study of Ghana found out that the country's fintech startups increased their market share by 10% thanks to using AI-powered technologies to develop innovative solutions. Zhumadilova et al. (2023) showed that the introduction of AI-enabled analytics enhanced customer segmentation thereby promoting competitive advantage.

Although the integration of AI caused job displacement in some industries, in others it promoted employment opportunities in tech-driven roles (World Economic Forum, 2024). In Ghana, data analytics and AI-related employment rose by 40% (Asante & Akowuah, 2023). Kazakhstan's financial sector also witnessed a shift towards tech-oriented jobs (Deloitte Kazakhstan, 2022).

AI has improved access to financial services by easing processes and reducing barriers (World Bank, 2024). AI-driven credit scoring models have helped more people to access loan facilities according to GCB Bank PLC (2023). Digital platforms have simplified the process of opening accounts and increased accessibility in Kazakhstan (National Bank of Kazakhstan, 2024a) and AI-powered virtual assistants have improved customer satisfaction (Zhumadilova et al., 2023). In Ghana, AI-based innovations have transformed customer service by providing 24-hours support and personalized interactions, with 60% of customer inquiries handled by AI chatbot (Deloitte, 2023; Krijnsen et al., 2023). McKinsey & Company (2023) claim that the integration of AI in the financial sector has increased product innovation, which caused the development of personalized financial products. AI is used by banks and fintech businesses in Ghana

to create customised saving plans (Coffie & Hongjiang., 2023), and in Kazakhstan to provide investment advisory services (Hall, 2024). Fraud detection is another major advantage brought about by AI, which significantly improves risk management by facilitating compliance monitoring (Krijnsen et al., 2023). Bank of Ghana (2024) stated that the adoption of AI-driven systems helped it reduce fraud by 25%; according to the National Bank of Kazakhstan (2024a) AI allowed financial organizations to strengthen their risk management capabilities.

Despite the progress made, digital transformation remains a challenge, with gaps in digital and AI literacy as well as in access to the internet (ITU, 2024). Rural Ghana is lagging in the adoption of AI because of limited infrastructure (World Bank, 2024); similar gaps exist in digital service between rural and urban areas in Kazakhstan (Hall, 2024). The lack of cultural acceptance and understanding in both countries can lead to low trust in AI technologies and thus impede the adoption of AI (MTN Mobile Money, 2023; Hall, 2024)

Analysis of AI adoption in Ghana and Kazakhstan

Ghana and Kazakhstan have different patterns of AI implementation, determined by their economic and technological infrastructures. Whereas Ghana leads in the mobile money innovations and concentrates on using AI adoption to improve financial inclusion, Kazakhstan has a stronger traditional banking digitalization with a focus on modernizing its existing banking infrastructure (World Economic Forum, 2024; ITU 2024).

The obstacles both countries need to overcome include limited availability and low quality of data (IMF, 2024a), insufficient levels of cybersecurity (Deloitte, 2023), inadequate technical expertise (Krijnsen et al., 2023) and unresolved regulatory issues (Ernst & Young, 2024). The benefits of AI implementation in these countries are very significant: Kang et al. (2022) projects that the adoption of AI in Kazakhstan's financial sector could contribute about 2.5% to its GDP growth by 2025 and Ghana's AI-driven financial services could increase its GDP by 1.8% in 2026.

The social impact of using AI in the financial sector is also enormous in both economies. Thus, AI-powered mobile banking caused an increase in financial inclusion by 25% in Ghana (Boladale, 2023). In Kazakhstan, AI adoption in the financial sector enhanced customer satisfaction by 40% (Gazi et al., 2023).

In 2024, Kazakhstan's government released the Concept of Artificial Intelligence Development till 2029 (Kazakhstan Ministry of Justice, 2024). This document outlines target indicators and expected outcomes, including the growth of IT service exports and increased numbers of AI startups, patents and AI-powered products in the real sector of the economy.

To address the AI-related regulatory gaps, Kazakhstan plans to adopt a new "Artificial Intelligence Act" in the first half of 2025, which should outline conditions for the safe, responsible, and ethical use of AI (Madiyev, 2024). At the same time, given the rapid pace of AI development, the legislation is to keep up with evolving standards.

Therefore, the newly created regulatory framework should be flexible enough to adapt to AI advancements, drawing on international experience.

Implementation of AI-driven technologies and innovations is beneficial to society as it has the potential to stimulate, accelerate and sustain growth in many sectors of the economy. AI-powered systems have changed the capacity of the financial institutions in Ghana and Kazakhstan by improving competitiveness, inclusivity, and efficiency (Deloitte, 2023). Yet, these countries need to address some technical and cultural challenges to pave the way for further development.

The future of AI-enabled innovations in developing countries, including Ghana and Kazakhstan, is promising as it presents many opportunities for growth through financial inclusion, expanding digital financial services, enhanced competition, increased cross-border collaborations, and improved risk management and fraud detection. To harness the potential of AI-based technologies, both Kazakhstan and Ghana need to develop and implement robust policies that will encourage and support innovation while ensuring compliance, data privacy and security. These policy frameworks must encourage country-specific and locally tailored research and development in the area of AI application for growth. It is essential that they provide clear guidelines for the ethical use of artificial intelligence.

Also, to gain the benefits of AI, the countries must encourage investment in digital infrastructure, which is a prerequisite for the adoption of AI. Ghana, for instance, should concentrate on increasing internet connectivity in remote areas, while Kazakhstan needs to improve its digital infrastructure to provide the needed capacity for AI applications. Developing countries should invest in education and training programs to build, upgrade, and increase AI and digital expertise. Knowledge and technology transfers through international partnerships may enhance skill development in AI adoption and implementation.

Conclusion

The comparative analysis of the adoption of artificial intelligence (AI) in the financial sectors of Ghana and Kazakhstan shows the two countries' similar challenges and prospects, which also reflect broader dynamics of technological innovation in developing countries. This paper highlights the need for studying the socioeconomic impact of AI in developing economies and particularly in Ghana and Kazakhstan, which are different in terms of geography and culture but face similar challenges in AI adoption.

The paper has explored the drivers, processes, and implication of the adoption and integration of AI into the economies of these nations based on the diffusion of innovation theory, Technology-Organisation-Environment framework and institutional theory. It shows that AI has serious potential to improve financial inclusion, refine operational efficiency, and drive economic development; at the same time, it outlines the obstacles that ought to be addressed to achieve the full potential of AI.

The study reveals the drivers of AI-powered solutions in these countries. In Ghana the adoption of AI was driven by the willingness to improve financial inclusion and operational efficiency. It was based on successful development and implementation of mobile money services and their interoperability with banks. The regulatory sandbox initiatives by the central bank of Ghana fostered innovation, encouraging financial institutions to experiment with AI-driven instruments, such as chatbots, fraud detection systems, and algorithms for credit scoring. In Kazakhstan, the government implemented the flagship Digital Kazakhstan program and created the Astana International Financial Centre (AIFC), making the country a regional leader in fintech innovation. Under a broader economic diversification agenda of the country, banks in Kazakhstan have developed and implemented sophisticated AI tools, such as predictive analytics and algorithmic trading.

The factors that limit both countries' capacity of integrating AI and realising its full potential, include inadequate technological infrastructure, data security concerns, and shortage of skilled AI workforce. The lack of comprehensive regulatory framework for data protection and cybersecurity remains an impediment to AI adoption and integration in Ghana. Kazakhstan's major difficulties are related to regulatory enforcement and harmonisation, and workforce upskilling.

The legal environment in both Ghana and Kazakhstan are indicative of their respective priorities and challenges. Legal sandboxes intended to facilitate innovation and ensure consumer protection are introduced in Ghana to promote financial inclusion. In Kazakhstan, a focus on economic diversification and the country's leading position in the region has led to the development of more robust regulatory policies.

The adoption of AI in the financial industries of Ghana and Kazakhstan has both short- and long-term implications for economic growth, financial inclusion, and regulatory oversight. In Ghana, AI-powered tools are expected to further improve access to financial services for the unbanked and underserved people. The adoption of AI-driven innovation has positioned Kazakhstan as a regional hub for fintech innovation attracting investment and talent from across the region.

This paper contributes to the theoretical understanding of AI adoption in developing economies by integrating the most useful theories such as DOI theory, TOE framework and institutional theory. The comparative study of Ghana and Kazakhstan reveals the interplay between technological, organisational and environmental elements influencing AI adoption, and offers a nuanced perspective on the drivers of and obstacles to technological innovation in the financial sector.

The results provide useful insights for policymakers, financial institutions and other stakeholders. The study highlights the importance of creating conditions for adopting and integrating AI. This requires comprehensive regulatory frameworks for cybersecurity and data protection, promotion of digital skills and establishment of legal sandboxes to facilitate innovation growth. Financial institutions need to create technological infrastructure, upskill the labour force, and integrate AI-driven innovations that align with the national priorities and customer needs.

It is therefore recommended that Ghana concentrates on building foundational AI infrastructure and governance framework to boost trust; Kazakhstan should use its national AI strategy to introduce more effective AI applications in its financial sector; and both countries should try to balance innovation with governance in order to maximise AI benefits for financial inclusion and stability and to spur economic growth and performance.

The creation of an ecosystem for effective AI adoption requires collaboration of governments, financial organisations and technology providers. It is also important to work with societal attitudes and build trust in AI-driven financial services. Finally, the socioeconomic impact of adopting AI in terms of employment and financial inclusion should be monitored and addressed when necessary.

This research opens many directions for future studies. First, further research into socioeconomic impact of AI adoption, especially in terms of employment and income inequality, could offer better understanding of the trade-offs involved. Next, comparative analysis of other developing countries' experience may help identify best practices and lessons to be learned. Finally, conducting longitudinal studies to track the evolution of adopting AI in Ghana and Kazakhstan could offer insights into the long-term outcomes and sustainability of such initiatives.

References

- African Banker. (2023). The African Digital Banking Transformation Report 2023. https://african.business/wp-content/uploads/2023/05/Backbase_Report23_Digital.pdf
- Agyekum, F., Locke, S. & Hewa-Wellalage, N. (2017). *Financial Inclusion and Digital Financial Services: Empirical evidence from Ghana*. MPRA paper 82885, University Library of Munich, Germany. <https://ideas.repec.org/p/pramprapa/82885.html>
- Aker, J. C. & Mbiti, I. M. (2010) Mobile Phones and Economic Development in Africa. *Journal of Economic Perspectives*, (24), 207–232. <http://dx.doi.org/10.1257/jep.24.3.207>
- Adrian, T. (2024). *Artificial Intelligence and its Impact on Financial Markets and Financial Stability*. International Monetary Fund. <https://www.imf.org/en/News/Articles/2024/09/06/sp090624-artificial-intelligence-and-its-impact-on-financial-markets-and-financial-stability>
- Arner, D. W., Barberis, J., & Buckley, R. P. (2015). *The Evolution of FinTech: A New Post-Crisis Paradigm?* Research Paper No. 2015/047, University of Hong Kong, Faculty of Law. <https://dx.doi.org/10.2139/ssrn.2676553>
- AIFC. (2020). *Annual Report on the Activities of the Astana International Financial Centre*. https://aifc.kz/wp-content/uploads/2024/06/aifc_ar2020_eng.pdf
- Asante, S. & Akowuah, F. N. (2023). *Ghana's 2023 Legal and Regulatory Outlook-Financial Institutions and Capital Markets*. Chambers and Planner. <https://chambers.com/articles/ghanas-2023-legal-and-regulatory-outlook-financial-institutions-and-capital-markets>
- Asian Development Bank. (2021). *Financial Technology for Regional Cooperation in Central Asia Regional Economic Cooperation Countries: Technical Assistance Report*. <https://www.adb.org/projects/documents/reg-55122-001-tar>

- Asongu, S. A., & Nwachukwu, J. C. (2018). The Mobile Phone in the Diffusion of Knowledge for Institutional Quality in Sub-Saharan Africa. *World Development*, 86(C), 133–147. <https://doi.org/10.1016/j.worlddev.2016.05.012>
- Aygül, T., Ayşegül, Ö.T. & Cemal, Z. (2015). A Theoretical Model Proposal: Personal Innovativeness and User Involvement as Antecedents of Unified Theory of Acceptance and Use of Technology. *Procedia - Social and Behavioral Sciences*, (210), 43–51
- Bank of Ghana. (2021). *Regulatory sandbox framework*. <https://www.bog.gov.gh/wp-content/uploads/2022/08/Regulatory-Sandbox-Framework-19th-August-2022-1.pdf>
- Bank of Ghana. (2023). *FinTech Sector Report 2023*. <https://www.bog.gov.gh/news/fintech-sector-report-2023-full-year/>
- Bank of Ghana. (2024). *Financial Technology Implementation Report. FinTech and Innovation Office*. BoG Publications. <https://www.bog.gov.gh/wp-content/uploads/2024/08/FinTech-Sector-Report-2024-Q2.pdf>
- Barboza, F., Kimura, H., & Altman, E. (2017). Machine learning models and bankruptcy prediction. *Expert Systems with Applications*, (83), 405–417. <https://doi.org/10.1016/j.eswa.2017.04.006>
- Bell, C., & Hidary, J. (2024). *How AI and quantum technologies are transforming the financial industry*. World Economic Forum. <https://www.weforum.org/stories/2024/01/ai-quantum-technologies-transforming-financial-industry/>
- Biais, B., Foucault, T., & Moinas, S. (2015). Equilibrium fast trading. *Journal of Financial Economics*, 116(2), 292–313. <https://doi.org/10.1016/j.jfineco.2015.03.004>
- Boladale, H. H. (2023). Financial Technology and Financial Inclusion in Africa. *Canadian Social Science*, 19(4), 160–166. <http://dx.doi.org/10.3968/13043>
- Business and finance consulting. (2024). *Kazakhstan's Financial Sector Increasing Adoption of Artificial Intelligence*. Fintech Bulletin. <https://bulletins.bfconsulting.com/en/kazakhstans-financial-sector-increasing-adoption-of-artificial-intelligence/>
- Chen, M. A., Wu, Q., & Yang, B. (2019). How valuable is FinTech innovation? *The Review of Financial Studies*, 32(5), 2062–2106. <https://doi.org/10.1093/rfs/hhy130>
- Coffie, C. P. K., & Hongjiang, Z. (2023). FinTech market development and financial inclusion in Ghana: The role of heterogeneous actors. *Technological Forecasting and Social Change*, (186), 122127. <https://doi.org/10.1016/j.techfore.2022.122127>
- D'Acunto, F., Prabhala, N., & Rossi, A. G. (2019). The promises and pitfalls of robo-advising. *The Review of Financial Studies*, 32(5), 1983–2020. <http://hdl.handle.net/10.1093/rfs/hhz014>
- Davenport, T. H., & Ronanki, R. (2018). Artificial intelligence for the real world. *Harvard Business Review*, 96(1), 108–116.
- Delloite (2020). *Natural Language processing in investment management*. <https://www2.deloitte.com/us/en/insights/industry/financial-services/natural-language-processing-investment-management.html>
- Deloitte Kazakhstan. (2022). Deloitte conducts its second cybersecurity analysis of Kazakhstan commercial banks. https://www2.deloitte.com/kz/en/pages/about-deloitte/articles/cybersecurity_of_Kazakhstani_banks.html
- Deloitte. (2023). *The future of financial services: How disruptive forces are transforming the financial services landscape*. <https://www.deloitte.com/global/en/Industries/financial-services/perspectives/the-future-of-the-financial-services.html>

- Ernst & Young. (2024). *The future of the talent agenda in payments*. <https://www.ey.com/content/dam/ey-unified-site/ey-com/en-in/newsroom/2024/03/documents/ey-in-future-of-pay-report-03-2024-v1.pdf>
- FSB. (2024). *The Financial Stability Implications of Artificial Intelligence*. Financial Stability Board. <https://www.fsb.org/uploads/P14112024.pdf>
- Gazi, M. A. I., Masud, A. A., Amin, M. B., Hossain, M. A., bin S Senathirajah, A. R., & Abdullah, M. (2024). Evaluating customer satisfaction with the quality of online banking services after COVID-19: Developing country perspective. *Cogent Business & Management*, 11(1), 2423057. <https://doi.org/10.1080/23311975.2024.2423057>
- GCB Bank PLC. (2023). *Digital Landscape of Banks 2023*. <https://www.gcbbank.com.gh/research-reports/sector-industry-reports/357-digital-landscape-of-banks-2023-final-v1/file>
- Geneva Internet Platform digWatch (2025). Kazakhstan rises as an AI superpower URL: <https://dig.watch/updates/kazakhstan-rises-as-an-ai-superpower>
- Gomber, P., Koch, J. A., & Siering, M. (2017). Digital finance and FinTech: Current research and future research directions. *Journal of Business Economics*, 87(5), 537–580. <https://doi.org/10.1007/s11573-017-0852-x>
- Grzybowski, L., Lindlacher, V., & Mothobi, O. (2023). Mobile money and financial inclusion in Sub-Saharan Africa. *Information Economics and Policy*, (65), 101064. <https://doi.org/10.1016/j.infoecopol.2023.101064>
- Hall, I. (2024). *Kazakhstan steps up open banking implementation after pilot project*. Global Government Fintech. <https://www.globalgovernmentfintech.com/kazakhstan-steps-up-open-banking-implementation-after-pilot-project/>
- Hendershott, T. & Riordan, R. (2013). Algorithmic Trading and the Market for Liquidity. *Journal of Financial and Quantitative Analysis*, 48(4), 1001–1024. <https://doi.org/10.1017/S0022109013000471>
- International Monetary Fund. (2024a). *Advances in artificial intelligence: implications for capital market activities*. <https://www.imf.org/-/media/Files/Publications/GFSR/2024/October/English/ch3.ashx>
- International Monetary Fund (2024b). Republic of Kazakhstan: Financial Sector Assessment Program-Technical Note on Astana International Financial Center and the Kazakhstan Financial System. <https://www.elibrary.imf.org/view/journals/002/2024/313/article-A001-en.xml>
- ITU. (2024). *Measuring digital development ICT Development Index 2024*. International Telecommunication Union. <https://www.itu.int/itu-d/reports/statistics/idi2024/>
- Kang, J. W., Helble, M., Avendano, R., Crivelli, P., & Tayag, M. C. (2022). *Unlocking The Potential Of Digital Services Trade In Asia And The Pacific*. Asian Development Bank. <https://www.adb.org/sites/default/files/publication/842321/digital-services-trade-asia-pacific.pdf>
- Kazakhstan Ministry of Justice. (2024). *On approval of the Concept for the development of artificial intelligence for 2024–2029*. <https://adilet.zan.kz/rus/docs/P2400000592>
- Krijnsen, E., Sprenger, B. & Crijns, J. (2023). *Financial institutions must position themselves within a wider network of partners as they adapt to growing demand for frictionless finance*. PwC Global. <https://www.pwc.com/gh/en/publications/banking-survey.html>

- Kou, G., Peng, Y., & Wang, G. (2014). Evaluation of clustering algorithms for nancial risk analysis using MCDM methods. *Information Sciences*, (275), 1–12. URL: <https://doi.org/10.1016/j.ins.2014.02.137>
- Lessmann, S., Baesens, B., Seow, H. V., & Thomas, L. C. (2015). Benchmarking state-of-the-art classification algorithms for credit scoring: An update of research. *European Journal of Operational Research*, 247(1), 124–136. <https://doi.org/10.1016/j.ejor.2015.05.030>
- Loughran, T., & McDonald, B. (2016). Textual analysis in accounting and finance: A survey. *Journal of accounting research*, 54(4), 1187–1230. <https://doi.org/10.1111/1475-679X.12123>
- Madiyev, Z. (2024). *Kazakhstan's readiness to introduce AI into economic structures is assessed as high*. The Press Service of the Government of the Republic of Kazakhstan. <https://primeminister.kz/ru/news/gotovnost-kazakhstana-k-vnedreniyu-ii-v-struktury-ekonomiki-otsenivaetsya-kak-vysokaya-zhaslan-madiyev-28790>
- McKinsey & Company. (2023). *Global Banking Annual Review*. <https://www.mckinsey.com/industries/financial-services/our-insights/global-banking-annual-review-2023>
- Mehrabi, N., Morstatter, F., Saxena, N., Lerman, K., & Galstyan, A. (2021). A survey on bias and fairness in machine learning. *ACM Computing Surveys (CSUR)*, 54(6), 1-35. <https://doi.org/10.1145/3457607>
- Meyer, J., & Rowan, B. (1977). Institutionalized Organizations: Formal Structure as Myth and Ceremony. *American Journal of Sociology*, (83), 340–363. <http://dx.doi.org/10.1086/226550>
- Mhlanga, D. (2024). The Impact and Benefits of Digital Banking Transformation in Africa. *AfricaGrowth Agenda*, 21(3), 10–14.
- MTN Mobile Money. (2023). *Annual mobile money (MoMo) revenue of Scancom PLC (MTN Ghana) from 2019 to 2023*. Statista Publications. <https://www.statista.com/statistics/1314928/mtn-ghana-momo-annual-revenue/>
- National Bank of Kazakhstan. (2023). Digital Tenge. <https://nationalbank.kz/en/page/Digital-Tenge>
- National Bank of Kazakhstan. (2024a). *The report Artificial Intelligence in the Financial Market of Kazakhstan was published*. <https://nationalbank.kz/en/news/informacionnye-soobshcheniya/16693>
- National Bank of Kazakhstan. (2024b). *Report Artificial Intelligence in the Financial Market of Kazakhstan*. <https://nationalbank.kz/ru/news/informacionnye-soobshcheniya/16693>
- Ngai, E. W. T., Hu, Y., Wong, Y. H., Chen, Y., & Sun, X. (2011). The application of data mining techniques in financial fraud detection: A classification framework and an academic review of literature. *Decision Support Systems*, 50(3), 559–569.
- Organization Economic Cooperation and Development. (2023). *Improving Framework Conditions for the Digital Transformation of Businesses in Kazakhstan*. https://www.oecd.org/content/dam/oecd/en/publications/reports/2023/05/improving-framework-conditions-for-the-digital-transformation-of-businesses-in-kazakhstan_c62df12f/368d4d01-en.pdf
- Pattnaik, D., Ray, S., & Raman, R. (2024). Applications of artificial intelligence and machine learning in the financial services industry: A bibliometric review. *Heliyon*, 10(2024), e23492. <https://doi.org/10.1016/j.heliyon.2023.e23492>
- Quaye, W., Akon-Yamga, G., Akuffobe-Essilfie, M., & Onumah, J. A. (2024). Technology adoption, competitiveness and new market access among SMEs in Ghana: What are the

- limiting factors? *African Journal of Science, Technology, Innovation and Development*, 16(7), 1023–1037. <https://doi.org/10.1080/20421338.2024.2414949>
- Rogers, E. M. (2003). *Diffusion of Innovations* (5th ed.). Free Press.
- Rose Innes, C., & Andrieu, J. (2022). *Banking on FinTech in Emerging Markets*. World Bank. <https://openknowledge.worldbank.org/entities/publication/659a8647-71c7-5023-b77b-7ae977a0c3ac>
- Russell, S. J., & Norvig, P. (2020). *Artificial Intelligence: A Modern Approach* (4th ed.). Pearson.
- Scott, W. R. (2014). *Institutions and Organizations: Ideas, Interests, and Identities* (4th ed.). Sage Publishing.
- Sironi, P. (2021). *FinTech Innovation: From Robo-Advisors to Goal Based Investing and Gamification*. Wiley.
- Kapsalyamova, S., Yessentemirova, A., Rakhymbekova, A., Ryskaliev, D., & Osmanova, D. (2025). Legal Challenges of Regulating Generative Ai in Kazakhstan: A Comparative Assessment in Light of the EU Ai Act. <http://dx.doi.org/10.2139/ssrn.5274268>
- Tornatzky, L. G. & Fleischer, M. (1990). *The Processes of Technological Innovation*. Lexington.
- World Bank. (2020). *Digital Financial Services* <https://pubdocs.worldbank.org/en/230281588169110691/digital-financial-services.pdf>
- World Bank. (2024). *Inclusive Digital Financial Services*. World Bank Group.
- World Bank (2025). *On Credit to GDP, Population and GDP per capita growth*. <https://data.worldbank.org/indicator/fs.ast.prvt.gd.zs%C2%A0?locations=GH>
- World Economic Forum. (2021). *The Future of AI in Emerging Markets*. <https://www.weforum.org>
- World Economic Forum. (2024). *The Future of Global Fintech: Towards Resilient and Inclusive Growth*. https://www3.weforum.org/docs/WEF_The_Future_of_Global_Fintech_2024.pdf
- Yong, S. M. (2023). 4th Industry Revolution Digital Marketing Adoption Challenges in SMEs and its Effect on Customer Responsiveness. *Information Management and Business Review*, 15(2(I)SI), 152–172. [https://doi.org/10.22610/imbr.v15i2\(I\)SI.3429](https://doi.org/10.22610/imbr.v15i2(I)SI.3429)
- Zarsky, T. Z. (2016). The trouble with algorithmic decisions: An analytic road map to examine efficiency and fairness in automated and opaque decision making. *Science, Technology, & Human Values*, 41(1), 118–132. <https://doi.org/10.1177/0162243915605575>
- Zetsche, D. A., Buckley, R. P., Arner, D. W., & Barberis, J. N. (2020). From Fintech to Techfin: The Regulatory Challenges of Data-Driven Finance. *NYU Journal of Law & Business*, 14(2), 393–446. <https://dx.doi.org/10.2139/ssrn.2959925>
- Zhumadilova T., Kassenova, G., & Supugaliyeva, G. (2023). Digitalization of financial services of banks in Kazakhstan: trends and prospects of development. *ECONOMIC Series of the Bulletin of the L N Gumilyov ENU*, (3), 328–340. <https://doi.org/10.32523/2789-4320-2023-3-328-340>