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ХАБАРЛАРЫ

ИЗВЕСТИЯ

РОО «НАЦИОНАЛЬНОЙ
АКАДЕМИИ НАУК РЕСПУБЛИКИ
КАЗАХСТАН»
ЧФ «Халық»

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В 2016 году для развития и улучшения качества жизни казахстанцев был создан частный Благотворительный фонд «Халык». За годы своей деятельности на реализацию благотворительных проектов в областях образования и науки, социальной защиты, культуры, здравоохранения и спорта, Фонд выделил более 45 миллиардов тенге.

Особое внимание Благотворительный фонд «Халык» уделяет образовательным программам, считая это направление одним из ключевых в своей деятельности. Оказывая поддержку отечественному образованию, Фонд вносит свой посильный вклад в развитие качественного образования в Казахстане. Тем самым способствуя росту числа людей, способных менять жизнь в стране к лучшему – профессионалов в различных сферах, потенциальных лидеров и «великих умов». Одной из значимых инициатив фонда «Халык» в образовательной сфере стал проект Ozgeris powered by Halyk Fund – первый в стране бизнес-инкубатор для учащихся 9-11 классов, который помогает развивать необходимые в современном мире предпринимательские навыки. Так, на содействие малому бизнесу школьников было выделено более 200 грантов. Для поддержки талантливых и мотивированных детей Фонд неоднократно выделял гранты на обучение в Международной школе «Мирас» и в Astana IT University, а также помог казахстанским школьникам принять участие в престижном конкурсе «USTEM Robotics» в США. Авторские работы в рамках проекта «Тәлімгер», которому Фонд оказал поддержку, легли в основу учебной программы, учебников и учебно-методических книг по предмету «Основы предпринимательства и бизнеса», преподаваемого в 10-11 классах казахстанских школ и колледжей.

Помимо помощи школьникам, учащимся колледжей и студентам Фонд считает важным внести свой вклад в повышение квалификации педагогов, совершенствование их знаний и навыков, поскольку именно они являются проводниками знаний будущих поколений казахстанцев. При поддержке Фонда «Халык» в южной столице был организован ежегодный городской конкурс педагогов «Almaty Digital Ustaz.

Важной инициативой стал реализуемый проект по обучению основам финансовой грамотности преподавателей из восьми областей Казахстана, что должно оказать существенное влияние на воспитание финансовой грамотности и предпринимательского мышления у нового поколения граждан страны.

Необходимую помощь Фонд «Халык» оказывает и тем, кто особенно остро в ней нуждается. В рамках социальной защиты населения активно проводится работа по поддержке детей, оставшихся без родителей, детей и взрослых из социально уязвимых слоев населения, людей с ограниченными возможностями, а также обеспечению нуждающихся социальным жильем, строительству социально важных объектов, таких как детские сады, детские площадки и физкультурно-оздоровительные комплексы.

В копилку добрых дел Фонда «Халык» можно добавить оказание помощи детскому спорту, куда относится поддержка в развитии детского футбола и карате в нашей стране. Жизненно важную помощь Благотворительный фонд «Халык» оказал нашим соотечественникам во время недавней пандемии COVID-19. Тогда, в разгар тяжелой борьбы с коронавирусной инфекцией Фонд выделил свыше 11 миллиардов тенге на приобретение необходимого медицинского оборудования и дорогостоящих медицинских препаратов, автомобилей скорой медицинской помощи и средств защиты, адресную материальную помощь социально уязвимым слоям населения и денежные выплаты медицинским работникам.

В 2023 году наряду с другими проектами, нацеленными на повышение благосостояния казахстанских граждан Фонд решил уделить особое внимание науке, поскольку она является частью общественной культуры, а уровень ее развития определяет уровень развития государства.

Поддержка Фондом выпуска журналов Национальной Академии наук Республики Казахстан, которые входят в международные фонды Scopus и Wos и в которых публикуются статьи отечественных ученых, докторантов и магистрантов, а также научных сотрудников высших учебных заведений и научно-исследовательских институтов нашей страны является не менее значимым вкладом Фонда в развитие казахстанского общества.

С уважением,
Благотворительный Фонд «Халык»!

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ADVANCEMENTS IN MOBILE AND ONLINE BANKING: A COMPREHENSIVE ANALYSIS OF TECHNOLOGIES AND INNOVATIONS

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Abstract. The article provides an in-depth review of the rapid progression of digital banking driven by technological advancements and breakthrough innovations. The manuscript explores the journey from the inception of online banking to the rise of mobile banking, and further to the advent of digital-only banks. It elucidates how these digital channels have revolutionized the financial landscape, enabling unprecedented convenience, speed, and accessibility in banking services. The paper also discusses the transformational impact of technologies such as mobile applications, biometric authentication, artificial intelligence (AI), machine learning (ML), and blockchain in reshaping the banking sector. The crucial role of AI and ML in enhancing customer service, fraud detection, credit risk assessment, and personalization of product recommendations is comprehensively examined. Moreover, the manuscript delves into the potential of blockchain technology in

ensuring secure, transparent, and efficient transactions. Furthermore, it underscores the role of regulatory frameworks and compliance in the digital banking ecosystem. It brings to light the challenges and risks associated with digital banking, including cybersecurity threats and the digital divide, while suggesting mitigation strategies. Looking ahead, the manuscript identifies future trends and opportunities such as the integration of digital banking with emerging financial technologies (e.g., digital currencies, robo-advisors), the role of 5G and Internet of Things (IoT) in digital banking, and the importance of creating personalized, customer-centric banking experiences. The paper concludes with implications for the banking industry and policymakers, and directions for future research, making it an indispensable resource for anyone interested in understanding the evolution and future of digital banking.

Keywords: digital banking, financial innovation, cybersecurity, regulatory framework, emerging technologies

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МОБИЛЬДІ ЖӘНЕ ОНЛАЙН-БАНКИНГТЕГІ ЖЕТІСТІКТЕР: ТЕХНОЛОГИЯЛАР МЕН ИННОВАЦИЯЛАРДЫ КЕШЕНДІ ТАЛДАУ

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Аннотация. Мақалада технологиялық жетістіктер мен серпінді инновацияларға негізделген цифрлық банкингтің қарқынды дамуына егжей-тегжейлі шолу берілген. Қолжазба онлайн-банкингтің пайда болуынан мобильді банкингтің көтерілуіне дейінгі және тек цифрлық форматта жұмыс істейтін банктер пайда болғанға дейінгі жолды зерттейді. Онда бұл цифрлық арналар бұрын-соңды болмаған банктік ыңғайлылықты, жылдамдықты және қолжетімділікті қамтамасыз ету арқылы қаржылық ландшафтты қалай

өзгерткені көрсетілген. Мақалада сонымен қатар мобильді қосымшалар, биометриялық аутентификация, жасанды интеллект (AI), машиналық оқыту (МО) және блокчейн сияқты технологиялардың банк секторының өзгеруіне трансформациялық әсерін талқылайды. Жасанды интеллект пен машиналық оқытудың тұтынушыларға қызмет көрсетуді жақсартудағы, алаяқтықты анықтаудағы, несиелік тәуекелді бағалаудағы және өнім ұсыныстарын жекелендірудегі шешуші рөлі жан-жақты зерттеледі. Сонымен қатар, қолжазба қауіпсіз, мөлдір және тиімді транзакцияларды қамтамасыз етудегі блокчейн технологиясының әлеуетін қарастырады. Сонымен қатар, ол цифрлық банкинг экожүйесіндегі нормативтік-құқықтық базаның және сәйкестіктің рөлін көрсетеді. Ол цифрлық банкингке қатысты мәселелер мен тәуекелдерді, соның ішінде киберқауіпсіздік қатерлерін және цифрлық алшақтықты анықтайды және азайту стратегияларын ұсынады. Қолжазбада болашақ тенденциялар мен мүмкіндіктер, мысалы, цифрлық банкингті жаңа қаржылық технологиялармен біріктіру (мысалы, сандық валюталар, робо-кеңесшілер), цифрлық банкингтегі 5G және Заттар интернетінің (IoT) рөлі және жеке, клиентке бағытталған банктік қызметті құрудың маңыздылығы анықталады. Мақалада банк саласы мен саясаткерлер үшін салдармен, сондай-ақ болашақ зерттеу бағыттарымен аяқталады, бұл оны цифрлық банкингтің эволюциясы мен болашағына қызығушылық танытқандар үшін таптырмас ресурс етеді.

Түйін сөздер: цифрлық банкинг, қаржылық инновациялар, киберқауіпсіздік, нормативтік база, жаңа технологиялар

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ДОСТИЖЕНИЯ В МОБИЛЬНОМ И ОНЛАЙН-БАНКИНГЕ: КОМПЛЕКСНЫЙ АНАЛИЗ ТЕХНОЛОГИЙ И ИННОВАЦИЙ

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Аннотация. В статье представлен подробный обзор быстрого развития цифрового банкинга, обусловленного технологическими достижениями и прорывными инновациями. В рукописи исследуется путь от зарождения онлайн-банкинга до подъёма мобильного банкинга и далее до появления банков, работающих только в цифровом формате. В нем показано, как эти цифровые каналы произвели революцию в финансовом ландшафте, обеспечив беспрецедентное удобство, скорость и доступность банковских услуг. В документе также обсуждается трансформационное влияние таких технологий, как мобильные приложения, биометрическая аутентификация, искусственный интеллект (ИИ), машинное обучение (МО) и блокчейн на изменение банковского сектора. Всесторонне исследуется решающая роль искусственного интеллекта и машинного обучения в улучшении обслуживания клиентов, обнаружении мошенничества, оценке кредитного риска и персонализации рекомендаций по продуктам. Кроме того, в рукописи рассматривается потенциал технологии блокчейн в обеспечении безопасных, прозрачных и эффективных транзакций. Кроме того, в нем подчеркивается роль нормативно-правовой базы и соответствия требованиям в экосистеме цифрового банкинга. В нем выявляются проблемы и риски, связанные с цифровым банкингом, включая угрозы кибербезопасности и цифровой разрыв, а также предлагаются стратегии смягчения последствий. Забегая вперед раскрою, что в рукописи определяются будущие тенденции и возможности, такие как интеграция цифрового банкинга с новыми финансовыми технологиями (например, цифровые валюты, роботы-консультанты), роль 5G и Интернета вещей (IoT) в цифровом банкинге, а также важность создания персонализированного, клиентоориентированного банковского обслуживания. Статья завершается последствиями для банковской отрасли и политиков, а также направлениями будущих исследований, что делает его незаменимым ресурсом для всех, кто интересуется эволюцией и будущим цифрового банкинга.

Ключевые слова: цифровой банкинг, финансовые инновации, кибербезопасность, нормативная база, новые технологии

Introduction

Mobile and online banking have revolutionized financial management, offering unparalleled convenience, speed, and accessibility. These digital banking channels evolved with advancements in information and communication technologies, playing a critical role in shaping the modern financial landscape. Online banking emerged in the early 1980s when banks began offering limited electronic services via telephone lines and dedicated terminals (Sanli, 2015). With the internet's

advent in the 1990s, banks started providing online banking services through websites, allowing customers to access accounts, transfer funds, pay bills, and view transaction history from personal computers.

As mobile phones advanced and became widespread, banks saw potential in offering banking services through mobile devices. Mobile banking debuted in the early 2000s with basic SMS-based services for account balance checks and alerts. The late 2000s saw the launch of smartphones and mobile applications, as banks developed dedicated mobile apps offering comprehensive features like account management, remote check deposit, and peer-to-peer payments (Prisc, 2021). The banking landscape further evolved with the rise of digital-only banks, or neobanks, which operate exclusively online without physical branches. These banks focus on user experience, competitive fees, and innovative features, making them an attractive alternative to traditional banks.

Mobile and online banking have profoundly impacted the banking sector, driving competition, improving customer experiences, and reducing operational costs. Customers now expect seamless, secure, and efficient banking experiences accessible anytime, anywhere. Consequently, banks invest heavily in digital transformation initiatives to meet demands and remain competitive in an increasingly digital financial landscape. Mobile and online banking have come a long way since their early beginnings, becoming integral components of the modern banking experience. With rapid advancements in technology and changing customer preferences, digital banking channels will continue to evolve and reshape the financial industry.

Digital banking has become a cornerstone of the modern financial landscape due to its transformative impact on the banking sector and the numerous advantages it offers (Arrighi, 2014). It provides convenience and accessibility, enabling customers to access financial services 24/7 from anywhere with an internet connection, saving time and resources. Leveraging digital channels allows banks to reduce operational costs and pass on savings to customers in the form of lower fees and better interest rates. Improved customer experience, real-time services, and enhanced security are other benefits of digital banking. User-friendly interfaces and personalized services lead to increased customer satisfaction and loyalty. Real-time transaction processing and instant access to account information keep customers informed about their financial status. Advanced security measures protect sensitive financial data. Digital banking promotes financial inclusion by reaching unbanked and underbanked populations, fostering economic growth and reducing income inequality in underserved communities. The rise of digital banking spurs innovation and competition in the financial industry, ultimately benefiting customers through new features and improved services (de Lis, 2018). Additionally, digital banking contributes to environmental sustainability by reducing the need for physical branches and paper-based transactions.

Data-driven decision-making and integration with emerging technologies are other key aspects of digital banking. Analyzing customer data helps banks tailor

their products and services, improve risk management, and make better-informed decisions. Digital banking platforms can easily integrate with technologies such as artificial intelligence, machine learning, blockchain, and the Internet of Things (IoT) to enhance offerings and streamline operations.

Digital banking plays a vital role in the modern financial landscape by driving innovation, improving customer experiences, and promoting financial inclusion. As technology continues to advance and customer preferences shift, the importance of digital banking will only grow, shaping the future of the banking industry (Liu, 2020).

The scope of this review is to examine the historical development, current state, and future trends of mobile and online banking, with a focus on the technologies and innovations that have shaped this transformation. The review will provide a comprehensive analysis of the digital banking landscape, highlighting its impact on customers, banks, and the broader financial industry.

By achieving this aim, the review will offer a comprehensive understanding of the evolution of mobile and online banking, providing valuable insights for academics, industry professionals, and policymakers interested in the ongoing digital transformation of the banking sector.

Methodology

To provide a comprehensive and well-structured analysis of the evolution of mobile and online banking, the following methodology was employed:

1. Literature Search Strategy:

A systematic search of relevant literature was conducted using various electronic databases, such as Google Scholar, IEEE Xplore, ScienceDirect, and JSTOR. The search focused on academic articles, conference proceedings, whitepapers, and industry reports published in English. To identify relevant publications, a combination of keywords and phrases was used, including "mobile banking," "online banking," "digital banking," "technological advancements," "innovations," "challenges," and "future trends."

2. Inclusion and Exclusion Criteria:

To ensure the quality and relevance of the selected literature, specific inclusion and exclusion criteria were applied. Inclusion criteria consisted of factors such as:

Publication date: Focusing on sources published within the last 10-15 years to capture recent developments and trends.

Relevance: Articles must have had a primary focus on mobile and online banking technologies and innovations.

Methodological rigor: Preference was given to studies that demonstrated methodological rigor and provided clear, well-supported conclusions.

Exclusion criteria included: Non-English publications; opinion pieces or editorials without substantial evidence or analysis; publications with a narrow focus that did not contribute to the broader understanding of the topic.

3. Data Extraction and Analysis:

Once the relevant literature was identified, the following data were extracted:

Bibliographic information (author, title, publication date, source); study design and methodology; key findings, technologies, innovations, challenges, and trends.

The extracted data were synthesized and analyzed to address the review's objectives. This analysis involved: a chronological overview of the development of mobile and online banking, highlighting key milestones and technological advancements; a thematic analysis of the identified innovations, challenges, and trends in mobile and online banking; a discussion of the regulatory frameworks, compliance requirements, and their impact on digital banking; an exploration of future trends and opportunities, including the potential implications of emerging technologies.

By employing this methodology, the review manuscript offered a comprehensive and systematic analysis of the evolution of mobile and online banking, focusing on the technologies and innovations that drove this transformation. This approach ensured that the review was grounded in the existing literature, providing valuable insights for academics, industry professionals, and policymakers interested in the digital transformation of the banking sector.

Discussion

The emergence of online banking systems can be traced back to the early 1980s, when financial institutions began experimenting with electronic banking services to meet the evolving needs of their customers. Early online banking systems were quite different from the sophisticated platforms we know today, as they were limited in functionality and accessibility.

Before the widespread adoption of the internet, banks offered limited electronic services using telephone lines and dedicated terminals. Some of the earliest electronic banking services were introduced by major banks in the United States, such as Bank of America and Citibank. These services typically allowed customers to access basic account information and perform simple transactions like transferring funds between accounts (Gonzalez, 2015).

During this period, home banking systems were also developed, allowing customers to access their accounts through a personal computer equipped with a modem. These early systems often used proprietary software provided by the bank and required customers to dial directly into the bank's computer systems (Shaikh, 2015). Despite offering limited features, these early home banking systems were considered innovative and paved the way for the development of more advanced online banking services.

With the advent of the internet in the 1990s, banks saw the potential for expanding their electronic banking services and started offering online banking through websites. These enabled customers to access their accounts, transfer funds, pay bills, and view transaction history from their personal computers. These early online banking websites were relatively basic in design and functionality compared to today's standards. They relied on static HTML pages, lacked personalization features, and often required the use of specific browsers for compatibility.

Security was also a significant concern in the early days of online banking.

Banks implemented various security measures, such as usernames, passwords, and security questions, to authenticate users and protect sensitive financial data. Over time, encryption technologies like Secure Socket Layer (SSL) were adopted to enhance the security of online transactions and communication between users and banking websites.

Despite the limitations of early online banking systems, they represented a significant breakthrough in the banking industry, offering customers increased convenience and accessibility to their financial information. As internet usage continued to grow and technology advanced, online banking systems evolved to offer more sophisticated features, better user experiences, and improved security measures.

Early online banking systems played a crucial role in shaping the digital banking landscape we know today. By providing customers with the ability to access and manage their finances electronically, these systems laid the foundation for the rapid development of mobile and online banking technologies and innovations. The emergence of mobile banking can be attributed to the rapid development of mobile technology and the widespread adoption of smartphones and mobile internet. As the use of smartphones became more prevalent, banks saw an opportunity to leverage these devices to offer financial services to their customers on the go, providing greater convenience and accessibility. This led to the birth of mobile banking.

In the early stages of mobile banking, banks primarily used text messages (SMS) to communicate with customers. Customers could receive account balance updates, transaction alerts, and even perform basic transactions by sending text messages to their banks. The convenience of SMS banking was a significant step forward, but the system was relatively simple and limited in functionality.

As mobile technology progressed, banks began developing mobile applications (apps) specifically designed for smartphones. These early mobile banking apps allowed customers to access their accounts, view transaction history, transfer funds, and pay bills directly from their smartphones. Mobile apps offered a more user-friendly and convenient experience compared to SMS banking, as they provided a richer interface and more advanced features.

The development of mobile banking apps was further accelerated by the emergence of app stores, such as Apple's App Store and Google's Play Store, which made it easier for customers to discover and download banking apps. This led to a surge in the adoption of mobile banking services, as customers increasingly embraced the convenience and flexibility provided by these apps.

In addition to traditional banks, the growth of mobile banking also spurred the creation of new financial institutions, such as digital-only banks or neobanks, that operate exclusively through mobile apps and online platforms (Norohna, 2023). These digital banks often offer innovative features, lower fees, and personalized services that cater to the needs of the tech-savvy, mobile-first generation.

The emergence of mobile banking also introduced new security concerns, as banks had to find ways to protect customer data and ensure the security of

transactions performed through mobile devices. Banks responded by implementing advanced security measures, such as biometric authentication, encryption, and secure mobile application development practices.

Over time, mobile banking has continued to evolve, with new technologies and innovations being integrated into the apps. Today, mobile banking offers a wide array of features, such as mobile check deposits, person-to-person (P2P) payments, budgeting tools, and even access to financial products like loans and investments.

Mobile banking has revolutionized the banking industry and customer interaction with financial institutions. Offering convenient, accessible, and user-friendly financial services via smartphones, it has become an integral component of the contemporary financial landscape.

Technological advancements have reshaped customer interaction with banks and financial management, enabling institutions to offer innovative services, enhance customer experience, and improve operational efficiency. Crucial developments include mobile apps that increase accessibility and enable customers to perform various banking tasks from their smartphones, contributing to mobile banking's growing popularity (Chou, 2004). Biometric authentication, including fingerprint, facial recognition, and voice recognition, provides a secure and convenient way for customers to access their accounts, enhancing digital banking security and streamlining user experience. Artificial intelligence (AI) and machine learning have improved customer service through AI-powered chatbots and virtual assistants, while machine learning algorithms enable better fraud detection, credit risk assessment, and personalized product recommendations (Manser Payne, 2018).

Open banking and application programming interfaces (APIs) have transformed the digital banking landscape, creating a more interconnected and collaborative financial ecosystem involving traditional banks, fintech companies, and other financial service providers (Fiedler, 2022). Blockchain technology offers potential solutions for secure, transparent, and efficient transactions, reducing transaction costs and streamlining cross-border payments. The growing popularity of digital wallets and contactless payments has also impacted digital banking, providing a fast and convenient alternative to traditional payment methods. These key technological advancements have revolutionized customer interaction with financial institutions and financial management, contributing to the ongoing digital transformation of the banking industry.

Mobile apps and responsive web design are two approaches used by businesses and organizations, including banks, to ensure that their digital services are accessible, user-friendly, and functional across a wide range of devices. These approaches aim to provide customers with seamless and engaging experiences, regardless of the type of device they use to access the services.

Mobile apps are standalone applications specifically designed for smartphones and other mobile devices. They are developed using native programming languages, such as Java for Android devices and Swift for iOS devices, and offer a tailored user experience optimized for the device's operating system. Mobile apps

typically provide a rich, interactive interface, making it easy for users to navigate through the app and perform various tasks. They can also take full advantage of the device's hardware features, such as the camera, GPS, and biometric sensors, to offer additional functionalities and a more personalized experience. Information about the most famous mobile banking apps and their features are shown in Table 1.

Table 1 – Most Famous Mobile Banking Apps and Their Features (Horton, 2023; Richter, 2018)

Mobile Banking App	Description
Chase Mobile	Chase Mobile is the mobile banking app developed by JPMorgan Chase, one of the largest banks in the United States. The app allows customers to view account balances, transaction history, deposit checks, pay bills, transfer funds, and locate ATMs and branches. It also offers features like personalized alerts, budgeting tools, and Zelle integration for quick P2P payments.
Bank of America	Bank of America's mobile banking app enables customers to access their accounts, transfer money, deposit checks, pay bills, and locate nearby ATMs and financial centers. The app also includes features like custom alerts, mobile credit card management, and integration with the bank's virtual financial assistant, Erica, which uses AI to provide personalized financial guidance.
Wells Fargo Mobile	Wells Fargo Mobile app allows customers to manage their accounts, pay bills, deposit checks, transfer funds, and find ATMs and branches. The app also offers additional features such as budgeting tools, custom alerts, and card management options, including the ability to temporarily freeze a lost or misplaced card.
Citi Mobile	Citi Mobile is the mobile banking app developed by Citibank, offering customers access to their account information, transaction history, bill payments, fund transfers, and mobile check deposits. The app also features Citi Mobile Snapshot, which allows users to view account balances and recent transactions without logging in, and integration with Citi's virtual assistant.
Capital One	Capital One's mobile banking app lets customers manage their accounts, pay bills, deposit checks, transfer funds, and locate nearby ATMs and branches. The app also integrates with Capital One's CreditWise feature, enabling users to monitor their credit score and receive personalized credit insights. The app offers additional security features like fingerprint login.

Kaspi.kz, a leading fintech company in Kazakhstan, offers a comprehensive mobile banking solution through its all-in-one mobile app (Ivashina, 2019). As a key player in the nation's digital banking landscape, Kaspi.kz provides innovative and user-friendly services, including account access, transaction history, bill payments, and seamless fund transfers. The app also supports instant peer-to-peer payments and various financial products like loans, insurance, and investments. Kaspi Gold, a loyalty program integrated into the app, rewards users with cashback for purchases made using Kaspi.kz cards. Security is a notable focus for Kaspi.kz, employing advanced measures like biometric authentication to protect user data and ensure transaction safety. Users can manage card settings, such as blocking and unblocking cards or setting transaction limits, to further enhance security.

The Kaspi.kz app also offers non-financial services, enabling users to book movie tickets, pay for utilities, and top up mobile phone balances within its ecosystem. This holistic approach to digital services makes Kaspi.kz an essential tool for users seeking to manage finances and access everyday services effortlessly.

Mobile apps can be installed directly from app stores, such as Google Play Store and Apple App Store, and often provide offline functionality, allowing users to access certain features even without an internet connection. This can be particularly useful for banking services, as customers may need to access their account information or perform transactions when they are not connected to the internet.

On the other hand, responsive web design is an approach to website development that ensures the website's layout, images, and other elements automatically adjust to fit the screen size and orientation of the device being used. This enables users to have a consistent experience across various devices, such as smartphones, tablets, and desktop computers. Responsive web design is achieved through the use of fluid grids, flexible images, and CSS media queries that detect the characteristics of the user's device and adapt the website accordingly.

Responsive web design is particularly important for online banking services, as customers may access their accounts using different devices throughout the day. By ensuring that the website's layout and content are displayed optimally on every device, banks can provide a more user-friendly and efficient experience for their customers.

Both mobile apps and responsive web design have their advantages and drawbacks. Mobile apps tend to offer a more engaging, feature-rich experience and can leverage the device's hardware capabilities. However, they require more development resources and maintenance, as separate versions of the app must be created and updated for each operating system. Responsive web design, in contrast, offers a more universal solution that can be accessed across various devices with minimal additional development effort. However, it may not provide the same level of interactivity and hardware integration as a dedicated mobile app.

Mobile apps and responsive web design are both essential components of a comprehensive digital strategy for banks and other organizations. By providing customers with accessible, user-friendly, and functional digital services across different devices, banks can enhance customer satisfaction, increase engagement, and ultimately strengthen their position in the competitive digital banking landscape.

Biometric authentication has emerged as an innovative and effective method for ensuring security in various industries, including digital banking. As traditional authentication methods such as passwords and PINs become increasingly vulnerable to security breaches and hacking attempts, biometric authentication offers a more reliable and user-friendly alternative.

Biometric authentication refers to the process of verifying an individual's identity based on unique physiological or behavioral characteristics. These characteristics include fingerprints, facial recognition, iris or retina scans, voice recognition, and even gait analysis (Michaels, 2022). By utilizing these unique identifiers, biometric

authentication can provide a higher level of security compared to traditional methods, as they are difficult to forge, hack, or replicate.

One of the primary advantages of biometric authentication in digital banking is the enhanced security it provides. By requiring users to verify their identity using their unique biometric traits, banks can significantly reduce the risk of unauthorized access to their customers' accounts. Biometric authentication is particularly useful in protecting against common cyber threats such as phishing, identity theft, and brute-force attacks, which often target weak or stolen passwords.

Another benefit of biometric authentication is the improved user experience it offers. Instead of requiring customers to remember and enter complex passwords or PINs, biometric authentication allows users to access their accounts quickly and conveniently using their fingerprints, facial features, or voice. This streamlined process not only enhances the overall customer experience but also encourages the adoption of digital banking services.

However, the implementation of biometric authentication also raises certain concerns related to privacy and data security. As biometric data is highly sensitive and unique to each individual, it is crucial that banks and other organizations employing biometric authentication take necessary measures to protect this information. This includes ensuring that biometric data is stored securely, encrypted, and not shared with unauthorized parties.

Moreover, biometric authentication systems are not immune to potential vulnerabilities or hacking attempts. For example, sophisticated attackers may try to bypass facial recognition systems using high-quality masks or 3D-printed replicas. To mitigate these risks, banks may employ multi-factor authentication methods, which combine biometrics with other security measures, such as passwords or one-time codes, to provide a more robust layer of protection.

The application of AI and ML technologies in mobile and online banking has led to significant advancements in the way financial institutions provide services, enhance customer experience, and improve operational efficiency (Donepudi, 2017). By leveraging AI and ML, banks can develop intelligent systems that can analyze vast amounts of data, make predictions, and adapt to new information. Here are some key applications of AI and ML in mobile and online banking (Figure 1):

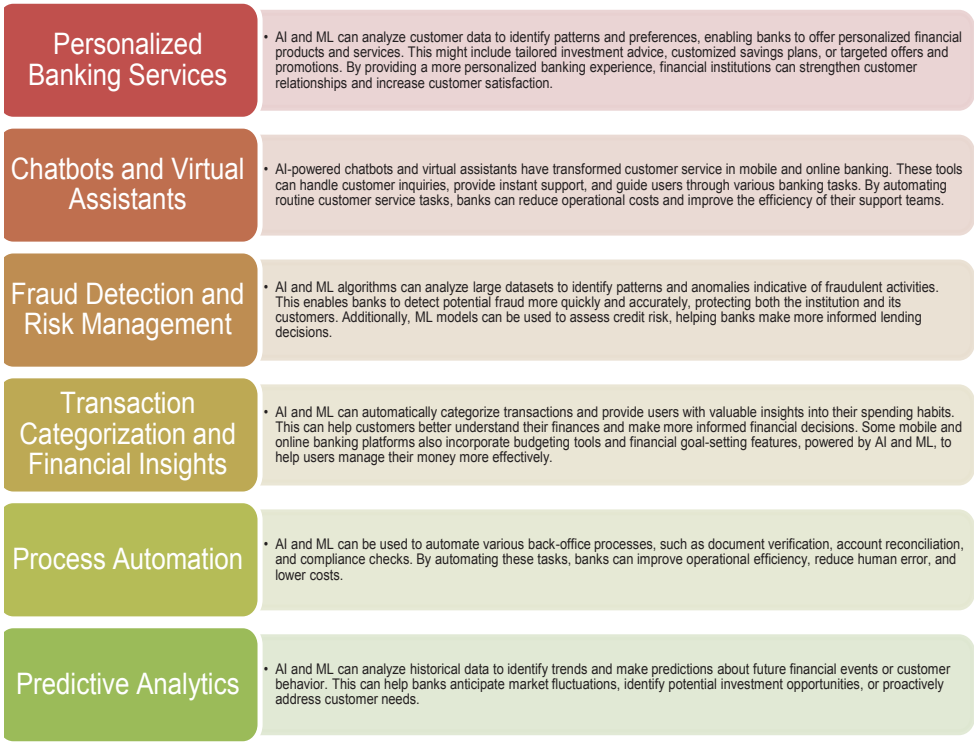

Fig 1. Essential uses of artificial intelligence (AI) and machine learning (ML) in mobile and online banking (Bhatore, 2020; Basdekis, 2022)

AI and ML have brought about significant advancements in mobile and online banking, allowing financial institutions to offer innovative services, enhance customer experience, and improve operational efficiency. By leveraging these technologies, banks can better understand and serve their customers, stay ahead of emerging trends, and remain competitive in the ever-evolving digital landscape.

Open banking refers to the practice of sharing customer financial data securely and with their consent among different financial institutions through open Application Programming Interfaces (APIs). This practice enables the development of innovative and customer-centric financial products and services that can enhance the overall banking experience. API integration is an essential aspect of open banking, allowing different systems and applications to communicate with each other seamlessly.

API integration enables banks to connect their systems and data with third-party applications and services, such as personal finance management tools, investment apps, or credit reporting services. This integration facilitates the sharing of data and enables the development of more customized and personalized financial products and services.

One of the main benefits of open banking and API integration is the enhanced

customer experience. With APIs, banks can offer a more holistic view of their customers' financial lives, allowing them to provide more personalized services that better meet their customers' needs. For example, a customer's financial data from multiple banks can be integrated into a single dashboard, enabling them to view all their accounts and transactions in one place.

Another advantage of open banking and API integration is the increased competition and innovation in the financial services industry. By enabling third-party developers to access customer data and build new products and services, open banking fosters a more competitive and dynamic market that benefits consumers.

However, there are also potential risks associated with open banking and API integration, particularly related to data privacy and security. Banks must ensure that customer data is only shared with authorized third-party providers and that appropriate security measures are in place to protect that data from unauthorized access or misuse.

Open banking and API integration offer significant opportunities for banks and financial services providers to enhance the customer experience and promote innovation in the industry. By leveraging APIs to share data securely, banks can offer more personalized services and enable third-party providers to develop new and innovative financial products and services. However, it is essential for banks to address potential privacy and security concerns to ensure the safety and trust of their customers.

Digital wallets and contactless payments have emerged as a popular and convenient method for consumers to make purchases both online and in-store. A digital wallet is a virtual wallet that stores payment and identification information securely and enables users to make payments via a mobile device. Contactless payments, on the other hand, allow users to make payments by simply tapping their card or mobile device on a payment terminal, without the need for a physical signature or PIN. One of the main benefits of digital wallets and contactless payments is the convenience they offer to consumers. By eliminating the need for physical cards and cash, these payment methods offer a quick and easy way to make purchases. Additionally, digital wallets can store multiple payment options and loyalty cards, allowing users to manage all their payment and rewards information in one place. Digital wallets and contactless payments also offer enhanced security compared to traditional payment methods. With features such as biometric authentication and tokenization, these payment methods provide an extra layer of protection against fraud and unauthorized access. Tokenization replaces sensitive payment information with a unique token, reducing the risk of data breaches and ensuring that customer information is kept secure (Kajdi, 2022).

Moreover, digital wallets and contactless payments have become increasingly popular during the COVID-19 pandemic, as consumers seek to minimize physical contact and reduce the spread of germs. Contactless payments, in particular, have seen a surge in adoption as retailers and businesses promote cashless payment options to minimize the need for physical contact between customers and employees.

However, there are also potential drawbacks to digital wallets and contactless payments. Some consumers may be concerned about the security and privacy of their personal and payment information when using these payment methods. Additionally, some retailers and businesses may not accept digital wallets or contactless payments, limiting their usefulness in certain situations. Digital wallets and contactless payments offer convenience and enhanced security to consumers, particularly in the age of COVID-19 (Hellemans, 2022). As these payment methods continue to evolve and become more widely accepted, they have the potential to transform the way people make purchases and manage their finances.

Blockchain and distributed ledger technologies (DLT) have gained increasing attention in recent years as potential game-changers in the financial industry. Blockchain is a type of DLT that allows for secure, transparent, and decentralized record-keeping of transactions without the need for a central authority. DLT refers to a broader category of technologies that enable the decentralized and secure sharing of information across a network of participants. One of the main benefits of blockchain and DLT is their potential to increase the efficiency and security of financial transactions. By eliminating the need for intermediaries and enabling direct peer-to-peer transactions, these technologies can reduce transaction times, lower costs, and improve transparency. Additionally, the decentralized nature of blockchain and DLT can enhance security by removing a single point of failure or attack. Blockchain and DLT also have the potential to transform various aspects of the financial industry. For example, they can enable the development of new financial products and services, such as decentralized exchanges, smart contracts, and peer-to-peer lending platforms. These technologies can also facilitate cross-border payments and remittances by reducing the need for intermediaries and simplifying compliance with regulations.

However, there are also challenges associated with blockchain and DLT adoption. One of the main challenges is scalability, as these technologies are currently limited in their capacity to handle a large number of transactions. Additionally, there are still concerns around the regulation and governance of blockchain and DLT networks, particularly in regards to data privacy and security.

Big data and analytics play an increasingly important role in the financial industry, enabling banks and financial institutions to analyze large amounts of data to gain insights, make predictions, and improve decision-making. Big data refers to the vast amount of data generated by various sources, such as customer transactions, social media, and internet searches. Analytics refers to the process of analyzing and interpreting this data to extract meaningful insights. One of the main benefits of big data and analytics is the ability to gain a deeper understanding of customers and their behavior. By analyzing customer data, financial institutions can identify patterns and trends, and gain insights into customer needs and preferences. This information can then be used to develop more targeted marketing campaigns, create personalized financial products and services, and improve customer engagement and retention.

Big data and analytics can also be used to detect and prevent fraudulent activities. By analyzing large amounts of data, banks can identify anomalies and patterns indicative of fraudulent transactions, enabling them to take proactive measures to prevent financial losses and protect their customers.

Moreover, big data and analytics can be used to improve operational efficiency and reduce costs. For example, banks can use data analytics to optimize their supply chain, forecast demand, and automate routine tasks, reducing the need for manual intervention and improving productivity.

However, there are also potential risks associated with the use of big data and analytics in the financial industry, particularly related to privacy and security. Banks must ensure that customer data is collected and analyzed in compliance with relevant regulations and that appropriate security measures are in place to protect that data from unauthorized access or misuse.

Big data and analytics have become essential tools for banks and financial institutions to gain insights, improve decision-making, and enhance customer experience. By leveraging the power of big data and analytics, financial institutions can develop more targeted and personalized financial products and services, prevent fraudulent activities, and optimize their operations. However, it is essential for banks to address potential privacy and security concerns to ensure the safety and trust of their customers.

Conclusion

In conclusion, this systematic review of the evolution of mobile and online banking provides valuable insights into the key technologies and innovations shaping the future of digital finance. Our analysis reveals the growing importance of addressing cybersecurity threats, the digital divide, user experience and adoption barriers, as well as the potential impact of emerging technologies such as 5G, IoT, digital currencies, and robo-advisors on the banking industry.

The findings have important implications for both the banking industry and policymakers. Financial institutions must prioritize the development of secure, accessible, and customer-centric services to remain competitive in the digital landscape. This includes investing in robust cybersecurity measures, enhancing digital literacy, and promoting financial inclusion through innovative banking solutions. Policymakers, on the other hand, should focus on creating a supportive regulatory environment that encourages innovation while safeguarding consumer interests.

Future research directions in the field of mobile and online banking could explore the long-term impact of emerging technologies, such as AI and blockchain, on the financial industry. Moreover, researchers may investigate strategies for addressing the digital divide in developing countries, fostering financial inclusion, and optimizing user experience to ensure the successful adoption of digital banking services. Additionally, further studies could examine the role of public-private partnerships in driving innovation and promoting a secure, inclusive, and sustainable digital finance ecosystem.

By understanding the key drivers of change in mobile and online banking, stakeholders can better prepare for the future and harness the power of digital technologies to transform the financial landscape and promote economic growth worldwide.

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