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Edited by Anita Maček and Michael Murg



The Future of Banking - Innovation, Risk and Inclusion

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Contributors
Abdul Baghi Nabiyev, Abigail Vasquez, Adaleta Gicić, A K M Kamrul Hasan, Albert Acheampong, Alessandro Berti, Anna Baranowska, Anna Omarini, Annisaturrahmah Maulida, António Pedro A. Ferreira, Ari-Pekka Hameri, Asif Yaseen, Bnar Kareem Darwish, Dadan Rahadian, Dominic Roberts, Dženana Đonko, Ekililu Salifu, Fidelis Akanga, Georgios L. Vousinas, Gokhan Ovenc, Huseyin Semih Yildirim, i, Ilias Pnevmonidis, Jono Mintarto Munandar, José de Jesús Rocha Salazar, Kawa Wali, Khawar Naheed, María Jesús Segovia Vargas, Mazen Diwani, Medhat A. Hassanein, Mohammed Bou, Muhammad Hassaan, Pius Bienz, Rabiatul Adwiyah, Rizki Sejat, Sania Usman, Shefali Saluja, Stephan Zilker, Talha Karim, Virginie van Doorn, Widi Adyanto

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Aims and Scope of the Series

This series will provide a comprehensive overview of recent research trends in business and management, economics, and marketing. Topics will include asset liability management, financial consequences of the financial crisis and covid-19, financial accounting, mergers and acquisitions, management accounting, SMEs, financial markets, corporate finance and governance, managerial technology and innovation, resource management and sustainable development, social entrepreneurship, corporate responsibility, ethics and accountability, microeconomics, labour economics, macroeconomics, public economics, financial economics, econometrics, direct marketing, creative marketing, internet marketing, market planning and forecasting, brand management, market segmentation and targeting and other topics under business and management. This book series will focus on various aspects of business and management whose in-depth understanding is critical for business and company management to function effectively during this uncertain time of financial crisis, Covid-19 pandemic, and military activity in Europe.

Meet the Series Editor



Prof. Choudhry holds a BSc degree in Economics from the University of Iowa, as well as a Masters and Ph.D. in Applied Economics from Clemson University, USA. In January 2006, he became a Professor of Finance at the University of Southampton Business School. He was previously a Professor of Finance at the University of Bradford Management School. He has over 80 articles published in international finance and economics journals. His research interests and specialties include financial econometrics, financial economics, international economics and finance, housing markets, financial markets, among others.

Meet the Volume Editors



Dr. Anita Maček is a Senior Lecturer at the Institute of Banking and Insurance Industry, FH JOANNEUM (Graz), and a Professor of Economics at the DOBA Faculty (Maribor). Since 2009, she has served on the Management Board of the Union of Economists of Slovenia. Her consulting and research span innovation management, business process optimization, and strategy implementation across EU-funded projects, with a current focus on financial literacy and inclusion. She has authored books and peer-reviewed articles in economics and international economics and leads international collaborations between academia and industry.



Dr. Michael Murg chairs the Institute of Banking and Insurance Industry at FH JOANNEUM and leads the Bachelor's programmes in Banking and Insurance Industries and Banking and Insurance Management. He holds a Ph.D. in Finance (University of Graz) and has over a decade of professional experience, including as a licensed exchange trader and court-certified expert witness across money, banking, securities, derivatives, and cryptoassets. His research spans digitization in finance, innovation management, data analytics, FinTech/InsureTech, and financial education, with publications in international journals and co-authored books.

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Preface

Banking is entering a decisive period. Platforms are redrawing distribution, data and AI are reshaping decision-making, and societies expect finance to be both resilient and inclusive. *The Future of Banking – Innovation, Risk and Inclusion* assembles research and practice from multiple regions to clarify where value is moving, which risks matter most, and how governance can align innovation with public purpose.

Section I — *System-Level Vision: Innovation, Regulation, Stability and Risk Culture* sets the scene. It traces how technological change, regulatory cycles, and market structure interact, and why risk culture, reinforced by hard lessons from recent failures, remains the anchor for any transformation.

Section II — *AI Transformation in Banking: Use-Cases and Enterprise Adoption* moves from concepts to operating models. Chapters demonstrate how AI enhances front-to-back banking, from customer-experience analytics and personalization to process efficiency and improved credit decisions, while emphasizing model risk management, explainability, and accountability.

Section III — *Platforms and Ecosystems: Open Banking, Payments and Fintech Collaborations* examines data-sharing, APIs, wallets, and bank-fintech partnerships. It explains when collaboration scales (and when it does not), how wallets and real-time payments shift value pools, and what ecosystem conditions help incumbents and challengers compete fairly.

Section IV — *Retail and Financial Inclusion: Mobile, Rural and MSME Credit Models* focuses on "last-mile" access. Evidence on Gen-Z mobile payments, rural delivery models, and targeted credit for MSMEs and women shows how design, affordability, and enablement translate inclusion from aspiration into measurable outcomes.

Section V — *Risk and Capital under Supervision: Credit, Counterparty, Operational and Resilience* covers the engine room. Contributions span creditworthiness assessment aligned with supervisory expectations, machine-learning backtesting for counterparty credit risk, operational-risk capital across markets, and efficiency-based resilience in crisis conditions.

Section VI — *Governance, Ethics and Alternative Banking Models* addresses trust in practice. Chapters discuss ethical conduct, governance in private banking, and faith-based finance, and ask a hard question for wealth management: can new rules be implemented without needless complexity and cost? The answers point to proportionality, process design, and shared data standards.

Section VII — *Sustainability, Climate Risk and Green Finance* links disclosure with action. A critical review of climate-risk frameworks, along with a case study from the

Global South, demonstrates how governance, capacity, and incentives shape whether green ambitions become bankable pipelines and credible risk-management strategies.

Across all parts, a recurring theme is execution: moving from pilots to scale while staying within risk appetite and earning trust. The contributions argue for "trust by design", clear accountability in models and data, proportionate regulation that lowers total system cost, and collaboration that expands choice without fragmenting responsibility.

This book is written for practitioners making decisions now, for supervisors balancing innovation with stability, and for students who will shape the next wave of banking. We hope the evidence, case studies, and practical frameworks gathered here help readers turn debate into design, building financial services that are innovative, well-governed, and genuinely inclusive.

Anita Maček and Michael Murg
FH JOANNEUM,
University of Applied Sciences,
Graz, Austria

Section 1

System-Level Vision: Innovation, Regulation, Stability and Risk Culture

Chapter 1

Perspective Chapter: Banking Reimagined – Navigating Innovations, Regulations, and the Path to Sustainability

Albert Acheampong

Abstract

The banking sector is at a transformative crossroads, driven by technological innovation, evolving regulations, and the imperative for sustainability. This chapter investigates how banks are responding to these challenges through FinTech adoption, regulatory adaptation, and environmental, social, and governance (ESG) integration. It finds that artificial intelligence (AI) and big data analytics are significantly enhancing risk management and customer personalization, while blockchain improves transaction security and efficiency. Regulatory frameworks like Basel III and the General Data Protection Regulation (GDPR) are promoting financial stability but pose operational burdens, especially for smaller institutions. On sustainability, the chapter reveals that ESG-aligned products such as green bonds and sustainability-linked loans are gaining traction, though measurement inconsistencies and greenwashing remain obstacles. Real-world cases, including ING, BNP Paribas, and JPMorgan, illustrate successful strategies. Overall, the chapter provides actionable insights into how banks can align innovation and compliance with long-term environmental and social goals, offering a practical roadmap for navigating the future of banking.

Keywords: banking innovations, regulatory frameworks, sustainability in banking, financial technology, future of banking

1. Introduction

The banking sector is undergoing a profound transformation, standing at the intersection of tradition and innovation. Historically, banks have been cornerstones of economic stability, enabling essential functions such as transactions, savings, and credit facilitation. However, the twenty-first century has introduced unprecedented disruptions that are reshaping the foundation of the banking industry and redefining its societal role.

This chapter argues that banking institutions must embrace a multidimensional transformation—technological, regulatory, and ethical—in order to maintain legitimacy and competitive relevance in an era of rapid change.

Three pivotal forces drive this transformation: technological advancements, regulatory evolution, and the global demand for sustainability. Technologies like blockchain, artificial intelligence (AI), and machine learning are not merely innovations but catalysts for change, pushing the boundaries of efficiency and accessibility in banking. Meanwhile, regulatory frameworks such as Basel III and GDPR exemplify a concerted effort to enhance financial stability, safeguard data integrity, and build consumer trust. Simultaneously, the rise of environmental, social, and governance (ESG) considerations has shifted sustainability from a peripheral concern to a central determinant of competitiveness and resilience in the financial sector. This convergence of innovation, regulation, and sustainability presents both opportunities and complexities. Banks must harness technological potential while navigating regulatory pitfalls, integrate sustainability into operations without compromising profitability, and ensure that their progress benefits not just shareholders but a diverse range of stakeholders, including underserved communities [1, 2].

This chapter explores these critical dynamics, offering insights into the interplay of innovation, regulation, and sustainability in reimagining banking for the future. Drawing on an extensive literature review and descriptive synthesis of real-world banking cases, emerging industry trends, and scholarly perspectives, this chapter provides a roadmap for navigating the challenges and opportunities that lie ahead. The journey is complex, but the banking industry's resilience and adaptability highlight its capacity to meet the demands of a rapidly evolving global economy.

2. Drivers of transformation: Technology and regulation

2.1 The role of financial technology

Financial technology (FinTech) has profoundly reshaped the banking landscape, introducing transformative solutions that enhance customer experiences, streamline operations, and strengthen risk management. The emergence of technologies such as blockchain, artificial intelligence (AI), machine learning, and big data analytics has positioned FinTech as a cornerstone of innovation, enabling banks to adapt and thrive in an increasingly dynamic financial ecosystem. For instance, blockchain technology is revolutionizing transaction systems by ensuring secure, transparent, and immutable record-keeping [3]. Particularly in cross-border payments, blockchain has reduced transaction times from days to seconds while significantly lowering associated costs. A typical example is Ripple's blockchain platform, which has been widely adopted by banks to streamline international payments and improve liquidity management. The secure and decentralized nature of blockchain also reduces the risks of fraud and enhances the efficiency of complex financial transactions [4, 5].

AI's role in banking extends far beyond automating routine tasks. AI has become indispensable for modern banking, driving innovation in customer service, risk assessment, and fraud detection. By analyzing vast datasets, AI-powered tools offer predictive insights into customer behavior, enabling banks to provide personalized services and proactive engagement. Machine learning models, particularly in credit scoring, have significantly improved the accuracy of risk assessment. Studies indicate that AI-based credit scoring systems not only reduce default rates but also enhance access to credit for underserved populations, thereby fostering greater financial inclusion [6, 7].

Big data analytics empowers banks to extract actionable insights from complex and voluminous datasets. Predictive analytics supports personalized marketing

campaigns, improving customer acquisition and retention rates. A notable example is JP Morgan's COiN platform, which leverages AI to analyze thousands of legal documents in seconds, reducing manual effort and improving operational efficiency. This capability illustrates the transformative potential of big data in redefining operational workflows and customer engagement strategies.

The rise of robo-advisors, such as Wealthfront and Betterment, exemplifies the disruptive impact of FinTech on wealth management. These AI-driven platforms democratize investment by providing low-cost, automated financial advice, thus making wealth management services accessible to a broader audience. By combining advanced algorithms with user-friendly interfaces, robo-advisors reduce barriers to entry and empower individuals to take control of their financial planning.

2.2 The broader benefits of FinTech

Beyond improving customer interactions, FinTech delivers operational, social, and economic advantages.

i. Enhanced customer experience: FinTech innovations deliver personalized and seamless services. Mobile banking apps, AI-powered chatbots, and intuitive digital wallets enable 24/7 access to financial services, significantly improving customer satisfaction and retention. For instance, Erica, Bank of America's AI-driven chatbot, efficiently handles customer queries, reducing wait times and enhancing service delivery.

ii. Increased financial inclusion: FinTech has broadened access to financial services, particularly for underserved populations. Mobile money platforms, such as M-Pesa in Kenya, illustrate how digital solutions can extend banking services to rural and unbanked communities, fostering economic empowerment and participation [8].

iii. Operational efficiency: Automation of routine processes, such as document processing and transaction monitoring, enables banks to reduce operational costs and allocate resources toward innovation. Robotic process automation (RPA) streamlines back-office functions, minimizing errors and shortening processing times.

iv. Advanced risk management: AI and big data analytics facilitate predictive modeling, improving the accuracy of risk assessment and fraud detection. For example, PayPal's use of machine learning for fraud detection has resulted in a 50% improvement in identifying suspicious transactions, demonstrating the potential of AI in safeguarding financial systems [9].

v. Scalability and innovation: Cloud-based FinTech solutions provide banks with scalable infrastructure to introduce new products and services rapidly. Platforms such as Amazon Web Services (AWS) and Microsoft Azure offer cost-effective, flexible environments that enable banks to innovate without the constraints of traditional IT systems.

By embracing these technologies, banks are reimagining their operations and redefining their value propositions. FinTech not only equips financial institutions to

meet the demands of the digital age but also lays the foundation for a more inclusive, efficient, and sustainable banking sector.

2.3 Challenges in adopting FinTech

While FinTech offers transformative potential, its adoption is not without significant challenges. Banks navigating this new technological landscape must contend with cybersecurity threats, regulatory uncertainties, high implementation costs, cultural resistance, and data privacy concerns. These hurdles can impede innovation and require proactive measures to overcome. Some of the key challenges are explained below:

2.3.1 Cybersecurity risks

The integration of FinTech solutions has amplified banks' exposure to cybersecurity threats. Data breaches, ransomware attacks, and phishing schemes are becoming increasingly sophisticated, targeting vulnerabilities in digital infrastructures. According to the IBM Cost of a Data Breach Report (2023), the financial sector continues to face some of the highest costs per data breach, averaging $5.85 million per incident. For example, the Equifax data breach in 2017 exposed the personal information of over 147 million people, highlighting the devastating consequences of inadequate cybersecurity measures. To address these risks, banks must invest in robust cybersecurity frameworks, including advanced encryption, real-time monitoring systems, and multifactor authentication. Collaborative initiatives, such as information-sharing platforms like the Financial Services Information Sharing and Analysis Center (FS-ISAC), allow institutions to stay ahead of emerging threats.

2.3.2 Regulatory uncertainty

The rapid evolution of FinTech often outpaces regulatory frameworks, creating a landscape fraught with ambiguity. Blockchain technology, for instance, faces inconsistent regulatory treatment across jurisdictions. In the United States, the regulatory stance varies between states, while globally, countries like China have imposed strict limitations on blockchain and cryptocurrencies, contrasting with more open approaches in nations like Switzerland and Singapore. This lack of clarity discourages investment and adoption, as banks remain cautious of potential compliance issues. Regulatory sandboxes, such as those implemented by the UK's Financial Conduct Authority (FCA), offer a solution by allowing banks and FinTech firms to test innovations in a controlled environment. These initiatives encourage experimentation while providing insights for future regulation.

2.3.3 High implementation costs

While FinTech solutions promise long-term operational efficiency, the upfront costs associated with their adoption can be prohibitive. These include technology acquisition, system integration, and employee training. For smaller financial institutions, limited resources further exacerbate the challenge, creating a competitive disadvantage compared to larger banks. For example, the integration of AI-driven solutions like robo-advisors or fraud detection systems often requires significant investment in infrastructure and expertise. A report by Accenture (2024) revealed

that over 70% of banks struggle to achieve a return on investment from AI implementations within the first 2 years. To mitigate these costs, partnerships with FinTech firms and leveraging cloud-based solutions can provide scalable and cost-effective alternatives.

2.3.4 Cultural resistance

The adoption of FinTech necessitates a cultural shift within banking institutions, often met with resistance from employees and stakeholders accustomed to traditional systems. Fear of job displacement due to automation and skepticism about the reliability of new technologies contribute to this resistance. A notable example is the initial reluctance within banks to adopt chatbots for customer service. Employees doubted the ability of AI-driven tools to match human expertise in handling complex queries. Over time, however, successful implementations, such as Bank of America's Erica chatbot, demonstrated the value of these tools, helping to foster acceptance. Effective change management strategies, including comprehensive training programs and clear communication of the benefits, are critical to overcoming cultural resistance.

2.3.5 Data privacy concerns

The reliance on big data and AI necessitates the collection and processing of vast amounts of customer information, raising significant ethical and legal concerns. Regulations such as the General Data Protection Regulation (GDPR) in the European Union impose stringent requirements on data collection, storage, and usage. Noncompliance can result in substantial fines, as evidenced by the €50 million penalty imposed on Google in 2019 for GDPR violations. Moreover, consumers are increasingly concerned about how their data is used. A survey by PwC (2021) revealed that 85% of consumers believe businesses should do more to protect their data. Banks must prioritize transparent data practices, incorporating measures such as data anonymization and secure consent mechanisms to build trust with customers [10, 11].

Considering the challenges explained, banks can overcome these challenges through strategic planning and partnerships with FinTech firms. Collaborations enable the sharing of expertise and resources, facilitating smoother implementation and regulatory compliance. Additionally, fostering an innovation-driven culture, supported by robust change management frameworks, can ease the transition. By proactively addressing cybersecurity, regulatory, cost, cultural, and privacy concerns, banks can harness the transformative potential of FinTech while safeguarding their operations and customer trust. Successfully navigating these challenges positions financial institutions to lead in a reimagined, technology-driven banking landscape.

2.4 Building digital banking ecosystems

The emergence of digital banking ecosystems represents a transformative shift in how financial institutions deliver services. By integrating diverse technologies and platforms, these ecosystems create seamless, customer-centric experiences while optimizing operational efficiency. This section explores the components, benefits, and challenges of digital banking ecosystems.

2.4.1 Components of digital banking ecosystems

The foundation of a digital banking ecosystem lies in its ability to unify various technologies into a cohesive and accessible framework. Key components include (**Figure 1**).

i. Mobile banking apps are the cornerstone of digital ecosystems, enabling customers to perform essential banking tasks such as fund transfers, bill payments, and account management from their smartphones. Banks like Citibank and HSBC have leveraged AI-powered insights in their apps to offer personalized financial recommendations. For instance, Citibank's app uses AI to analyze spending patterns and suggest budgeting strategies, while HSBC's app incorporates biometric authentication for secure and convenient access. In India, HDFC Bank's mobile app has transformed customer engagement by integrating AI chatbots to provide real-time assistance, driving app adoption among both urban and rural populations [12].

ii. Digital wallets, such as Apple Pay, Google Pay, and PayPal, offer secure and convenient payment options by eliminating the need for physical cards. These wallets utilize tokenization and encryption to safeguard transactions. For example, PayPal's integration with merchants worldwide has enabled small businesses to accept payments seamlessly, driving e-commerce growth. In China, Alipay and WeChat Pay dominate digital payments, revolutionizing the consumer payment landscape with QR code-based transactions that are fast, secure, and widely accessible [10].

iii. Neo-banks, such as Revolut and Monzo, operate entirely online, providing streamlined services without the overhead costs of physical branches. These banks focus on user-friendly interfaces and transparency, appealing particularly to younger, tech-savvy customers [13]. Revolut, for instance, offers multicurrency accounts with no foreign transaction fees, while Monzo provides real-time notifications for every transaction. The success of neo-banks

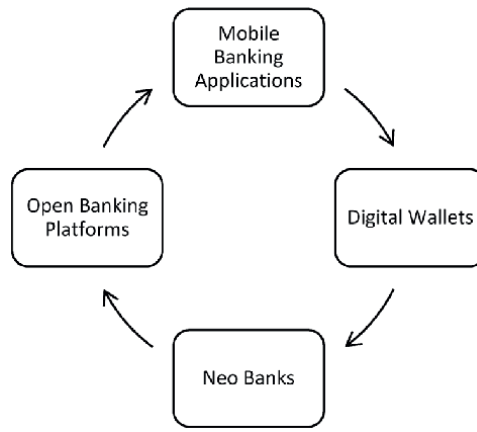


Figure 1.
Components of digital banking ecosystems.

in Europe, like N26, demonstrates their ability to scale rapidly. N26 attracted millions of users within a few years by offering seamless account setup processes and innovative features such as subaccounts for budgeting.

iv. Open banking utilizes APIs (Application Programming Interfaces) to connect traditional banks with third-party providers, fostering innovation through collaboration. For example, the PSD2 directive in the European Union mandates banks to share customer data securely with authorized third parties, enabling the development of tailored financial products. For example, BBVA in Spain pioneered open banking by launching an API platform that allows FinTech firms to integrate its services, resulting in the creation of innovative tools for expense management and financial planning.

2.4.2 Benefits of digital ecosystems

Digital banking ecosystems offer transformative benefits that extend beyond operational efficiencies to enhance customer experiences and support business scalability.

i. Customer empowerment: Digital banking ecosystems provide customers with tools to make informed financial decisions. Features such as budgeting tools, investment trackers, and personalized alerts empower users to improve financial literacy and plan effectively.

ii. Cost efficiency: Digital ecosystems reduce dependency on physical infrastructure, leading to significant cost savings. These efficiencies often benefit customers through reduced fees and competitive interest rates. Most banks were able to cut operational costs on average by 30% by migrating their services to the cloud and redirecting resources toward customer-facing innovations.

iii. Enhanced security: Advanced security measures, including multifactor authentication (MFA) and biometric verification, protect users against fraud. Banking apps employ facial recognition and dynamic passcodes, enhancing trust and adoption rates among their customers.

iv. Scalability: Digital ecosystems allow banks to scale services rapidly. By leveraging cloud computing and modular platforms, banks can introduce new features without disrupting existing operations. For example, Capital one successfully transitioned its operations to the cloud, enabling it to launch new products faster and efficiently handle peak transaction volumes.

2.4.3 Challenges in building digital ecosystems

While the promise of digital ecosystems is compelling, implementing them presents significant challenges. The journey toward establishing comprehensive digital banking ecosystems is fraught with challenges that banks must navigate strategically. These challenges encompass integration complexities, data privacy concerns, the digital divide, and operational risks, each of which has significant implications for the success and resilience of digital transformation initiatives [14].

2.4.3.1 Integration complexities

The integration of legacy systems with modern digital platforms is one of the most significant hurdles in building digital banking ecosystems. Many traditional banks operate on decades-old infrastructure that lacks the flexibility and scalability to accommodate innovative technologies. Upgrading these systems requires substantial financial investment, technical expertise, and time.

The merger of SunTrust Bank and BB&T to form Truist Bank in 2019 illustrates the challenges of system integration. The combined entity faced delays in launching a unified digital platform due to incompatibilities between the two banks' legacy systems. Customers reported issues with access to online banking services during the transition, highlighting the operational and reputational risks of such undertakings.

To address these complexities, banks are increasingly adopting modular and cloud-based platforms that can integrate more seamlessly with existing systems. For instance, HSBC's implementation of cloud-native solutions has enabled it to modernize its infrastructure incrementally, reducing downtime and enhancing system interoperability [12].

2.4.3.2 Data privacy concerns

The reliance on centralized data collection in digital ecosystems significantly increases the risk of data breaches and misuse. With personal and financial data at the core of banking operations, safeguarding this information is critical. Compliance with stringent regulations such as the General Data Protection Regulation (GDPR) in the European Union is not just a legal requirement but also a trust-building measure. In 2020, Experian South Africa experienced a data breach that exposed the personal information of millions of individuals and businesses. The breach highlighted vulnerabilities in data storage and access protocols, resulting in reputational damage and regulatory scrutiny [11].

To mitigate such risks, banks are implementing advanced data protection measures, including end-to-end encryption, tokenization, and real-time monitoring for unauthorized access. Additionally, fostering a culture of accountability and regular audits ensures compliance with data protection regulations. For example, Deutsche Bank has established a comprehensive data governance framework that emphasizes transparency and accountability in data management practices.

2.4.3.3 Digital divide

While digital ecosystems promise convenience and efficiency, they also risk excluding customers without access to the internet or digital literacy skills. This "digital divide" disproportionately affects rural populations, older demographics, and economically disadvantaged groups, creating a barrier to financial inclusion. Kenya's Equity Bank has pioneered hybrid solutions to bridge this gap. By combining mobile banking platforms with agent networks in rural areas, the bank ensures that customers can access financial services even in regions with limited digital infrastructure. Mobile money services like M-Pesa complement these efforts, enabling users to transact via basic mobile phones without requiring smartphones or high-speed internet [8, 15].

Banks can further address the digital divide by investing in digital literacy programs, subsidizing access to devices and connectivity, and designing user-friendly platforms that cater to diverse customer needs. For example, India's State Bank of India

(SBI) launched an initiative to train rural communities in digital banking, thereby empowering underserved populations to participate in the digital economy [15].

2.4.3.4 Operational risks

The dependence on digital platforms introduces heightened operational risks, including outages, system failures, and cyberattacks. Such incidents can disrupt services, erode customer trust, and invite regulatory scrutiny. In 2021, TSB Bank experienced a significant outage in its digital services, leaving customers unable to access their accounts or perform transactions for an extended period. The disruption was linked to technical issues during a system upgrade and resulted in widespread customer dissatisfaction, regulatory fines, and a loss of market confidence.

To mitigate operational risks, banks are investing in robust disaster recovery and business continuity plans. Measures such as redundant systems, real-time performance monitoring, and cyber incident response teams are critical to ensuring resilience. For example, JPMorgan Chase has implemented a multilayered cybersecurity strategy that includes threat intelligence sharing and simulations to prepare for potential disruptions.

2.5 Strategies for successful implementation

To overcome these challenges, banks must adopt a multipronged approach that combines technological innovation with strategic planning. Key strategies include incremental modernization, which involves adopting modular platforms and cloud-based solutions to enable gradual upgrades of legacy systems. Strengthened data governance by implementing advanced data protection measures and fostering a culture of transparency and compliance. Banks can also design hybrid models and digital literacy programs to bridge the digital divide and ensure financial inclusivity. Finally, exhibit operational resilience by investing in robust cybersecurity infrastructure and comprehensive disaster recovery plans to safeguard against disruptions [15].

By addressing integration complexities, prioritizing data privacy, promoting inclusivity, and mitigating operational risks, banks can build resilient digital ecosystems that meet the evolving needs of customers and the financial industry.

3. Trust, reputation, and cultural change

The regulatory landscape in banking is continuously evolving, driven by the dual imperatives of ensuring financial stability and protecting consumer interests. The proliferation of digital banking and FinTech innovations has added new dimensions to compliance requirements, compelling financial institutions to adopt more robust and adaptive regulatory strategies. This chapter explores the complexities of navigating compliance in a rapidly changing environment, with a particular focus on Basel III standards, anti-money laundering (AML) regulations, and data protection laws such as the General Data Protection Regulation (GDPR) [1, 2]. These frameworks not only ensure compliance but also reinforce public trust and institutional legitimacy. For example, Swedbank's 2020 AML failures, which resulted in record penalties, revealed how lapses in compliance can erode consumer confidence and trigger reputational crises. In contrast, Barclays' AI-driven transaction monitoring system demonstrates how banks can proactively detect anomalies and uphold responsible practices, reinforcing customer trust through transparency and ethical use of technology.

3.1 Navigating compliance

Compliance with regulatory frameworks is a cornerstone of modern banking, underpinning financial stability, market integrity, and consumer trust. However, the increasing complexity of these frameworks poses significant challenges for banks, particularly in the context of digital transformation.

For instance, the introduction of Basel III Standards: Strengthening Financial Stability in 2008 in response to the financial crisis represents a comprehensive set of measures aimed at improving the resilience of banks. Key provisions include stricter capital requirements, leverage ratios, and liquidity coverage standards. Banks globally have had to adjust their capital structures to comply with Basel III requirements. For example, Deutsche Bank significantly increased its capital buffer postcrisis to meet the enhanced standards, reinforcing its ability to absorb financial shocks. The emphasis on liquidity has also prompted institutions to adopt advanced liquidity management tools, ensuring they can withstand periods of market stress [1, 2].

AML regulations are designed to combat financial crimes, including money laundering and terrorist financing. Compliance involves rigorous customer due diligence (CDD), transaction monitoring, and reporting suspicious activities. In 2020, Swedbank faced significant penalties for AML lapses, including failure to identify suspicious transactions linked to money laundering. The case highlighted the importance of robust compliance systems and the integration of AI-powered tools to enhance monitoring capabilities. Many banks now employ machine learning algorithms to detect anomalies in transactions, improving their ability to identify and mitigate financial crimes [16].

Data protection regulations such as GDPR have redefined how banks handle customer information, emphasizing transparency, consent, and security. The increasing reliance on big data and AI in digital banking has made compliance with such laws a critical concern. Banks operating in the European Union have invested heavily in compliance programs to align with GDPR requirements. For instance, Barclays implemented comprehensive data governance policies, including customer data anonymization and secure consent mechanisms. Noncompliance can result in severe financial penalties, as evidenced by the €50 million fine imposed on Google for GDPR violations [11].

While these regulations enhance stability and consumer protection, they also impose significant compliance costs. Smaller banks often face disproportionate challenges, struggling to allocate resources for sophisticated compliance systems. Collaboration with RegTech (regulatory technology) firms offers a potential solution, enabling cost-effective automation of compliance processes. RegTech solutions like ClauseMatch and ComplyAdvantage help banks streamline compliance workflows by automating policy management and real-time risk assessments, allowing institutions to focus on core banking activities [17].

Navigating the regulatory landscape requires banks to adopt a proactive and dynamic approach. Key strategies include:

i. Technology-driven compliance: Leveraging AI, machine learning, and blockchain to enhance transparency and reduce manual errors in compliance processes.

ii. Global harmonization: Aligning internal policies with international standards to ensure seamless operations across jurisdictions.

iii. Stakeholder collaboration: Engaging regulators, industry peers, and technology providers to anticipate changes and cocreate innovative solutions.

By embracing these strategies, banks can not only meet compliance requirements but also turn regulatory challenges into opportunities for innovation and growth. This adaptive approach is crucial in a world where the regulatory landscape is both a safeguard and a catalyst for the evolution of the financial sector.

3.2 Balancing regulation and growth

The tension between regulation and growth represents a delicate balancing act for the banking industry. On the one hand, stringent regulatory measures are essential for maintaining financial stability, safeguarding consumer interests, and mitigating systemic risks. On the other hand, excessive regulation can hinder innovation, delay the adoption of emerging technologies, and stifle competitiveness. Conversely, underregulation can lead to financial crises, fraud, and erosion of trust. Achieving equilibrium is therefore imperative for fostering an environment where innovation and compliance coexist harmoniously.

3.2.1 The impact of overregulation and underregulation

Overregulation often creates a burden for financial institutions, especially smaller banks and FinTech startups, which lack the resources to navigate complex compliance requirements. Excessive rules can discourage innovation by limiting the flexibility needed to experiment with new technologies or business models.

While Basel III standards have improved the resilience of banks, critics argue that the stringent capital requirements have inadvertently restricted credit availability to small and medium-sized enterprises (SMEs). Research by the Bank for International Settlements (BIS) indicates that higher capital requirements have led to reduced lending, particularly in emerging markets where banks face resource constraints. To address these challenges, some jurisdictions, such as Singapore, have implemented tiered regulatory frameworks. This approach tailors compliance requirements based on the size and risk profile of institutions, allowing smaller players to innovate while maintaining systemic safeguards [1, 2].

Underregulation, on the other hand, can expose the financial system to significant vulnerabilities, as evidenced by past financial crises. A lack of adequate oversight can lead to risky behaviors, market manipulation, and widespread fraud. The 2008 global financial crisis highlighted the consequences of lax regulation in areas such as subprime lending and derivative markets. Insufficient oversight of complex financial instruments allowed systemic risks to accumulate, culminating in one of the most severe economic downturns in modern history. In response, reforms such as the Dodd-Frank Act in the United States introduced measures to increase transparency and accountability. However, critics argue that the act's complexity has disproportionately affected smaller banks, prompting ongoing debates about achieving regulatory balance.

3.2.2 Striking the right balance

To harmonize innovation with regulation, this chapter recommends that policymakers and financial institutions adopt collaborative, flexible, and forward-thinking strategies, including:

i. Regulatory sandboxes: Regulatory sandboxes provide a controlled environment for FinTech firms to test new products under the supervision of regulators. This approach fosters innovation while mitigating risks. The UK Financial Conduct Authority (FCA) has been a pioneer in implementing regulatory sandboxes. This initiative has enabled startups to trial blockchain-based payment systems and AI-driven financial tools without facing the full burden of compliance, accelerating their path to market readiness.

ii. Principles-based regulation: A shift from prescriptive rules to principles-based frameworks allows institutions to innovate while adhering to overarching regulatory objectives. Canada's approach to open banking adopts a principles-based model, encouraging collaboration between banks and FinTechs to create customer-centric solutions without stifling innovation.

iii. RegTech solutions: Leveraging regulatory technology (RegTech) enables banks to meet compliance requirements efficiently. AI and machine learning can automate processes such as risk assessments, fraud detection, and reporting, reducing compliance costs and operational bottlenecks. Companies like ComplyAdvantage and Thomson Reuters provide AI-powered tools that help institutions monitor regulatory changes, assess risks, and maintain compliance, allowing resources to be redirected toward innovation.

iv. International collaboration: Global regulatory harmonization ensures consistency across jurisdictions, reducing barriers for cross-border operations while maintaining high standards of oversight. The Basel Committee on Banking Supervision facilitates international cooperation on regulatory standards, helping to level the playing field for multinational banks and reducing the risk of regulatory arbitrage.

Striking the right balance between regulation and growth requires continuous dialog among stakeholders, including regulators, financial institutions, and technology innovators. Policymakers must remain agile, revisiting and refining regulations to address emerging risks without stifling progress. Financial institutions, in turn, must view compliance not as a constraint but as an opportunity to build trust, enhance resilience, and drive sustainable innovation. By adopting an adaptive approach to regulation, the banking industry can foster an ecosystem where innovation thrives alongside financial stability, ensuring long-term growth and prosperity.

4. ESG imperatives and strategic integration

The path to sustainability in banking reflects a broader global shift toward integrating environmental, social, and governance (ESG) principles into financial decision-making. Banks are no longer merely intermediaries for financial transactions but key drivers of sustainable development. By embedding ESG considerations into their core strategies, financial institutions are aligning their objectives with stakeholder demands, regulatory expectations, and global sustainability goals. This chapter explores how banks operationalize ESG principles through sustainable finance initiatives, innovative products, and strategic integration while addressing the challenges of this transformative journey.

4.1 ESG integration in banking

Integrating ESG principles into banking strategies is not simply a response to external pressures but a recognition of the industry's pivotal role in addressing some of the world's most pressing challenges. Climate change, social inequality, and corporate governance are no longer peripheral concerns; they are central to shaping the future of finance.

At the heart of ESG integration are sustainable finance initiatives, which channel capital toward projects that create positive environmental and social outcomes. These initiatives reflect a commitment to addressing global challenges while achieving long-term financial stability. One of the most significant tools in sustainable finance is the green bond, which funds environmentally sustainable projects such as renewable energy, energy-efficient buildings, and sustainable agriculture. HSBC, for example, issued $3 billion in green bonds in 2022, supporting a diverse portfolio of projects, including wind farms, solar energy installations, and urban sustainability programs. By allocating resources to such initiatives, banks actively contribute to the global transition to a low-carbon economy [12, 18].

Another avenue for sustainable finance is impact investing, which combines financial returns with measurable social or environmental benefits. Triodos Bank has been a pioneer in this area, exclusively financing projects that align with its sustainability mandate. These include organic farming initiatives, social housing developments, and clean energy projects. Through purpose-driven lending, Triodos has set a standard for banks seeking to embed ESG principles into their operations.

Renewable energy financing is another critical component of sustainable finance. Bank of America's $1 trillion commitment to sustainable finance by 2030 highlights the scale of opportunity for banks to drive decarbonization efforts. A significant portion of this commitment is directed toward funding renewable energy projects, illustrating how financial institutions can lead systemic change.

Evidence suggests that banks are also innovating ESG-aligned products to meet client demand for sustainable solutions. These products include green mortgages, sustainability-linked loans (SLLs), and carbon offset mechanisms, which incentivize environmentally and socially responsible behaviors. Green mortgages, for example, provide preferential interest rates for homebuyers investing in energy-efficient properties. A leading UK bank recently introduced a green mortgage program, offering reduced rates for energy-efficient homes. This initiative not only promotes sustainable housing practices but also aligns financial incentives with environmental goals [19, 20].

Sustainability-linked loans tie borrowing terms to the achievement of specific ESG targets, such as reducing carbon emissions or improving diversity metrics. ING Bank, for instance, provided an SLL to a global logistics company, with interest rates adjusted based on the company's progress in achieving its sustainability objectives. By linking financial performance to ESG outcomes, these products create a powerful incentive for change. Notably, banks like ING and BNP Paribas have taken the lead by issuing ESG-linked loan structures that directly tie interest rates to sustainability performance targets. ING's facility for Philips, for example, reduces interest costs as the borrower improves its ESG rating, making the financial benefit of responsible behavior explicit. Carbon offset products, such as carbon-neutral credit cards, empower customers to align their financial decisions with environmental goals. Mastercard's Carbon Calculator, integrated into banking apps, allows users to track and offset their carbon emissions, making sustainability accessible at the consumer level.

Beyond individual products and initiatives, banks are embedding ESG principles into their overarching strategies. This involves aligning operations with global frameworks such as the United Nations Sustainable Development Goals (SDGs) and the Paris Agreement, ensuring that their activities contribute meaningfully to global sustainability efforts. Integrating ESG factors into risk management frameworks is a critical aspect of strategic alignment. For example, JP Morgan Chase has incorporated climate risk scenarios into its stress testing processes, enabling the bank to identify and mitigate potential risks in a rapidly changing environment [21].

Stakeholder engagement is another pillar of ESG integration. By collaborating with clients, investors, and regulators, banks can cocreate innovative solutions that address sustainability challenges. Barclays, for instance, conducts ESG workshops for corporate clients, helping them develop sustainability strategies and access green finance opportunities. Transparency and accountability are essential to building trust in ESG initiatives. Many banks now publish annual sustainability reports aligned with standards such as the Task Force on Climate-related Financial Disclosures (TCFD) and the Global Reporting Initiative (GRI). Standard Chartered, for example, highlights its progress on ESG initiatives, including carbon-neutral operations and social impact financing, through detailed and publicly accessible reports.

The legitimacy of ESG efforts depends not only on the launch of sustainable products but also on credible governance, measurement, and disclosure. Initiatives such as the EU's Sustainable Finance Disclosure Regulation (SFDR) require banks to substantiate ESG claims, combat greenwashing, and align with long-term climate and social goals. For instance, BNP Paribas has begun reporting ESG risk exposures and sustainability performance targets under SFDR guidelines, reinforcing its accountability and stakeholder trust.

4.2 Challenges in achieving sustainability

Transitioning to sustainable banking is a complex and multifaceted process, requiring financial institutions to navigate a range of challenges. These challenges include aligning shareholder expectations with sustainability goals, developing robust methods for measuring ESG performance, and embedding sustainability into core operations. Each of these hurdles reflects the inherent tension between short-term financial imperatives and the long-term value creation associated with sustainability.

4.2.1 Aligning shareholder expectations

One of the most significant challenges banks face in their sustainability journey is reconciling the often-competing demands of shareholders and broader stakeholders. Shareholders, particularly in publicly listed banks, are traditionally focused on maximizing financial returns. Sustainability initiatives, while offering long-term benefits, frequently involve upfront costs, which may lead to resistance from shareholders prioritizing immediate profitability.

The tension between financial performance and sustainability is evident in the case of BlackRock, the world's largest asset manager. While BlackRock has advocated for ESG integration across its investment portfolio, it has faced criticism from some shareholders who argue that prioritizing ESG may dilute short-term returns. This highlights the need for banks to articulate a clear business case for sustainability, demonstrating how ESG initiatives contribute to financial resilience and competitive advantage over time. To address these concerns, banks are increasingly adopting

integrated reporting frameworks that highlight the financial and nonfinancial impacts of their ESG strategies. By transparently linking sustainability efforts to financial performance, institutions can build shareholder confidence in the long-term value of ESG commitments.

4.2.2 Measuring ESG performance

Developing reliable methods for measuring and reporting ESG performance is a critical challenge in achieving sustainability. The lack of standardized metrics and reporting frameworks complicates efforts to evaluate and compare the impact of ESG initiatives. This inconsistency undermines transparency and can lead to skepticism among stakeholders.

ESG rating agencies, such as MSCI, Sustainalytics, and FTSE Russell, often provide divergent scores for the same institution, reflecting differences in methodology and weighting. These inconsistencies can create confusion among investors and hinder the adoption of sustainability practices. For instance, a study by the MIT Sloan School of Management found a correlation of only 0.61 between the ESG ratings of major agencies, compared to a correlation of 0.99 in credit ratings. To improve measurement, extant evidence indicates banks are adopting standardized ESG metrics such as carbon intensity (CO_2 emissions per unit revenue), board gender diversity, employee turnover, water usage, and exposure to controversial sectors (e.g., fossil fuels or tobacco). These indicators are increasingly incorporated into both internal dashboards and public disclosures, with reporting aligned to the Sustainability Accounting Standards Board (SASB) and the Task Force on Climate-related Financial Disclosures (TCFD). For example, Standard Chartered reports its financed emissions using the Partnership for Carbon Accounting Financials (PCAF) methodology, enabling comparability across peers.

To overcome these inconsistencies, many banks now use materiality mapping to prioritize ESG factors based on relevance to their business model and stakeholder expectations. This process distinguishes between sector-specific material issues, such as water usage in agriculture or data privacy in finance, and general disclosures, ensuring that ESG reporting is both targeted and meaningful.

4.2.3 Integrating sustainability into core operations

Embedding sustainability into the core operations of a bank requires a fundamental shift in culture, processes, and decision-making. Many financial institutions struggle to move beyond surface-level initiatives, such as green product offerings, to fully integrate sustainability into their risk management, lending practices, and investment strategies.

Integrating climate risk into lending decisions is a significant operational challenge. For example, banks financing projects in carbon-intensive industries must balance the need for profitability with the long-term risks associated with climate change. Institutions like HSBC and Standard Chartered have committed to achieving net-zero financed emissions by 2050. However, aligning these commitments with lending portfolios requires robust methodologies for assessing climate risks and transitioning clients to greener business models [12, 21].

BNP Paribas provides an example of a bank taking proactive steps to embed sustainability into operations. The institution has set strict limits on financing fossil fuel projects and significantly increased its investments in renewable energy. This

strategic shift required retraining staff, reallocating resources, and revising credit risk policies—a testament to the operational complexity of achieving sustainability.

4.2.4 Addressing broader challenges

Despite the momentum around ESG, several systemic challenges persist. Greenwashing, where companies exaggerate their sustainability credentials, undermines market confidence and misleads investors. The lack of standardized ESG rating methodologies further complicates benchmarking, with a study by MIT Sloan revealing a low correlation (0.61) among major ESG rating providers. Data gaps, particularly in emerging markets, limit banks' ability to assess ESG risks comprehensively, while inconsistent disclosure practices reduce transparency. Regulatory efforts such as the EU's Sustainable Finance Disclosure Regulation (SFDR) aim to address these concerns through clearer classifications and stricter disclosure mandates.

4.3 Role of technology in sustainability

Technological advancements are playing a transformative role in enabling sustainability in the banking sector. By leveraging innovations such as blockchain, artificial intelligence (AI), big data analytics, and cloud computing, banks are redefining their approach to environmental, social, and governance (ESG) integration. These technologies not only enhance transparency and efficiency but also empower financial institutions to tackle the complexities of sustainability with greater precision and scalability.

4.3.1 Blockchain: Ensuring transparency in green finance

Blockchain technology is a game-changer in promoting transparency and accountability in sustainable finance. Its immutable and decentralized ledger system ensures that funds allocated for green initiatives are used as intended, reducing the risks of mismanagement or fraud. Blockchain platforms like the Energy Web Foundation are enabling traceability in renewable energy transactions. By tokenizing renewable energy credits, EWF provides verifiable proof of green energy production and consumption. Banks can leverage similar blockchain systems to ensure that green bonds and sustainability-linked loans are directed toward eligible projects [18]. In 2020, the Commonwealth Bank of Australia (CBA) used blockchain to issue a green bond for the Queensland Treasury Corporation. The blockchain ensured end-to-end transparency, allowing stakeholders to track how the funds were utilized to finance solar energy projects. This level of transparency builds trust and encourages more investors to participate in sustainable finance.

4.3.2 AI: Optimizing ESG performance measurement

AI-powered analytics are revolutionizing the way banks measure and manage ESG performance. By processing vast datasets, AI provides actionable insights into sustainability metrics, enabling institutions to identify gaps, mitigate risks, and optimize their ESG strategies. AI models are increasingly being used to predict the impact of climate-related risks on investment portfolios. For instance, BlackRock employs AI-driven tools to assess climate risks across its portfolio, enabling more informed investment decisions. These insights help align investment strategies with long-term sustainability goals while safeguarding financial returns [21].

ESG considerations are also being embedded into credit risk scoring models, particularly for commercial lending. For instance, banks are now adjusting credit terms based on borrowers' environmental performance, governance quality, or social risk exposure. BNP Paribas integrates ESG scoring into its loan origination system, where clients with poor ESG ratings may face higher capital charges or stricter lending covenants. Banks like UBS are leveraging AI to enhance ESG scoring systems. By analyzing unstructured data such as news articles, corporate reports, and social media, AI algorithms provide a more comprehensive and dynamic view of a company's ESG performance. This approach reduces reliance on inconsistent ESG ratings from traditional agencies and improves decision-making for sustainable investments. This integration transforms ESG from a reporting obligation into a core component of financial risk assessment and product pricing.

4.3.3 Big data analytics: Empowering data-driven sustainability

The integration of big data analytics enables banks to uncover patterns and trends that drive sustainable outcomes. Predictive and prescriptive analytics tools help institutions design targeted interventions to achieve their ESG objectives.

For example, big data analytics is being used to promote sustainable consumer behaviors. For instance, Barclays employs big data to analyze customer spending patterns and provide personalized recommendations for reducing carbon footprints, such as switching to green energy providers or using public transport. JP Morgan's COiN platform utilizes big data analytics to enhance operational efficiency in sustainability reporting. By processing vast amounts of legal and financial data, the platform reduces the manual workload associated with compliance and ESG reporting, allowing teams to focus on strategic initiatives.

4.3.4 Cloud computing: Scaling sustainability efforts

Cloud computing is another technological enabler of sustainability, allowing banks to scale their sustainability efforts while reducing their environmental impact. Cloud platforms minimize energy consumption by centralizing data storage and optimizing resource use. Banks like HSBC have transitioned to cloud-based systems, significantly reducing their carbon footprint by eliminating on-premises data centers. Cloud solutions also enable rapid deployment of sustainability-related applications, such as carbon tracking tools and real-time ESG dashboards. Amazon Web Services (AWS) partners with financial institutions to provide energy-efficient cloud infrastructure. For instance, DBS Bank adopted AWS's cloud solutions to optimize its digital services while adhering to its sustainability commitments [12].

4.3.5 Internet of things (IoT): Enhancing efficiency and monitoring

IoT technology is increasingly being integrated into sustainable banking initiatives, particularly in areas such as energy efficiency and resource management. IoT-enabled sensors can monitor energy consumption in bank branches, optimize heating and cooling systems, and track water usage. Bank of America has implemented IoT solutions across its branches to reduce energy usage and operational costs. By automating energy management systems, the bank has achieved significant reductions in its carbon footprint, aligning its operations with sustainability targets.

5. Institutional challenges and pathways forward

The future of banking lies at the nexus of innovation, regulation, and sustainability. These three forces are not merely shaping the financial sector; they are redefining its purpose and transforming its operations. The convergence of these elements provides an opportunity to create a resilient, inclusive, and adaptive banking ecosystem capable of addressing the evolving needs of consumers and societies alike. To navigate this future successfully, banks must embrace collaboration, prioritize agility, and leverage technology to achieve meaningful and lasting change. The trajectory of banking is guided by the interplay between innovation, regulation, and sustainability. These forces, while distinct, are deeply interconnected and collectively drive the evolution of the industry.

Innovation remains a central force in shaping the banking sector. Rapid advancements in artificial intelligence, blockchain, and digital platforms are transforming how financial institutions operate and interact with customers. These technologies enable banks to deliver personalized services, improve efficiency, and expand access to financial resources. For example, AI-powered robo-advisors like Betterment and Wealthfront have revolutionized wealth management by making sophisticated financial planning tools accessible to individuals at a fraction of the traditional cost. Regulation, on the other hand, ensures that innovation occurs within a framework that protects consumers and maintains systemic stability. While stringent regulations can occasionally slow the pace of change, they are essential for fostering trust and reducing risks. Initiatives such as regulatory sandboxes provide an innovative approach to balancing regulation and experimentation. For instance, the UK Financial Conduct Authority's sandbox program has allowed FinTech startups to develop and test groundbreaking solutions under controlled conditions, creating a pathway for scalable, compliant products. Sustainability represents a critical pillar of the future of banking as institutions integrate environmental, social, and governance (ESG) principles into their strategies. Banks are not only financing green initiatives but also embedding sustainability into their core operations. Major players such as HSBC and Citi have pledged to achieve net-zero emissions in their financing portfolios by 2050, underscoring their commitment to long-term environmental goals [12].

Collaboration among key stakeholders—governments, financial institutions, technology providers, and civil society—will be fundamental to shaping the future of banking. These partnerships enable the pooling of resources, expertise, and perspectives to address complex global challenges. Public-private partnerships are a powerful mechanism for driving financial innovation and inclusion. For example, the collaboration between the Indian government and private banks to develop the Unified Payments Interface (UPI) has revolutionized digital payments in the country, making banking services accessible to millions who were previously excluded. Technology providers are equally critical partners in the transformation of banking. By working with financial institutions, they bring cutting-edge solutions to market, ranging from AI-driven risk management tools to blockchain-enabled payment systems. A case in point is Microsoft's partnership with JP Morgan Chase to develop cloud-based banking solutions, demonstrating how technology can drive both scalability and innovation. Global cooperation is another vital aspect of collaboration. Addressing systemic challenges such as climate change and financial crime requires unified action across borders. Initiatives such as the Paris Agreement and the Financial Action Task Force (FATF) exemplify the importance of collective efforts in achieving shared goals.

The pace of change in the financial sector demands that banks remain agile, continuously adapting to evolving market conditions, consumer expectations, and regulatory requirements. Agility is not just about responding to change but proactively positioning institutions to thrive in an uncertain future. Consumer-centric innovation will be a hallmark of agile banking. As customer expectations shift toward more personalized and seamless experiences, banks must leverage data and technology to deliver tailored solutions. Neo-banks such as Monzo and Revolut exemplify this approach by offering user-friendly platforms that cater to tech-savvy customers seeking transparency and convenience. Resilience in the face of uncertainty is another critical aspect of agility. The COVID-19 pandemic highlighted the importance of operational flexibility, as banks rapidly transitioned to digital platforms and remote work models to ensure service continuity. Institutions like DBS Bank in Singapore demonstrated the value of robust digital infrastructures in navigating such disruptions effectively [17].

The future of banking will see a fundamental shift from being product-centric to purpose-driven. Financial institutions will increasingly embrace their role as enablers of societal progress, focusing on initiatives that drive economic growth, reduce inequality, and address environmental challenges. Inclusivity will be a defining feature of this vision. Banks must ensure that digital transformation benefits all segments of society, including underserved populations. Investments in digital literacy programs, the development of accessible platforms, and tailored services for marginalized communities will be essential to achieving this goal. At the same time, sustainability will remain at the forefront of banking strategies. By aligning operations with global ESG goals and leveraging technology to measure and enhance impact, banks can lead the transition to a greener, more equitable economy.

As the banking sector stands at a pivotal crossroads, its future will be defined by the ability to harmonize innovation, regulation, and sustainability. Collaboration among stakeholders, agility in adapting to change, and a commitment to leveraging technology will be critical to achieving this balance. By embracing these principles, banks can shape a resilient, inclusive, and purpose-driven financial ecosystem that meets the challenges and opportunities of the twenty-first century.

6. Conclusion

The banking sector stands at a critical juncture, shaped by the powerful convergence of innovation, regulation, and sustainability. This chapter has demonstrated that navigating this transformation demands more than incremental change; it requires a fundamental reimagining of how banks operate, serve stakeholders, and contribute to global progress.

Technological innovations, including artificial intelligence, blockchain, and digital platforms, have redefined customer engagement, risk management, and operational efficiency. At the same time, regulatory frameworks such as Basel III, GDPR, and ESG disclosure mandates have evolved to address emerging risks and uphold public trust. While these reforms promote transparency and stability, they also pose significant challenges, especially for smaller institutions striving to balance innovation with compliance.

Sustainability has emerged as both a strategic priority and a moral obligation. As climate risks intensify and stakeholder expectations evolve, banks are embedding ESG principles into lending, investment, and risk frameworks. Green bonds,

sustainability-linked loans, carbon-neutral products, and AI-powered ESG analytics are no longer niche tools; they are central to how banks define value and impact. However, these efforts must be underpinned by robust governance, transparent reporting, and credible measurement frameworks to avoid pitfalls such as greenwashing and data inconsistency.

The road ahead will be shaped by agility, collaboration, and purpose. Banks must continue to adapt to shifting technologies and regulatory landscapes while anchoring their strategies in long-term sustainability. This transformation also calls for cultural change where ethics, inclusivity, and accountability are deeply embedded in institutional DNA.

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Conflict of interest

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Author details

Albert Acheampong
Nottingham Trent University, Nottingham, UK

*Address all correspondence to: albert.acheampong@ntu.ac.uk

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Chapter 2

Perspective Chapter: The Audacity of Risk – Contemporary Failures

Dominic Roberts, Ekililu Salifu and Fidelis Akanga

Abstract

In Modern society, risk is a complicated concept often taken for granted, and measured, calculated and predicted as a surety in most instances using mathematical and calculative analysis as concrete affirmation of market behavior. While this approach to risk is widely used and accepted as a premise to market assertion, it does not incorporate some of the facets crucial to understanding risk. The focus of contemporary risk management, especially for financial houses, in which some of the biggest culprits are banks, is on measuring and predicting risk rather than understanding this evolving concept. This chapter delves into the social aspects of risk that are usually ignored and presents some of the demits of banking and other financial institutions that plague a heavily calculative approach to risk. Our research on which this chapter is based has found that this measurable and calculative approach to risk has impaired the ability of risk to be explored in other dimensions. For example, the concept of risk, if better understood before being measured, can possibly lead to better decision making both at the micro and macro level of operations that can eventually result in a more stable, robust financial system.

Keywords: risk, rewards, social investment, banking, contemporary failures

1. Introduction

The concept of risk has always been contentious since it entered the world of business in the early 1800s. However, although there has been widespread debate on the best way to manage and operationalize risk, there has been, for the most part, consensus on the methods that should be used. A calculable mathematical approach has been accepted as a valid and superior mechanism to understand and appreciate risk over all other approaches. This measurable, quantitative practice of perceiving risk has led to the development and adoption of a variety of complex matrices used by financial institutions (especially banks) to provide close to accurate assessment of some services like credit and investments.

While this computable status quo to risk acknowledgement is unlikely to experience any revolutionary changes, some prominent risk scholars (like Michael Power and Annette Mikes), have questioned the numerical imaging of risk and provided another path through which risk can be appreciated and understood. Power [1, 2]

argued that our obsession with measuring and calculating risk as a management technique has subjugated us to the risk management of something, anything, nothing and everything. This according to Power is because we are possibly omitting the social aspects of risk in our matrix. Mikes [3] contended that the calculative culture embedded in risk management is well-established in the banking industry but may be awry if the social attributes of risk are continuously ignored.

With this in mind, this chapter presents a critical discourse on the challenges of risk management in banking institutions and a debate on whether or not risk can be metamorphosized into a notion that includes both numeric and social factors. A brief history of risk management is presented in Section 2, followed by a discussion on why social factors are crucial to the concepts of risk and risk management. Section 4 discusses how the acknowledgement of the social facets of risk can help reshape risk management in the banking industry. The chapter concludes with a discourse on the future of risk management in banking institutions.

2. Risk management: A brief history

Risk management can be traced back to the early seventeenth century when John Arbuthnot asserted that the probability of an event occurring can be calculated [4]. This was based on what is now known as the "probability theory", that was developed by Pascal in 1657. This theory contends that possible results of an unknown situation can be translated into a known one through calculation and measurement. Although this may sound abstruse, the theory itself is not abstract; it was adopted from the Asipu Indians in the early 1600's. The Asipu were known for being brilliant and they instituted the probability theory by using special stones to try to determine the existence of God.

Throughout its trajectory, risk took on different forms. Nonetheless, its grounded mode in measurement and calculation remained unchanged. It entered almost all aspects of life along the way; including safety, engineering, psychology and public service. However, it was not until the early 1900's that risk entered the world of business. Today, risk management at financial institutions takes an unmodified culture of quantification and measurement. This has been the cemented path of risk ever since its inception in the early 1600s. Along this route, the perception of risk and its accompanying management strategies has been questioned by several theorists. For example, McGoun [5], claimed that although the calculable approach to risk management has validity and credibility (for instance in assessing and measuring returns and promoting economic prosperity), it is inherently flawed and encourages a personal practice of wealth creation for managers and experts that can eventually end in financial detriment. The financial crisis that began in 2007 can be akin to what McGoun was alluding to. Nevertheless, risk management has remained largely unchanged even in the face of the financial crisis. In 2003, in his book, risk and morality, Adams [6] noted that the moral codes that guide risk decisions have been absent from the risk atmosphere.

This argument is crucial since it sets the stage for a new and emerging sphere to risk management. Although similar arguments have been made in the past, (for example by Berger and Luckmann [7] and Beck et al. [8]), Adams developed a risk thermostat that included the social facets of risk management and proposed punishment for those managers and experts not incorporating the social face of risk. Adding to the quagmire of this debate is Hall in 2009 and Buckley [9] who impugned that the reason why risk did not

undergo any significant change after the financial crisis that began in 2007, is not because of social neglect, but rather the political nature of risk regulation and the continuing debate about the importance of risk in economic wealth creation.

Risk management has emerged with a perception that risk can be accurately measured based on past or historical data as a solid guide for future uncertainty. This approach has worked well in the past for financial experts, especially banking institutions, whose wealth creation depends on a system of assessment and measurement. This may be why banks did not seize the opportunity to reform risk management by venturing into other ways in which risk can be appreciated. Rather, they developed an impetus for conventional risk management by measuring and evaluating almost anything and everything relating to future events and labelling it as risk.

3. Risk and banking: An unmodified culture of measurement and calculation

The eventual meltdown of the financial system that began in 2007 resounded globally. Hundreds of banks had to close their operations in the United States and around the world. This should have signaled the beginning of a new era for banking and risk management; one colored with changes and emerging opportunities, because, although the effects of the financial crisis were catastrophic, it presented a new and impending opportunity for risk management reform. However, this opportunity, at best, was minimally capitalized. Very few changes, amendments and revisions were made to the system that support risk decisions. Rather than examine the philosophy of risk and the opportunities for forging changes and improvements, risk managers and other risk experts (especially at banking institutions) continued along the kindred path that triggered the financial collapse.

Even to date, this solidified structure of measurement and calculation continues to be the bona fide identity of risk management. But why has there been little or no change to the system? Especially in the face of such a global calamity? Not only was the financial crisis of 2007 destructive but it shook the economies of almost all of the G-8 countries. The United States, the most notable international powerhouse, under the leadership of President Barack Obama, had to allocate, invest and expend an unprecedented $787 billion in an effort to stimulate the American economy. This underscores the argument about the magnitude of the effects of the crisis. So why then were experts willing to forgo an opportunity for reform (however gradual) and opt instead to follow a similar path that brought the crisis in the first place?

In our research on the financial crisis and banking institutions, we uncovered three major reasons for the unwillingness to change.

3.1 First reason: Familiarity

Familiarity with the system and ease of use is one of the major reasons for the reluctance to change. The embedded risk policies and procedures are repeated constantly, over and over again, leading to a conformity of routinization. These routine risk actions do not require a conscious plan or process and expend little or no effort because it is well established in the institution. In context, risk managers and other risk experts at banks are reluctant to invest the time, effort and resources needed to divert from the old structure into a new one. The cost of this investment can be significant but may be well justified if it means preventing future debacles.

3.2 Second reason: False belief

Risk management in banking institutions has endured a journey of rigorous tests and trials. This has helped to shape its perception as a well-entrenched and ingrained ideology legitimized in measurement and calculations. As a result, managers and experts alike do not believe that the system is flawed and hence is unwilling to effect changes. When strong beliefs about procedures that are well established are called into question, risk managers shift blame on other variables. For example, with the financial crisis that began in 2007, a lot of the blame by risk experts was allocated to accountants who were chastised for producing and distributing outdated financial statements that did not reflect current market values.

3.3 Third reason: Economic prosperity

Banking and other financial institutions constitute a large percentage of the financial powerhouses of most Western economies. They are the primary generators and creators of monetary, commercial, fiscal and economic wealth. This wealth is a testament to the standard of living and industrial prosperity of any country. It also serves as strong evidence of the capability and influence for a dominant economic position on the world stage. The primary weapon of this massive wealth creation is the backbone of these countries (banking and other financial institutions) and risk management is a crucial part of their arsenal. Therefore, to alter, adjust, change, modify or reshape the principles and procedures that have been responsible for propelling these economic giants would be ludicrous.

Another reason why the system of risk management is unlikely to change is the financial rewards that the current system produces for managers and CEO's with little or no accountability or punishment for significant errors, carelessness or due diligence failures. In other words, the current system encourages enormous financial gains for the risk manager when he or she makes the right calculation but no losses to the manager when the wrong estimation surfaces.

Nevertheless, despite these arguments, risk management in its current state is far from perfect. No one is proposing any radical or subversive changes to risk managements structures, but to continue with a dependence on a regime marred by measurement and calculations may be counterproductive. For those who argue that the system has worked well for several years and is likely to continue to flourish in the future, there is an underlying problem with this viewpoint. If a system is working well, does that mean there is no room for improvement? How well is the risk management system working if it is responsible for the Asian crisis of 1997, and the global financial collapse of 2007? As previously mentioned, any changes to the current cemented risk management system is unlikely to be revolutionary and no one is proposing that it should be. However, recognition that there is room for growth and the possibility to prevent future financial chaos, may be the first steps to incorporating social ideas into the risk management pool.

4. Acknowledging the social facets of risk

When the current risk system fails (like it did with the last financial crisis) the broader society in most instances, is affected directly or indirectly. Retirement funds, education trusts, entertainment savings and monies for everyday living were grossly

diminished and, in some cases, completely lost during the last financial crisis. Not only did this lead to a reduced standard of living, but it also left a lasting negative impact on the people who were affected. The stress that was experienced by those who lost their life's work cannot be measured by any kind of mathematical device that we use to measure the risk that created it. The decline in mental health, the unforgettable deterioration in cognitive abilities and the pains felt by the loss of loved ones were all social. Some people committed suicide after losing their life savings and nothing to rely on to survive. To them, living was now meaningless. In other words, the downturn in human happiness and decline in family bonds that the debacle created was certainly not mathematical and could not be measured in any numeric form.

If the adverse impact created by risk management's reliance on numbers is social, why then are these not considered in the risk management mix? The answer lies in the lack of morals in risk decisions. In 2003, Adams developed a framework in which he proposes that risk should be understood before being managed. If we apply this logic, then understanding the impact a failure would have on society if managers were to completely trust the numeric outcomes would certainly lead to changes in some risk decisions. More care and consideration would be taken and this may help lessen the blow, if the projections turn out to be incorrect. A case in point is the 2007/2008 financial debacle that capsized the world's economic and financial systems that were built on mathematical risk attributes. If we are to examine Canada and the United States as two causalities of the financial fallout, we would find that the impact on the two economies were very divergent. How were two economies that are so closely tied economically and have similar governing systems, experience such different impingement from the financial blow? Here, perhaps is the tale of two countries, that view the fallout from a risk crisis differently and so prepared adversely.

4.1 The Canadian experience

Mark Carney, the current prime minister of Canada (2025) was then the senior associate deputy minister of finance in 2004, before the financial crisis. His previous experience at Goldman Sachs, and extensive background in risk management, sovereign risk, capital markets and investment banking created a rich resolution of foresight, intellect and financial resourcefulness to examine the housing market in the United States and the over-inflated prices, rising market investments and continuous profit creation through almost any means [10]. This prosperous trend, while, welcomed by the U.S market experts as a sign of continued financial growth and a prelude to sustained economic wealth creation, was worrisome to Carney. He argued that such immense profits in an economy cannot be sustained in the long term and would lead to eventual financial collapse of the markets. He took his concern to the then prime minister of Canada, Paul Martin, who was, initially unwilling to heed to the advice [11]. However, the added moral implications that Carney cited was the deciding factor. Carney, outlined along with the cost of the financial failure, the social implications for Canadians both at home and abroad [12]. The loss of retirement savings, education plans, daily livelihood and the possibility of Canada being pushed into a state of poverty before recovery, was too much for the prime minister to bear [11]. To add insult to injury, Carney reminded the prime minster that all this would be his burden to bear for Canadians will never forget that he had the opportunity to soften the fall but refused.

Eventually, Paul agreed, and gave Carney the authority to implement a plan to ensure that if the U.S financial system collapses, the Canadian people would be

adequately protected. That plan included the buttress of the Basel II capital banking requirements, safeguards to secure jobs and encouragements for savings [13]. A year and a half later the financial fall began. While hundreds of banks went bankrupt and many more had to be bailed out by the U.S government, not a single bank in Canada had to rely on government funds to continue operations. Carney was hailed as a Canadian hero and was subsequently hired by the Bank of England for his role in protecting Canada from the brunt of the financial debacle.

On the contrary, in the U.S.A. the welcomed boom in profitability and rising housing costs was not seen as a signal to an economic disaster, but was rather celebrated as a flag of continued economic longevity.

4.2 Risk and morality

In his framework, Adams conceptualizes risk as a network of interrelated workings of the organizational environment, human actions and rewards or sanctions for those actions. According to him, risk is a changing embodiment that should be approached and managed integrally with a moral undertone. It is crucial to note that no one is suggesting that the risk measurement and speculative coats be removed. However, by refusing to acknowledge the tragic outcomes of historical failures, we are missing an important opportunity to include social dynamics into the risk atmosphere.

Risk is a constructed behavior [14], supported by a management system that is idealistic and self-seeking. One approach to solving this self-seeking interest is to replace it with ethically justifiable actions through routine practices and habits that promote the greater good, similar to what happens in corporations that promote corporate social responsibility. However, if these actions are to be grounded in a moral archetype, then banking institutions themselves must contain, or promote the means to encourage and sustain risk decisions as a moral compass.

If 'Morality' is to become a part of risk decisions, there are other factors to consider. For example, who would be responsible for designing and implementing the new moral component of risk? What form would it take? Is it likely to bring any real improvement to the risk management function? Who would benefit most? What would be the opportunity cost of including moral behavior in risk decisions? We are proposing that the risk management system be revisited and revised without the forceful hand of regulators, but we concur that any real change in the risk management process may be a task too mountainous for voluntary occurrence from management and must be coerced by investors and consumers.

The inclusion of morality in risk decisions will not be an easy task. Hunt, argues that the reason why morality is unlikely to be included in risk management decisions is because of the expansion of calculative approaches to risk management [15]. This underscores the "false belief" argument, that managers do not see this approach as being faulty and when it fails, more numeric matrices are introduced as a means of correction. This is like adding water to a quagmire. According to Hunt, this behavior is unlikely to change since it is not only well established, but it suits managers and experts accurately since they benefit from it.

5. Risk and banking: Navigating the future

The debate on risk has been calm in recent years. However, after the financial crisis it was intensified, energetic and profound. This is mostly because of the impact

it has on human life and everyday living. Nevertheless, the affliction, convulsion and distress caused by the market crash has long been forgotten. It would only be relevant again, not if, but when another market failure occurs. It is unfortunate, that the imprints from the debacle have been erased and banks and other financial institutions are back to normal, using the same principles and wherever possible adopting an additive approach, magnifying the old ways and believing that the solution is to incorporate bigger, more accurate predictive measures. Operating outside the realms of measurement is not an option for these financial giants; the rewards that this approach brings is too great to gamble with its future. Hence, the financial crisis of 2007 that shook the core of our financial institutions and pushed it to the brink of complete collapse was not enough for risk managers and experts to explore possible options outside the boundaries of computerized estimations based on pure mathematical assimilations. The question that remains is: What will it take for changes to the risk atmosphere to occur? Changes that do not only rely on estimations and uncertainty but are also grounded in social ideals. Changes that recognize the crucial role of the banking system in our society and explore ways to strengthen and buttress risk decisions based on the social impact if the numbers are not accurate. Changes that do not rely on the voluntary role of corporate social responsibility but rather, tied to operating policies and supported by regulation.

We are certainly not proposing that going forward banks and other financial institutions revolutionize their risk process that has been the landmark of the institution for centuries. Rather we are advocating for and recommending that banks re-examine their current risk models and adjust it to include the social impact that any decision taken would have on the owners of the capital if the numbers do not pan out. This may involve a starting point of taking an ethical approach that does not include maximum profits in the matrix, nor enormous returns.

It may be common knowledge that investors are well aware that risks taken involve a certain possibility that you may lose. Nevethteless, in a drive to line their pockets and bolster super profits, banking institutions have failed miserably in their caring role as guidance barristers that show consideration for their customers and clients who trust them. The irony is that the losses incurred are not usually borne by the institution themselves but by the average investor who knows very little about the functioning of the bank procedures and who may easily choose moderate returns over total losses.

It is easy to suggest changes. Getting the responsible parties to listen is the difficult part. Surely, changes to the risk management system should not only include a social realm, but also behavioral patterns that include less risky practices. This may lead to a decline in wealth creation that would most likely be met by fierce objection by banks and other financial powerhouses. Regulating this unfamiliar path would be problematic but crucial, especially since it has been tried once before.

After the financial crisis, the then president of the United States, (President Obama) focused on recovery efforts. His next steps were to implement changes to curb the chances of a re-occurrence. The Dodd Frank Act was the result. A significant document that proposed sweeping changes to the financial industry, especially banks. While most commended the document, as the banks recovered, they rallied the new president in 2018 (Donald Trump), to remove the security barriers from their domain. The banks complained that the regulatory requirements were stifling and restricting their profit and wealth creation. President Trump, who was already an opponent and an antagonist to regulation, did not need much convincing to shred the document, rolling back protections against careless and ludicrous behavior. Before

long, the Dodd Frank Act became a distant memory and banks worldwide who rely on America's leadership, began to follow suit in scrapping measures that were meant to protect the customer from self-seeking ravenous risk managers.

Banks are a critical part of our society. The roles and functions that banks are tasked with is too mountainous to understate. From providing security for our lifelong savings, to providing an improved standard of living for our communities through loans and wealth creation. However, banks are not perfect institutions, and sometimes their risk management systems can lead to abysmal results, damaging and hurting the very communities that they were intended to serve. Preventing this from happening may be too high a goal to achieve, since the practices embedded in banks and their risks structures are designed to promote and advance prosperity and riches over all else. Unfortunately, the beneficiaries are the very same people tasked with implementing change. This is like asking police officers to police themselves. Be that as it may, all is not lost. The burst and boom cycles that the last financial chaos was blamed on, is a story all too familiar. What this means is that risk management systems would never fully be held responsible for any failures that ensues, regardless of the evidence to suggest that its culpable. Hence, implementing changes that can help improve the risk process (however small) that includes considering the social impact, is a task too towering. It is likely that banks will continue to do well in the future but risk devastating more human lives in the process using the current approach.

6. Concluding thoughts

Much has been said about the management of risk and several researchers have concluded that risk management systems are central to the operations of banking and other financial institutions. These institutions form a global financial network that is responsible for securing and maintaining economic wealth and prosperity. Although it began with an idea of measuring the probability of whether God exists, risk management has maintained its core as a model rooted in measurement, estimation and calculation. This makes risk one of the principal contributors to profits, wealth and prosperity. However, the Asian crisis of 1997 and the global financial meltdown of 2007, called into question these measurement principles and estimation techniques used. Some risk proponents have begun to suggest that risk is a concept to be explored and as a result, the social side of risk should be included in the decision-making process.

The decline in human health, the loss of lives and the mental decay from the financial devastation caused by risk management during the 2007 crisis, could not have been measured by any mathematical equations or computer devices. The effects were all social. Hence, the call for risk to be an inclusive approach that recognizes the social effects of financial decisions, gained momentum but only for a short time. Before long, banks returned to their routine and familiar systems of wealth creation, especially since the losses were not borne particularly by the banks alone.

Risk is an ever-evolving concept but its roots in mathematical measurements make it difficult to welcome or execute social changes. One way to do this is voluntarily through ethics or corporate social responsibility. However, the voluntary nature of both of these constructs presents another challenge since the role of banking institutions in society is too critical to leave changes to choice.

The next best step then is to regulate or mandate changes to the risk profile. However, this too is even more precarious. For regulation would possibly involve

government intervention, which would result in a political battle for supremacy and control.

The quantification of risk itself does not pose a threat to the financial system, but the measures used can be flawed. This is the argument put forward by risk experts during and after the financial collapse. This argument justifies banks heavy reliance on the measurement system and helps solidify their belief and perception of risk as a purely mathematical construct.

Author details

Dominic Roberts[1*], Ekililu Salifu[2] and Fidelis Akanga[3]

1 MacEwan School of Business, Edmonton, AB, Canada

2 University of the West of England, Bristol, United Kingdom

3 Bournemouth University, Dorset, United Kingdom

*Address all correspondence to: robertsd43@macewan.ca

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Section 2

AI Transformation in Banking: Use-Cases and Enterprise Adoption

Chapter 3

The Impact of AI on Banking Services: Trends, Challenges, and Future Aspects

Georgios L. Vousinas and Shefali Saluja

Abstract

In the continuously changing and sophisticated landscape of banking services, artificial intelligence (AI) has become an essential factor propelling significant transformation, reshaping all business aspects of the banking sector. The capability of AI to generate new and innovative content represents a major shift in core principles, steering the banking sector toward a future that is increasingly focused on innovation and digitalization. However, this transformation is accompanied by several challenges, including cybersecurity threats, compliance with a complex regulatory framework, the need for cultivation of skills, talent acquisition, and equity in financial issues. Consequently, this research aims to explore the transformative role of AI, emphasizing its vital influence across a range of banking applications such as cloud computing and Internet of Things (IoT), the use of biometric security solutions, banking gamification, and cryptocurrencies. It also outlines the strategic measures that financial institutions must adopt to fully leverage AI's potential, such as investing in digital transformation, collaboration with Fintechs, customer-centric solutions, and financial literacy promotion.

Keywords: artificial intelligence, banks, digitalization, Fintechs, cybersecurity

1. Introduction

The financial industry is currently at a juncture. At present, a number of critical indicators for banks are at an all-time low. The price-to-book ratio of this sector has decreased to less than one-third of the value in comparison to other industries, as per the McKinsey report published in 2022. This discrepancy is not as much attributable to current profitability as it is to the unpredictability of future profit growth. Despite their recent efforts to make substantial strides, banks are experiencing a decline in their margins. The last 15 years have seen a decrease of over 25%, and it is expected that this number will decrease to 30% in the coming decade, which is an additional 20% decrease. The more significant threat is a global trend: new challenges that frequently originate from different industries and frequently benefit from the kind of cross-industry platforms that have been the driving force behind the recent success of companies like Amazon, Google, Microsoft, PayPal, and Spotify. Regulation and the growing intersectional competition are still concerns; however, the more significant

danger is a global trend. The economic model of these new challenges is significantly more formidable. The market believes that banks are not following a reliable plan for the future and are making incorrect decisions. Substantial reform will be the hallmark of the financial industry in the future. In contrast, financial institutions that are capable of effectively managing this transition will ultimately expand, become more profitable, and develop at a quicker pace, which could lead to the creation of up to 20 trillion dollars in wealth.

The technological transformation that is currently taking place in the banking industry is unparalleled, and it is fundamentally transforming the character of the services that are provided by financial institutions [1]. The rapid improvements in digital technology have brought about a complete transformation in the manner in which banks conduct their business, communicate with customers, and provide goods and services over the course of the last 10 years. Through the automation of procedures, the reduction of operating expenses, and the enhancement of accessibility through mobile and online platforms, the application of digitalization has resulted in an increase in efficiency. Institutions have been able to deliver highly personalized services, anticipate client expectations, and boost user engagement as a result of the transition to data-driven banking, which has resulted in a banking experience that is both intuitive and frictionless. This change is not limited to huge financial institutions; rather, it involves regional banks, Fintechs, and neobanks as well. These financial institutions use technology to gain a competitive advantage in their respective markets. Artificial intelligence (AI) is a game-changing invention that is at the forefront of this digital transformation, creating major disruption throughout the banking environment [2]. AI is at the vanguard of this change. There have been new opportunities generated for customer service, fraud detection, and risk management as a result of the ability of AI to examine large datasets, recognize patterns, and make judgments based on future outcomes. These technologies, which range from chatbots powered by AI that provide instant assistance to algorithms that automate credit evaluations, are enhancing operational efficiency and making it easier to make decisions that are both speedier and more intelligent. The incorporation of AI into financial systems, on the other hand, is not without its challenges [3].

The complexity of integrating AI with existing legacy systems, algorithmic bias, and data privacy demands that financial institutions address these issues. Additionally, the advent of AI necessitates the upskilling of the workforce. This is because financial institutions are looking for staff who are skilled in the deployment of AI, machine learning, and data science [4]. This article dives into the revolutionary role that AI plays, highlighting its impact on a variety of locations and the strategic steps that institutions need to implement in order to fully utilize its potential while tackling the hurdles that are associated with it.

2. Innovations in banking

The major innovations that are taking place and leading to the transformation of the banking industry, reshaping the whole environment, are listed below:

2.1 Artificial intelligence

The business world is one of the most important industries to utilize AI. There has been a progressive process of incorporating AI into the financial sector. The process

started with the automation of simple tasks, such as data entry and providing support to customers. It has progressed to have more complex responsibilities, including the underwriting of loans and the detection of fraudulent activity. When it comes to risk management, AI is also being utilized in the banking industry. This is a sector that is increasing as a result of the surge in online fraud and cybercrime. The use of machine learning algorithms by financial institutions enables the identification of trends in past data, allowing the banks to foresee potential future risks and prevent their impact. A typical example is the US JPMorgan Chase, recognized as the largest bank globally by market capitalization in 2023, which consistently demonstrates a significant advantage over the broader market in the field of AI research, thereby maintaining its status as a frontrunner in AI-related banking innovation.

2.2 Cloud computing

Cloud computing in the banking sector pertains to the utilization of cloud technology for the storage and processing of data. This development is revolutionizing the global banking landscape by providing improved scalability, flexibility, and cost-effectiveness in operational activities. The primary aspects of this trend involve the ability to modify resources in response to varying demand, lowering operational expenses through cloud-based solutions, facilitating seamless access to data across multiple platforms, and enhancing data backup and recovery mechanisms. For instance, major international banks such as Barclays and HSBC have adopted cloud computing, supporting a transition toward cloud-centric solutions for data processing and analysis.

2.3 Biometrics

Biometric security solutions are implemented by financial institutions in order to protect customers and the data they provide. In addition, law enforcement authorities use these technologies to accurately identify those responsible for the crimes. Identification by the use of physical traits, such as fingerprints, ocular retinas, and facial features, is referred to as biometrics. This type of identification is used to verify an individual's identity. The term "biometric security system" refers to an electronic system that is used to identify persons based on their unique biological characteristics, which are often fingerprints or facial features. The first piece of biometric technology was the fingerprint detector, which was created in the 1970s for use in applications related to various government and law enforcement agencies. Recent changes have been made to it so that it is compatible with automated teller machines, access control systems, and other devices.

2.4 Internet of Things

An Internet of Things (IoT) network is a collection of physical objects that are interconnected and possess the capacity to collect and exchange data. It is a technology that enables the remote sensing and control of physical instruments over existing networks. This provides the opportunity for a more direct assimilation of the physical world into computer-based systems, resulting in a greater economic advantage, accuracy, and efficiency, revolutionizing and transforming the entire approach to banking. By facilitating the enhancement of customer service and the reduction of costs, the Internet of Things will aid financial institutions in achieving greater efficiency. For

example, consumers can withdraw funds without visiting a branch office by utilizing automated teller machines that are facilitated by the Internet of Things. This may be a more expedient option for customers who live in rural areas with limited access to financial services or are unable to visit their bank during regular business hours.

2.5 Online banking gamification

Banking gamification refers to the integration of game design principles into banking practices. This consumer trend seeks to captivate customers by transforming banking interactions into more engaging and enjoyable experiences, thereby promoting positive financial habits through rewards and challenges. Key trends in this area include the utilization of game mechanics to improve customer engagement, providing incentives for preferred banking actions, educating customers *via* gamified learning opportunities, and fostering loyalty and engagement through entertaining and interactive features. For example, Wells Fargo, one of the Big Four US banks, integrates gamified elements to help customers track savings goals and progress *via* its free online tool called "My Savings Plan."

2.6 Cryptocurrencies for banks

The finance industry is increasing its understanding of blockchain technology and cryptocurrency. It is crucial to emphasize that Bitcoin, a digital currency that has been in existence for more than a decade, was the initial notable application of this technology. Initially developed as an alternative to traditional cash, this digital currency is now recognized by a significant number of web retailers and a handful of traditional brick-and-mortar businesses. The finance sector has the potential to transform as a result of blockchain technology and cryptocurrency. And, in fact, certain organizations are attempting to leverage this technology for their own purposes, e.g., numerous individuals have started initiatives that involve the utilization of cryptocurrencies or have formed partnerships with entrepreneurs in the financial technology sector.

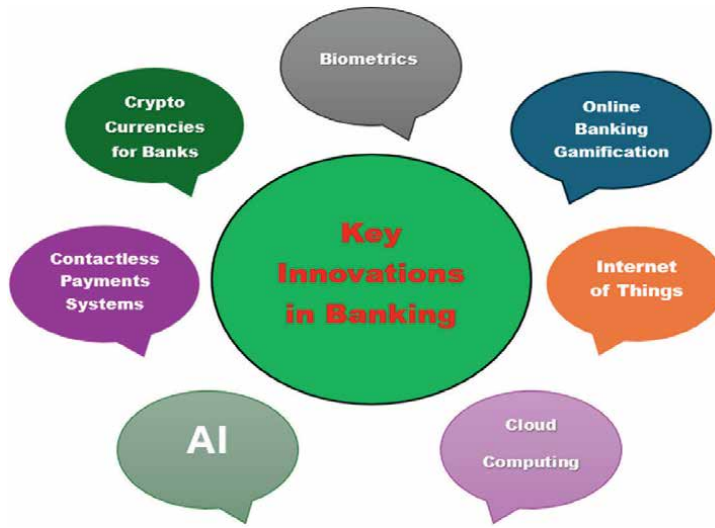


Figure 1.
Key innovations in banking.

2.7 Chip cards and contactless payment systems

A following iteration of credit and debit cards, chip cards are designed to be more secure than the old magnetic stripe cards. Chip cards are the next generation of credit and debit cards. A unique approach to the acquisition of goods and services, contactless payment systems are gaining popularity as consumer preferences continue to evolve. The banking industry is currently undergoing a technological transformation as a result of the implementation of various alternative payment systems. Chip cards and contactless payment systems will make it possible to pay for goods and services in a manner that is both more secure and more efficient (**Figure 1**).

3. AI implementation in banks

After analyzing the key innovations in this section, the main banking areas where AI is implemented are examined. First of all, regarding Customer Service and Customization of the experience, chatbots and virtual assistants, which are propelled by AI, are transforming customer service by providing personalized financial guidance and support around the clock. Banks can enhance the user experience and engagement by personalizing their products and services through the analysis of client data, which is facilitated by AI. As for Fraud Detection and Prevention, and Risk Management, AI algorithms are employed to analyze transaction patterns in order to detect anomalies, thereby preventing fraudulent actions in real time. The accuracy of fraud detection is enhanced while the number of false positives is concurrently reduced through the continuous adaptation of machine learning models. Even more, concerning the critical issue of Credit Scoring and Loan Approval, the process of determining creditworthiness is facilitated by the analysis of vast datasets, which may include data sources that are not traditionally considered, using AI. This enhances financial inclusion by expediting loan approvals and mitigating bias in decision-making. Finally, dealing with Operational Procedure Efficiency, the automation of routine tasks, including data entry and document verification, can be implemented to optimize banking operations. AI-powered technologies enhance productivity, decrease operating costs, and minimize the number of defects caused by humans.

4. Impact of AI in banking

The influence of AI in the financial sector is pervasive in our globalized environment, and its significant effects can be witnessed across various regions worldwide. More specifically, AI's implications in the banking sector of some of the largest countries and regions are:

- *United States*: AI adoption in banking has enhanced fraud detection and customer service through virtual assistants. Leading institutions such as JPMorgan Chase are investing heavily in AI to optimize trading algorithms and risk management.

- *Europe*: European banks are leveraging AI to comply with stringent regulatory requirements, improve customer engagement, and develop more accurate credit scoring models. The UK, in particular, has emerged as a hub for AI-driven fintech solutions.

- *Australia*: Australian banks are leading in the adoption of AI, with a significant 83% of banking executives reporting the implementation of AI within their organizations.[1]

- *China*: China leads in AI-driven banking innovations, with institutions like ICBC utilizing AI to drive financial inclusion and develop sophisticated mobile banking platforms. The rapid adoption of AI in China's banking sector has transformed consumer behavior and boosted digital payment ecosystems.

- *India*: Indian banks are embracing AI to expand digital financial services and improve fraud detection. AI-driven chatbots, such as those deployed by HDFC Bank and SBI, are enhancing customer engagement and streamlining operations.

- *Africa*: AI is being used to drive financial inclusion by providing credit to underserved populations. Mobile banking platforms powered by AI are helping banks reach rural areas and unbanked communities.

5. Challenges ahead

Of course, as with every tech innovation, the usage of AI in banking services is also related to several challenges. These include the following:

- *Potential dangers to cybersecurity*, as financial processes grow more computerized, the likelihood of cyberattacks is expected to increase. Safeguarding sensitive information pertaining to customers and ensuring that the system continues to function properly are of the utmost significance [5]. It is of the utmost importance that financial institutions commit resources to the creation of robust cybersecurity frameworks and continue to strengthen their defenses against the ever-evolving nature of cyberattacks.

- *Complicatedness of the regulations*, there is a common association between improvements in finance and the presence of regulatory impediments. Another factor that contributes to the complexity of operations is the requirement to adhere to a wide range of regulations that are subject to ongoing modifications in different jurisdictions [6]. It is of the utmost importance to preserve a delicate equilibrium between the advancement of innovation and the observance of regulatory requirements.

- *Legacy system integration*, the existence of a large number of organizations that continue to do business using antiquated legacy systems is a barrier to the implementation of modern technology [7]. The process of upgrading these systems or integrating them with contemporary solutions is one that requires a considerable number of resources and is laden with operational risks.

[1] "AI Readiness in Australian Organizations". Available from: https://www.inform-software.com/en/lp/a-report-ai-readiness-in-australian-organisations [Accessed: December 31, 2024]

- *Equity in financial matters,* although the use of digital banking has the potential to expand access to financial services, there are significant barriers to overcome, including differences in digital literacy and access to relevant technology. The prevention of technology innovations from aggravating existing inequities is a necessary step for financial institutions.

- *The cultivation of skills and the acquisition of talent*, in areas such as blockchain technology, AI, and data science, the banking industry is struggling to find qualified individuals to fill open positions. For the purpose of maintaining competitiveness and encouraging innovation, it is of the utmost importance to both engage and keep employees who possess knowledge in developing technologies.

6. Future recommendations

To compete in these changing conditions, banks must develop a complex strategy that incorporates technological advancements, regulatory frameworks, and consumer needs. Below are listed such strategies to assist banks in navigating the future:

6.1 Investing in digital transformation

Digital transformation is critical to future financial success. Prioritizing digital efforts allows banks to optimize operations, save costs, and establish new revenue streams. Fostering an innovative culture demands not just investing in cutting-edge technology like AI, blockchain, and big data, but also cultivating a new viewpoint throughout the firm [8]. To remain competitive, banks must continually research emerging technology and develop creative business strategies. The combination of mobile banking systems, cloud computing, and AI-powered analytics boosts operational efficiency and enables seamless consumer experiences.

6.2 Cybersecurity measures

As banks move to digital platforms, they become more vulnerable to cyber assaults. It is critical to employ advanced cybersecurity procedures to protect sensitive consumer data and maintain confidence. Banks should invest in AI-powered security solutions that can predict future attacks, reduce risks in real time, and detect anomalies. Overall, security frameworks can be strengthened by working with technology providers and regulatory agencies. Furthermore, it is critical to foster a culture of cybersecurity knowledge in the workplace to ensure that staff are prepared to identify and respond to possible threats.

6.3 Collaboration with Fintechs

Forming relationships with fintech businesses allows banks to harness specialized expertise and speed innovation. Fintechs provide agile and creative solutions that supplement traditional banking services. Collaboration with Fintechs enables banks to provide seamless digital experiences, improve payment processes, and rapidly deploy new products [9]. Open banking efforts foster collaboration by allowing for secure data sharing, encouraging innovation in tailored financial services, and increasing market reach.

Innovations	Challenges	Future proposals
Artificial intelligence	Cybersecurity threats	Cybersecurity measures
Biometrics	Complex regulatory environment	Collaboration with Fintechs
Cryptocurrencies	Legacy system integration	Investing in digital transformation
Contactless payment systems	Equity in financial matters	Focus on customer-centric solutions
Internet of Things and cloud computing	Skills cultivation and talent acquisition	Financial literacy promotion

Table 1.
Innovations, challenges, and future proposals on the impact of AI on banking.

6.4 Concentrating on customer-centric solutions

Customer-centricity is a key to the digital banking experience. AI allows for hyper-personalized products and services by evaluating consumer preferences and habits. Banks must prioritize the development of dynamic pricing models, individualized financial planning tools, and user-friendly interfaces that address each customer's specific needs. The use of AI-powered virtual assistants and proactive financial information to engage clients promotes loyalty and customer satisfaction.

6.5 Promoting financial literacy

As digital banking evolves, it is critical to promote financial literacy to ensure inclusivity. Numerous consumers' interactions may be hampered due to their unfamiliarity with AI-powered tools or digital platforms [10]. Banks must create educational efforts and user-friendly tutorials to help clients understand and use digital services. Banks may increase client trust and drive widespread adoption of digital solutions by providing financial education.

To summarize, in the next table, all the key innovations, the associated challenges, and the future proposals are presented to provide an overview of the main insights of this research (**Table 1**):

7. Concluding remarks

The expanding trend of digitalization and the application of cutting-edge technical advancements are becoming the driving forces behind the impending revolution that will take place in the banking industry in the future. The financial services business is currently undergoing a transformation that is being brought about by one of the major technological advancements, which is AI. By adopting predictive analytics, which is made possible by AI, financial institutions can improve their decision-making processes, speed up their client service, and increase their operational efficiency. AI can be used by financial institutions to provide more tailored services to their customers. These services can include customized investment advice, credit scoring, and fraud detection [11]. In the end, this can lead to increased customer happiness and loyalty. Through the continued use of AI technology, financial institutions will be able to provide customers with experiences that are both real-time and seamless,

which are necessary in the fast-paced, digital economy of today. In spite of this, these breakthroughs also bring forth new dangers and difficulties that need to be overcome in order to make progress possible. Despite the development of digital banking, which creates chances for data invasions and cyberattacks, banks continue to place a high priority on cybersecurity [12]. When it comes to using more advanced AI tools, financial institutions are required to ensure that the technology they use is secure and complies with regulatory criteria. On top of that, financial institutions have a responsibility to be aware of the ethical implications of AI decision-making as well as the risks connected with algorithmic biases in light of the growing reliance on automated systems [13]. Implementing solid governance frameworks, engaging in ongoing monitoring, and working together with regulators will be absolutely necessary in order to reduce the impact of these risks and increase the level of trust that customers have in organizations [14]. Furthermore, the pace of change in the banking industry is so quick that it is imperative that institutions maintain their flexibility and adaptability. Traditional financial institutions have no choice but to embrace innovation or run the risk of falling behind in the face of intensifying competition from fintech businesses, digital-only banks, and huge technology companies. It will be vital to make investments in research and development, engage with external technology partners, and embrace a mindset that is forward-thinking in order to maintain competitiveness and relevance in the context of a market that is always shifting. It will be necessary for financial institutions to reevaluate their traditional business models, giving transparency, ease, and accessibility higher priority, and implementing tactics that are more focused on the consumer. To summarize, the path that the financial industry is about to embark on is going to be both hopeful and challenging [15]. By taking preventive measures against emerging threats and embracing technological breakthroughs such as AI, financial institutions have the potential to put themselves at the forefront of the digital revolution. Because of this, it will be necessary to demonstrate a strong dedication to providing value to customers in a world that is getting more interconnected, as well as adaptability and resilience [16]. In the process of adjusting to these problems, banks will not only ensure their place in the future of finance, but they will also have an impact on the larger economic landscape of the world as a whole.

8. Future implications

The study's future implications are wide-ranging, providing vital insights into how the banking industry can adapt to rising technology developments, with a focus on the use of AI. As financial institutions continue to integrate AI and other modern technologies, the study's findings can help banks strategically navigate this shift to remain competitive and responsive to client needs [17]. One important consequence is the potential for AI-driven innovations to significantly increase operational efficiency and customer experience, potentially disrupting traditional banking structures. Banks that successfully integrate these technologies are expected to see improvements in areas such as fraud detection [18], risk management, and tailored financial services. Another key aspect is the need for a balanced approach to technological adoption. Although AI and automation might improve efficiency, they also introduce new challenges, particularly in terms of cybersecurity, privacy, and regulatory compliance [19]. The study emphasizes the importance of proactively addressing these risks, aiming to minimize vulnerabilities that could weaken consumer trust or result in regulatory sanctions. This indicates that, in order to ensure the responsible and transparent

use of AI technology, institutions must establish ethical rules for AI applications, stay up to date on new regulations, and invest in strong cybersecurity measures.

The research also emphasizes the growing influence of nontraditional actors, such as fintech companies and tech behemoths, on the evolution of the financial landscape. Traditional banks must adapt by implementing new digital strategies, exploring collaborations, or even rethinking their core services as upstart startups undermine traditional models [20]. This means that the future of banking may involve greater cross-sector collaboration and innovation, particularly between banks and fintech firms, in order to provide consumers with fully integrated and seamless financial products. In this context, the study's findings highlight the importance of creating an innovation-driven culture within financial institutions to ensure their adaptability and responsiveness to market swings.

Finally, the study's findings suggest that the future of finance will be more customer-focused. Banks must prioritize ease, transparency, and personalization in their offers as consumer expectations shift in the digital age. According to the research, financial institutions would be obliged to invest in technologies that not only increase operational efficiency but also provide consumers with value-added experiences. In an increasingly competitive industry, the ability to meet these expectations will be critical for building long-term partnerships and retaining customer loyalty. Finally, the study's conclusions provide a strategic guide for banks to navigate the complex and rapidly changing financial services business.

Author details

Georgios L. Vousinas[1]* and Shefali Saluja[2]

1 Center for Financial Studies, National & Kapodistrian University of Athens, Athens, Greece

2 Chitkara Business School, Chitkara University, Punjab, India

*Address all correspondence to: vousinas@yahoo.com

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Chapter 4

Perspective Chapter: Artificial Intelligence-Driven Customer Experience Analytics in Banking

José de Jesús Rocha Salazar and María Jesús Segovia Vargas

Abstract

A comprehensive understanding of customer experience within banking institutions is essential for maintaining competitiveness in the sector, as it encompasses critical factors such as customer loyalty, churn and satisfaction with products and services—elements that have a significant impact on revenue generation, market share and cost efficiency. With the advent of the digital age, new artificial intelligence (AI) tools and methodologies have emerged to take the study of customer experience to the next level of depth and accuracy. This chapter aims to provide a perspective on how artificial intelligence can improve customer experience insights over traditional Customer Relationship Management (CRM) analytics and customer surveys in banking. It also presents solutions to mitigate the factors that limit the adoption of these technologies, such as a lack of trained staff and technology culture, poor communication between developers and stakeholders, high costs and strict privacy policies.

Keywords: customer experience, banking sector, artificial intelligence, natural language, GenAI

1. Introduction

The relationship between customers and businesses is a fundamental pillar of economic activity. Through this relationship, companies exchange goods and services to achieve three main market objectives: maximising revenues, minimising costs and gaining market power. To achieve these objectives, companies provide customers with valuable products that they are willing to buy. In doing so, they generate greater customer satisfaction, loyalty and recommendations, which translates into increased demand (higher revenues). They also use technology to automate production processes that involve repetitive tasks to increase efficiency and reduce errors (lower costs). To increase their market share (market power), they offer differentiated products with unique value to attract and retain customers.

Banking institutions, as variable capital businesses, are also striving to achieve the above objectives, with understanding the customer experience serving as a key strategy for achieving these objectives. By better understanding their customers' experience, banks can create a more direct relationship by tailoring solutions to their needs. In addition, this understanding enables banks to implement customer retention

strategies, which have proven to be more cost-effective than new customer acquisition. Articles such as Reichheld and Teal [1] have conducted studies that show that acquisition costs are significantly higher than retention costs. They also argue that increasing customer retention by 5% can increase profits by 25–95%, depending on the industry. According to Bankuoru-Egala et al. [2], retaining existing customers is less expensive than acquiring new ones and generates higher revenues in the long run. Recent articles such as Refs. [3, 4] explain how customer retention is more valuable than customer acquisition. They mention that understanding the satisfaction and happiness of current customers allows for more significant product differentiation in a competitive market environment. This is supported by Refs. [5–7], who confirm that it is typically more costly to acquire a new customer than to retain an existing one. Similarly, Gurung [8] states that retaining existing customers typically costs only 15–23% of the original acquisition cost, whereas reacquiring lost customers can be 5–10 times more expensive.

Before the advent of artificial intelligence (AI) and data science, banking institutions lacked the technological tools to conduct in-depth customer experience studies. In particular, large storage capacities for processing big data or software with specialised libraries for analysing such data were not yet available. Today, cloud computing and AI tools enable the processing and analysis of millions of interactions, including call centre conversations and chats between agents and customers, chatbot conversations and activity in mobile applications. This allows banks to extract insights, sentiments and aggregated feedback to understand customer satisfaction, happiness and loyalty [9, 10]. While these capabilities are valuable, they are not without challenges and limitations. The implementation of AI techniques is hampered by the natural limitations of the sector, such as resistance to change, poor communication between developers and stakeholders, lack of specialised personnel, strict data protection policies and high implementation costs [11].

This chapter explores and provides perspectives on how artificial intelligence, in particular Generative AI, can outperform insights from traditional CRM methods. It also provides recommendations and solutions to mitigate the aforementioned factors that limit the implementation of these emerging technologies.

After this introduction, the current chapter is structured as follows. Traditional methods of Customer Experience Analysis (CEA) are presented in Section 2. Section 3 describes how AI has impacted banking processes. Section 4 shows the positive impact of AI on customer experience analysis. Section 5 explains the difficulties in implementing AI. Finally, the chapter ends with the main conclusions and remarks.

2. Traditional methods of customer experience analysis in banking

Customer Relationship Management (CRM) is a cross-functional approach designed to maintain ongoing communication with customers across all touch points, providing personalised attention to the most valuable customers to improve customer retention and maximise the effectiveness of marketing efforts. CRM aims to strengthen the relationship between companies and their customers by improving the customer experience and analysing loyalty patterns [12]. It represents a shift from traditional product-centric strategies to a more customer-centric approach that prioritises the needs and preferences of individual customers [13]. The key objective of CRM is to understand the customer experience, which is defined as the perception and reaction of customers towards the institution that provides them with a product or service [14, 15].

Using insights from Customer Experience Analysis (CEA), institutions can maximise revenues, minimise costs and gain market power. For example, CEA can include

sentiment analysis that ranks satisfaction levels as 0-negative, 1-neutral or 2-positive, which is one of the simplest configurations. By identifying customers with positive satisfaction, the bank can provide incentives to keep them loyal, so they buy more products and recommend the bank to their contacts. Conversely, customers with negative satisfaction can be incentivised to change their perceptions, thereby preventing churn and negative word-of-mouth. These results contribute to increased revenue and market share. In addition, retaining customers at risk of churn helps to avoid the significant costs associated with acquiring new customers to replace them, thereby helping to minimise costs.

Until recently, customer experience research in banks was limited to conducting two methods. The first one consists of surveys that typically have fixed questions for which customers are given a few multiple-choice options. Questions such as "How do you rate the quality of service provided by the agent" "How do you feel about the product provided" "Would you recommend the product to a friend/family member", etc., were commonly observed in surveys. The disadvantage of this approach to customer experience is that it does not allow customers to express their feelings, opinions or complaints naturally. The second method is an indirect way of assessing customer experience by analysing their account activity. Patterns such as decreases or increases in current account balances from one period to another and cancellations or product subscriptions between periods were observed. Customers with increases in account balances and new product subscriptions were assumed to be loyal and satisfied with the institution. Customers with progressive declines in account balances and product cancellations were considered dissatisfied and at risk of leaving the company for a competitor.

The downside of the above methods is that they do not consider the natural language that customers use when chatting with agents, consulting chatbots and making phone calls. Today, banks are constantly interacting with customers through agent calls, agent chats, chatbots and digital interactions such as those that take place through mobile apps and online banking. This results in millions of conversations, chats and site/page clicks by customers that can be easily stored for analysis using advanced storage solutions such as data warehouses and cloud platforms. This information is also readily available in its original form, exactly as it was generated by the customer. For example, if a customer loses their credit card or identifies an unrecognised transaction, the first step is to contact a service agent by phone. The customer explains the problem, and the agent gives instructions on how to proceed. Throughout the conversation, different emotions, reactions, questions, answers, opinions, feedback and complaints emerge. In other cases, customers may choose to chat first, and if the issue is not resolved, they may be transferred to an agent for a phone call. In this way, calls between customers and agents generate millions of audio conversations in which customers express their problems, complaints or needs. Chat conversations with agents and bots generate millions of texts written by customers expressing their feelings. Analysing this data in natural language enables a more accurate and realistic understanding of the customer experience, providing deeper insights than those typically captured by traditional multiple-choice surveys.

3. AI and GenAI to improve banking processes in the cloud

3.1 AI, GenAI and cloud computing as emerging technologies

Historically, the only option for banks was to use local servers to store data and instal applications for various analyses. Excel spreadsheets and software running on

the local server were essential for all types of calculations and scenario modelling. Now, the digitalisation of the banking sector has created more options for carrying out transactions and contracting products. This has increased the amount of data entering the institution's internal systems, requiring more storage and processing capabilities. The emergence of the fourth Industrial Revolution has brought with it new emerging technologies that have helped banks streamline and automate internal, regulatory and non-regulatory processes.

Cloud computing, artificial intelligence and Generative AI platforms are the emerging technologies that are having the greatest impact on banks' day-to-day operations. Transaction data, customer service, account opening, credit product placement and asset acquisition are constantly feeding internal storage systems to be processed and analysed by these technologies. Cloud computing consists of services delivered over the network, such as email, storage, applications and others, typically accessed through a web browser. When using these services, the information used and stored, as well as most of the applications required, are processed and executed by a server on the Internet [16]. AI is any method, system or algorithm that mimics the cognitive functions normally associated with the human mind [17]. Generative AI refers to a type of AI that can generate new content, such as text, images, music or even video, by learning patterns from existing data [18].

Cloud computing, as provided by new platforms such as Google Cloud Platform (GCP), Amazon Web Services (AWS) and Microsoft Azure, meets these needs and is run by servers on the Internet. Banks are currently working on migration projects from local servers to the cloud, which are usually private due to the sensitivity of the data stored [19]. Once banks have adopted cloud computing platforms, they often add products for AI development.

AI has penetrated almost every area of the financial sector. Supervised and unsupervised machine learning are the leading AI paradigms that have been most widely adopted by different departments within banks [20]. The supervised paradigm teaches a system/machine to learn from data that has already been labelled [21]. For example, if there are observations of customers who have cancelled their credit card and those who have not, those who have cancelled can be labelled 1 and the others 0. Once this is done, a system can be trained to learn the relationship between the act of cancellation and the attributes of the customer and make future predictions. On the other hand, the unsupervised paradigm does not have labelled data, but works with latent variables [22]. For example, money laundering is an act that cannot be explicitly observed at the time of execution and therefore cannot be labelled. Related factors such as duplicate addresses, unusual transactions, virtual offices and dealings with the government can be observed. Unsupervised models, such as clustering techniques, are often used to detect this type of crime.

Generative AI is mainly used in banks for text analysis, such as surveys, customer feedback and customer opinions. The goal is to extract insights, summaries and key themes that help understand the customer experience.

3.2 AI and GenAI implementations in the cloud

Implementing AI and GenAI methods on cloud platforms is a powerful strategy that banks can use to become more competitive. Here are the most common applications of these emerging technologies across key departments.

CRM departments develop supervised machine learning models such as random forest, logistic regression, and neural networks to predict customer churn and launch

retention campaigns. The implicit goal is to estimate the probability of churn in order to identify those customers at risk of abandoning the product, service or company [23]. These models are typically programmed in Python and PySpark and implemented in private clouds on GCP, AWS or Microsoft Azure platforms.

Compliance departments use unsupervised machine learning algorithms to detect financial crimes such as money laundering and shell company activity [24, 25]. Supervised machine learning models are used to detect crimes such as credit card cloning, identity theft and cheque fraud [26–29]. Crime detection takes place at the transaction level, and an individual customer may have one or more suspicious transactions. Millions of transactions are made every day by various means, and the institution has a legal and ethical obligation to detect any criminal activity. Transactions and their associated attributes are stored in data warehouses and highly structured databases, and are later processed on cloud platforms such as Databricks and AWS Glue using SparkR, Python and PySpark languages. At this stage, AI facilitates the task of detecting suspicious transactions by recognising atypical patterns.

The customer service department analyses millions of call and chat conversations between agents and customers to extract insights that help understand the customer experience. These millions of conversations are translated into text and processed on cloud platforms using GPT APIs, Natural Language Processing (NLP) and Generative Artificial Intelligence (GenAI) algorithms [30]. These text processing algorithms already include supervised and unsupervised machine learning models.

The risk management department runs supervised and unsupervised machine learning models such as logistic regression and k-means to assess the risk of default when underwriting consumer, auto and mortgage loans [31, 32]. For many years, external providers developed these algorithms on local servers using software such as C++ and SAS. Today, more and more institutions are implementing these analyses in cloud platforms.

The bank's Revenue Growth Management (RGM) department develops strategies to increase the bank's profits. One of the most common analyses is the study of the impact of investment in promotion and advertising through various digital media on the acquisition of new customers. For example, the impact of investment in product promotion through television, SMS, Internet, mobile applications and radio on customer portfolio growth is studied [33]. To this end, supervised machine learning models are implemented and automated using programming languages such as Python and PySpark on cloud platforms. Recommendation algorithms are also developed using supervised methods to determine the likelihood that a customer with certain characteristics and products will make a new purchase. This is done to improve product placement for existing customers and thus increase revenue [34].

Banks' market research departments continuously monitor their competitors to identify opportunities for differentiation and areas of strategic advantage. Some AI analytics, using models such as GPT or Gemini, are used to analyse customer suggestions, recommendations and feedback gathered through calls, chats or online interactions. These analyses extract valuable information to create new products that meet customer preferences.

In addition to investing in cloud platforms and AI tools, banks have allocated resources to hiring qualified talent to meet the demand for AI skills. Positions in 'business intelligence', 'data science' and 'engineering science' are common in the job market.

4. Positive impact of AI and GenAI on understanding the customer experience

The main objective of implementing AI in customer experience analysis is to extract natural language insights. Banks need to continually assess the factors that contribute to customer satisfaction, identify their needs and determine the improvements needed to enhance their products and services. Extracting this information in natural language from millions of call and chat conversations is a challenge that requires new technologies. Extracting insights in natural language means generating clear, coherent and understandable text, as if a human had written it. For example, customers generate millions of feedback responses *via* phone or chat following a service interaction. This feedback, which can be written or audio, expresses their positive or negative opinions about the service. Examples of feedback include comments such as "the agent did not resolve the issue", "the service was delayed", "the agent was very friendly"', or "the agent handled the issue in the best possible way".

It would be impossible for the banking institution to summarise the huge amount of feedback it receives into five main points using traditional reading. In this case, there can be a superior method to human intelligence, in the form of AI, capable of extracting the summary in a few seconds in an understandable way. The solution is an example of what GenAI can do for banks.

Banks use GenAI to provide 24/7 customer support through chatbots, recommend products based on customer attributes, and measure customer eligibility for credit/loans [35]. GenAI can also be used to analyse customer experience. But why is it important to understand the customer experience? Customers' feelings and experiences of a particular service or product are captured in exit surveys, which are recorded in chats and calls with agents. Some feedback is positive and some is negative. Negative feedback is the most interesting for banking institutions, as it allows them to take action to improve satisfaction and product differentiation.

Two of the GenAI tools currently used by banking institutions are GPT, developed by OpenAI, and Gemini, developed by Google. These newer technologies have been in use since 2022 and are trained using machine learning models on texts available on the web and on public and private documents. The latest versions of these technologies are GPT 4-Turbo and its specialised version, GPT-4o for Microsoft Azure, and Gemini 1.5, which has variants Gemini 1.5 Pro and Gemini 1.5 Flash. In practice, these technologies work through the use of so-called "prompts". A prompt is an instruction written in natural language, usually text, although it can take other forms. In other words, they are the instructions given to GPT and Gemini to perform a specific task.

Below we present a use case where GenAI was implemented to study the customer experience within a banking institution with a presence in the UK, Hong Kong and Mexico, whose name is withheld for privacy reasons.

1. *Use case proposal*. The aim is to capture and understand the customer experience as reflected in the feedback provided at the end of a call or chat with a service agent. When a customer has a problem or question about their product or service, they contact a service agent by phone or chat. During the interaction, the agent attempts to resolve the issue by requesting information from the customer and performing some actions. When the interaction is complete, the customer is asked to provide feedback about their experience with the service. In addition to providing feedback, customers can rate the service they received using the Net Promoter Score (NPS). The NPS is a metric commonly used in customer service

centres to evaluate the customer experience. The NPS for the mentioned institution takes three possible values: 0 for a service perceived as poor, 1 for a neutral service and 2 for a good service.

2. *Data collection*. The feedback from customers with a negative NPS is selected. The objective is to identify the main issues that customers rate negatively and to correct them. After that, the feedback provided by chat remains in text form, and the feedback provided by calls is converted to text. **Table 1** shows an example of feedback in text format.

3. *Data pre-processing*. Feedback texts are tokenised to start processing. Tokenising means breaking the text into units called tokens, which can be words or individual characters. For example, the feedback "The agent was not sufficiently trained" can be tokenised as the following set of words ["The", "agent", "was", "not", "sufficiently", "trained"]. The aim of tokenisation is to generate units that allow the creation of a dictionary of elements that can help to transform text into matrices. The dictionary created is considered a global vector that defines the assignment of zeros and ones. Each word is expressed as a vector of the same length as the global vector. The value "1" is assigned to the position of the word in the dictionary and "0" to the rest of the positions. **Table 2** shows how the text feedback is transformed into a matrix of zeros and ones, assuming that ["The", "agent", "was", "not", "sufficient", "trained"] is the global dictionary.

4. *Dimension reduction through clustering*. Clustering techniques such as k-means are implemented to group the tokenised texts into representative topics [36]. **Figure 1** illustrates the clustering dimension reduction. This helps to reduce the dimension of the initial data and the computational effort. Thus, if there were "m" feedbacks at the beginning, clustering reduces the dimension to "n" topics, where $n < m$.

5. *Plane text creation*. Random samples of text from each of the topics are selected. These samples are concatenated into a single integrated text containing elements of the main topics identified.

6. *Prompt execution*. GPT and Gemini are GenAI tools that generate new text based on a prompt (set of instructions). In this case, the prompt is 'Summarise the text provided into five main points and give them a title'. **Figure 2** depicts one of the outputs generated for this prompt.

7. *Actions*. The summary generated contains, in natural language, the main issues that the institution can address and suggest corrective actions. For example, as shown in **Figure 2**, if one of the issues is credit card disputes and delays, the institution can implement new functionality in the application to report unrecognised charges and request a timely refund. In this way, the customer can be self-sufficient without the need for a chat or call to an agent.

The case study above is being implemented in the banking institution, providing natural language insights that are being translated into actionable strategies. This has led to a 60% reduction in calls and chats with agents over the past year, making customers self-sufficient. A result that is difficult to achieve with traditional methods.

Customer ID	Feedback	Channel
Client 1	The agent was not sufficiently trained	Call
Client 2	The waiting time was long	Chat
Client 3	My problem could not be resolved	Chat
Client n	The agent's service was not friendly	Call

Table 1.
Customer feedback sample.

Text	The	Agent	was	not	sufficiently	trained
The	1	0	0	0	0	0
agent	0	1	0	0	0	0
was	0	0	1	0	0	0
not	0	0	0	1	0	0
sufficiently	0	0	0	0	1	0
trained	0	0	0	0	0	1

Table 2.
Example of tokenisation and vectorisation.

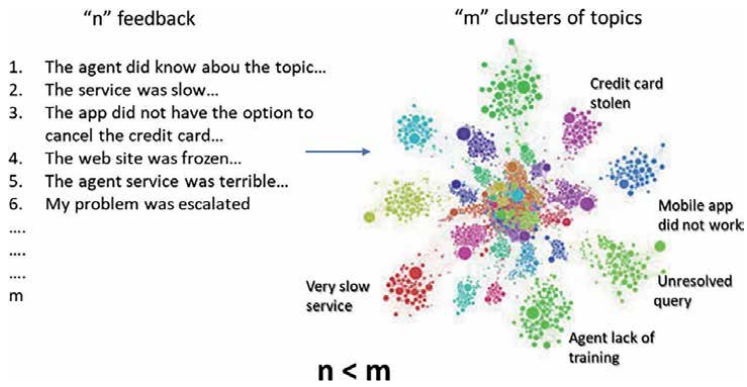


Figure 1.
Text clustering by topics.

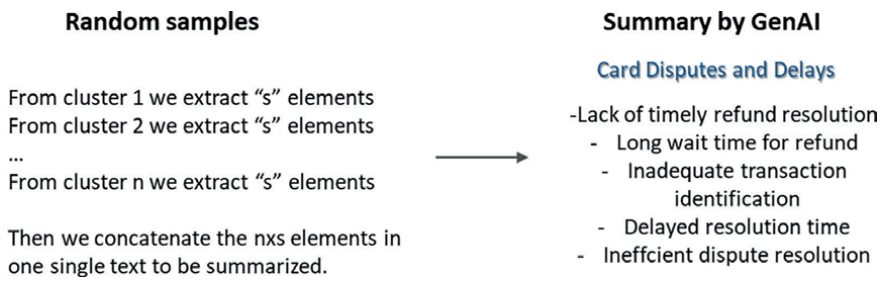


Figure 2.
Summary extraction with GenAI.

5. Difficulties in AI and GenAI implementations

The implementation of AI and cloud computing has a positive impact on the efficiency of banks' internal processes. However, the implementation of these emerging technologies faces several challenges. The main obstacles are the high cost of these technologies, banks' strict privacy policies, technology culture, poor communication and the need for specialised personnel with high salaries.

The implementation of GPT and Gemini tools is done through an Application Programming Interface (API), which is the communication between software. For example, using the Jupyter application, which is the Python interpreter, it is possible to access GPT and Gemini services through APIs. The cost of using these APIs depends on the amount of data processed. According to the pricing section of the OpenAI website, reviewed on 15 December 2024, the GPT-4o version costs $2.5 per million input tokens and $10 per million output tokens. Tokens are strings of text that the model uses for input and output. Tokens can be whole words, parts of words or characters. On the same day, the Flash API for Gemini version 1.5 costs $0.075 per 1 million input tokens and $0.30 per 1 million output tokens for prompts under 128 K tokens. This makes it a relatively affordable option for high-volume applications such as summarisation or categorisation. For banking institutions that process millions of phone and chat conversations every day, these amounts can add up to millions of dollars. This is where the challenge of customer experience analysis comes in, as institutions must decide whether to invest in these technologies. The best strategy is to carry out a cost-benefit analysis, which shows whether there is an economic benefit to be gained from such an investment. If the financial benefit is greater than the investment made, it is concluded that the project is viable. Otherwise, the institution must look for other tools, such as Gemini, if GPT is considered the first option, or less expensive traditional alternatives, such as fixed-question and answer surveys, which sacrifice the accuracy of the analysis. Another way of reducing costs is to work with a representative sample rather than using the full data.

In addition to cost, "hallucination" is another limitation of GenAI solutions. Hallucination occurs when the model produces output that sounds plausible but is factually incorrect, misleading or insensitive. This problem can be addressed in the testing phase by improving the quality of the input text and the clarity of the prompt.

The banking industry is characterised by strict privacy and data protection regulations. This regulation is necessary because sensitive data such as customer names, addresses, account numbers, balances, security codes and access are manipulated daily, and any undue exposure could lead to fraud or hacking. However, if this regulation is too restrictive, technological limitations become more apparent than necessary. Some connections through APIs and Python language libraries are restricted with locks and security devices to prevent infiltration by external hackers. Although the privacy policy is complied with, a customer experience analysis that requires these APIs and libraries cannot be implemented. Banks can relax their privacy policies for specific libraries and APIs to overcome this barrier. The other option is to use these libraries and APIs in private or hybrid accounts on cloud platforms, avoiding the use of local equipment and servers, which pose more risk.

The use of new, emerging technologies such as GPT and Gemini requires the recruitment of trained and specialised staff. This has become another major constraint as salaries in the sector have skyrocketed due to high demand, resulting in high recruitment costs for banks. The positions of data scientist, business intelligence analyst and data engineer are among the most common and sought-after in the market. Faced with

this difficulty, banks can reduce costs by accessing these professionals through outsourcing services. On the other hand, large banks with an international presence can recruit part of their professional staff in lower-cost countries and the rest locally.

Resistance to technological change and a lack of communication and understanding between the departments involved are other reasons why a GenAI implementation does not succeed. The traditional retail bank has often been using the same technology for years, with staff already trained to use it, in their comfort zone. The introduction of new technology will be seen as a threat or a difficulty to the existing staff, and there will be resistance to change. The other reason is the lack of communication and understanding between stakeholders who do not have the technical knowledge, but generate the need, and the technical development department. According to Reggio and Astesiano [37], 80% of Business Intelligence implementations fail because of this lack of communication. The solution is to educate and train non-technical stakeholders on the positive benefits of implementing new technologies. Emerging technologies should be presented as an area of opportunity rather than a threat. This, in turn, helps to reduce the knowledge gap between stakeholders and the technical development team.

6. Conclusions

This chapter provides an overview of the applications of AI for the study of customer experience in the banking sector. The study of customer experience is a key process that banking institutions need to develop, as it provides insights that help understand customer satisfaction. The latter enables the implementation of measures to prevent customer churn and increase customer loyalty. These actions reduce customer acquisition costs, increase market share through referrals from loyal customers and increase revenue by offering new products to existing customers.

AI, and more specifically GenAI, makes it possible to develop an accurate analysis of the customer experience in natural language, overcoming the shortcomings of traditional methods. As a result, the banking institution can accurately identify the shortcomings that lead to a negative customer experience and implement mitigating measures.

Implementing these technologies is a competitive advantage in the era of digital transformation, streamlining digital service methods that do not require contact with an agent. This reduces queues, improves service times and leaves the really important cases to the contact centre.

Banking institutions around the world need to adapt their internal processes and culture to the AI era. They need to invest in cloud infrastructure, skilled staff and adapt internal privacy and security policies to the use of AI tools. In this way, implementations can proceed with minimal constraints and reap the benefits.

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Conflict of interest

The authors declare no conflict of interest.

Author details

José de Jesús Rocha Salazar[1*] and María Jesús Segovia Vargas[2]

1 EGADE Business School, Tecnologico de Monterrey, San Pedro Garza García, Nuevo León, Mexico

2 Faculty of Economics and Business Administration, Complutense University of Madrid, Madrid, Spain

*Address all correspondence to: rocha.jose@tec.mx

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Chapter 5

Revolutionizing Credit Risk Management: Opportunities and Challenges in Credit Scoring with AI and Deep Learning

Adaleta Gicić and Dženana Đonko

Abstract

Credit scoring is an essential part of financial risk management, with various techniques and models developed to enhance the accuracy of predicting creditworthiness. A review of the published relevant works in this field concludes that there is no universally accepted ideal model for automatic credit scoring, despite significant advancements in computer technology in recent years. This chapter explores artificial intelligence (AI) and deep learning in credit risk management, analyzing their limited adoption in credit scoring. It presents a practical deep learning model for tabular credit scoring datasets, addressing class imbalance and offering notable performance. Despite superior predictive performance, deep learning models face explainability and regulatory compliance challenges. This chapter explores the application of AI-driven credit risk models in regulated banking, emphasizing how they can improve assessment accuracy while ensuring transparency and regulatory compliance.

Keywords: credit scoring, deep learning, explainability, regulatory constraints, unbalanced dataset, tabular data

1. Introduction

Risk management, a crucial aspect of banking operations, has undergone significant transformations in recent years, leading to numerous research studies. The accuracy of risk assessment directly impacts the stability of the financial system. Risks in banks and microcredit organizations can be categorized into credit risk, market risk, operational risk, and liquidity risk [1]. There is a growing trend toward developing AI-based systems to improve credit risk management. Additionally, the rise in internet-based services that provide financial resources without physical interaction with clients underscores the necessity of using credit scoring systems for automated decision-making. This type of lending typically involves smaller amounts and shorter repayment periods.

Credit scoring methodologies are crucial for decision-making processes, aiding credit officers and managers in determining the approval of loan applications. These methodologies predict the probability of a borrower displaying undesirable behavior in the future. Credit scoring models for such decision-making are typically based on the applicant's historical data, which generally pertains to individuals.

Existing studies show that due to the small number of instances and the quality of publicly available datasets, prediction results for models based on classical tabular credit scoring datasets are unsatisfactorily low, especially compared to models trained on transactional and larger datasets that are not classical credit scoring datasets. Advanced algorithms, such as neural networks, achieve good performance but are often difficult to express with a clear formula or flowchart.

Many high-performing algorithms function as "black boxes," a characteristic that is unacceptable in the banking sector, where it is imperative to provide clear justifications for the acceptance or rejection of specific clients. Thus, in the context of rising ethical standards and rigorous regulations, the focus on developing explainable artificial intelligence (AI) models has grown significantly. Trends in credit scoring and deep learning emphasize the need to prioritize interpretability as a core feature of these models. This not only builds user trust but also ensures compliance with regulatory demands.

This chapter examines how AI technologies, such as deep learning algorithms, can enhance credit risk assessment while addressing transparency and regulatory compliance, with a focus on their practical deployment in regulated banking environments. It also discusses the associated challenges and potential solutions, particularly through enhanced model explainability.

2. Traditional vs. AI-based credit risk models

A significant threat to banks and financial organizations is the inability to distinguish financially "healthy" applicants from those likely to default. Default refers to the failure to repay debt as agreed, including both interest and principal. Traditional credit scoring models, relying on statistical techniques, often fall short due to unmet statistical assumptions in real-world scenarios. In contrast, machine learning and deep learning algorithms, such as Long Short-Term Memory (LSTM), analyzed and applied in this chapter, operate on pattern recognition in data, proving effective in predictive modeling.

This chapter reviews newer models for more efficient credit risk management, emphasizing the enhancement of credit scoring models based on deep learning.

Despite the longstanding nature of the credit scoring problem and decades of advancements in credit scoring models driven by the development of new, efficient, and sophisticated machine learning and deep learning algorithms: Multilayer Perceptron (MLP), Convolutional Neural Network (CNN), LSTM, GAN, TabTransformer, most models do not yield satisfactory results. Deep learning models are now widely used across various scientific fields. Numerous studies have explored their application in financial disciplines such as foreign exchange prediction, stock market forecasting, trading, credit risk assessment, portfolio management, macroeconomic prediction, and price forecasting [2]. However, their use in credit rating assessment remains limited.

Early implementations of deep learning in credit rating involved deep belief networks for predicting corporate defaults [3]. Other approaches included deep belief networks with restricted Boltzmann machines [4] and ensembles of deep multilayer

perceptron (MLP) networks and deep convolutional neural networks (CNNs) [5]. CNN-based models have shown superior performance compared to deep MLPs (DMLPs) [6].

Credit rating models leveraging CNNs have been analyzed using datasets from Chinese consumer finance companies [7], rather than traditional credit scoring datasets like German Credit [8] or Australian Credit Approval [9]. Significant improvements in classification have been demonstrated using deep neural networks (DNNs) and CNN algorithms on standard public credit scoring datasets [10]. A proposed 29-layer deep genetic hierarchical network of learners showed limitations in complexity and training duration [11]. Dynamical feedforward neural networks (DFNN) with nonlinear activation functions have also been explored [12].

New techniques have been compared for German credit rating models, including stepwise multigrained augmented gradient boosting decision trees [13], dynamic 1-Nearest Neighbor [14], and cost-sensitive neural network ensembles [15]. Solutions addressing high-dimensionality issues in credit risk estimation using deep learning methods have been proposed [16]. Reinforcement learning and deep learning can effectively predict and detect complex market trends, offering advantages in attribute extraction and constructing efficient problem-solving frameworks [17].

Most research on Long Short-Term Memory (LSTM) models has focused on other financial fields rather than credit scoring [18]. Applications of LSTM models in early warning systems for financial market risks in China have been noted [19].

Inspired by natural language processing research, LSTM-based models for credit scoring of peer-to-peer lending have significantly improved predictive accuracy compared to traditional methods [20]. A comprehensive review of recent advancements in deep learning techniques for credit scoring highlights the increasing replacement of traditional machine learning methods by deep learning algorithms due to their higher accuracy [21].

Deep learning-based models have demonstrated superior performance compared to logistic regression or random forest algorithms in consumer credit scoring in the banking sector [7]. Some studies [22] conclude that random forest-based models outperform deep learning-based models, but only a limited number of deep learning algorithms and a nonstandard dataset were included. Gunnarson et al. [23] notably conclude that deep learning (DL) is unsuitable for credit scoring, advocating instead for the use of Extreme Gradient Boosting (XGBoost). XGBoost is popular for probability of default (PD) modeling, achieving significantly higher accuracy than older models, though at the cost of transparency.

However, literature reviews in credit scoring mostly suggest that ensemble algorithms outperform basic classifiers and that deep learning models should eventually replace traditional models in credit scoring implementations. A key challenge for both types of algorithms is model transparency. Increasing research on this topic includes integrating deep learning methods with explainable AI (XAI) techniques to enhance decision-making transparency using the Default of Credit Card Clients (Taiwan) dataset.

3. Benefits of AI in credit risk management

This chapter discusses the advantages of introducing AI-driven models over traditional approaches in banks and fintech. From improving underwriting decisions to facilitating early risk detection and automating complex analysis, real-world examples demonstrate the tangible value of AI models in credit risk management. Additionally, the chapter proposes a concrete implementation of a deep credit scoring model based on the LSTM algorithm to illustrate its practical value and impact.

3.1 Real-world use cases in banks and fintech

Banks and fintech innovators have begun to see practical benefits and revenue increases from deploying AI in credit processes. A few notable use cases illustrate how these models are used in the field:

Financial institutions increasingly employ neural networks to achieve more granular segmentation of customers and borrowers compared to traditional approaches. These advanced models facilitate the identification of distinct behavioral or risk-based subgroups, enabling more tailored strategies. For example, Bank of America, by applying neural network-driven customer segmentation, improved the effectiveness of its marketing campaigns by 60% through more precise targeting [24].

Additionally, HSBC Bank, incorporating NLP-based automation in processing legal loan documents such as customer reviews, business plans, or news about borrowers, reduced processing time from hours to just minutes and also reduced their default rates by 20% and operational costs by 15% within the first year [25].

Harvard research [26] performed a case study that presented a significant change in bank lending by introducing alternative measures in the new credit risk model proposed by a California-based startup, Zest-AI, used by more than 180 banks and credit unions, which increased loan approvals by 25% while retaining the same risk. The model builds on a significantly broader set of variables, several hundred, compared to the 10 to 20 typically used in traditional credit scoring.

Another notable example is the AI lending platform Upstart, which enhances operational efficiency and borrower experience by automating loan approvals, with over 87% of loans approved without human intervention. Empirical results proved that Upstart's approach allows for the approval of over 43% more borrowers compared to conventional FICO-score-only, while cutting defaults by 53% at the same approval rate. Additionally, it ensures transparency and operational control, effectively aligning technological innovation with institutional governance [27].

There is also the successful JPMorgan Chase's implementation of an AI-driven credit risk assessment tool for borrower default prediction that continuously monitors various indicators such as account balances, transaction patterns, declining cash flow, payment delays, and even external news, enabling proactive interventions like credit line adjustments and loan restructuring [28]. JPMorgan Chase built AI-based credit risk tools, reduced default rates by 20%, and cut operational costs by 15% within the first year. This approach enhances traditional credit reviews with real-time, data-informed oversight [25].

3.2 Proposed deep learning model for credit scoring

This chapter outlines specific AI deep learning models utilized in credit scoring, with practical implementation by financial institutions to demonstrate their effectiveness.

A comprehensive review from the year 2024 on deep learning and machine learning techniques for credit scoring [29] highlights a continued lack of research specifically focused on LSTM-based networks in this domain. Due to the nature of the credit scoring problem, LSTM networks are not frequently used in credit scoring models. In practice, however, they can yield exceptional results with additional model adaptation and a new approach to 3D tensor modeling. An example of one such model is proposed in a publication [30] and is illustrated in **Figure 1**.

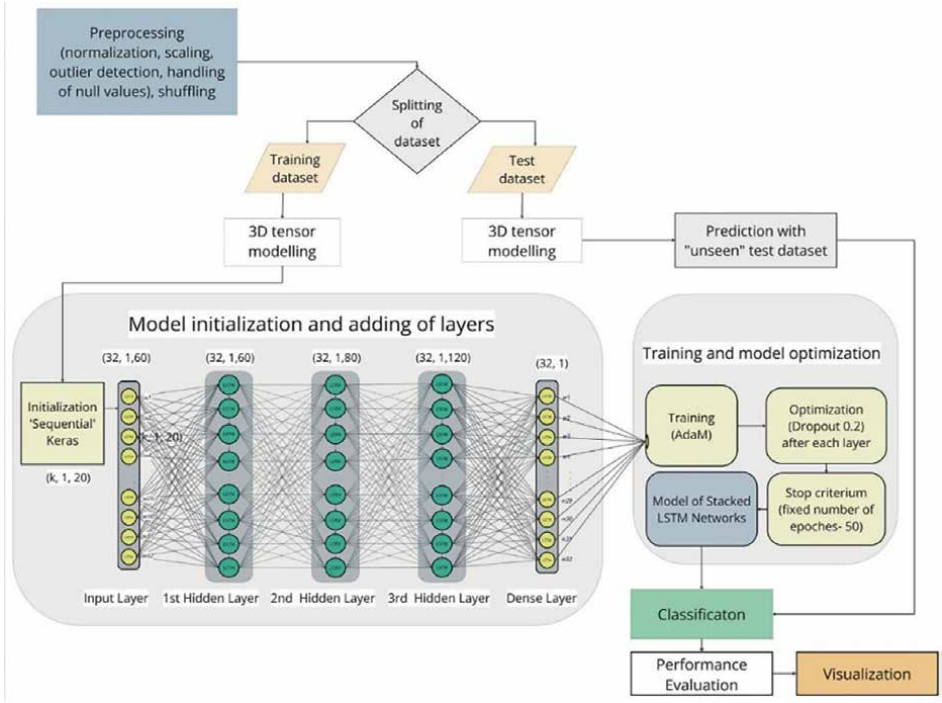


Figure 1.
Deep learning model for credit scoring based on the LSTM algorithm.

The key components of the model, presented in **Figure 1**, are described as follows. Preprocessing, a standardized step essential for any machine learning model, involves identifying and handling missing values, scaling, encoding, outlier detection, and feature construction. Synthetic minority oversampling combined with preprocessing is essential for improving credit scoring performance by addressing class imbalance. However, this step can be bypassed as LSTM networks handle this aspect effectively. Emphasis is put on adapting tabular datasets for credit scoring to deep learning models based on time series, which have proven to be highly effective in identifying patterns in credit scoring. Modeling input data involves adapting 3D matrices to the specific problem, introducing an approach by applying a fixed sliding window without overlapping time series data.

The credit scoring model is based on complex, multilayered LSTM networks, incorporating hyperparameter tuning, training, and validation to capture nonlinear patterns in client data. Unlike typical sequential LSTM applications, this approach excludes temporal dependencies, as credit scoring does not involve inherent time-based correlations between clients. Instead, the model learns from independent client vectors, focusing on relationships among demographic and credit history attributes. This adaptation enables LSTM networks to identify patterns within static, nonsequential data structures.

The model is trained and tested on very limited-sized, publicly available classical credit scoring datasets: the *German Credit Data* [8] and the *Australian Credit Approval* [9] datasets, which contain 1000 and 690 rows, respectively. Although the datasets were small, the resulting model outperformed most existing ones and was more straightforward, eliminating the need for additional techniques or methods [30].

Visualizations support the evaluation of model performance, providing insights into predictive accuracy and practical applicability. Metrics are analyzed iteratively until an acceptable accuracy threshold is reached.

To address class imbalance, a common issue where standard classifiers underperform, this approach leverages LSTM's inherent ability to handle uneven distributions without the need for techniques like Synthetic Minority Oversampling Technique (SMOTE), as demonstrated in the model from **Figure 1**.

LSTM networks achieve superior performance by leveraging gated architectures, input, output, and forget gates that enable effective management of short- and long-term dependencies [31]. Their ability to capture complex, nonlinear feature relationships through hidden layers makes them well-suited for credit scoring, despite the computational demands of deep learning models.

Despite the proposed model's strong performance, explainability remains a critical challenge, particularly for deep learning models like LSTM, given their complexity. The following section addresses this issue and outlines approaches to improving model transparency and interpretability.

4. Risks and limitations

This section begins by examining the risks and limitations of applying deep learning models to credit scoring. While deep learning algorithms such as MLP, CNN, LSTM, GAN, and Tab Transformer possess enormous potential, their application in credit scoring is constrained by significant challenges.

These include small datasets, a scarcity of publicly available traditional tabular data for credit scoring, regulatory constraints, high model complexity, slow model training, and limited explainability of results.

One more limitation to consider is that real-world data sets often differ in practice, making it evident that establishing and defining universal learning models is impossible [32]. Models must be adapted to the domain structure, which presents an additional challenge. However, the core challenge is that deep learning algorithms perform best with large-scale datasets, whereas credit scoring data is often limited in size.

Another important set of concerns centered around bias, fairness, and ethical risk has brought increased attention. These biases often originate from historical data, proxy variables, or unbalanced training samples, which can lead to discriminatory outcomes, particularly against marginalized or underrepresented populations. This chapter explores the origins of bias in AI credit models, evaluates fairness metrics, and discusses risk mitigation and ethical governance.

In addition to the bias, fairness, and ethical risk, the explainability of credit scoring models is a critical obstacle that must be addressed. Inconsistent evaluation metrics also pose a challenge for effectively comparing deep learning models. Explainability and regulatory constraints will be discussed in detail in Chapter 5, while this chapter will discuss risks and potential solutions related to biased data.

4.1 Managing bias and fairness in AI credit models

Beyond their predictive superiority, AI-based systems pose significant ethical challenges, particularly biases from data, algorithms, and human oversight.

Historical lending data often reflects past discrimination, such as rejecting applicants based on postcode or income, which AI systems can learn and repeat. As

a result, models may unfairly penalize applicants from disadvantaged groups, even if they are creditworthy. These biases come from flawed data, algorithmic focus on accuracy over fairness, and human decisions during development.

Real-world cases of gender and geographic bias show why fairness-aware design, regular bias audits, and regulatory oversight are essential. Without these safeguards, AI models can exclude qualified borrowers and harm individuals and financial institutions. Models trained on biased data may also fail when applied to new, more diverse populations, reducing their effectiveness [33].

Continuous monitoring and evaluation in real-world applications are essential to detect emerging biases or unintended effects, enabling timely interventions to uphold fairness and ethical integrity [34].

Key approaches to addressing these concerns are [35]:

- Data auditing and debiasing
- Fairness constraints in modeling
- Post-hoc review and adjustments
- Transparency and customer communication.

Data auditing and debiasing involve identifying distributional imbalances and potential sources of bias, especially when certain groups consistently show higher default rates due to external factors. In such cases, biased variables should be removed, and the dataset rebalanced or enriched with additional data. Fairness metrics—mathematical indicators used to assess whether the model treats subgroups (e.g., by gender, age, or ethnicity) equally—should also be introduced.

Fairness constraints in modeling are predefined rules applied before or during model training to prevent harm to minority or vulnerable groups. Without such constraints, models may prioritize accuracy at the expense of fairness. These constraints can be implemented through preprocessing (e.g., oversampling underrepresented groups) or in-processing techniques, such as incorporating a regularization term in the loss function when intergroup approval disparities exceed a defined threshold.

Post-hoc review and adjustments are done in the post-processing phase by correcting results and calibrating thresholds separately for each group after the model is trained.

Transparency and customer communication are crucial for explaining how decisions are made. Regulators encourage banks to disclose the main factors in AI-driven decisions in plain language, which not only builds trust but also acts as a discipline on the model to remain within understandable and justifiable bounds [35].

5. Regulatory considerations and explainability

Artificial intelligence in credit decisions introduces critical challenges around compliance and transparency. Unlike traditional statistical models, complex black-box AI systems require robust mechanisms to ensure explainability, accountability, and governance. Banks must balance predictive accuracy with interpretability, especially in consumer lending and small and medium-sized enterprises (SME) portfolios, where regulatory requirements and transparency demand models that are

both effective and explainable. Thus, banks are investing heavily in tools and governance practices to ensure AI models remain transparent and accountable.

This chapter examines key regulatory expectations and the role of explainability in risk oversight and outlines a practical, compliance-aligned framework for deploying AI credit scoring systems in real-world financial institutions.

5.1 Ensuring explainability and governance in AI-based credit scoring

Following the financial crisis, new regulations were introduced to monitor banks and financial institutions, enforcing a rigorous model for risk assessment in lending to businesses and individuals. The opacity of AI and machine learning models has raised significant concerns, particularly in sectors where adherence to regulations and maintaining trust are crucial [36]. To address this, modern approaches such as explainable AI (XAI) have been developed, combining predictive power with transparency.

Among the most widely adopted XAI tools in banking are *SHAP* (SHapley Additive exPlanations) and *LIME* (Local Interpretable Model-Agnostic Explanations) [37]. SHAP uses game-theoretic principles to assign each feature a consistent contribution to a prediction, offering insight into factors like income or credit history in loan approvals. LIME provides localized, case-specific explanations by approximating complex models with simpler ones, helping loan officers and customers understand individual decisions. In practice, banks often apply SHAP for global and per-customer analysis, while LIME is used for generating user-friendly, case-level explanations [38].

These tools have become essential in financial AI applications, where understanding a model's decision is often as important as its accuracy. However, the most accurate models, such as deep learning and ensembles, are often the least interpretable. This trade-off has prompted the development of interpretation techniques like SHAP and LIME, which enable transparency without significantly sacrificing performance [39].

5.2 Operationalizing AI credit scoring models: A compliance-driven deployment framework

Due to stringent regulatory requirements and the need for explainability, credit scoring models often employ a hybrid approach that integrates rule-based systems with machine learning.

A practical example of transitioning from a pilot project to a real-world implementation was demonstrated at a local financial institution, where adopting a hybrid credit scoring methodology—combining traditional rule-based systems with machine learning techniques—required a series of critical steps. Key steps ensured model refinement, feasibility, acceptance, and compliance. These included:

1. *Current rule-based system setup*

   - Weight factors and scaled values of certain parameters were initially defined based on best practices implemented in other financial institutions.

   - The loans were monitored over an extended period, and it was validated that the decisions were accurate.

- The accuracy and relevance of these factors were additionally validated by applying machine learning algorithms to similar data from the current institution and were adapted *accordingly*.

2. *Machine learning approach*

- Supervised feature selection techniques were applied to evaluate parameter significance. Common methods include RFE, LASSO, mutual information, Correlation-Based Feature Selection (CFS), PCA, and Relief [40, 41]. Each one offers advantages depending on data characteristics and model complexity.

- This chapter prioritized enhanced regularization techniques, particularly those tailored for LSTM networks [42], which improve interpretability and reduce overfitting by dynamically adjusting feature weights during training.

- Validation of existing weight factors.

- A 10-fold cross-validation was used to ensure robustness.

- Various algorithms were evaluated, with the LSTM algorithm proving to be the best in terms of classification accuracy.

3. *Experimental dataset*

- Data was sourced from a larger database of other financial institutions due to limitations in available parameters at local financial institutions.

- The dataset consisted of over 200,000 rows, with instances classified as "good," "average," and "bad," and exhibited significant class imbalance.

- Class imbalance issues were addressed using the SMOTE technique.

4. *Data processing and selection*

- Data undergoes preprocessing, including discretization, handling missing values, transformation, and mapping.

- Feature importance is assessed using *Enhanced Regularization Functions*, which dynamically adjust input weights during training to rank features by relevance.

- This method improves model accuracy and interpretability, highlighting the most influential predictors in the decision-making process.

5. *Weight factors and scaling*

- Parameters were scaled according to predefined values to ensure consistent user evaluation.

- The top factors influencing the final score were:

- Credit history (including Central Credit Registry (CCR) categories of the user and household members).
- Payment capacity of the credit applicant (PST).
- Available amount (PSD).

6. *Cyclical reevaluation and model validation*

- The model was reevaluated every six months to ensure its reliability and adaptability to changes in the client portfolio.

6. Conclusion and strategic implications

With the trend toward full automation in credit approval processes, the need for reliable credit assessment systems has become more apparent. Banks that have embraced AI innovations report higher lending volumes and lower default rates, validating the promise of AI-driven credit scoring in a competitive financial industry. Simultaneous improvements in accuracy, efficiency, and adaptability contributed to greater cost-effectiveness and increased revenue. However, in the banking sector, there remains a certain resistance to the adoption of automated decision-making systems. This is primarily due to the requirement for detailed explanations from regulatory bodies for each decision, including the reasons for rejecting a particular client and the basis for such decisions. Deep learning models, such as neural networks and LSTM networks, can be applied in credit scoring for identifying complex patterns and nonlinear relationships within financial data. Given the complexity and "black box" nature of deep learning models, it is challenging to provide explicit and straightforward explanations for why a specific client was rejected. This creates a tension between accuracy and interpretability. Explainable AI (XAI) techniques, such as SHAP and LIME, have emerged as valuable tools to address these challenges. These methods provide insights into the model's predictions, enhancing transparency but also ensuring compliance with regulatory requirements.

Additionally, by recognizing that teaching data drawn from biased decisions will inevitably distort AI outputs, organizations can adopt a comprehensive debiasing and governance framework to help ensure their models learn from the signal of genuine risk, not the noise of historical inequity.

A practical example in this chapter shows the implementation of a hybrid credit scoring model at a local financial institution, illustrating the balance between advanced AI techniques and regulatory compliance, combining traditional rule-based systems with machine learning approaches. Industry and regulators such as Bank for International Settlements (BIS) agree that the objective is to harness AI's benefits—better prediction and efficiency—while maintaining trust, transparency, and fairness in credit decisions. The result is a more holistic approach to credit scoring in banks, where an LSTM default prediction model in a local bank's pilot is not an isolated innovation but part of a broader movement toward data-driven, yet accountable and inclusive, credit risk management in the financial sector.

This chapter offers several implications for practitioners in the banking sector. First, AI-based credit scoring systems can approve more loans and predict borrower defaults without raising loss rates, thus benefiting both consumers and lenders.

Second, the issue of explainability remains a critical regulatory challenge, particularly in retail banking, where transparency in decision-making processes is essential for compliance. Third, biased historical data can result in severe consequences, including unfair lending decisions, legal risks for institutions, and broader economic harm. Finally, future development and deployment of AI models in credit risk assessment should focus on hybrid governance frameworks that combine conventional validation methods with AI-specific risk controls, enhancing operational efficiency.

Conflict of interest

The authors declare no conflict of interest.

Acronyms and abbreviations

AI	artificial intelligence
PSD	available amount
MLP	multilayer perceptron
CCR	central credit registry
CNN	convolutional neural network
CFS	correlation-based feature selection
DNN	deep neural network
DMLP	deep MLP
DFNN	dynamical feedforward neural networks
XGBoost	extreme gradient boosting
XAI	explainable AI
GAN	generative adversarial network
LASSO	least absolute shrinkage and selection operator
LIME	local interpretable model-agnostic explanations
LSTM	long short-term memory
PST	payment capacity of the credit applicant
PCA	principal component analysis
RFE	recursive feature elimination
SHAP	shapley additive explanations
SMOTE	synthetic minority oversampling technique

Author details

Adaleta Gicić* and Dženana Đonko
Faculty of Electrical Engineering, University of Sarajevo, Sarajevo,
Bosnia and Herzegovina

*Address all correspondence to: adaleta.gicic@etf.unsa.ba

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Section 3

Platforms and Ecosystems: Open Banking, Payments and Fintech Collaborations

Chapter 6

Perspective Chapter: Open Banking – Collaborative Bridge to Increase the Economy of Scale and Scope of Banking

Dadan Rahadian

Abstract

Banks are essential to the economy and have historically held a monopoly on consumer transaction data. However, this data ownership could be crucial in real-world frictions, as banks may be motivated to hold this valuable resource to avoid competition and foster a data monopoly. Open banking addresses this issue by reducing data ownership in the banking industry. The unbundling of traditional banking in the late 2010s led to the growth of fintech and a shift in competition between fintech companies and traditional financial institutions. The next generation of open banking is open finance, a transparent banking model centered on sharing data, assets, resources, and products. A study in Indonesia found that a co-innovation platform between fintech and digital banks positively impacted company development through radical and incremental innovation. Open banking is revolutionizing financial services by enabling third-party developers to access bank data through APIs. However, it presents challenges such as security, privacy, and regulatory compliance issues. Collaboration among stakeholders is crucial for addressing these risks, while implementation challenges include cybersecurity threats, regulatory compliance, and low adoption due to poor consumer education. Open banking success relies on customers' willingness to share information, and regulators must foster an environment that supports its growth.

Keywords: open banking, open finance, digital bank, bank 5.0, APIs, Open APIs

1. Introduction

The banking sector is undergoing significant change as a result of altered market conditions, the entry of new competitors and digital technologies, and a strong regulatory push. The banking industry is undergoing significant change as a result of shifting business models. The pipeline, a vertical paradigm of banking business models, may give way to open banking models, where banks may benefit from modularity [1]. Open banking is a growing trend in the financial sector, aiming to improve data sharing and efficiency. It empowers customers by granting them the rights to their data, a departure from traditional models [2]. The open banking market

is experiencing rapid growth, which is being driven by the growing demand for personalized financial services and the increasing adoption of digital banking [3]. In 2023, the global open banking market was estimated to be worth USD 25.14 billion. It is anticipated to expand at a Compound Annual Growth Rate (CAGR) of 27.4% from 2024 to 2030 [4]. Approximately 19.7 percent of the worldwide open banking market's revenue in 2023 came from the Asia-Pacific region. The open banking market in the Asia-Pacific region is anticipated to generate a projected revenue of USD 28,894.7 million by 2030. Expected growth in the Asia-Pacific open banking market is 28.7% on a compound annual basis from 2024 to 2030 [5].

From the standpoint of academics and business professionals, open banking seems to have distinct meanings. Open banking is a concept that enables financial institutions to generate productive innovations and provide customers with significantly better services by getting access to previously restricted customer data [2]. Open banking as a concept promotes competition in banking by sharing client data with competitors. In conclusion, despite the fact that there is a lack of consensus regarding the various components of open banking, it can be characterized as a generally regulated framework that allows banking customers to share their data with third parties, typically through standardized interfaces like application programming interfaces (APIs), in order to enhance competition in the financial sector. The proposed definition encompasses the eight elements identified in the proposed open banking integrated framework and can be interpreted as a generalization of all the analyzed fragmentary definitions [6]. Open banking is an emerging concept that has the potential to transform the financial services landscape and deliver superior value to customers [7].

Open banking is a collaborative framework wherein banking data is exchanged *via* APIs among two or more independent entities to provide improved functionalities to the market [8]. Open banking is a financial services framework that enables third-party developers to access financial data within conventional banking systems using APIs [9]. This paradigm fundamentally alters the manner in which financial data is disseminated and accessible [10]. Open banking is a technology-driven architecture for banking systems that enables safe data exchange between financial institutions and authorized third-party suppliers *via* secure APIs [11]. Finally, we can conclude that open banking is a regulated framework that allows secure data sharing between financial institutions and third parties *via* APIs, promoting competition and innovation in the financial services sector to enhance customer experiences. This is the definition used in this chapter, based on the ones mentioned above.

Indonesia is home to an astonishing 17,000 islands. With a population exceeding 273.5 million in 2023, the country is primarily populated by Generations Y and Z, who are known for their preference for mobile and prompt services. This demographic trend is closely linked to a significant shift toward digital engagement. Despite the fact that the country has a 56% internet penetration rate, approximately 92 million individuals are still unbanked, and approximately 46 million people are underbanked. Open banking presents an opportunity to increase financial literacy and promote financial inclusion throughout the nation [12].

The Indonesian Payment System Blueprint 2025 (BSPI 2025) includes open banking as a solution to address the challenges of the digital era in Indonesia. The Indonesian Payment System Vision 2025 is the final form of the Blueprint, and it is implemented through five initiatives: open banking, retail payment system, financial market infrastructure, data and regulation, licensing, and supervision [13]. The implementation of open banking solutions is a critical step toward the modernization

and financial inclusivity of Indonesia. This profound transformation is being orchestrated by the strategic convergence of traditional financial institutions and cutting-edge financial technology (fintech) companies, which is granting Indonesian consumers enhanced access, convenience, and security [12].

Open banking introduces significant challenges to the traditional banking model, particularly the interplay between open banking and financial risk. Consumer education is essential in the context of open banking. Open innovation enables financial institutions to generate better services by getting access to previously restricted customer data. However, non-bank and fintech lenders often face significant barriers in accessing comprehensive customer data, restricting their capacity to support non-standard credit models. More emphasis is required to be assigned to research on the economic impact of open banking [2]. Open banking fosters competition, innovation, and enhanced consumer control over financial data, enabling access to a broader array of financial services and apps while upholding robust security protocols. Open banking seeks to augment transparency, elevate consumer experiences, and stimulate the creation of more tailored financial goods and services [11].

2. Traditional banking system: Pipeline-based approach

Banks traditionally play a critical role in the economy, despite the fact that the relative significance of the various functions of banks varies significantly across countries and eras, they are always essential to the financial system. Firstly, they enhance the information by monitoring the creditors and ensuring that the depositors' funds are used appropriately. Secondly, they offer depositors protection against unforeseen consumption disruptions and intertemporal buffering of risk that cannot be diversified at a specific moment in time. Nevertheless, banks are susceptible to systemic risk and run due to the maturity mismatch between their assets and liabilities. Third, banks contribute to the expansion of the economy. Fourth, they play a significant role in corporate governance [14].

The selection of risk impacts banks' production choices, including asset composition, asset quality, off-balance sheet hedging strategies, capital structure, debt maturity, and resource allocation for risk management, hence influencing banks' costs and profitability [15]. The bank benefits from both general and product-specific economies of scale and scope, allowing for operational expansion at decreasing average costs [16]. Banks may compete with one another without altering their pricing *via* non-price competition [17]. This is one reason the conventional retail banking system is fundamentally centered on service provision. The value proposition encompasses limited branch and personnel services conducted at designated times, with service quality reliant on the qualifications and experience of bank staff [9].

Banks traditionally have maintained a monopoly on consumer transaction data; however, they have failed to capitalize on this wealth of data ownership [18]. In a frictionless environment, the Coase theorem suggests that data ownership is immaterial to achieving efficiency, as parties can negotiate the transfer of rights to those who can most effectively harness the data. However, in the practical context of real-world frictions, the ownership of data could be crucial, as banks may be motivated to hold this valuable resource, avoiding competition and fostering a data monopoly [2].

A complicated and dynamic regulatory structure that controls data ownership and privacy applies to the banking sector. Among the most important regulatory frameworks are the General Data Protection Regulation (GDPR), the Basel Committee on

Banking Supervision 239 (BCBS 239), and the Payment Card Industry Data Security Standard (PCI DSS). GDPR is a global regulation that mandates that banks comply with rules governing data privacy. The Basel Committee on Banking Supervision has a rule called BCBS 239 that regulates risk data reporting and management. PSI DSS is a regulation that oversees payment security.

The approach of open banking addresses the question of data ownership, which is a thriving literature [2]. Efforts are being made by a number of nations and regions to decrease the ownership of data in the banking industry. Strong regulatory frameworks within Revised Payment Services Directive 2 (PSD2), which requires strict customer authentication, data protection, and security standards for both banks and third-party providers (TPPs), oversee open banking in the European Union. The redesigned PSD2 in the European Union (EU) seeks to enhance the accessibility and personalization of financial goods *via* open banking platforms [19]. Although there is not a specific regulatory framework for open banking in the United States, banking-related activities are governed by a variety of current financial regulations and data protection laws, including those enforced by federal agencies such as the Federal Reserve, the Office of the Comptroller of the Currency (OCC), and the Consumer Financial Protection Bureau (CFPB). In the United States, the Financial Data Exchange (FDX) is also significant. With the goal of creating the FDX API standard as a common interoperable data standard, the FDX is a non-profit organization composed of representatives from the biggest financial services companies in North America [11].

While Indonesia does not have an exact equivalent to PSD2, the country has implemented its own regulatory framework for payment services and fintech. Bank Indonesia has regulated electronic money (e-money) and mandated licensing and operational requirements for fintech companies (regulation number PBI No. 19/12/PBI/2017). Standardization and integration of payment systems across the country have also been regulated by Bank Indonesia through regulation number PBI No. 20/6/PBI/2018 concerning the National Payment Gateway. Furthermore, Bank Indonesia has also encouraged open banking through the BSPI 2025, which promotes collaboration between banks and fintech companies to drive innovation and financial inclusion. The Financial Services Authority (OJK) has issued several regulations to oversee fintech lending and other digital financial services, ensure consumer protection, and promote a safe and competitive environment. While not as comprehensive as PSD2, these regulations aim to modernize Indonesia's payments ecosystem and drive innovation in the financial sector.

3. Reshaping banking system: Unbundling to re-bundling services

The sources of economies of scale and scope in banking can be broadly divided into four groups, economies of scale and scope related to reputation and branding, risk diversification, innovation, and information and communication technology (ICT) [20, 21]. Historically, banks have depended mostly on reputation and branding, as well as risk diversification, to enhance economies of scale and scope. Innovation, along with information and communication technology, has been utilized more internally. According to innovation and ICT, banking institutions have evolved consistently throughout time, and the major changes may be categorized into five main eras, analogous to the industrial revolutions: Banking 1.0, 2.0, 3.0, 4.0, and 5.0. Banking 5.0 will initiate a cultural shift for clients, necessitating a transformation from passive to preventive and proactive engagement, accompanied by an array of new services

and products, innovative business structures, and a heightened focus on default prevention [9]. The extensive utilization of the Internet signifies the onset of the Fourth Industrial Revolution, characterized by the integration of industrial operations technology with information and communication technology. Industry 4.0 pertains to the amalgamation of the Internet of Things (IoT), the Internet of Persons (IoP), and the Internet of Everything (IoE). The Internet facilitates dependable communication across machines, individuals, and digital applications in real time and at little expense. This scenario facilitates the adoption of "smart banking" and enhanced digitalization inside and across organizations or service operation websites. This signifies Banking 4.0, a disruptive breakthrough akin to the preceding three revolutions [9].

The unbundling of traditional banking was a general trend in the industry in the late 2010s—services that were not "core" to what a bank could do alone were gradually moved to smaller, more specialized businesses that were champions of those services, and they provided the APIs for these services to the banks [22]. The early "unbundling" yielded several advantages in the reconfiguration of financial services [23]. Fintech broadens this notion to encompass various services, including firms focused on payments, card issuance, merchant acquisition, lending, customer support, chatbots, process automation, wealth management, account verification, customer reporting, fraud detection, and others, each offering an extensive array of APIs [22]. Following the emergence of "unbundling," which facilitated the growth of fintech and compelled banks and financial institutions to enhance their innovation, the industry has recently observed a nuanced shift in the trend of new entrants competing with established financial institutions, accompanied by a growing sense of collaboration across the sector. The consequences of this current "re-bundling" are expected to be highly advantageous for the sector, promoting collaboration between fintech companies and conventional financial institutions [23].

Platform-based banks benefit from a two-way network effect, in which incremental customer growth attracts additional service providers and vice versa. To remain relevant in the new ecosystem, businesses will need to think beyond open banking and toward a shared marketplace future, and new specialist roles are emerging. These roles, which include supplier, aggregator, and orchestrator, are business case-specific rather than business model-exclusive. As a supplier, the bank focuses on developing products and services while outsourcing distribution to a third party. In its role as an aggregator, the bank delegated product and service creation to a third party while using internal channels for distribution. In the orchestrator role, banks act as facilitators of a marketplace for various FS and non-FS propositions, enabling beyond traditional banking with a broader service portfolio and client base (**Figure 1**).

Financial institutions controlled every facet of consumer data, goods, and services in the compartmentalized system of traditional banking. According to [25], this approach restricted innovation, competition, and customer-centricity while prioritizing institutional control. With little integration of third-party services, customers relied on their banks for all of their financial needs. The emergence of open banking marked a paradigm shift enabled by regulations like the European Union's Revised PSD2 and the UK's Open Banking Initiative. These frameworks mandated banks to share customer data (with consent) *via* secure APIs, allowing TPPs to develop innovative financial services [26]. Key outcomes include enhanced competition, customer empowerment, and technological integration. Fintech companies and startups are enhancing competition by leveraging bank data to offer personalized services (e.g., budgeting apps and loan comparisons). Users gain control over their financial data; this customer empowerment enables seamless account aggregation and payment

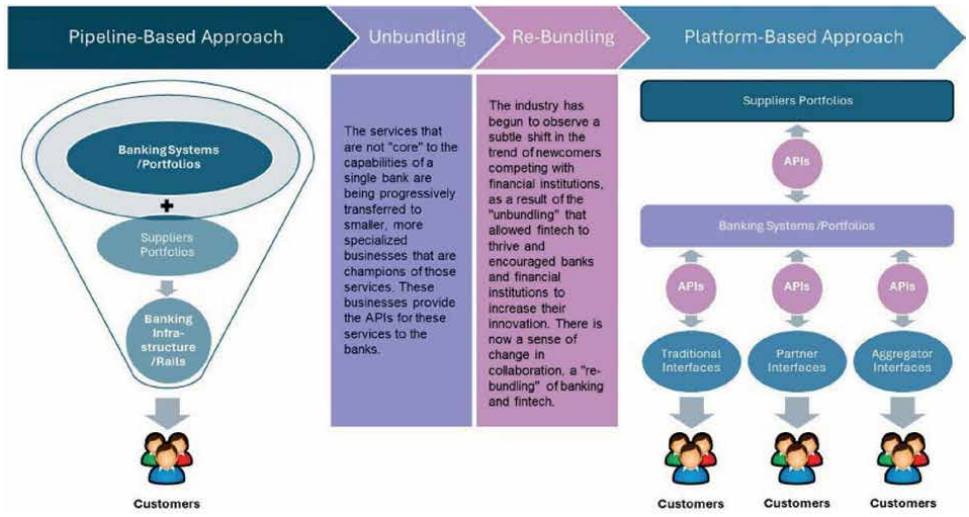


Figure 1.
Reshaping banking system. Source: Adopted from Capgemini [24] and Harisson [23].

initiation. By leveraging alternative data (e.g., utility payments), underserved populations gain access to credit and financial tools, which will ultimately increase financial inclusion.

The banking industry in Indonesia is now experiencing significant digital change, but within a restricted scope. The findings from the Bank Indonesia evaluation, **Figure 2**, indicate that several banks in Indonesia are beginning to use digital technology adoption to enhance their competitiveness and client services [27]. Two primary conclusions emerge: firstly, the majority of payment products created by national banks are in quadrant I (IT developed) and are transitioning toward quadrant II (digital banking 1.0). Secondly, the majority of banks in Indonesia remain in quadrant I. It has been determined that the BUKU 4 banks and many other large institutions are situated in quadrant II. No national bank has successfully entered quadrant III

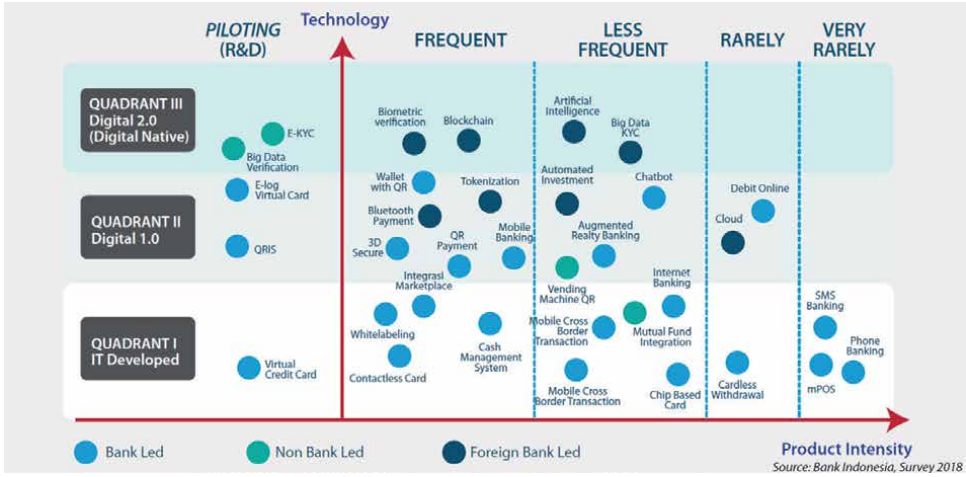


Figure 2.
Indonesian banking digital technology adoption. Source: Bank Indonesia [27].

(digital banking 2.0). The adoption rate of digital banking by national banks remains comparatively sluggish. This circumstance was instigated by inadequate adaptability of infrastructure and domestic payment system rules, the banking sector's sluggish reaction due to stringent restrictions, and elevated investment costs. The Indonesia Payment System Blueprint 2025 mandates national banks to best use breakthroughs in digital technology. In addition to the use of the Application Programming Interface (API), several forms of innovation are anticipated to facilitate banks' transition into the digital-first banking age.

Digital-first banks function exclusively online, providing customers with banking services *via* a mobile application, website, or other digital platforms. They may provide convenience and reduced fees compared to conventional banks with physical locations [28]. Digital-first banks will be characterized by a number of trends, including personalization, mobile-first, AI and machine learning, real-time payments (RTPs), invisible banking, cryptocurrencies and blockchain technology, and a people-first approach. Banks will prioritize personalized experiences for their customers [29]. Banks will focus on mobile strategies to provide effortless digital experiences [29]. AI and machine learning will be more integrated into financial services, with generative AI enhancing customer service and predictive analytics improving fraud detection [30]. RTP will become more critical as consumers and businesses demand faster, more secure transactions [31]. Virtual assistants like Alexa, Google Home, and Siri will become more prevalent as invisible banking [32]. Cryptocurrencies and blockchain technology will be integrated into banking [33]. Banks will focus on exceptional engagement and empowerment of customers and bankers [34]. Banking is transitioning from a traditional model with economies of scale and conflict of interest to a new wave of third-party service bundling focused on customers [1].

The next generation of open banking is what is called open finance [35]. The concern extends beyond restricting access to banking accounts; it also encompasses mortgages, investment accounts, pensions, and insurance, provided they are all integrated into APIs [9, 35]. Customers may swiftly transfer funds across accounts and oversee their complete financial portfolio in a single centralized location [9, 35]. Capgemini [24] called open finance an open X, a concept of a transparent banking model that is centered on the sharing of data, assets, resources, and products throughout the banking industry. A crucial component in the process of integrating the economy and digital finance in Indonesia is the management and exploitation of data pertaining to digital payment systems [27]. A study examines the impact of a co-innovation platform between fintech and digital banks on company development in Indonesia. The study found that New Customer Base and New Customer Value are important components of the Co-innovation platform, which influences company development through radical and incremental innovation. The Open Financial System can be a form of collaboration that provides added value to both parties and has an impact on company development [36].

4. The new valuable assets in digital age: Data

Personal data transforms business boundaries, shifting profit pools to companies automating and mining data. However, the value and profit creators remain uncertain due to complex regulatory, business, and technological issues. In 2010, the World Economic Forum's (WEF) Rethinking Personal Data project highlighted

the rapid growth of personal data, promoting a user-centric data ecosystem based on trust and individual control in data sharing. The WEF report aims to create a user-centric data ecosystem based on trust and individual control over data sharing. It envisions a future where individuals have greater control over their data, digital identity, and privacy, and government agencies can exchange data more easily. The report highlights complex business, policy, and technological issues requiring coordinated leadership [37].

Personal data is transforming into a valuable economic asset, requiring a balanced ecosystem with increased trust between individuals, government, and the private sector to unlock its full potential. In the banking industry, the use of customer data is difficult and complicated due to the protection of customer data, which includes the protection of sensitive personal information provided by customers during transactions. Banks use various methods to protect customer data, including encryption, authentication methods, security policies, and fraud monitoring. Banks safeguard customer data by adhering to self-regulation and government regulations, complying with GDPR, and implementing cybersecurity measures to safeguard sensitive information and systems from unauthorized access.

Banks must be cautious with customer data, as it is expected to function as a secure data repository. To protect customers, rules on data protection, data exchange arrangements, and data governance in banking are crucial. Implementing these elements will increase public trust in banking, especially in the digital era, and ensure a wider range of uses for customer data. Data protection policy is a scheme regulating customer data collection, processing, and storage, involving several principles for Bank consideration, as illustrated in **Figure 3** [38].

Banks must adhere to seven main principles when collecting and processing customer data (**Figure 4**). These include lawfulness, transparency, purpose limitation, data minimization, accuracy, storage form, and security. Personal data must be

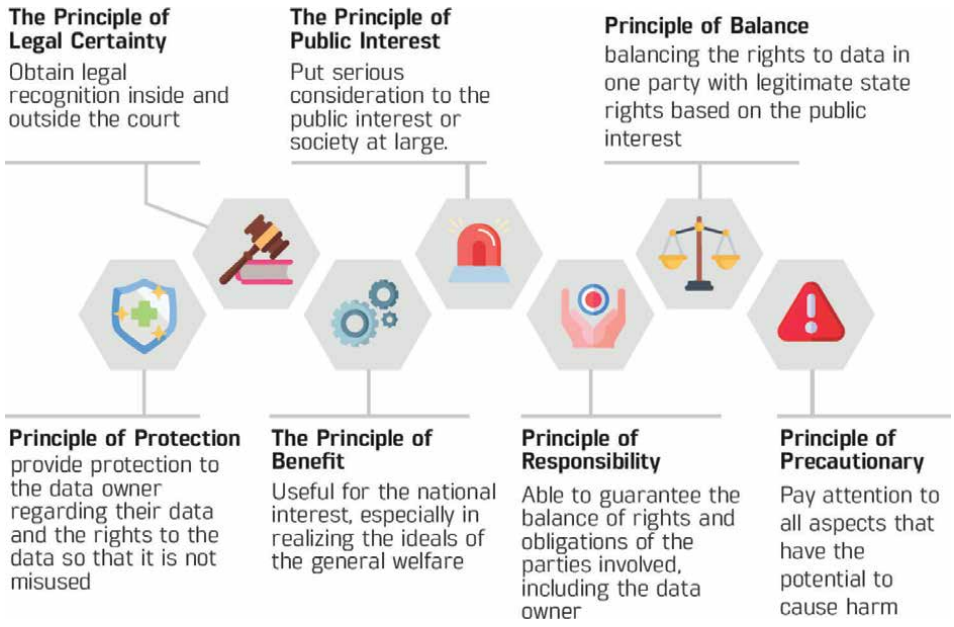


Figure 3.
Principles of data protection governance. Source: Financial Services Authority of Indonesia (OJK) [38].



Figure 4.
Principles of data collection and processing. Source: Financial Services Authority of Indonesia (OJK) [38].

lawfully, fairly, and transparent, with a clear, explicit, and legitimate purpose. Data minimization ensures that data is adequate, relevant, and limited to the required amount. Accuracy must be constantly updated and stored in a form that allows identification of the data subject. Security measures include protection against unauthorized or illegitimate processing and accidental loss, destruction, or damage. Banks as data controllers must demonstrate compliance with these principles, requiring documentation, technical steps for organization and data protection, and the appointment of a data protection officer.

The bank must ensure lawfulness in processing personal data, obtaining consent from the data subject, executing contracts, fulfilling legal obligations, protecting vital interests, implementing public tasks, and fulfilling legitimate interests. Fairness requires the bank not to misuse or deceive individuals and transparency requires the bank to communicate clearly and honestly about how their personal data is used. This ensures compliance with laws, protects vital interests, and upholds the rights and freedoms of data subjects. Data standards for banks and fintech players will cover data types, technical specifications, security requirements, consumer consent, dispute resolution, API life cycle, and governing body standards. They will also outline principles for open API business contracts, including consent rules, access procedures, and risk management [27].

Indonesia's financial sector is increasingly adopting open banking, which requires banks to share customer data with third parties. However, compliance with data privacy regulations (**Figure 3**), particularly the principles of data collection and processing issued by the OJK (**Figure 4**), poses significant challenges. One of the key issues is differentiating between personal data and aggregated or anonymized data. Below are the primary challenges and their implications for compliance:

4.1 Definitional ambiguity

The OJK Principles and the broader Personal Data Protection Law (PDP Law) emphasize strict protections for personal data, which includes any information that can identify an individual. However, differentiating between personal data and aggregated/anonymized data is not always clear. Aggregated data combines individual data points into groups, while anonymized data removes identifiable information. In practice, banks may struggle to ensure that anonymization techniques are robust enough to prevent re-identification, especially with advancements in data analytics. In this case, the challenge is to prevent aggregated or anonymized data from being reverse engineered to reveal personal information.

4.2 Technological limitations

Effective anonymization requires sophisticated technology. In Indonesia, many banks—particularly smaller ones—lack the resources to implement advanced anonymization techniques. Poorly anonymized data can still be traced back to individuals, creating compliance risks under the OJK Principles and the PDP Law. In this regard, the challenge is to achieve true anonymity while navigating technological and resource limitations.

4.3 Dynamic nature of data

Open banking involves continuous data sharing, which means that data once considered anonymized may later be re-identified as new datasets or technologies emerge. This dynamic nature makes it difficult for banks to guarantee compliance over time. Maintaining adherence to OJK principles as data and technology advance is the difficult part of this situation.

4.4 Third-party risks

In open banking, data is shared with third parties (e.g., fintech companies), increasing the risk of misuse or breaches. Even if banks anonymize data before sharing, third parties may not adhere to the same standards, potentially leading to non-compliance. One of the challenges in this regard is making sure that third parties manage aggregated or anonymous data in compliance with OJK regulations.

4.5 Regulatory uncertainty

While the OJK Principles and PDP Law provide a framework, there is still ambiguity around specific requirements for handling aggregated or anonymized data. This creates uncertainty for banks trying to balance innovation with compliance. The obstacle in this instance is the interpretation and application of OJK regulations within the context of open banking.

4.6 Customer awareness

Customers may not fully understand how their data is being used, even in aggregated or anonymized forms. This raises ethical concerns and could lead to reputational risks for banks if customers perceive their privacy as being compromised.

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Banks must confront the challenge of establishing customer trust while simultaneously maintaining regulatory compliance.

To comply with OJK's data privacy regulations, particularly the principles of data collection and processing, Indonesian banks must address these challenges by investing in robust anonymization technologies, clarifying regulatory requirements, and ensuring third-party compliance. A proactive approach will help banks balance innovation in open banking with the need to protect customer privacy.

5. The new way of collaboration: Open banking APIs

The origins of open banking are grounded in regulatory requirements and technological advancements, fundamentally altering the conventional interactions between corporate and individual clients and their banks [35]. APIs are the technology that underpins open banking. An API is a collection of functions that facilitate the exchange of data and requests between systems, typically in a secure and controlled manner [39]. Private, partner, and open APIs are the three main categories of APIs that are currently used in the open banking sector. Every kind of API has a distinct function and application as can be seen in **Figure 5** [39, 40]. Open banking is made feasible by APIs. They guarantee that both parties can comprehend and collaborate with each other's systems without the necessity of understanding the complexities of the other's architecture. Banks can ensure that third parties have access to only the data they require and nothing more by implementing fine-grained controls over what data is accessible *via* APIs through the use of strict authorization mechanisms. APIs or API gateways typically include auditing capabilities that enable banks to monitor and trace data access. This feature assists in the identification of suspicious or unauthorized activity and the preservation of a record of the data accessed and the time it was accessed [11].

Bank Indonesia, Central Bank of Indonesia, promotes the participation of the industry in shaping the trajectory of open banking development within Indonesia's payment system by engaging in the formulation of Open API Standards and facilitating connections between banks and financial technology (fintech) entities. This engagement is achieved by allowing industry and the public to contribute feedback

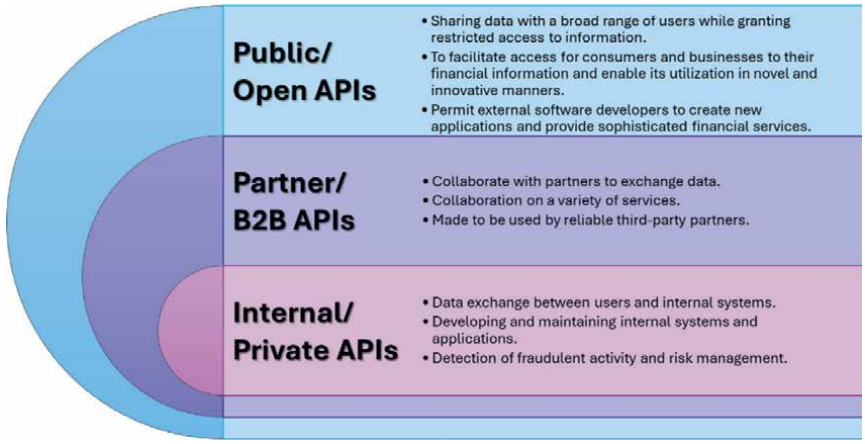


Figure 5.
Types of APIs in banking. Source: Adopted from and AlexSoft [39] and Muduroglu [40].

and responses to the Consultative Paper on Open API Standards concerning Open Banking and the integration of banks with fintech for payment system service providers. The Open API standard enables banks and fintech companies to mutually access financial data and information pertaining to customer payment transactions, adhering to the principle of equality. This is further substantiated by contractual collaboration regarding the utilization of open API technology (open API).

As part of the aspirations for the Indonesia Payment System 2025 (IPS 2025), Open Banking is intended to foster digital transformation within the banking industry and to establish interlinks between financial institutions and fintech companies. This goal was brought to fruition *via* the First Initiative, which was Open Banking. Another conclusion that has been reached in the past is that the implementation of open banking in Indonesia has not yet been proceeding on an optimal basis. When it comes to contractual, technical, and security-related matters, the use of APIs tends to vary and is not standardized like other APIs. Additionally, it is done in a restricted scope with certain contract schemes, both of which are often bilateral and are accomplished *via* the use of open partner API [27]. As a result, the Open API standard is on one of the Working Groups' key discussion topics for IPS 2025 [27]. The ultimate goal of Open Banking is to promote the Open API standard, which encompasses technological requirements, security standards, data standardization, and governance. To serve as a roadmap for banks and fintech companies adopting Open Banking, the standard will be described in guidelines (**Figure 6**).

Integration with local digital platforms, provision of financial services through banking agents, and development of personalized microfinance products are all part of open banking's role for Indonesia's unbanked and underbanked.

5.1 Access to financial services through alternative data

Fintech companies and non-bank service providers can obtain consumers' financial transaction data from banks or digital platforms through open banking (as long



Figure 6.
IPS blueprint 2025 roadmap and timetable. Source: Bank Indonesia [27].

as they have permission). People without a bank account or official credit history can have their creditworthiness evaluated using this data. Fintech companies like Kredivo and Akulaku exploit utility payment data and internet purchasing patterns to provide microfinance to unbanked individuals.

5.2 Integration with local digital platforms

Open banking facilitates cooperation between banks and digital platforms, lowering transaction costs and geographic barriers, particularly in rural areas. Digital platforms like Gojek, Shopee, and DANA are frequently more acquainted to Indonesia's unbanked populace. Open banking makes it possible to incorporate banking services (such microinsurance and savings) straight into the apps that people already use. Users may now manage their finances more easily without having to visit a bank branch thanks to a partnership between Bank Jago and Gojek that offers digital accounts connected to the GoPay digital wallet.

5.3 Financial services provided by banking agents

The penetration of financial services in rural areas was enhanced by banking agents who were outfitted with open banking technology. By enabling real-time smartphone transactions, open banking can support banking agent programs (like OJK's Laku Pandai program). Bank APIs allow agents in remote locations to process loans or open accounts without the need for physical infrastructure. With API support for client data verification, Bank BRI leverages a network of 500,000 agents to deliver essential services like payments and transfers.

5.4 Development of customized microfinance products

Real-time transaction data analysis makes it possible to provide financial services that are specifically suited to the requirements of low-income populations. Service providers can create flexible-term products like micro-enterprise loans or agriculture insurance by using open banking to analyze transaction data. The Amartha platform provides loans based on business performance using micro, small, and medium enterprises (MSME) transaction data from e-commerce.

6. Challenges and opportunities

Open banking is revolutionizing financial services by enabling third-party developers to access bank data through APIs. However, it presents challenges such as security, privacy, and regulatory compliance issues. Collaboration among stakeholders is crucial for addressing these risks, while implementation challenges include cybersecurity threats, regulatory compliance, and low adoption due to poor consumer education. Open banking success relies on customers' willingness to share information, and regulators must foster an environment that supports its growth, as customers greatly benefit from this financial ecosystem [41]. Open banking presents both benefits and challenges, according to the findings of a survey of many linked literatures [42–44].

6.1 Challenges

6.1.1 Data security and privacy concerns

Open banking raises privacy and security concerns due to the sharing of sensitive financial data between banks and third-party providers. Risks include unauthorized access, data breaches, and misuse of personal information. To mitigate these risks, financial institutions must implement robust cybersecurity measures and comply with data protection regulations like GDPR. Customers must explicitly consent to share their financial data, ensuring control over who can access it and protecting data from breaches and misuse.

6.1.2 Regulatory compliance

Open banking regulations vary across regions, such as the EU's PSD2 and the UK's Open Banking Standard. Financial institutions must stay updated and comply, often requiring significant investments in legal and technological infrastructure. These regulations are subject to evolving standards, which can vary across jurisdictions. Financial institutions and third-party providers must navigate complex compliance landscapes to ensure adherence to data protection, consumer rights, and anti-money laundering regulations. This requires significant investment in legal and technological infrastructure.

6.1.3 Legacy systems integration

Banks often use outdated legacy systems, making it challenging to integrate modern APIs. To support seamless data sharing and third-party integration, significant IT overhauls are required.

6.1.4 Customer trust

Open banking success relies on customers willingly sharing their financial data with third-party providers, building trust in its benefits and security. Financial institutions and fintech companies must engage in transparent communication and education to address consumer concerns and encourage adoption, ensuring explicit consent for data sharing and clear usage information.

6.1.5 Consumer education and awareness

The successful adoption of open banking requires comprehensive education, resources, and support to empower consumers to make informed decisions and protect their financial interests.

6.1.6 Cybersecurity threats

Cybersecurity risks such as malware, phishing, and denial-of-service attacks concern open banking environments. Strong cybersecurity measures, such encryption, authentication, and intrusion detection systems, must be put in place by financial institutions and outside suppliers to reduce the risk of cyberattacks and protect private information.

6.2 Opportunities

6.2.1 Enhanced customer experience

Open banking allows for personalized financial services, including budgeting apps, personalized loan offers, and integrated financial dashboards. This enhances the banking experience by providing relevant and timely solutions based on customer data. Open banking technology enables consumers to access a wider range of financial products and services through integrated platforms, resulting in a more seamless and personalized banking experience.

6.2.2 Increased competition and innovation

Open banking encourages competition among financial institutions by lowering entry barriers for fintech startups, leading to the development of innovative financial products and services. Traditional banks can collaborate with fintech to integrate these innovations, ensuring they stay competitive in a rapidly evolving market. This system also facilitates data sharing, resulting in better consumer offerings and industry innovation.

6.2.3 New revenue streams

Open banking offers financial institutions new revenue streams by monetizing APIs and leveraging customer data for targeted marketing campaigns. It also provides opportunities for innovation and growth through collaborations with fintech companies, enabling banks to develop new revenue streams and offer advanced services that cater to the changing demands of tech-savvy customers.

6.2.4 Financial inclusion

Open banking can enhance financial inclusion by offering tailored financial services to underserved populations. Fintech companies can use alternative data sources to offer credit and financial products to those with limited credit histories, expanding access to financial services. This allows third-party providers to access customer data, enabling the creation of tailored financial products and services tailored to specific needs and preferences.

6.2.5 Improved financial management

Open banking systems consolidate financial data from multiple accounts and institutions, enabling better budget management and informed financial decisions. This system enhances customer engagement by offering personalized experiences and seamless integration with various financial management tools.

6.2.6 Access to new services

Open banking enables third-party developers to create innovative financial applications and services, including budgeting tools, investment platforms, loan comparison services, and personalized financial advice, thereby enhancing competition among financial service providers.

6.2.7 Enhanced security and control

Open banking initiatives prioritize data protection, privacy, and security, allowing consumers greater control over their financial data and explicit consent to sharing, reducing unauthorized access or misuse.

6.2.8 Cost reduction for businesses

Open banking can streamline business processes, improve operational efficiency, and lower compliance and data management costs by leveraging APIs and data analytics, ultimately reducing costs.

7. Conclusions

Banks have historically held a significant role in the economy, but their data ownership has been a challenge. Open banking addresses this issue by reducing data ownership in the banking industry. The unbundling of traditional banking services in the late 2010s led to the growth of fintech and a shift in competition between fintech companies and traditional institutions. This "re-bundling" is expected to be beneficial for the sector, promoting collaboration between fintech companies and conventional financial institutions.

The next generation of open banking is open finance, which is a transparent banking model that focuses on sharing data, assets, resources, and products throughout the banking industry. A study in Indonesia found that the co-innovation platform between fintech and digital banks significantly influenced company development through innovation. The Open Financial System can provide added value to both parties and impact company development.

Open banking is revolutionizing financial services by allowing third-party developers to access bank data through APIs. However, it presents challenges such as security, privacy, and regulatory compliance issues. Collaboration among stakeholders is crucial for addressing these risks. Implementation challenges include cybersecurity threats, regulatory compliance, and low adoption due to poor consumer education. Open banking success relies on customers' willingness to share information, and regulators must foster an environment that supports its growth. Overall, open banking is revolutionizing financial services by enabling third-party developers to access bank data through APIs.

Open banking is transforming the financial sector by empowering users with control over their data, resulting in enhanced personalization of services, improved financial inclusion, and heightened innovation. In Indonesia, it provides an effective means to engage the unbanked, bolster small enterprises, and enhance the accessibility and relevance of financial services. Open banking fosters collaboration among banks, Fintechs, and other providers, thereby enhancing the scope and diversity of available services, while data-driven tools augment efficiency and customer experience. To fully attain these advantages, Indonesia must also confront significant challenges in regulation, data protection, and digital infrastructure. With appropriate support, open banking can facilitate inclusive growth and empower individuals across all societal strata.

This study examined the regulatory landscape, benefits, technological drivers, risks, and global conditions affecting the development of open banking in Indonesia.

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Based on these themes and adapted to the Indonesian context, there are numerous research questions to be addressed in the future. How can open banking help bridge the gap for Indonesia's unbanked and underbanked communities? What types of public-private partnerships are most effective in advancing open banking innovation in Indonesia? What is the effect of open banking implementation on the growth of financial services? How can Indonesian banks and fintech companies collaborate to create mutually beneficial open banking platforms? How can Indonesia's current digital identity systems be integrated with open banking to improve onboarding processes?

Author details

Dadan Rahadian
Faculty of Economics and Business, Telkom University, Bandung, Indonesia

*Address all correspondence to: dadanrahadian@telkomuniversity.ac.id

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Chapter 7

The State of the Turkish Fintech Ecosystem and Case Studies on Bank-Fintech Collaborations

Abdul Baghi Nabiyev and Gokhan Ovenc

Abstract

The chapter gives an overview of the current state of the Turkish fintech sector and conducts case studies between traditional banks and fintech companies in Türkiye. The analysis shows that Türkiye has significant potential for fintech sector development and attracting foreign investors, attributed to its tech-savvy young population, implementation of key regulations, and establishment of the Istanbul Financial Center. The second part of the chapter provides a detailed analysis of how fintech firms threaten traditional banks and how these banks are strategically responding. It also explains both parties' collaboration models and motivations within the context of an innovative management strategy. After conducting detailed exploratory case studies across various global regions, we applied the same research methods to the specific cases in Türkiye for an in-depth analysis. Collaborations between Turkish banks and fintech companies primarily focus on the payment segment, aligning with the global fintech landscape. Traditional banks in Türkiye continue to hold significant positions in the financial sector. However, fintech companies are expanding and are expected to become potential competitors with the emergence of digital banks and peer-to-peer lending platforms.

Keywords: banks, fintech, collaboration, case study, build, M&A, alliance, incubation, invest, joint venture

1. Introduction

The financial services landscape in Türkiye has undergone a significant transformation in recent years, mainly driven by the rapid emergence and adoption of financial technologies (fintech). These innovations have not only disrupted traditional financial models but also created new opportunities for expanding financial inclusion, enhancing service efficiency, and improving customer experience. As fintech continues to evolve, it increasingly plays a pivotal role in reshaping Türkiye's economic ecosystem.

This article provides a comprehensive examination of the fintech sector in Türkiye, with a particular focus on the collaborative dynamics between traditional banking institutions and fintech companies. To structure this analysis, the study introduces a conceptual framework that categorizes various modes of collaboration,

including strategic partnerships, acquisitions, venture capital investments, and innovation platforms.

A review of the existing literature offers critical insights into the technological, regulatory, and behavioral dimensions that underpin fintech development. These include advancements in payment systems, the challenges of regulatory harmonization, and changing consumer preferences in a digitally connected economy. This contextual understanding is essential for analyzing how stakeholders in Türkiye navigate both the opportunities and risks presented by fintech innovation.

The study also explores the role of key fintech actors—such as Aköde, Moka, Finberg, Garaj, and Logo—who have emerged as influential players offering solutions across digital payments, enterprise software, and open banking. A notable trend in the Turkish market is the deepening collaboration between these fintechs and established banks. Complementary strengths characterize such partnerships: while banks contribute regulatory know-how, customer trust, and infrastructural capacity, fintechs offer technological agility, innovation speed, and customer-centric design. These interactions reflect a broader strategic response to digital transformation pressures within the financial sector.

The article concludes by synthesizing the main findings on the nature and impact of bank-fintech collaborations in Türkiye, discussing their effectiveness and associated challenges. It also outlines directions for future research, with an emphasis on exploring the long-term implications of fintech integration for financial stability, competition, and innovation in emerging markets.

2. Evolution of the Turkish fintech ecosystem

Türkiye has a vibrant and tech-savvy young population with high internet and smartphone usage rates. These conditions create an ideal environment for adopting and proliferating digital financial solutions, whether at home or on the go. It is important to remember that Türkiye holds a prominent position in the banking sector with its strong emphasis on technology use and digitalization. The State of Turkish Fintech Ecosystem 2023 report highlights Türkiye's remarkable position as a global leader in banking, ranking 5th worldwide for the sheer volume of credit card transactions. With an impressive 117.8 million credit cards in circulation, a substantial portion of the population is engaged in digital financial activities. This robust infrastructure is further underlined by 2 million point-of-sale (POS) devices and 52,900 ATMs, facilitating seamless transactions nationwide. Moreover, Türkiye boasts a significant demographic of 106.6 million active retail digital banking customers, indicating a substantial shift toward digital finance. The fintech landscape has flourished due to progressive regulations that promote innovation, resulting in a vibrant ecosystem featuring 696 active fintech companies. Among these, 81 are licensed payment and electronic money institutions, and 21 crowdfunding platforms contribute to financial diversity. In addition to these impressive figures, the trend of mobile contactless payments has surged, with 50.5 million transactions occurring *via* this method. QR code transactions have also gained popularity, totaling 35.5 million. Collectively, these statistics paint a picture of a dynamic and rapidly evolving fintech landscape, solidifying Türkiye's status as a key player in the global banking industry. Financial institutions are increasingly channeling their resources into fintech startups, utilizing their established funds to foster innovation in the sector. By doing so, they bolster

their investment portfolios and engage in the broader ecosystem by providing support through specialized acceleration programs. These initiatives are designed to nurture and encourage the emergence of new fintech enterprises, creating a dynamic environment ripe for technological advancement and financial solutions. **Figure 1** shows a snapshot of the Turkish fintech ecosystem.

The Interbank Card Center consistently provides detailed updates on the volume and value of transactions *via* mobile contactless methods and QR codes. As shown in **Figure 2**, the number of mobile contactless transactions in Türkiye increased by more than threefold between 2019 and 2020, primarily due to the impact of COVID-19. This surge indicates a significant upward trend in mobile contactless transactions. Similarly, QR code-based transactions have experienced a rise in popularity in recent years. **Figure 3** illustrates that the volume of QR code transactions has increased by more than four times in the past 2 years. In **Figure 4**, the data represents a notable surge in mobile contactless and QR code payment volume. Despite this increase, their representation in the contactless transactions made with domestic and international cards remains comparatively tiny, with 1% as of 2023. This highlights the importance of initiatives to bolster public understanding and adoption of digital payment methods.

In the early 2010s, Türkiye established regulations for fintech companies. In 2012, the mandatory adoption of new-generation payment devices sparked a surge of fintech initiatives in the country. These initiatives continued to grow after the issuance of e-money and payment institution licenses in 2015. As of December 2023, 81 companies had obtained licenses to conduct operations within this industry, as depicted in **Figure 5** [1].

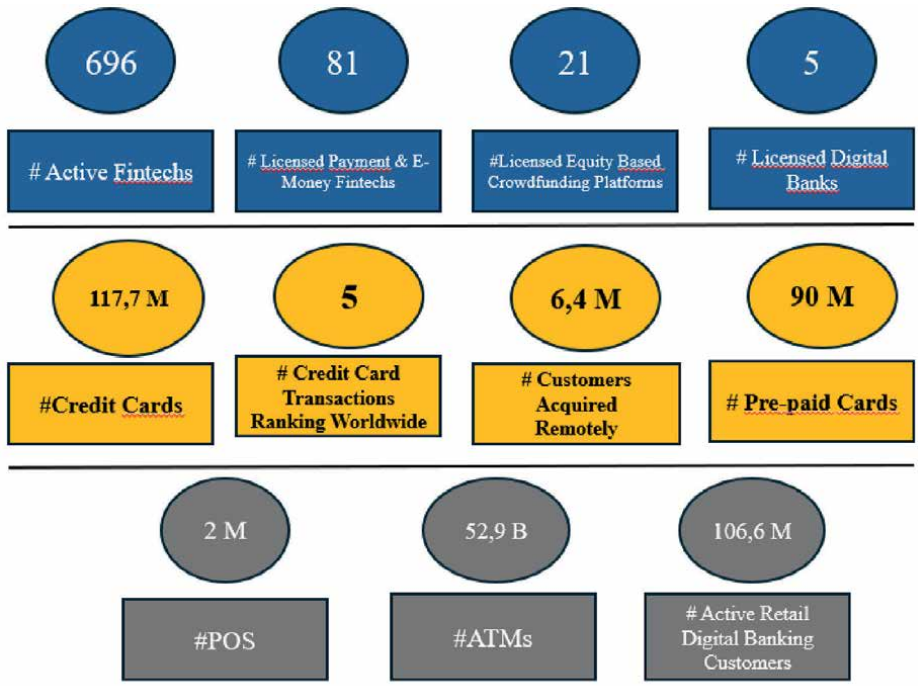


Figure 1.
Türkiye fintech ecosystem with numbers [1].

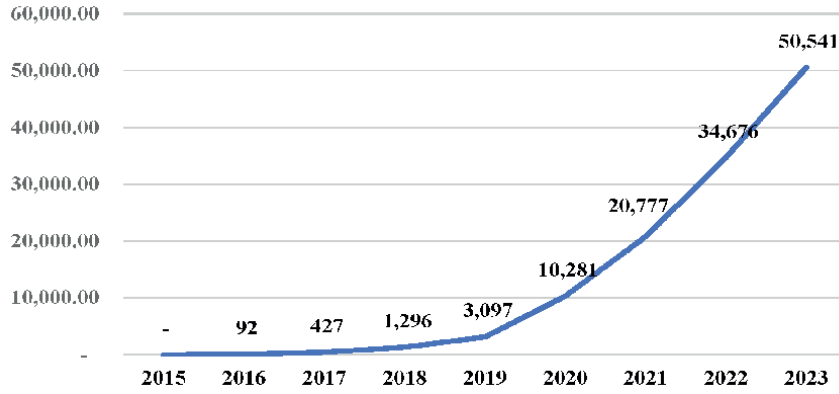


Figure 2.
Number of mobile contactless transactions (in thousands) [2].

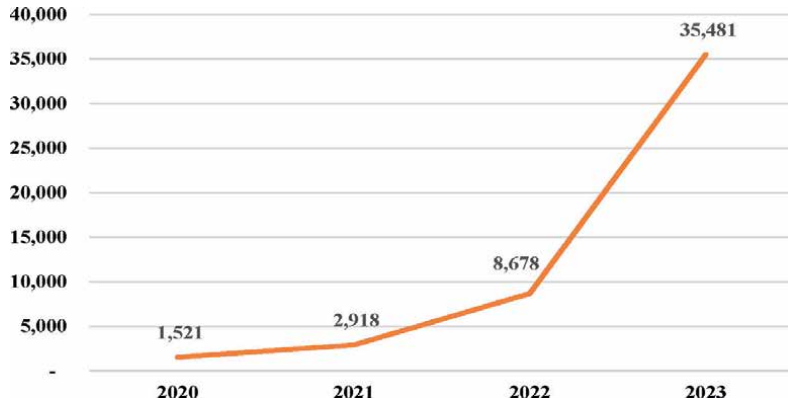


Figure 3.
Number of QR code transactions (in thousands) [2].

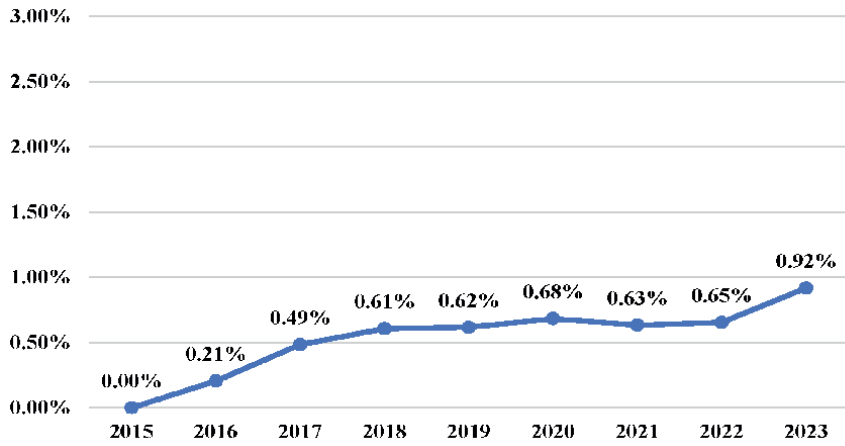


Figure 4.
Mobile contactless and QR code transactions/total contactless transactions of domestic and international cards (%) [2].

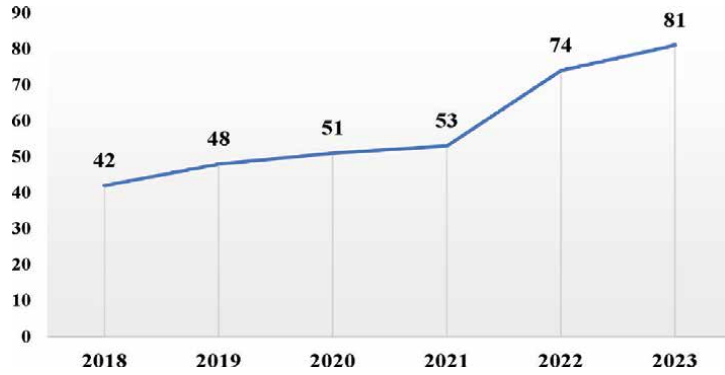


Figure 5.
Number of licensed e-money and payment institutions in Türkiye [1].

3. Regulatory landscape and policy environment

In the past 3 years, several regulations have been introduced to support fintech companies, promote bank digital transformation, and lay the groundwork for open banking. The year 2022 marks the beginning of seeing the benefits of these regulations come to fruition. The major fintech-related regulations are summarized in **Table 1** [3, 4].

According to the reference [4], the significant developments in fintech regulations in 2022 are as follows:

- Digital banking regulation and the Istanbul Financial Center Law entered into force.
- The first digital bank establishment permit was issued.
- New guidelines for payment services and open banking were introduced.
- The first Digital Turkish Lira Network payment transaction was also realized.

The recent advancements suggest that Türkiye will significantly increase its activity shortly. Establishing the İstanbul Financial Center (IFC) will further boost this upward momentum.

In Türkiye, the fintech sector is thriving, with 696 active startups in the ecosystem, representing 26 newly founded startups in 2023. According to **Figure 6**, the number of new fintech startups in 2023 was lower than usual because many established startups did not immediately announce their launch. However, it is anticipated that approximately 67 new fintech startups will be established each year over the past 5 years. Regulatory changes in 2021 are expected to increase the average number of new fintech startups in the years to come. Türkiye's focus on areas such as open banking, service banking, digital currency, and digital banking is set to boost initiatives in these areas significantly.

Türkiye has a growing presence of innovative startups in the financial technology sector. **Figure 7** shows the breakdown of fintech companies by vertical as of the end of 2023. This includes 268 payment technology startups, 108 banking technology startups, and 100 blockchain and crypto asset startups. Additionally, emerging

Year	Title	Purpose	Unit
2013	Revenue Administration of Türkiye Communiqué No. 426 on Tax Procedure Law	The mandatory use of POS devices by vendors has led to an increase in fintech startups in Türkiye.	TRA
2013	The Law on Payment and Securities Settlement Systems, Payment Services and Electronic Money Institutions (the "Law no. 6493")	The widespread adoption of fintech applications such as electronic payments, money transfers, loyalty cards, digital wallets, and credit card installment plans.	CBRT
2019	Secondary Legislation on Equity-Based Crowdfunding by Capital Markets Board of Türkiye	Technology and production startups to raise capital for equity on crowdfunding platforms, leading to more opportunities for renewable energy and agricultural technology startups.	CMB
2019	Amendment to Law on Payment and Securities Settlement Systems	Enhancing the ecosystem for startups offering open banking applications for online platforms and account information processing.	CBRT
2019	Regulatory Change	Supervisory and regulatory authority over payment service providers was transferred from the BRSA to the CBRT.	CBRT
2020	TÖDEB	Payment and Electronic Money Institutions Association of Türkiye was established.	
2020	Amendment to Electronic Communication Law	Financial institutions can now contract digitally, increasing financial inclusion and trade feasibility, especially during crises like the pandemic.	
2020	TR QR Code	The system allows for quick and secure QR code payments, offering customers faster and contactless payment options.	CBRT
2021	Initiation of Centralized Instantaneous Fund Transfer System (FAST) by CBRT	Money transfers are now completed instantly and can be done 24/7 to speed up financial transactions.	CBRT
2021	Secondary Legislation on IBAN (International Bank Account Number) provision by CBRT	Payment institutions and electronic money institutions were enabled to create IBANs.	CBRT
2021	Secondary Legislation on Equity-Based and Debt-Based Crowdfunding by CMB of Türkiye	Expanded the range of crowdfunding applications subject to regulation by incorporating debt-based crowdfunding.	CMB
2021	Secondary Legislation on Banks' Information Systems and Electronic Banking Services by BRSA	The regulations governing electronic payment systems have recently been revised, and the legal framework for open banking has been established, building upon the PSD2 directive.	BRSA
2021	Secondary Legislation on Digital Banking and Banking as a Service (BaaS) by BRSA	Regulation on digital banking and Banking as a Service was published.	BRSA
2021	Digital Money	Digital Turkish Lira Collaboration Platform established.	CBRT
2021	NFC Authentication	NFC technology is now the go-to method for verifying identity documents.	ITCA

Table 1.
The major fintech regulations in Türkiye [3, 4].

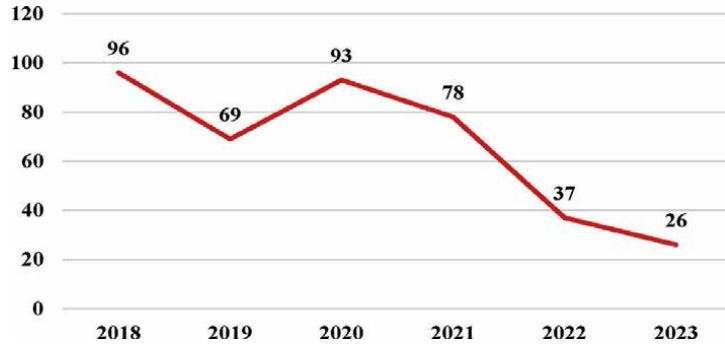


Figure 6.
Number of newly established fintechs in Türkiye [1].

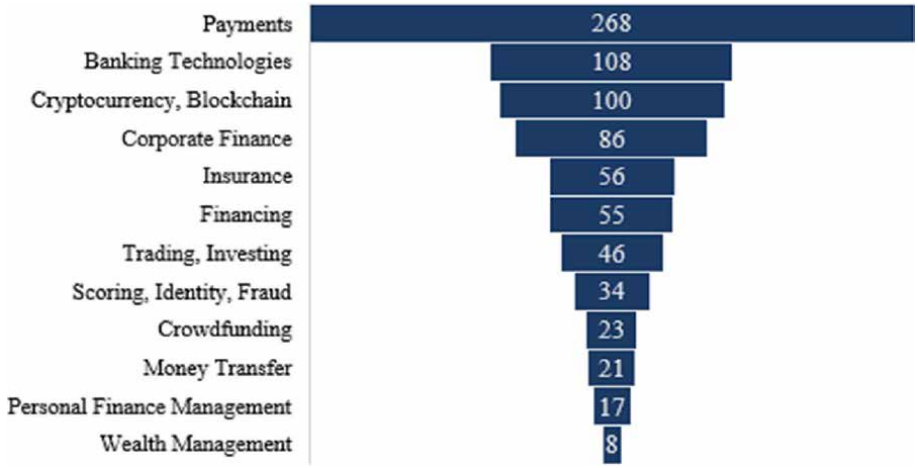


Figure 7.
Fintech firms by vertical as of 2023 [1].

initiatives focus on corporate finance solutions, insurance technology, and financing solutions. This trend reflects a dynamic and vibrant ecosystem of financial technology innovation in Türkiye.

The high level of interest from banks and investors has made the fintech sector one of the most popular in Türkiye. However, Turkish fintech startups have faced challenges expanding globally due to the complexities of navigating diverse regulatory processes. Despite this, successful Turkish fintech startups are starting to establish a presence abroad in 2022. **Figure 8** shows the deal size and count of fintech companies in Türkiye between 2018 and 2023.

In 2022, several Turkish initiatives, including "Arf," "Param," "Figopara," "Midas," and "Fimple," received significant fintech investments for expanding abroad, resulting in a record level of fintech investment (Presidency of the Republic of Türkiye Finance Office, 2023). "Arf" initiative has successfully expanded internationally with its blockchain-based solution and has secured the most significant fintech investment since the "Param" initiative. Moreover, 2022 saw the highest number of fintech investments in the Turkish startup ecosystem, with $90 million invested in fintech.

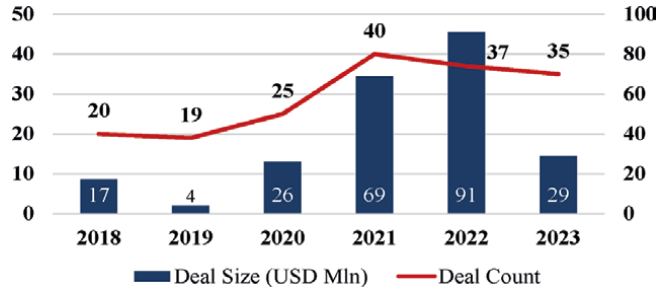


Figure 8.
Fintech deals in Türkiye [1].

In 2021, startups such as "to writi" broke the record, which showcased globalization in the fintech sector. Another popular initiative, "Hadi," is the banking application of TOM Bank, Türkiye's most prominent digital bank, launched in 2023. With the Hadi application, you can enjoy shopping at A101, the largest retail chain (with more than 13,000 stores), offering buy now, pay later options, savings on shopping, access to term deposit accounts, and make secure payments with Hadi cards globally. Hadi makes all financial transfers quick and easy. You can quickly deposit money into your Hadi account and access the funds from an ATM or secure A101 safes. You can also instantly send money to anyone in your contact list using their mobile phone number or International Bank Account Number (IBAN). Keep track of your bills and set up automatic payments for added convenience. As part of the collaboration with A101, customers using the Hadi app in 2023 saved an average of 500 TL, while some saved over 11,000 TL. In early 2022, a slowdown in digitalization and regional conflicts led to global money shortages in startup ecosystems, causing investors to focus on protecting their existing portfolios rather than making new investments. This resulted in a decline in fintech investments worldwide. In Türkiye, investments also dropped, with only $29 million invested across 35 rounds in 2023. While Türkiye ranked 15th globally in the number of fintech investments, it was 49th in total investment amount. Contributing factors include global money scarcity and slower fintech globalization in Türkiye. Notable 2023 acquisitions included Param's purchase of PayCore and TeamSystem's acquisition of Mikro Yazılım.

In response to the evolving financial landscape and the growing interest of public institutions in financial innovations, the Finance Office of the Presidency of the Republic of Türkiye has developed a comprehensive "National Fintech Strategy Document." This strategy seeks to integrate all relevant factors and stakeholders in the fintech ecosystem to ensure its sustainable growth. The document, currently in its preparatory stages, is expected to be officially released in 2023 and is anticipated to play a pivotal role in shaping the future of the fintech sector. In parallel with this strategy, Istanbul Finance and Technology Base was established in 2022 to unlock the potential in the fintech field and respond to the development and needs of fintech entrepreneurship. The incubation center will support entrepreneurs in the target group, contributing to a sustainable structure and investing in entrepreneurs with growth potential. Efforts will be made to develop this perception throughout Türkiye with virtual acceleration and incubation services on the Fintech Hub Türkiye platform, bringing fintech entrepreneurs together and facilitating matching between entrepreneurs and investors.

Türkiye's regulatory framework—anchored by Law No. 6493 and overseen by the Central Bank of the Republic of Türkiye (CBRT) and the Presidential Finance

Office—has played a vital role in enabling fintech growth. Initiatives such as digital banking licenses, open banking regulations, and fintech sandboxes demonstrate a commitment to innovation. However, regulatory procedures can still be complex, particularly for startups aiming to scale internationally. Compared to the EU or agile MENA ecosystems like the UAE, Türkiye's approach is less harmonized and slower to adapt, presenting both opportunities and constraints for fintech development.

4. Literature review and theoretical framework

The rapid rise of the fintech sector, driven by advancements in digitalization and IT-enabled technologies, poses significant threats to traditional financial institutions. Divya and Murali [5] classified the nature of these threats to the incumbent bank's business model as technology-based and market-based. Fintech companies' solutions to specific financial service needs are considered business model innovations from the perspective of incumbent banks. Traditional financial institutions have developed various strategies to respond to the perceived levels of risk they face. Divya and Murali [5] defined five simple categories of responses for a bank: (1) hold, (2) make (build), (3) ally, (4) buy; (5) exit. Suppose both technological and market-based risks are perceived as low. In that case, the bank adopts the "hold" strategy, which involves conducting business as usual but implementing revitalization efforts to mitigate the detrimental effects of fintech threats. In the event of higher market-based and lower technology-based risks, the bank will choose the "Make" strategy, wherein the incumbent will establish a new R&D center or laboratory, a new entity or project, and a novel process or system. When market-centered risks are higher than technology-based risks, the incumbent prefers the "Ally" strategy, which engages strategic alliances with fintech companies to avoid losing its target customers. Lastly, when the perceived level of both threats is higher, incumbents can buy the entrant fintech if the bank is large enough or exit from the sector.

The current study examines the modes of collaboration between fintech companies and traditional financial institutions, as well as their case studies in Türkiye. Before explaining these modes, it is essential to emphasize the critical motives behind strategic partnerships between incumbents and fintech startups. Klus et al. [6] conducted semi-structured interviews with banks and fintech companies to find the strategic motivations of both parties. The results suggest that banks' primary motives are outsourcing, innovation, business model evolution, and achieving competitive advantage, whereas fintechs' primary motives are resources, trust, credibility, and customer acquisition. A recent study by Bomer and Maxin [7] investigated 14 case studies and found that fintech companies collaborate with banks for several reasons. (i) Banks provide fintech companies with an entryway into the market; (ii) Collaboration with banks can help fintech companies generate more profits; (iii) Banks can facilitate the development of new fintech products and services. Furthermore, fintech companies use various labeling approaches when collaborating with banks to market their products. **Figure 9** shows the cooperation process between fintech companies and banks.

Another study by Bartolacci et al. [8] found several motives for establishing strategic alliances between banks and fintech. Banks outsource, innovate, develop business models, gain competitive benefits, improve efficiency and service quality, and learn. On the other hand, fintech startups aim to reach customers, obtain credit and banking licenses, achieve economies of scale, and establish trust. **Table 2** summarizes the fundamental motivations of collaborations between banks and fintech companies in the existing literature.

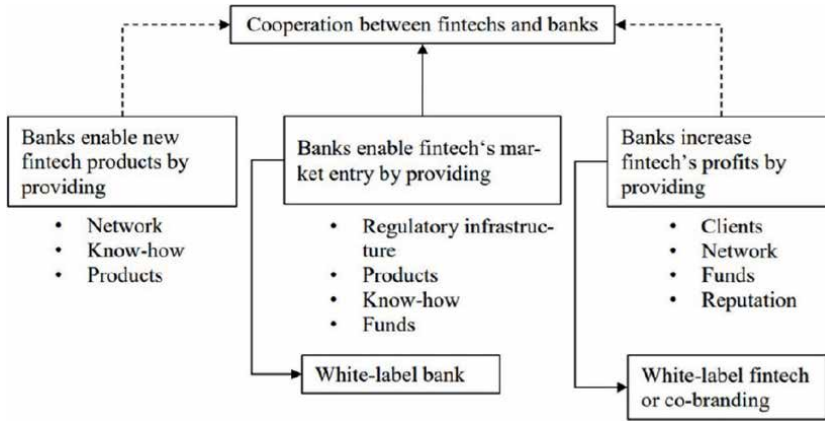


Figure 9.
The cooperation process between fintech and banks [7].

Motives of Banks	Motives of Fintech	Common Motives
External Innovation Access	Reputation and Credibility	Customer Satisfaction
Business Model Innovation	Regulatory and Synergies	Financial Return
Strategic Advantage	Product Development	Knowledge Transfer
Access to Top Talent	Market Entry Support	Competition

Table 2.
Strategic collaboration motives between banks and fintech [9].

The literature outlines different collaboration modes between traditional banks and fintech companies. According to a study by Birgl et al. [10], corporations utilize five types of innovation vehicles when collaborating with startups: innovation or digital labs, accelerators, corporate venture capital, partnership units, and incubators. Drasch et al. [11] studied 136 bank-fintech collaboration cases and developed a taxonomy of 13 factors to categorize these collaborations. They identified four primary modes of cooperation: acquisition, alliance, incubation, and joint venture. Following Drasch et al. [11] and Gold and Ali [12], **Table 3** shows four principal collaboration modes applied in this study.

Collaboration Type	Definition
Acquisition/ M&A	A corporate action in which the acquiring company purchases a majority of the target company and merges it into its existing operations.
Alliance/partner	A contract between companies to share resources and knowledge to achieve common goals.
Incubation / build	Supporting early-stage companies through financial, managerial, or other forms of assistance, setting up internal labs for creating and testing product prototypes, and building a new entity or division.
Joint venture / Invest	The resources are pooled in an independent but shared entity, and the participating organizations bear the risks and responsibilities.

Table 3.
Bank fintech collaboration modes [11, 12].

Several case studies examine the nature and dynamics of partnerships between traditional financial institutions and fintech companies. Gold and Ali [12] investigate three collaboration modes using exploratory case studies to demonstrate how Australian financial institutions integrate and leverage fintech innovations. The first case study examines the "build" strategy mode, which involves General Insurance Group launching Insurtech Lab to develop new customer solutions and introduce product innovations into the organization. The Lab can manage insurance coverage for digital platforms using a Business-to-Consumer (B2B2C) model. The Lab enabled the Group to quickly pilot and scale its on-demand insurance within 6 months, giving it a first-mover advantage as the only Australian general insurer offering this cover. The second case study examines the collaboration between one of Australia's central full-service banks and a foreign accounting software-as-a-service (SaaS) platform used by 2 million accountants and their small to medium-sized enterprise (SME) customers. To be 'Australia's Best Business Bank', the bank has formed a strategic alliance with a leading accounting platform SaaS to provide direct feeds and access to a range of the bank's products and payment functionality through the Bank's APIs. Within 6 months of partnering with SaaS, the bank's SME customers increased by approximately 40%, providing seamless transaction payment capabilities to over 100,000 customers. The last case study examines the "invest" strategy mode employed by full-service banks and the Fintech Venture Capital Fund. In 2015, the bank announced its investment in the equity of a P2P platform. This investment closely examined novel innovations in the P2P sector, including loan assessment and scoring algorithms, as well as loan platform management. Furthermore, the bank provides FinTech investees access to capital resources and industry expertise, helping entrepreneurs rapidly scale their product innovations.

Hung and Luo [13] studied the strategic considerations of the bank when investing in fintech companies in Taiwan. While T Bank, one of the top 5 banks in Taiwan, excels in SME loans, its personal finance business is weak. The bank invested in a fintech company that offers intelligent point-of-sale (POS) systems to facilitate personal loans after meeting the necessary selection criteria in 2016. Expanding the market share in SME loans and supporting personal finance through credit card issuance, the Fintech company complements T Bank. Furthermore, the study has several outcomes: (1) regulations and policies influence the development of FinTech; (2) banks, technology companies, and customers are not yet ready for FinTech; (3) the relationship between banks and FinTech companies is complex; (4) Taiwan may struggle to create FinTech disruptors soon; and (5) compare top-down with bottom-up strategies.

Riikkinen and Pihlajamaa [14] investigated how Nordea Bank achieved strategic alignment in its collaboration with a fintech startup by establishing an accelerator and incubator program. Three startup programs, implemented between 2015 and 2018 during a major fintech boom, were investigated to analyze how they utilized corporate sponsorship and facilitated corporate innovation. In the first Nordea Startup Accelerator in 2015, a mismatch existed between Nordea's strategic targets and the startups' knowledge base. However, in the second program in 2016, the strategic fit was enhanced due to the more focused selection of startups and increased unit participation. The 2018 Nordea Runway program achieved a high strategic fit by incubating internal teams. This accomplishment was primarily due to iterative adjustments to the accelerator/incubator design over time. By 2018, Nordea had increased its technological and market knowledge, enabling it to generate new ideas internally.

Santander and Kabbage collaborated to provide better financing options for small and medium-sized enterprises, leveraging their strengths in banking infrastructure

and innovative technology to make quick lending decisions [15]. The collaboration with Kabbage enabled Santander to integrate cutting-edge fintech solutions into its traditional banking services, aligning with its digital transformation goals and allowing Kabbage to reach a broader customer base through Santander's extensive network.

Commerzbank AG and Deutsche Börse AG have established a strategic investment and partnership with the NFT marketplace startup 360X [16]. This startup is developing a digital, blockchain-based trading platform for art and real estate assets, aiming to facilitate secure and efficient transactions in these sectors.

Based on the collaboration examples above, the current study aims to investigate partnerships between traditional banks and fintech startups in Türkiye. This research makes several contributions to existing literature. To our knowledge, this is the first paper to conduct such case studies in Türkiye. Secondly, the findings of these case studies offer valuable insights that can help entrepreneurs, traditional banks, and policymakers in emerging markets make informed decisions about future partnerships with fintech startups.

5. Methodology, data collection, and case studies

The qualitative methodology analyzes and understands the collaborative relationships between traditional banks and fintech companies. This approach enables the exploration of key questions surrounding the intricacies of fintech advancements and partnerships, including identifying key stakeholders, the nature of the collaboration, and the specific impact areas. The retrospective case studies focused on capturing particular characteristics of incumbents engaged in fintech collaboration. This allowed for the effective utilization of commercial benefits and technologies to enhance their business models and products within a rapidly evolving industry. The primary data for these case studies is primarily obtained from secondary sources, including public documents, investor presentations, annual reports, and media releases. **Table 4** outlines the key data sources used for the exploration case studies. As illustrated in the table, most of the data is derived from internal documents, particularly the annual reports of related banks.

Case 1: Akbank – AKÖde.

Collaboration Mode	**Build**
Incumbent	Akbank
Fintech Firm	AKÖde
Product vertical	Payment Services

Akbank, one of the top six banks in the Turkish banking sector in terms of total assets as of 2023, was founded in January 1948 in Adana to provide financing to cotton producers in the region. The bank's primary shareholder is Sabancı Holding, the second-largest multi-business enterprise in Türkiye, with multinational business partners. In 2023, the bank increased its credit support to the economy to 757 billion TL, with 616 billion TL in cash. Additionally, with 12,860 employees, the bank significantly contributed to employment, reaching a total customer base of 13.1 million and 5850 ATMs.

Akbank stated that its corporate strategy is to be "Türkiye's best and most valuable bank in terms of customer experience and satisfaction" in 2016. As part of the

Organization	Details	Year
Internal Documents		
Akbank	Annual Reports	2018–2023
Albaraka Türk	Annual Reports	2017–2023
Fibabanka	Annual Reports	2018–2023
İş Bankası	Annual Reports	2021–2023
Web Site		
Garanti BBVA	Logo Yazılım Web Site	2024

Table 4.
Data source of the case studies.

ongoing transformation efforts since 2016, with the New Generation Akbank vision, the number of customers will be increased through digital channels. The sales and service model in branches and digital channels will be enhanced with more innovative, simple, mobile, and paperless experience designs. In parallel with this strategy, the bank initiated strategic collaborations with fintech startups that offer digital solutions to meet the needs of SMEs and enhance their productivity.

In 2018, the bank established "AkÖde", Türkiye's first bank subsidiary fintech company, within the scope of Law No. 6493 on Payment and Securities Settlement Systems, Payment Services, and Electronic Money Institutions to reach new customers in the young generation segment. With its AkÖde mobile application and prepaid card infrastructure, the bank aims to produce accessible, fast, and creative solutions for the financial needs of non-customers and young users.

In 2019, AkÖde launched its first product, "Tosla," a fun, playful, simple, and fast social mobile platform that targets young users, providing core financial services. In Tosla, created with the slogan "The social state of money," users can share all the transactions they carry out with their friends. Thanks to strategic alliances with e-commerce companies and music and entertainment platforms, Tosla increased its financial transaction users tenfold and reached more than 1 million customers by opening approximately 100,000 new monthly accounts in 2020. In 2021, strategic alliances were formed with Belbim in the transportation sector to enable the loading of the Istanbulkart balance. A partnership was established with Starbucks Tosla, allowing users to make payments easily. In 2022, AkÖde began providing customers with Virtual POS and payment link services under the name "AkÖde POS." Furthermore, AkÖde introduced a new Digital-Only innovative card that supports mobile contactless (NFC), QR payments, and QR withdrawal projects to expand our digital payment capabilities. In collaboration with Helpsteps, Tosla supports customers' health as part of its social responsibility. Customers can also convert their steps into TL balances in Tosla. As part of "AkÖde POS," AkÖde introduced its first physical product, the Cash Register POS, and the "Payment Gateway with Tosla Credit" product, allowing businesses to offer customer loans with a single integration on their payment pages starting in 2023.

AkÖde's focus on customer growth resulted in a 4.5-fold increase in active customers and a 3.3-fold increase in customers performing monetary transactions compared to the previous year, as of 2022. Moreover, AKÖde reached over 3500 member businesses and a turnover volume of 2 billion TL in the first year of business with the POS product.

In **Figure 10**, AkÖde's financial performance from its establishment to 2023 shows a negligible increase in total assets and interest income per average total assets in the first 3 years, followed by a significant increase in the last 2 years, with both almost tripling. Thanks to this partnership, Akbank has gained a first-mover advantage, allowing it to reach its target customers in the market. According to a study by Bomer and Maxin [7], Aköde (a combination of "Ak" and "Öde") exemplifies successful co-branding, leveraging both the established reputation of Akbank and the innovative brand of the fintech company. Customers are aware that they are utilizing a product from a well-known bank, combined with new technology.

Case 2: İş Bankası – Moka.

Collaboration Mode	Acquisition / M&A
Incumbent	İş Bankası
Fintech Firm	Moka
Product vertical	Payment Services

İş Bankası, established in 1924, maintains its position as "Türkiye's largest private bank," with total assets reaching 2.5 trillion TL by the end of 2023. The bank's funds to the economy reached 1.6 trillion TL in 2023, with 1.2 trillion TL in cash loans and 427.3 billion TL in non-cash loans. İş Bankası remains the top private bank, with the largest branch and ATM network, comprising 1066 branches and 6312 ATMs that cover all cities in Türkiye.

İş Bankası launched the "Digital Transformation Program" in 2015 to become the closest bank to customers in digital environments and to define the digital transformation journey within its business models. The Bank's goal of becoming "Türkiye's Best Multi-Channel Bank" has been expanded to "Being Türkiye's Best Digital Bank." In line with this objective, innovation has consistently been at the core of business strategies. Current trends in innovation include supporting common platforms, enhancing collaborations with fintech, and reaching underserved groups. In İş Bankası's 2021 annual report, attention was drawn to the rise of fintech companies as competitors to traditional banks. This change is attributed to shifting customer and employee expectations, digitalization, and the growing ease of operating in the

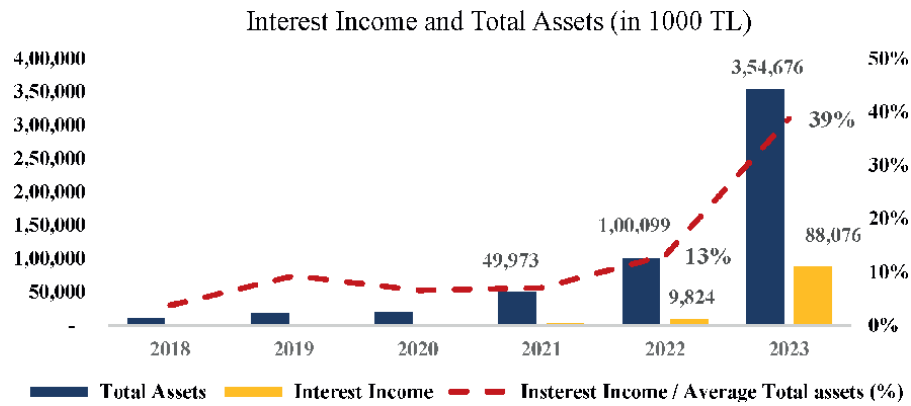


Figure 10.
AkÖde's financial performance.

banking and finance sector, which leads to increased demand for purpose-driven institutions. Traditional banks can enhance their competitive position by embracing common platforms, fostering strong partnerships with fintech companies, and extending their services to underserved population segments.

To expand its inclusiveness in the world of payment services, which are at the center of e-commerce and platform economy, İş Bankası completed the acquisition of shares of "Moka Ödeme Kuruluşu A.Ş." for 3.8 million USD in 2021. With this investment, the aim is to increase İş Bankası's competitiveness in digital payment systems by leveraging the agile contribution of fintechs to the corporate way of doing business. "Moka Ödeme Kuruluşu A.Ş." joined the industry in 2014 to offer quick, convenient, and efficient payment solutions, including mobile payments and virtual POS. It has operated as a licensed payment institution since obtaining permission from the Banking Regulation and Supervision Authority (BRSA) in 2016. In 2021, the company received authorization from the CBRT to issue electronic money and changed its title to "Moka Ödeme ve Elektronik Para Kuruluşu A.Ş." The Moka Super Virtual POS Campaign enables small and medium-sized companies to process installments to different bank cards using a single virtual POS as of 2022. This service is now available to customers through İşCep and the Commercial Internet Branch. In 2023, İş Bankası collaborated with its payment institution subsidiary MOKA to offer the prepaid card infrastructure of S-Wallet, a mobile wallet application developed for Samsung users in Türkiye. Thanks to integrating İş Bankası prepaid card APIs into Moka, Samsung digital wallet users can now make contactless payments using their smartwatches and smartphones and quickly load money into their mobile wallets for secure purchases online and in stores, both domestically and abroad. Moka started negotiations regarding its merger with "Birleşik Ödeme Hizmetleri," one of the subsidiaries of Oyak Group, to evaluate the synergy and growth opportunities at home and abroad at the end of 2023. Moka has increased its monthly business volume through new business partnerships this year and now ranks 3rd in the payment institutions market based on POS volume. **Figure 11** illustrates Moka's financial performance. Following its acquisition by İş Bankası, total assets increased from 119 million TL to 1.385 million TL. Additionally, its equity more than doubled, and the return on average equity dramatically rose from 5 to 68% over the last 2 years. To summarize, this acquisition offers significant benefits for both parties in terms of target customers and enhancing their position in the market.

Case 3: Fibabank – Finberg.

Collaboration Mode	**Invest/Joint Venture**
Incumbent	Fibabank
Fintech Firm	Finberg
Product vertical	Financial management; Investment

Established as a subsidiary of Fiba Group on December 27, 2010, Fibabanka, a medium-sized dynamic bank, has made significant strides in the Turkish finance industry. The bank is dedicated to providing agile solutions, focusing on personalized customer service, adhering to the motto "Agile thinking, agile solutions." Fibabanka aims to become a technology company with a banking license, transforming its financial services into an end-to-end digital experience. In parallel with this strategy, Fibabank launched the first "Investment and Financial Technology Initiative," known as "Finberg," in 2018 to revolutionize entrepreneurship in the Turkish banking sector.

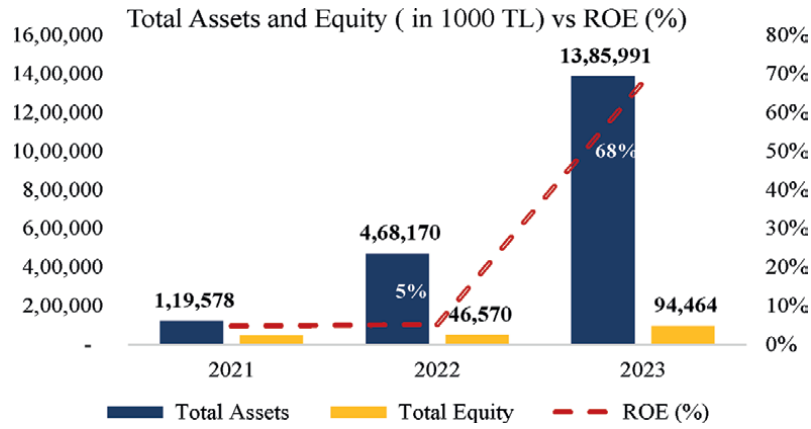


Figure 11.
Moka's financial performance.

The primary purpose of Finberg's establishment is to provide classic banking products and offer new products that combine financial services and technology. These technological products will help Finberg reach new customers, better understand existing bank customers, and provide them with the most suitable products and services. It aims to eliminate difficulties in accessing customer information and incorrect information in traditional banking products, while minimizing high costs and time losses associated with providing products and services.

In 2018, Finberg supported "Bizim Hesap A.Ş.," which offers an online pre-accounting reporting program, and Garaj Sepeti, which connects auto dealerships and expertise companies on a digital platform. Furthermore, it invested both in "Birleşik Ödeme Hizmetleri A.Ş." which has a license for payment services and e-money, and in the venture capital fund Revo Capital Fund I BV, which invests in startup companies operating in the field of financial technology, especially in the fields of information services, communication, and payment systems.

In 2019, Finberg funded two strategic initiatives. ComPay Ödeme Çözümleri A.Ş. ("Compay"), a payment system platform in which Finberg has invested, expanded the bank's on-site loan application service to small-scale business partners and implemented a similar model at many key locations. Bizim Hesap A.Ş., one of Finberg's first investments, attracted the attention of various investors in 2019 due to its stable growth and received an investment from n11.com. Birleşik Ödeme Hizmetleri A.Ş. collaborated with Fibabanka in 2018 to introduce innovative practices, including "loan collection from stores." In the last quarter of 2019, the company was added to Finberg's investment portfolio.

In 2020, the fund size was increased from 15 million TL to 15 million USD. The most significant investment agreement made by Finberg is with "Getir Perakende Lojistik A.Ş." for the Getir Application. Finberg joined Garaj Sepeti's new 1.5 million USD investment round, which grew 12 times in 1 year, reaching a volume of 100 million TL. This helped expand access to financial products for Garaj Sepeti and its dealers while indirectly benefiting the automotive industry, especially the second-hand car market. Finberg invested in ComPay, a payment platform that facilitated the distribution of 20 products from 12 banks to 2200 sales points across the country. ComPay's turnover increased ninefold in 2020, further expanding its network. Finberg invested in Figopara to provide services to SMEs by combining Figopara's

invoice financing experience with Fibabanka's products. Finally, in 2020, Finberg made its first investment exit with the sale of "Birleşik Ödeme Hizmetleri A.Ş." to Oyak Holding A.Ş. after attracting significant attention due to its rapid growth.

Finberg invested USD 34 million in 14 startups and increased its fund size to USD 130 million in 2021. In 2021, Finberg made nine investments and expanded its international presence. It led to transferring information from abroad to Türkiye through successful investments in companies such as Invstr, Plum, and Bits of Stock. Additionally, it reinforced its fund-of-funds approach by investing in the Revo II fund following its investment in the Revo I fund. "Getir", developed by "Getir Perakende Lojistik A.Ş.," is on track to become Türkiye's second decacorn, hitting a valuation of USD 7.56 billion in the latest investment round, marking Finberg's most prominent investment deal. The second exit happened when Mexico-based Kavak Intermediate Holding acquired Garaj Sepeti and its dealers, an investment initially funded by Fibabanka and made by Finberg. Finberg, which closely follows blockchain and cryptocurrency technology, made its first investment in this field with BiAltın, Türkiye's first cryptocurrency platform that offers cryptocurrency equivalent to 1 gram of gold and is implemented with 100 percent Turkish partners. Moreover, Finberg invested in Easycep, Figopara, Mobilet, and Colendi. In 2022, Finberg invested in 23 new ventures across fintech, retail tech, cybersecurity, e-commerce, and investment funds, totaling 41 investments and USD 51 million. Finberg aims to exceed a fund size of USD 150 million by the end of 2022, with 31 active venture investments and 7 fund investments.

Since its inception, Finberg has invested around USD 67 million. As of the end of 2023, its total investment had reached USD 110 million, comprising 55 investments, including those it had exited. Currently, Finberg manages over USD 71 million in assets. It has successfully exited 6 venture investments and has a portfolio of 39 active ventures and 10 venture capital fund investments. Finberg has achieved a significant milestone in its transformation journey by effectively concluding its investments in all startups between 2018 and 2019. This marks a noteworthy accomplishment for the organization.

Figure 12 illustrates that the total amount and number of investments almost doubled and tripled between 2021 and 2023.

Case 4: Albaraka – Garaj.

Collaboration Type	**Incubation**
Incumbent	Albaraka Türk
Fintech Firm	Albaraka Garaj
Product vertical	AI; SaaS; Payment; Blockchain; IoT

Albaraka Türk, established in 1984, was the first participation bank in Türkiye and the only one traded on the Borsa Istanbul. It operates under Banking Law No. 5411, pioneering interest-free banking in the country through a collaboration between Al Baraka Group, the Islamic Development Bank, and a domestic industrial group. Albaraka Türk is a global participation bank offering practical, fast, and seamless banking services to 2.5 million customers through 223 domestic branches, two international branches, and alternative distribution channels, with a team of 2723 employees. Albaraka Türk had an outstanding year in 2023, achieving a total profit of TL 3.4 billion. The company also experienced an impressive 58.7% increase in total

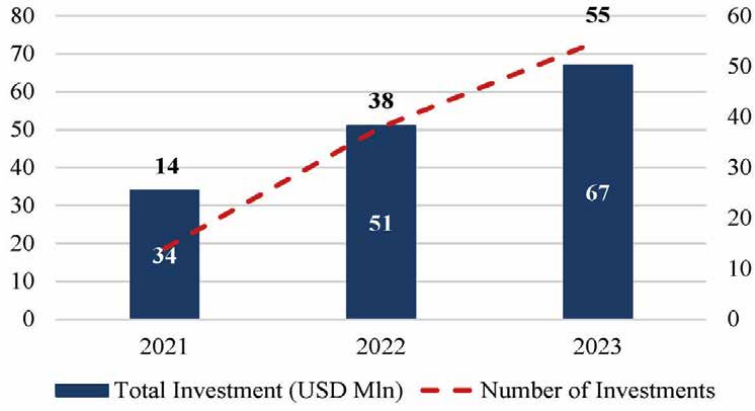


Figure 12.
Finberg investments with numbers.

assets, achieving significant growth with a 44.6% increase in total funded credits and a 43.6% rise in funds collected. According to the 2017 annual report prepared by Albaraka Türk, banks are integrating innovation into business processes and focusing on digitization. There will be differentiation among branches and changes in business models in response to developments such as mobility and the Internet of Things (IoT). Albaraka Türk will prioritize digitization and personalization by customer segment in the coming years, aiming to bolster its leadership position through digital transformation. As part of our strategic initiative, we took a significant step forward by establishing Albaraka Garaj in 2017. This pioneering move marked the launch of the world's first startup accelerator by a bank that participates in the industry. Albaraka Türk aims to become a leader in innovation and entrepreneurship within the financial industry. During 2017, 455 applications from across the country were carefully assessed, and Albaraka Garaj's first entrepreneurs were selected. The center offers a comprehensive range of services to entrepreneurs with finance-based business ideas and innovative projects, all under one roof. Albaraka Garaj offers entrepreneurs an acceleration program, seed capital assistance, mentoring, office space, and opportunities to develop projects within the ank to test their products. The bank utilized Albaraka Garaj to leverage the energy and talent of the startup community. This initiative led to discussions among employees on emerging technologies, including chatbots, artificial intelligence, machine learning, and blockchain. As a result, various bank departments and enterprises collaborated on joint projects with the help of Albaraka Garaj. In 2018, Proof of Concept (POC) studies were performed with seven first-round applicants at Albaraka Garage, and the bank acquired the products of four others. The bank has rapidly extended the culture of collaboration with entrepreneurs. In 2018, 500 entrepreneurs from 50 cities applied to the startup acceleration center Albaraka Garaj, and 11 additional startups were accepted. Several startups within the Garage have been incorporated into the Albaraka Venture Capital Fund, established by Albaraka to provide them with financing. Furthermore, through a partnership with one of the supported startups, it is now feasible to conduct transactions at bank counters by capturing a customer's biometric signature on a tablet PC, eliminating the need for printed bank receipts. In 2019, POC studies were conducted with five second-round entrepreneurs at Albaraka Garage. Albaraka Türk acquired two products to enhance collaboration with entrepreneurs. The Albaraka

Garaj program underwent some changes based on the experiences from the first two rounds. A two-month pre-acceleration phase was introduced before the actual acceleration program. The program received nearly 800 applications for the third round, marking the highest application rate to date. After including 22 startups in the pre-acceleration program, the bank accepted 14 startups into its acceleration program following the final round of eliminations. After a surge in startup activity prompted by Albaraka Garaj, the Bank established the Fintech Venture Capital Investment Fund to create partnerships with talented entrepreneurs interested in learning more about the bank. Investment decisions were made for four initiatives within the Fund, totaling TL 3 million. These initiatives include Inooster (a gamification platform), Pedudi (an educational technologies initiative), Tam Entegre (a SaaS solution for e-commerce sites), and Kronnika (a robotic process automation solution).

Albaraka Garage Startup Acceleration Center completed its 2021 program entirely online. In 2021, the center introduced a preliminary program to examine initiatives and maximize their growth closely. Albaraka Türk aims to contribute to the Turkish economy and entrepreneurship ecosystem. As one of the few implementing organizations in Türkiye under the TÜBİTAK 1512 Individual Young Initiative Program (BİGG), they conduct projects and Garaj programs. Within the scope of the TÜBİTAK BİGG Program, applications were evaluated based on specific criteria, and business plans were prepared following entrepreneurship training and mentorship. Startups approved by TÜBİTAK for a grant of TL 200,000 are offered participation in a preliminary acceleration program by Albaraka Türk, providing end-to-end support from idea to investment and backing for initiatives in the Minimum Viable Product (MVP) or commercialization stage. In 2023, many applications were received in the fields of SaaS, Social Enterprise, AI, Edutech, and FinTech. After a rigorous selection process, 24 startups were accepted into the pre-accelerator program based on their alignment with Albaraka's strategic goals, the team's experience, market viability, and the maturity level of the startup. "Gokido," a startup incubated at Albaraka Garaj, is dedicated to developing smart canes for visually impaired children. In collaboration with Albaraka Türk, the team organized events in Adana, Gaziantep, and Hatay, providing 75 smart canes to visually impaired earthquake survivors in these affected cities. Since its establishment, Albaraka Garaj has supported over 120 startups with financial aid and will continue contributing to the intellectual capital of Albaraka Türk and the entrepreneurial world.

Figure 13 shows the application distribution and success rate at Albaraka Garaj from 2017 to 2023.

During the initial 3 years, the number of applications rose; however, the success rates remained consistent at 2%. After 2019, the success rate increased by introducing a two-month pre-acceleration phase before the official acceleration program and targeting experienced individuals from related industries. This strategic move not only improved the success rate but also enhanced the alignment between startups and the bank, demonstrating the program's adaptability and forward-thinking approach.

Case 5: Garanti Bankası – Logo.

Collaboration Type	**Alliance**
Incumbent	Garanti BBVA
Fintech Firm	Logo Yazılım
Product vertical	Enterprise Resource Planning (ERP) Software

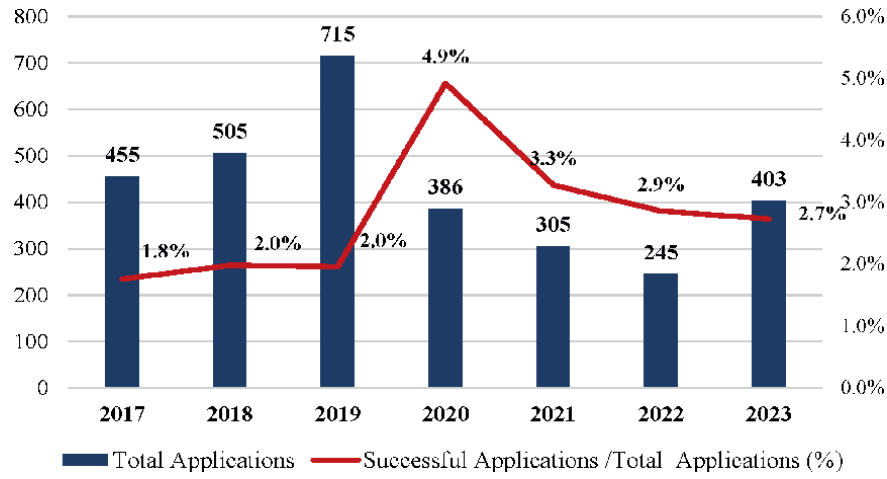


Figure 13.
Applications made to Albaraka Garaj center.

Established in 1946 in the capital city of Ankara, Garanti BBVA is Türkiye's second-largest privately owned bank. As of December 31, 2023, the bank's consolidated assets totaled 2.2 trillion TL. Garanti BBVA is a comprehensive financial institution covering all banking industry aspects, catering to corporate, commercial, SME, individual, private, and investment banking. Additionally, they offer a wide range of services, including payment systems, private pension and life insurance, financial leasing, factoring, and investment and banking services. Beyond that, they have international subsidiaries in the Netherlands and Romania. Garanti BBVA is an integrated financial services group with specialized subsidiaries in portfolio management, making it a complete solution for all financial needs.

Garanti BBVA subsidiaries recognized a need for a comprehensive system to streamline their business processes. This is why they collaborated with "Logo Yazılım" to address their needs. Established in 1984 to create software applications for personal computers, Logo Yazılım has become one of Türkiye's most prominent and influential software companies. Through its diverse range of solutions, services, and innovative offerings, Logo has solidified its position as the leading innovator in Türkiye's thriving software industry.

Garanti BBVA sought a web-based ERP solution to manage its resources centrally, drive operational improvements, and facilitate faster access to data from any location. Additionally, it aimed to efficiently onboard new subsidiaries and transition to a flexible system that could adapt to its evolving business needs.

Throughout the project, the Logo digital transformation services team thoroughly assessed the structure of the current parts and identified the specific needs, particularly in sales, purchasing, and finance, for the transition to the new structure [17]. Following the analysis phase, the components were automated, and swift installations were carried out, resulting in a more precise organization and presentation of data. Moreover, integrating e-invoice, e-archive, and e-ledger applications, integral to Logo's e-transformation solutions for the digital transformation process, was successful.

The tangible outcomes and the advantages obtained from the project [17]:

- Following the implementation of the Logo j-Platform project, Garanti BBVA successfully streamlined the centralized management of its subsidiaries' basic

requirements, resulting in improved operational efficiency. This initiative also led to enhancements in sales, purchasing, and finance processes, alongside the digitization of various business operations.

- Garanti BBVA's projects, considered the first in their field, were achieved by providing solutions appropriate to the needs.

- The automatic transfer of banking transactions of Garanti BBVA subsidiaries to the Logo j-Platform solution was carried out with standard file format compatibility.

- Thanks to the successful integration of e-transformation solutions, gains in digitalization, efficiency, optimization, rapid adaptation to regulatory changes, process management, and cost savings in business processes were achieved.

Upon the successful conclusion of this project, the key manager at Garanti BBVA provided the following assessments relating to the collaboration: "*As Garanti BBVA, we have been using j-Platform, one of Logo ERP solutions, for a long time in nearly 10 of our subsidiaries. In addition to ERP solutions, we prefer Logo products in e-Transformation solutions. In the software industry, the quality of the solutions offered and the strength, reliability, and speed of support of the companies offering these solutions come to the fore. We also feel the power of Logo Yazılım, which understands the needs of our subsidiaries correctly and provides quality solutions in the required time in the maintenance and support processes*" [17].

6. Conclusion

Since the financial crisis of 2008, the financial services sector has been gradually changing. Technological innovations have brought new business models, applications, processes, products, and financial services. As traditional financial institutions strive to adapt to the digital landscape, it is evident that a new wave of disruptive players, fintech firms, quickly integrated technological innovations, and challenged incumbent banks. These Fintech firms are reshaping the financial landscape by offering micro-segmented products and prioritizing enhanced customer experiences. Due to its implications, examining the FinTech phenomenon, including its evolution, critical business models, and components of the fintech ecosystem, has become relevant. Fintech has facilitated the digitalization of both developed and emerging economies. In doing so, Fintech firms have contributed to expanding financial inclusion by providing services to underbanked populations. Additionally, the evolution of the FinTech industry indicates that it has become a global issue deserving of attention.

The study examines the current state of the Turkish fintech sector, highlighting its fundamental dynamics and the essential regulations that contribute to its growth. With a dynamic and tech-savvy young population demonstrating high internet and smartphone usage rates and the establishment of the Istanbul Fintech Center aimed at accelerating the growth of fintech solutions in sustainable finance, Türkiye has significant potential for developing the fintech sector and attracting foreign investors. In the latter part, a thorough examination of the threats posed by fintech firms to traditional banks and the strategic reactions of incumbents is provided. The collaboration

models between fintech firms and traditional banks, along with the motivations of both parties, are described based on the innovation management strategy. After conducting exploratory, collaborative case studies at the global level, similar research methods were applied to the Turkish cases for in-depth analysis. Each case study has unique internal dynamics; however, the common goal of these collaborations is to obtain strategic advantages and benefits for all involved parties. When examining collaborative efforts between Turkish banks and fintech companies, it becomes evident that most partnerships are centered around the payment segment. Like in the global fintech landscape, the payment segment is prominent in Türkiye's fintech sector. As a result, traditional banks form strategic partnerships with these companies to leverage their innovations and align with their business models. In Türkiye, traditional banks hold significant positions in the financial sector, while fintech companies are still expanding to challenge the incumbents. With the recent authorization of digital banks in 2022 and the imminent emergence of peer-to-peer lending platforms, these fintech firms will be poised to become formidable competitors to traditional banks by offering a wide range of banking products and services.

This study offers valuable insights for investors, bankers, and policymakers navigating Türkiye's evolving fintech ecosystem. The case studies illustrate how traditional banks—tiny and medium-sized institutions—can form strategic partnerships with fintech companies to stay competitive in a fast-changing digital landscape. For larger banks, the findings underscore the need for careful segmentation analysis before investing or building fintech subsidiaries. Fintech investors may also draw lessons on potential exit strategies, while business owners can better plan ownership transfers or acquisitions based on proven collaboration models.

Türkiye's fintech success is primarily driven by its youthful, tech-savvy population, widespread smartphone use, and strong banking infrastructure. However, several structural challenges remain. Access to early-stage capital is limited, regulatory processes are often complex, and alignment with international standards, especially for cross-border operations, lags behind. Compared to other upper-middle-income countries, Türkiye demonstrates strong domestic adoption. Still, it lags behind fintech leaders such as the UAE in regulatory agility, Brazil in venture capital access, and Poland in cross-border integration.

To maintain growth and global competitiveness, future priorities should include advancing open banking implementation, strengthening cybersecurity regulations, and enhancing cross-border scalability through clearer and more streamlined regulations. Encouraging further collaboration between banks and fintech startups will also be critical in unlocking innovation.

This study is limited by its reliance on secondary data sources, such as annual reports and publicly available documents. Future research would benefit from primary data collection through structured or semi-structured interviews with representatives from both banks and fintech companies. Additionally, exploring partnerships between fintechs and non-banking financial institutions, such as insurance firms and venture capital funds, would offer a broader understanding of the ecosystem. Ultimately, adopting the fintech firm's perspective in future studies could offer a more nuanced view of the collaboration dynamics and strategic motivations involved.

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Author details

Abdul Baghi Nabiyev[1]* and Gokhan Ovenc[2]

1 Faculty of Economics, Istanbul University, Fatih, Istanbul, Türkiye

2 Department of Management Information Systems, Faculty of Economics, Istanbul University, Fatih, Istanbul, Türkiye

*Address all correspondence to: abdulbaghi.nabiyev@ogr.iu.edu.tr

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Chapter 8

Perspective Chapter: Banks, Payments, and Wallets – Who Will Lead the Future of Digital Transactions?

Anna Omarini

Abstract

Digital wallets are a phenomenon that has been growing in our society for some time and evolving at a fast pace. There are many species of digital wallets; some of them serve as a secure holder of debit and credit card information, while others enable users to maintain deposits, complete peer-to-peer transactions, and access broader financial services, or hold many of these functionalities. Their versatility is pushing the total number of digital wallet users to increase and leading them to a great percentage of the global population using them in the near future. The payments landscape has evolved significantly with the introduction of mobile wallets. The European Union (EU) has taken steps to recognize that mobile wallets are part of the payments system, and other jurisdictions are looking to do the same, such as Australia. They are a dynamic and evolving innovation with important impacts on banking and financial services. Many players are crowding the market, and this innovation is becoming more and more transformative; thus, it plays the role of a facilitative vehicle for several initiatives in the market by moving beyond payments. This conceptual chapter aims to provide a big picture of this phenomenon, also highlighting the role banks can play in it by taking a conceptual perspective.

Keywords: digital wallet, mobile wallet, e-wallet, payments, cards, ecosystem

1. Introduction

The payments industry is undertaking a set of multiple innovations and transformations in both the methods, tools, infrastructures, and players. Indeed, payment is one of the most disrupted financial services markets, with profit pools expected to shift across the value chain.

For many years, banks have played a major role in the industry, often considering payments a Cinderella business compared to lending and investments. Fintech startups, high-tech firms, and mobile network operators have started challenging their status quo by introducing innovative propositions in the market with material impacts on the role banks have played so far.

At present, the incumbent banking system is looking at payments with different eyes to catch up to a silent disintermediation due to several players that have been entering this business arena for several years.

Parallel to this, payment systems in terms of infrastructures and tools for more efficient transactions, both online and offline, are becoming more and more crucial for a well-functioning economy. Consumers are more and more in favor of digital payments over paper and coins, and noncash transactions are surging.

In 2023, noncash transaction volumes worldwide increased substantially, and this is also supposed to happen in the next year to come [1], even though some recent statements coming from the Central Bank of Sweden as well as the Norwegian Parliament are both taking some new perspectives on the need to let people always be able to pay for food, healthcare, and medicines both digitally and with cash. This also comes from the increasingly turbulent global situation; the increased cyberattacks and the major power outages that occurred recently are all showing the importance of being able to make payments even when the internet is down. All of the above highlights the need for a more correct balance approach of digital and cash transactions.

Innovations and new value propositions are increasing in the market to meet new requests from both consumers and businesses. In particular, payments are driven by the need to improve fluidity, certainty, and security in the execution of transactions, which means increasing efficiency, reducing the time and costs of execution, and finally improving the user experience (UX) for both actors: the payer and the payee. Sometimes, new payment systems emerge in the market; other times, there are traditional payment instruments that are adapting themselves to new requests to differentiate experience and evolve their use cases in the market. In the latest group of innovations, mobile payments and digital wallets are emerging and becoming increasingly capable of both contactless and remote payments.

For many players, namely incumbents, a strategic shift is fundamental to keeping competitiveness and driving long-term profitable growth in this business. Behind it, there is also the renewed interest in payments because they are valuable for data on transactions.

It is worth underlining that payments generate roughly 90% of banks' useful customer data [2]—information about who is buying what, how much, and when. All of this offers interesting insights into the behavior of individuals, and they are a valuable ingredient in big data applications.

This is creating new revenue streams for payments businesses that can monetize that data, yet it also exposes them to issues and risks related to data privacy and data protection laws, as well as data governance; all of them are becoming crucial to keep trust in all the alternative noncash transactions and their related ecosystems. This is because data allows for targeted marketing, price differentiation, and other initiatives in the market.

The choices for customers on their ways to pay and receive money are increasing consistently. In addition to the traditional payment tools, such as direct debit, credit transfers, cards (debit and credit), and checks, a new set of schemes of payments is emerging in the market under the umbrella term of alternative payment methods (APMs), within which digital and mobile wallets represent one of the innovations with the highest potential for growth in the consumer-to-business segment. Digital and mobile wallets are gaining popularity and adoption across many countries.

The APMs category refers to any form of payment that is not cash or a major international credit card brand. The rationale behind it is that payments are becoming more and more seamless and invisible in the customer journey—fostered by technology.

The act of making a payment will become instantaneous, even disappear, as payment functionality becomes embedded in many individuals' everyday situations.

Payment transaction itself becomes a commodity; this gives back a perspective where if this is recognizable then payments become a means to another company's end-user experience, and value-added services, which will offer the company a key element for differentiators that is monetizable. This means payments will be used as a boost to enter other revenue pools and develop innovative business models for both the retail and merchant businesses.

It is also worth outlining that payment is an "industrial" business of scale where technology plays a major role and where differentiation requires strong investments—scale being a key driver for cost-position effectiveness on information technology (IT) infrastructures, as well as research and development (R&D) investments in technology.

This conceptual and perspective chapter aims to highlight the wallet phenomenon from different points of view (typologies, actors, business models, and future trends). In doing this, the perspective is that of incumbents and the way they might consider these wallets from a strategic point of view. Digital wallets, besides being payment solutions, are an interesting channel for developing bank-customer relationships, as will be highlighted in this chapter.

The chapter is structured as follows: paragraph 2 (and related subparagraphs 2.1, 2.2, 2.3, and 2.4) will be devoted to starting a deep dive into some definitions, challenges, and difficulties to their adoption and classification so as to move toward outlining the benefits for customers in using wallets in their payments and describe some features of the market competition.

Paragraph 3 (and the related subparagraph 3.1) will highlight the value proposition perspective of digital wallets by taking a bank's strategic perspective.

Paragraph 4 is going to summarize the major conclusions and delve into some critical reflections on the topic.

2. The digital and mobile wallets: Setting the scene

The common factor for digital and mobile wallets is their suitability to store something and their digital format. The wallet securely stores virtual versions of debit and credit cards, so an individual does not need to enter his/her card details or carry a physical card to pay. They are used to make purchases online, in-store, or on the go. They can also store loyalty memberships, reward cards, payment information, and passwords in the cloud and be accessible from a computer, and much more [3–5].

It not only lets the holder add cards to use other devices such as smartwatches but also use online accounts in stores, online, or through apps used through application programming interfaces (APIs) [6].

From a business point of view, they are digital platforms where a wide range of services, suppliers, and business partners can provide a wider range of services to the users. They can also store other sets of information, such as digital verification (driver's licenses and government IDs); digital access, such as keys for cars, hotels, etc.; transportation passes or tickets; event tickets; boarding passes; rewards cards; and gift coupons.

A digital wallet is also known as an e-wallet. Nevertheless, the terms "digital wallet" (or "e-wallet") and "mobile wallet" should not be confused. A mobile wallet is available exclusively through an app on the mobile device (such as PayPal, Google Pay, and Venmo); some of them also come preinstalled on devices—such as Apple Wallet,

Google Wallet, and Samsung Wallet. A digital wallet is accessible on both a personal computer and a smartphone. Nonetheless, today the two terms are often used interchangeably, since online purchases are performed mostly on mobile and adoption is growing, specifically due to the convenience of not carrying around a physical wallet.

These wallets are becoming more and more the channel of choice worldwide because they are a kind of technology able to be embedded into people's everyday lifestyles. They have the power to change it, just like other disruptive inventions, such as smartphones, over the last decade.

To grasp why the popularity of digital wallets has grown, it is important to understand how they started.

Digital wallets have been part of the payment landscape since the late 1990s, when PayPal made storing card credentials online possible for frequent eBay customers. Then it became independent in 2015. Born in the U.S., it received the license to operate in Europe in 2009. PayPal, being the biggest digital wallet in the world, functions in a wide range of countries, and it accepts payments in more than 20 currencies. Its services include mobile payments, online payments, and in-store payments. PayPal is positioning itself as a trusted and secure payment option for both consumers and merchants. Its leading position is also reinforced by its policy of continuous innovation; indeed, it has been expanding its services to include features such as peer-to-peer payments, subscription services, and small business loans. Recently, PayPal bought Venmo, which is a digital wallet that allows users the functionality of sending and receiving money, splitting expenses with friends, and making online purchases.

Over time, new players (in 2006, Google launched its wallet—Google Pay—and in 2014, Apple started its Apple Pay) have joined the industry, and technological progress has been made so that the digital wallet era has started kicking off initially among the youngsters and later on among other generations of users.

Apple Pay is the second player that has been developed by Apple, and its strength lies in the way it allows users to make payments using their iPhone, iPad, or Apple Watch. The strategy that made Apple Pay able to compete with PayPal is its intrinsic linkage with Apple products and the overall Apple ecosystem, which is growing constantly.

In 2016, digital wallet transactions accounted for 8.6% of global noncash transactions [1]. This figure was driven by a few countries that are considered pioneers in adoption, such as China, India, and Sweden.

Consumers continue to warm up to using a digital wallet for payments [7], which estimates that digital wallets will account for 61% of e-commerce payments and 46% of point-of-sale payments worldwide by 2027.

It is also found that [7] the total number of digital wallet users will exceed 5.2 billion globally in 2026. This will lead to over 60% of the global population using digital wallets in 2026 [8].

At present, consumers have plenty of options when it comes to payment methods, either online or at the offline point of sale. Consumers' quest for convenience is the driver for the growth in wallet adoption, with much of the push coming from Generation Z and Millennials. They both crave frictionless experiences. In addition, acceptance is increasing in the market thanks to the availability of options such as Tap to Pay with iPhone technology, which eliminates the need for a dedicated terminal capable of accepting digital wallets.

The digital wallet ecosystem is quite peculiar since it is characterized by the presence of very different players belonging to different industries but all trying to compete in the same business arena, which can be summarized in terms of "being chosen by payers and payees." It is also interesting to note that non-similar companies

tend to develop singular digital wallet products, according to their capabilities and value propositions.

Digital wallets are very much connected with mobile technology, so telecommunication companies as well as mobile manufacturers have joined the industry.

Big names in the digital wallet industry are Big Techs and retailers. Big Techs, such as Google and Apple, mentioned before, are shaping their way into financial services through digital wallets. Strong in a large customer base, their competitive advantage is also represented by technological capabilities and the ability to answer people's growing demand to do everything with their smartphone. However, there are also retailers, on the other hand, that offer single-destination wallets with a spending circuit based on the acceptance network of payees. Highly popular in the United States is the case of Starbucks' digital wallet, which is a closed-loop app that allows payments through multiple nonbank card methods, including stored cash value or a Starbucks card.

In China, the online retail giant Alibaba, together with the fintech company Ant Group, instead ventured into digital wallets with Alipay and overtook PayPal as the largest mobile payments platform in the world in 2014. It is widely used in China, and it allows users to make payments, transfer money, and manage their finances. At present, another national competitor has entered the market, which makes Alipay stay behind; this is WeChat Pay. Because of the fast-growing phenomenon of digital wallets, both these players have created a new paradigm around "super-apps" as payment platforms.

Besides these big players, the market arena is becoming populated with many new players entering the market with innovative business models. So that the competitive framework of the digital wallets market is constantly evolving and growing.

There are also banks wishing to become protagonists of the digital wallet industry. Their participation has been mainly a consequence of the fear of losing relevance in the payment industry, as well as transaction fees, but overall, becoming irrelevant in everyday customers' lives.

Due to their lack of technological capabilities and app development not being part of their core business, banks have often opted for partnerships or acquisitions in order to compete in the digital wallets market. A successful example is Swish in Sweden, a joint venture of six Swedish banks and the Central Bank of Sweden, which entered the lives of more than half of Sweden's population.

Finally, there are the card issuers, in particular, who are working to become "top of wallet" at the point of sale with the digital wallets. However, because of the way consumers tend to use them—keeping fewer digital cards in their mobile wallets than they keep plastic cards in their physical wallets—the balance of power in the card business may shift in the market.

The last two players can also look for some partnerships with wallet businesses to create payment platforms with scale, such as the case of Standard Chartered Bank's venture with Toss, the largest payments company in South Korea, operated by Viva Republica [5].

2.1 Challenges and difficulties to their adoption

Convenience and ease-of-use standards alone are important factors, but they are not going to be the dominant selling points forever, because other payments will improve on the same point.

Furthermore, digital wallets' adoption has been slow due to diverse barriers and issues, such as security concerns and a lack of education on the subject, as well as a low degree of acceptance in the market. All of them need to be resolved.

More in detail, some difficulties in their adoption can be summarized as follows:

- Security issues are an issue, but consumers are concerned about the security of their financial information. They worry that someone might steal or jeopardize their personal information, causing them to suffer financial losses. Therefore, to protect the security of customers' financial information, it is essential to have secure encryption and authentication methods in place.

- The lack of uniformity across various mobile payment systems and digital wallets is another difficulty. There are numerous payment options available today, each with its own needs and protocol. This may cause difficulties for customers in selecting the appropriate payment option for their requirements.

- Limited adoption can also be a problem for the uptake of mobile payments and digital wallets. Even if digital wallets and mobile payments have become more common, not all merchants will accept them, and this can be a substantial barrier. To promote greater use, it is crucial to expand the acceptability of mobile payments and digital wallets among merchants.

- The regulatory restrictions are another obstacle to the use of mobile payments and digital wallets. The laws governing digital wallets and mobile payments are complicated and vary from nation to nation. Consequently, their international circularity can compromise their ability to compete in many markets.

  This is a relevant issue because when consumers are able to make cross-border transactions, they overwhelmingly prefer to leverage digital wallets. According to a recent report [9], across the four countries analyzed (U.K., U.S., Singapore, and Saudi Arabia), it is shown that consumers are 2.5 times as likely to cite digital wallets as their top choice as they are to cite the next-most popular picks, money transfer services and bank account transfers. Overall, more than 4 in 10 consumers said digital wallets were their favorite method. In particular, consumers in the U.S. lead in their adoption of digital wallets for cross-border payments, with 44% citing this as their most preferred method. Singaporean consumers are least likely to be on this bandwagon, with just 27% citing digital wallets as their top choice for sending and receiving cross-border payments. In fact, Singapore was the only country surveyed in which consumers were more likely to choose a different payment method over digital wallets, as 37% cited bank accounts as their preferred option.

- Connectivity is necessary for mobile payments and digital wallets to function properly. Therefore, limited connectivity continues to be a major issue in many parts of the world. Mobile payments and digital wallets may not function properly in places with inadequate connectivity, rendering them unusable for users.

- The lack of confidence is another obstacle to their adoptio. This is because some consumers may still be hesitant to use mobile payments or digital wallets because of security and fraud issues.

Because of the above points, there is a need for developing international standards and guidelines for mobile payments and digital wallets. This will help consumers

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to trust institutions and technologies regardless of where they are used. Regulators should also prioritize the security and privacy of consumers when regulating mobile payments and digital wallets. This includes ensuring that these technologies have robust security measures in place to protect users' personal and financial information and offer a more transparent set of information about their data collection and usage policies. This is related to the need for developing guidelines to protect consumers from fraud and other forms of abuse by requiring companies to provide clear and concise information to consumers about their rights and responsibilities when using these technologies. It is always a regulator's issue to be the one to encourage interoperability between different mobile payment and digital wallet systems under a framework of fair competition, which can lead to lower costs and better services for consumers.

Finally, digital wallets are also weaker on factors like customer support, and the major battle, besides improving customer services, at present, is to reward consumers and incentivize them to use one wallet over another. All of this will also drive the possibility of a consolidation in the industry, which will see the exit of some of the actors toward the dominance of a few world players.

2.2 Classifying wallets in the market: A proposal

Different players may develop different types of wallets designed to serve different purposes, depending on the needs and the end users.

Because of this, there are many criteria to classify them; however, looking at their purpose is one of the most insightful ones.

Based on the purpose, digital and mobile wallets can be classified as follows:

- Wallets are used to store cards. They hold virtual cards for temporary payments and are able to be loaded with funds from other cards, bank transfers, card cash, or through their mobile carrier. Making purchases, transferring money person-to-person, and paying bills can be done electronically online, in-app, or in-person via the contactless interface, via QR code, or via SMS on a feature phone. They can also be used for purchases both offline and online (for e-commerce). Examples are Apple Pay, Alipay, WeChat, Google Pay, Samsung Pay, PayPal, Revolut, Venmo, M-Pesa wallet, Swish, etc.

Wallets such as Apple Pay and Google Pay are also examples of a pass-through digital wallet classification, which means that they act as the go-between in a traditional card transaction. The wallet is not involved in the mechanics of moving money, hence the term "pass-through." A pass-through wallet is a kind of proxy for a 'normal' credit or debit card purchase; the mechanics are largely the same. The critical difference is that the pass-through wallet creates a unique token for each transaction, so actual card details are never shared.

In the U.S., 74% of consumers have stored payment credentials or other information in at least one digital wallet. Brazil leads the field, with 84% of local consumers storing information in at least one digital wallet, and though France has the lowest adoption overall, two-thirds of consumers there have stored information in a wallet [10]:

- Wallets used to store loyalty schemes, gift cards, and bonuses, such as Stocard, but also Google Pay and Apple Wallet.

- Wallets used to store Digital Identity (DIWs) [11].

In this case, they are applications allowing the secure storage, management, and sharing of personal identification data, credentials, and other pieces of information, often called "attributes," relating to the owner of that virtual wallet. Digital identity wallets can exist in various forms, including mobile apps, browser extensions, or even dedicated hardware devices. They can hold different information, such as first and second names, addresses, birth dates and places, driver's licenses, credentials to access places (e.g., a sports facility), resources (e.g., public transport), certifications, and debit and credit cards, as well as digital currencies. A DIW can potentially contain any kind of digital content related to that individual. In that regard, DIW can feature functionalities similar to those of a Personal Information Management System (PIMS). An interesting example is the European Union (EU) Digital Identity Wallet project that will enable users to access online services, store and share digital documents, and create binding signatures.

- Wallets storing cryptocurrencies. They are called wallets because they are used similarly to a wallet, where an individual can put cash and cards in it. However, instead of holding these physical items, it stores the passkeys they use to sign for their cryptocurrency transactions and provides the interface that lets them access their cryptos. They allow the holder to store, send, and receive other digital currencies. Exodus is one of these wallets, from July 2023. It manages cryptocurrencies through the enhancement of the speed of transactions, ease of use, and flexible functionality. It supports more than 260 cryptocurrencies and Non-Financial Tokens (NFTs).

- The Internet of Things (IoT) wallets. They are embedded in several devices such as smartwatches, which can be used with virtual currencies or e-money. These wallets enable any transaction between one party and each of the IoT devices. Their specialty is that they eliminate manual inputs, as they directly interact with connected devices.

From this first classification based on the wallet's purpose, it is clear that many wallets are multipurpose; this is becoming crucial for them to increase their acceptance and circularity in the market. This also underlines the need for them not only to acquire payers/users and holders in general but also to retain them over a long-term horizon to gain traction in terms of data availability and future monetization.

Another useful criterion to classify wallets is the one that looks at them as business ecosystems, where many stakeholders cover different roles. In this situation, the keystone player is the owner of the platform that works for developing its model with the goal to increase the number of holders and the related individual utilization. Based on this business perspective, wallets can be classified as follows:

- Big Tech-centric model wallets (such as PayPal, Amazon Pay, Samsung Pay, Google Pay, etc.);

- Telco-centric model wallets (such as M-Pesa);

- FinTech-centric model wallets (such as Revolut); and

- Bank-centric model wallets, such as Zelle in the U.S.; Swish, launched in Sweden by a pool of banks and the cooperation of the Central National Bank; Wero, which is available in France, Germany, and Belgium; and Synch, which has been developed in Ireland by four major banks to build a shared mobile payment app that can handle every type of consumer payment—in-person retail, e-commerce, friends and family, and more—and offer an instant payment experience. And, in Scandinavia, the merger of two mobile payments companies received final regulatory approval in late 2022, where MobilePay, owned by Danske Bank but open to all institutions in Denmark and Finland, has been combined with Vipps, owned by a group of Norwegian banks, with the idea to establish a regional mobile payments company—Vipps MobilePay—as a "one Nordic mobile wallet."

The major goal for each keystone player is to enrich the platform with additional functionalities and make them work as multisided platforms (MSPs) [12], where monetization of the business is key for every business model to grow and prosper in the market. Therefore, they need to identify and remunerate value creators, such as content providers, and retain users within the wallet by offering value from the use of the platform (e.g., discounts, coupons, etc.), which can be able to monetize the transactions occurring through it. An interesting example is that of card-based mobile payments in mobile wallets.

Platforms may also get revenues from 'consumer attention' through advertising as well as licensing technological infrastructure (open APIs) [13]. Monetization of API-based value-added services, for example, could be delivered in collaboration with payment products and several service providers.

Because engaging the wallet's holders is the core of this business, digital and mobile wallets are becoming an interesting tool for the embedded finance phenomenon, which is the integration of financial and nonfinancial services into everyday life customer experience. The impact of embedded finance in digital wallets makes the wallet leverage its business structure—the platform—from which new services can be promoted and offered to the end users.

In this regard, users get access to multiple financial and nonfinancial services from a single platform and exploit different functionalities of the wallet, such as insurances, investments, loans, bonus points, etc.

This trend is also introducing another phenomenon, which is strictly related to it, that is called "wallet-as-a-service." Because wallets can be an interesting channel for developing new customer relationships, many players, namely merchants among them, may be willing to develop their own wallet and embed it in their user-journey value proposition. In this regard, customers continue injecting money and retaining it in the wallet, but not for a single purpose, as the funds can be employed for several different purposes and activities. All of them were carried out through the digital wallet.

Therefore, if looking at wallets just as pure payment channels, this can offer only a limited picture of the phenomenon, and this might marginalize banks in the payment-only service arena, not letting them consider the embedded market opportunity.

Another interesting criterion to classify wallets takes into consideration their market structure. Based on this, there are vertical versus horizontal wallets, as well as hybrid wallets.

- Vertical wallet. The wallet provider acts as the exclusive service provider. It designs, controls, and manages the mobile wallet and provides services for it. For example, a financial institution develops its own mobile wallet and provides all its financial services in the wallet. This type of wallet maximizes the control and brand value of the service provider, not being threatened by competition in providing services in the wallet. In this case, the wallet operates in a 'closed ecosystem' [14].

- Horizontal wallet. The mobile wallet provider aims to offer a wallet capable of integrating services from other service providers. The wallet provider aggregates services and drives mass-market adoption. It often offers design and management services for other service providers. This type of wallet maximizes the control and brand value of the wallet provider, giving visibility to the wallet provider and maximizing adoption due to the wide range of services offered by different providers. Most of the wallets are horizontal wallets.

- In between the two, there are varieties of hybrid wallets that combine the features of vertical and horizontal wallets. The extent to which the two approaches are combined depends on the degree of openness and control the wallet provider wishes to retain over its solution. This option is defined as "open ecosystem" [15].

All of these wallets can also be classified into closed-loop versus open-loop wallets according to the degree of openness in terms of circularity and their magnitude to be accepted in the market. The closed wallets are designed for use with a single merchant or brand. They function like a store-specific prepaid account. Funds are loaded into the wallet, and they allow customers and users to make transactions and payments through apps and websites, exclusively within the issuer's range of services and products. This may affect the number of merchants and counterparties available to accept them. Their goal is to create strong relationships between the service provider and the customer to increase loyalty. The drawback is that these wallets have limited functionality because payments are efficient only if they are pretty universally accepted. Amazon Pay represents the perfect example of a closed kind of digital wallet; however, this type of wallet uses the massive customer base of Amazon.com and works by providing users with the option to pay with their Amazon accounts on external merchant websites. The payment on external websites is allowed exclusively using the payment methods stored in their Amazon accounts, and for this specific reason, it can be labeled as a closed digital wallet. However, the more the owner of the platform engages other counterparties, the more this limitation is perceived as a weakness to customers/buyers and payers. Other examples are Starbucks and WeChat Pay in China, where the system is based on smartphones and QR codes.

Then there are the open-loop wallets. In this case, the providers are usually third parties who offer wallets used freely by customers for any type of transaction to any service provider. These allow transferring funds and making online and in-store payments without any geographical restriction, and they can be used with any merchant supporting digital payments. The only rule is that both the sender and receiver of the transaction must have accounts on the app of the digital wallet. The most popular and widely used digital wallets currently on the market are Apple Pay, Google Pay, PayPal, Zelle, and Revolut. They allow subscribers to pay for purchases using whatever card and targeting whatever merchant. This inherent openness and flexibility are the main reasons why these wallets hold the biggest share of customers in this business arena.

This category of wallets, opposite to closed wallets, has the benefit of total flexibility, as anyone can be targeted by a payment made through these services. They offer flexibility and interoperability across different payment networks.

Finally, in between the two categories of wallets, there are the semi-closed-loop wallets, which are limited in terms of the coverage area of the allowed transactions, only within a defined network of participating merchants or service providers. To accept these types of payments, merchants must agree to a contract with the issuer of the wallet, and this mechanism usually leads to the creation of a closed network of merchants for each service provider. No one outside the network can receive transactions from customers. The upside of these wallets is the inherent security for the customer, created by the closed network. The downside, on the other hand, is again the limited functionality, as it is not open to everyone in terms of receiving transactions. These lay in between closed wallets, secure but not flexible, and open wallets, less secure but more functional and flexible. These wallets also allow peer-to-peer transfers, but only within the same wallet ecosystem. Semi-closed digital wallets can be exemplified by Bizum (a Spanish account-funded P2P and peer-to-merchant digital wallet), Venmo, and Paytm Wallet, which is an Indian-based wallet that has the largest number of subscribers. It is a semi-closed wallet as it allows a restricted number of transactions, based on the type of merchant the customer is dealing with; however, it has improved its usability as Indian travelers can use it in many popular destinations, including the United Arab Emirates (UAE), Singapore, France, Mauritius, Bhutan, and Nepal.

Another criterion to classify wallets is the one that classifies them according to the ways they are funded. Based on this, there are card-funded wallets, which are funded via a linked payment card or directly from a bank account. Therefore, there are:

- Card-funded wallets. They are when users add a debit, credit, or prepaid card to their wallet, and when the transaction takes place, it is processed over existing card rails and charged to the linked account, just as it would be with a physical card. They are Google Pay and Apple Pay.

- Account-funded wallets. They are connected directly to the user's bank account, removing the need to upload a card. Payments are processed via account-to-account (A2A) rails, bypassing card networks, which can reduce costs by avoiding their schemes and interchange fees. They are Revolut, Zing, Zelle, Paytm, and Bizum.

However, there are also card- and account-funded wallets such as PayPal and Alipay.

2.3 Benefits to holders

The most evident set of benefits that have come along with the advent of digital wallets is the following:

- They enhanced security. As previously mentioned, this can also be an issue for consumers. However, digital wallets use encryption technology and other security measures to protect payment information from fraud and unauthorized access. This aspect acted as a real value-added feature with respect to traditional payment services, which, being physical, used to have no defense strategy against security attacks. More recently, customers also see their security

enhanced by features such as two-factor authentication, encryption through a private software code, biometric authentication, and end-to-end encryption. These measures significantly reduce the risk of fraud compared to traditional payment methods.

- They offer convenience. With a digital wallet, the user can make payments quickly and easily without the need to carry cash or cards. Convenience turned out to be the most targeted benefit, as payments nowadays are so common that customers were seeking that speed and ease while performing a transaction.

- They grant availability. Some digital wallets allow the user to earn rewards or cashback for their purchases, making it a great way to save money. These options really work as attraction forces for those customers who want to save and who want to stick to a single provider. Loyalty represents an important component of customer satisfaction, and digital wallet providers are able to exploit it.

Moreover, digital wallets also work positively by improving financial services in underserved areas, such as the case of M-Pesa, launched in 2007 by Vodafone and Safaricom in Kenya and, at present, accepted in several other African countries, where transactions are made by mobile phone and through SMS-based transactions. Their availability, in fact, gives people more options for payment and commerce and improves financial inclusion. New wallets have enlarged the pool of services from which people can draw when they have to perform a transaction. They give the possibility to make payments in real-time, regardless of their location, and have facilitated peer-to-peer payments, making it easier for people to send and receive money.

2.4 The market framework: From regulation to competition

The global digital wallet market was valued at $1.39 trillion in 2020, and it is expected to reach $7.64 trillion by 2027, growing at a compound annual growth rate (CAGR) of 24.6% from 2021 to 2027 [16]. Due to the sudden growth of the market size, it has also grown to be a very competitive one, where players grow fast and compete to get their own market share.

In terms of regional analysis, the market for digital wallets is segmented geographically into North America, Europe, Asia-Pacific, and the rest of the world.

Asia-Pacific is the largest market for digital wallets, accounting for more than 40% of the global market share. This is primarily due to the large population in the region and the increasing adoption of smartphones.

Regulators are watching this trend in payment systems, as it can be crucial for a well-functioning economy. Because of the value in payment data, regulators are putting in place different data protection laws for any targeted marketing initiatives, as well as price discrimination tactics. Therefore, the market is regulated at the regional level, resulting in different regions abiding by different laws and regulatory authorities. The regional division of the market can be described using the different existing laws in some of these areas, such as the following ones.

- The Payment Services Directive 2 (PSD2) is a regulatory framework that governs the payment services in the European Union (EU). It requires digital wallet providers to comply with strict security standards and ask customers to possess strong customer authentication (SCA) for security in payments. The PSD2 also

allows chosen third-party providers to access customer account information, a trend that has ultimately led to the emergence of open banking and, consequently, to the birth of new services in payments, which could be strictly related to the evolving value propositions of both digital and mobile wallets.

- The Electronic Transactions Act in the United States establishes the legal framework for electronic signatures and records and provides guidance on how electronic transactions have to be carried out in the area.

- The Payment and Settlement System Act in India is the legal framework for payment systems and electronic funds transfers. It obliges digital wallet providers to obtain a license from the Reserve Bank of India and to comply with strict anti-money laundering (AML) and counter-terrorism financing (CTF) regulations.

- The Personal Information Protection Law in Japan regulates the management of personal customer information and requires digital wallet providers to ask for customer consent before collecting, using, or sharing their personal information. It also requires implementing security measures to protect customer data.

As noted above, there is no unique framework regulating the market for digital wallets, but there are commonalities among them. Actually, everyone is taking care of security and data protection, and they evolve consequently of the emergence of new technologies in the market and the growing number of transactions individuals are doing through them.

In this regard, it is worth mentioning the case of the Reserve Bank of Australia (RBA), which recognizes that each month, citizens are making over 500 million payments with mobile wallets worth over $20 billion. Therefore, the Australian Treasury has proposed far-reaching reforms that will widen the regulatory net to incorporate a new wave of products and services that are making a run in the digital economy. The aim is to amend the Payment Systems (Regulation) Act 1998 to update the definition of "payment" and "payments systems" to capture new methods [16], as the EU has done [17]. The Australian Banking Association also declares that the new legislation will give the RBA powers to regulate all players within the payments system, including Apple and Google, to create a level playing field with nonbank competitors. In fact, taking a closer look at the competition, the key players in the arena are PayPal, the leading provider of the service and in the e-commerce market in general, and Apple Pay.

3. The wallet value proposition: A strategic perspective for banks

The market for digital wallets is growing year by year. The reason why they are having such a huge success must lie in their business model. In fact, what really highlights the value added of digital wallets can be discovered by looking at their operability and customer treatment. This means pointing out how the business initiative creates, delivers, and increases value over time. In the specific case of wallets, the key components of value creation are many. The value proposition of digital wallets ranges from

- Customer retention and acquisition strategies. Often, wallet providers' customer base is created using a multichannel approach. Customers are acquired through

app stores, partnerships with banks and merchants, and more traditional methods such as word of mouth. Customer retention instead is gained using the technique of incentives and bonuses, such as discounts, cashback offers, or rewards.

- Transaction strategies providing revenues. Being tech-driven, wallets are a kind of platform business, and they work through network effects, which perfectly fits the payments core value proposition, which is that of being highly accepted. As the wallet counts more users' subscriptions and more transactions, revenues increase.

  At the same time, the strategy of the digital wallets' model works through a multichannel revenue stream. Several streams of revenue are present for a single digital wallet provider, such as transaction fees, merchant fees, subscription fees, premium accounts' fees, etc.

- Exploitation of partnerships. One of the main digital wallet's business model features is collaboration and partnership with several different merchants and service providers. Through these partnerships, wallet providers offer an efficient and convenient set of uses to consumers (which moves from payments to other value-added services) and so gain a part of the transaction. Wallets sometimes offer innovative services to customers, which provide additional value both to the customer and to the provider, such as loyalty programs (very common among digital wallets), cash and financial management tools, or various types of premiums and discounts.

- Use of data. Wallets' business model involves an extensive use of customer data. Their strategy consists of collecting customer transaction data or history and, under security regimes, aggregating the data to provide merchants with insights. This can translate into new sources of value and different revenues.

- Security regime. In a business model of the payment field, the pillar of security cannot be missed. Digital wallets strive to build a reputation for being secure and not subject to cyberattacks.

- Innovation and cost efficiency. Digital wallet business models revolve around the management of costs to be more efficient and convenient for the customer. Their focus on constant innovation helps maintain cost efficiency and the competitive advantage. The strategy is a race to the most innovative technology to be more competitive and to be up to customer expectations. Think of using IoT in the customer's user experience.

3.1 Mobile and digital wallets: Threat or opportunity?

Based on the above, the digital wallet market is mostly driven by nonbank-led digital wallets. At present, we observe that banks and other payment institutions are already involved in mobile wallet ecosystems by playing a set of multiple roles: they can be acquirers and issuers in the payment process, but also wallet and content providers. Notwithstanding, they should consider it strategically because they both manage customers' money; they are owners of payment infrastructures and services

already in place. Indeed, people highly trust banks to manage personal financial operations and have well-established security processes and systems in place to do it safely. Banks already hold customers' financial accounts and are established issuers of payment cards and other instruments, allowing them to obtain economies of scale and scope. However, to take full advantage of the opportunities, banks need to cope with factors such as time-to-market, speed of execution, and new security and authentication procedures in order to gain a deep understanding of the mobile environment.

At this point, the question is no longer whether wallets will become dominant, but how they will respond as that dominance takes hold and how banks can actively want to shape their role in this evolving payments ecosystem. This means starting by asking some of the following critical questions:

- Will banks continue to fund third-party wallet solutions?
- Will banks build or brand their own?
- Alternatively, will banks focus on infrastructure, data, and value-added services to keep their market centrality in their everyday customer life?

Because of all this, there are many different options and related business perspectives through which incumbents may decide to undertake or not this venture, moving from competition, collaboration, innovation, and adaptation, as from below. The most important starting point for a bank is to understand what the vision for digital wallets is. They can be considered:

1. A tool of a disruptive competition [18]. If this is the perspective, incumbents are facing disruptive threats from digital wallet providers, which offer convenient and user-friendly payment solutions, potentially challenging the dominance of traditional players. This is a passive situation, where incumbents simply may react in terms of adding on top of their core services a wallet produced by third-party providers to remain competitive and enhance customer experiences. This is a light involvement, where a bank decides to commercialize a third-party wallet.

2. An opportunity for collaboration with new players. Some incumbents have chosen to collaborate or form partnerships with digital wallet providers. They recognize the potential of digital wallets in enhancing their existing services or reaching new customer segments. By integrating with digital wallets, incumbents can offer their services within these platforms, expand their reach, and leverage the technology and user base of digital wallet providers. This is a solution to catch up to the competition with new players.

3. A context where coexistence and synergies can be reached [19]. This perspective suggests that incumbents and digital wallet providers can coexist and create synergies on the same platform. Incumbents may continue to provide traditional banking and payment services while incorporating digital wallets as an additional offering, but with a different strategic view. They can leverage their customer base, infrastructure, regulatory compliance, and expertise while adopting digital wallet features to enhance their services. This perspective is being embraced by many traditional players because of their choice of building in-house versus buying outside. Some incumbents prefer buying others' solutions rather than

> building them internally overall for economies of scale and scope reasons. This can be a route to collaborate with FinTechs. On the one hand, banks need these companies to exploit new technology and innovation to compete in the field of payments, and on the other hand, FinTechs need the collaboration with traditional players due to their lack of regulatory and compliance expertise and the infrastructure they would face acting alone.

This can also be read as a boost for innovation and adaptation for incumbents to stay relevant and be compelled to innovate and improve their services by incorporating features like digital wallets, mobile payments, contactless transactions, or any enhanced user experiences. This perspective emphasizes the importance of incumbents adapting to changing customer preferences and market dynamics.

Banks and payment institutions have the resources to gain a competitive advantage over some competitors in the mobile wallet space. Banks have payment infrastructures and services already in place. Indeed, people highly trust banks to manage personal financial operations and data and have well-established security processes and systems in place to do it. Banks already hold customers' financial accounts and are established issuers of payment cards and other instruments, allowing them to obtain economies of scale and scope. Such as in the case of U.S. banks that have worked with retailers to launch digital wallets and payment apps, but big tech dominates the digital wallet field.

The opportunities mentioned above offer a broad spectrum of propositions for banks to participate in the wallet business, acting as a service provider with a collaborative approach or selling it through their delivery channels. In the former case, the bank selects to provide some content or infrastructure for the mobile wallet released by a third-party provider (TPP) as a strategy to enter the market.

Broadly speaking, there are two strategic scenarios to assess, and the correct approach to each bank will depend on each one's vision, appetite for risk, investments, digital capabilities, and the specific expectations of their customer base.

Therefore, on the one hand, there is the scenario where banks and issuers, in general, continue to focus on embedding their existing card products—credit, debit, and charge—in third-party wallets. This situation ensures that banks maintain their relevance in the digital wallet space by providing the underlying payment rails. This is because, on the one hand, card funding remains in banks' hands, so that banks keep capturing transaction volumes without building new platforms. On the other hand, consumers benefit from the speed and convenience of wallets while keeping their card-linked rewards and protections. Under this situation, to remain competitive, banks need to prioritize push provisioning, improve user experience in adding cards to wallets in a few taps, and boost the likelihood of a card becoming the user's top-of-mind wallet choice.

On the other hand, there is the second scenario, where banks and issuers, in general, decide to build their own digital wallet solutions as card-funded, account-funded, or hybrid offerings. In this situation, banks have a natural advantage, which is customer trust because of their long-term customer relationships. There is also growth potential beyond the existing customer base. This is the case of the Indian ICICI Bank's Pockets wallet. This is available to both customers and noncustomers, enabling broader acquisition opportunities.

Under this scenario, there are also multiple options, such as the one for banks to explore collaborative wallets, as seen with Vipps in Norway or Zelle in the U.S. Whether these joint ventures will succeed, this can be a challenge.

In the past, there have also been examples of banks developing and commercializing proprietary vertical wallets; the amount of resources needed is significantly high.

The other opportunity is that of developing a proprietary horizontal wallet, which means that the bank develops its own mobile wallet but allows third parties to deliver content into it. This approach is based on the belief that consumer adoption will be driven by the extent to which the mobile wallet is enriched by third-party value-added services (VAS), which should be able to engage and create true value for customers.

However, both vertical and horizontal wallet solutions require banks to deploy relevant resources for development, launch, etc., and this requires the business to scale up significantly. Any bank's decision to look at entering this business arena should be driven by a systematic strategic assessment. **Table 1** analyzes benefits, drawbacks, and strategic reflections on the options presented above.

Strong interest in building a collaborative approach to mobile payments is not always a guarantee of success, however. Consider the U.K.'s Paym, which is shutting down. Paym

Strategic options:	Pros	Cons	Strategic reflections
Option 1: Third-party mobile wallet	• Limited efforts on resource perspective (e.g., no development costs) • Economies of scope: the bank can leverage some resources already in place (e.g., payment infrastructures, customer base, etc.) • Speed to market • Rich ecosystem with potential benefits such as external knowledge spillovers	• Lack of decision-making power within the wallet ecosystem • Low brand visibility • No direct relationship with users • Little possibility for differentiation	• Banks not willing to invest a high level of resources • Banks partnering with third-party providers with strong brand value and customer base (e.g., high-tech firms)
Option 2: Joint venture mobile wallet	• Potential synergy creation with partner (e.g., cost savings, availability of different core competencies) • Speed to market	• Complex setup and management of joint venture solution • Low brand visibility	• Banks able to find and partner up with noncompeting entities • Banks willing to be first movers in the market
Option 3: Proprietary vertical wallet	• Full control over technology, branding, and market penetration strategy • Cross-selling opportunities • Data flow control and ownership as a revenue stream and tool to gain valuable customer knowledge • Customer direct relationship and retention • Opportunity for differentiation • Brand visibility • Other advantages of platform ownership: network effects, scale advantage	• Creation of attractive and engaging content (VAS may be challenging to select) • Time and resource (e.g., high development costs) consuming • Agile organizational structure in place required, generally lacking in traditional FIs	• Banks with brand awareness and a customer base may leverage this option • Banks with a broad offering of services, having the capability of differentiated services • Banks with agile organizational structure and international footprint

Strategic options:	Pros	Cons	Strategic reflections
Option 4: Proprietary horizontal wallet	• Full control over technology, brand, and market penetration strategy • Highest revenue potential: new revenues from TTPs sharing their profit in exchange for the use of the platform and data flow control and ownership as a revenue stream and tool to gain valuable customer knowledge • Rich ecosystem with a wide range of VAS, while maintaining platform ownership and potential external knowledge spillovers • Customer direct relationship and retention • Opportunity for differentiation • Other advantages of platform ownership: network effects, scale advantage	• Time and resource (e.g., high development costs) consuming • Operational complexity, involving negotiations with other service providers • Risk of brand dilution	• Banks pursuing a strong digitalization strategy, aiming to be market leaders in the area—shapers of the industry • Banks willing to invest a high amount of resources with a forward-looking approach to develop a business ecosystem

Table 1.
A strategic assessment framework on the market-entry options for banks in the wallet business arena.

was a collaborative effort launched in 2014 in the U.K. More than a dozen U.K. banks and building societies took part, but now the partners plan to close it down by early March 2023. It was designed to be a common payments app among all of the participating financial institutions. It required little more than inputting a phone number to make a payment. It was supposed to become a ubiquitous payments app for the U.K., but over time, transaction volume fell, and the decision was made to close as fewer people signed up to use the service. This is due to a shift by U.K. consumers toward newer forms of mobile payment and access to faster payments through online banking. The paradox is that these changes have also come in consumer preferences built on the foundation created by Paym to offer ever faster and better ways to move money and support everyday lives [20].

Finally, the reality is made by many different business opportunities lying between the two scenarios mentioned above and within a variety of options.

This can be the case for Citi, which is bringing buy now, pay later to Apple Pay, enabling cardholders to split purchases into fixed monthly payments.

4. Conclusions and further reflections

Over time, the digital wallets industry has changed at a rapid pace, and in the next few years, it will evolve further [21]. The market trends reflect the evolution of the industry, driven by changing consumer behaviors, technological innovations, and global economic shifts. So that the industry can offer significant growth opportunities driven by technological advancements, emerging markets, and untapped potential.

Many companies can drive innovation, enhance their competitiveness, and secure long-term profitability by capitalizing on these opportunities.

The bigger boost will come from customers, who are already showing a high degree of satisfaction in using digital wallets. They recognize relevant features to them, such as easy to hold; lower risk of losing physical identity documents, cards, cash, etc.; convenient access; fast processing; low or no cost; ability to keep all identification documents in one place; widespread acceptance; ability to store and use personal identification documents; etc.

However, if, on the one hand, customers are boosting the industry, on the other hand, they are also reacting to the increasing competition among means of payment. This is because they can switch away easily from one to another payment opportunity, so that volumes in transactions may decrease on the one hand, and this may cause a critical issue to players, such as the case of Paym in the U.K. being closed in 2023. Additionally, sometimes it is the same industry that is boosting a fierce competition with the result that cannibalization is increasing consequently, because of an ever-evolving interoperability of means of payment.

A great challenge or a great opportunity will also come from the future of payments that is characterized by the ever-expanding and evolving mobile-first strategies; the increasing seamless and smart mobility solutions; the requests for more sustainable payment options; the more verticalized and personalized payment experiences; and the rise of Central Bank Digital Currencies (CBDCs). There are also other trends shaping the future of the industry, and they are the AI-powered security options and the voice-activated payments.

If in the past, most digital wallets have adopted similar business models, in the future, their evolution and expansion strategies will differ depending on their respective business ecosystems and on the ways they are going to develop fresh and new collaborative networks and ecosystem-driven business strategies.

In this regard, the market will also drive itself toward a consolidation of the industry that will decide the inclusion or exclusion of financial institutions from the competitive landscape.

Based on the above, there are some further critical reflections to highlight on the topic.

The first reflection takes us to consider the wallet as a pipeline, where there are funds moving inwards and funds moving outwards. The first ones rely on all the many noncash payment methods, which can fuel the pipeline. They are cards, bank transfers, direct debits, and checks. All of them are eligible ways a wallet can be recharged with money to spend. They all represent different rails (cards versus bank transfers' infrastructures), which can be impacted by the flows of funds (inwards and outwards) differently, and according to the way the competition is going to evolve in the wallet market (incumbents *versus* innovative players).

Then, once the wallet is loaded with its purchasing power, this money can be allocated to the many opportunities the platform, or the ecosystem-driven business model, offers to the holder. At this stage, the major business becomes one of keeping money in the platform. This requires the platform to evolve toward a business ecosystem (we refer to it as a type of horizontal wallet), where the more opportunities for spending and the several VAS bundled are offered to customers, the more they can stick to the wallet. All of this requires the customers to recharge their wallet more and more and, if offered, maintain their purchasing power in it. If all this happens, the money goes from the customer's digital wallet to the merchant's, and the banks are excluded from it. This is because digital wallet companies incentivize both parties to

keep the money in the wallet by offering them more advantages, discounts, cashback, etc. Besides all this, the wallet provider can rely on a large amount of liquidity useful for further business initiatives.

By losing both the customer and merchant experience in favor of the digital wallet provider, banks risk losing their margins from interchange fees, overdraft fees, acquiring fees, and interest rate spread, but overall, banks may become marginal players in their customers' everyday lives.

Some evidence from the market shows that if it is fundamental for banks to enter this business, venturing into it as a single bank is not a sustainable strategy in the end. That is why seeking and maintaining collaboration with other banks is essential. Cases such as Swish, developed by banks in partnership with many other players, are also able to offer Swish's customers all the technicalities needed to set up the payment solution integrated with the digital wallet in-store and online.

Understanding the importance of creating a bank network for bank-backed digital wallet solutions can be an interesting starting point. The collaboration of the most popular bank-backed e-wallets around Europe can be considered an interesting strategy to prevent other competitors from gaining traction. In fact, allowing each person to use the service abroad and transfers between foreign digital wallets could scale the customers' lock-in effects at the European level.

Under these circumstances, the wallet is charged with money moving among banks in the network, thanks to the account-to-account transfer, which can be a viable option for a sustainable bank-backed wallet's business model, among others.

This collaboration within banks in the form of distribution partners has resulted in advantages for the long-term success of the platform, giving new importance to value network and ecosystem building. This can be the case of the Nordic e-wallet experience (e.g., Swish and MobilePay).

This is also the case in the U.S., where banks such as Wells Fargo, JPMorgan Chase, and Bank of America are among the seven lenders backing the wallet, which will be run by the bank-owned venture behind P2P payments service Zelle [22]. Besides these banks, there are also Visa and Mastercard onboard so that the wallet is leveraging a large number of debit and credit cards available for use. All these examples show banks are reacting by taking on third-party players such as PayPal and Apple.

A recent example is that of the European Payments Initiative (EPI), which is a European player committed to offering a sovereign payment solution to all consumers in Europe. It is available in Belgium and in Germany, delivered by a group of banks. The first service is person-to-person transactions, but other functionalities will be added to it.

All of these initiatives find their rationale in the gradual erosion of banks' payments dominance, which is becoming increasingly costly to banks; this is the reason why banks have to consider their role in the evolving game of wallets by leveraging their consumers' trust. In this regard, digital wallets are becoming more and more a new distribution channel for banks to enhance their bank-customer relationship.

Trying to give a full picture of this game, it is also worth mentioning that even though there is a strong interest in building collaborative approaches to mobile payments, this is not always a guarantee of success. The U.K. Paym case, launched in 2014 by a group of banks and building societies, closed in 2023. However, there are many lessons learned. By taking a strategic perspective, it can be said that looking at the idea of a digital wallet partnership more broadly requires understanding each partner's interest, risk appetite, and resiliency, and the way the choice is selected for supporting the different structures behind the business model (cards versus bank transfers).

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A lot of thinking still needs to be done around each player's experience in the digital wallet game and what role they want to play within it. A major driver on top of this is business culture, which drives vision and strategy to develop the digital wallet business.

Author details

Anna Omarini
Bocconi University, Milan, Italy

*Address all correspondence to: anna.omarini@unibocconi.it

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Section 4

Retail and Financial Inclusion: Mobile, Rural and MSME Credit Models

Chapter 9

Mobile Payments Is the Future of Banking for Pakistani Generation Z: Navigating through UTAUT

Muhammad Hassaan, Asif Yaseen, Khawar Naheed and Sania Usman

Abstract

This empirical investigation explores the factors that influence Generation Z's use of mobile payment systems (MPS) through the Unified Theory of Acceptance and Use of Technology (UTAUT) framework. Specifically, it examines how various determinants impact MPS usage behavior among Gen Z. Furthermore, this study incorporates a Customer Financial Resources (CFR) construct to gain a deeper understanding of the phenomenon, providing valuable insights into the complex dynamics of MPS adoption. This study employed Partial Least Squares Structural Equation Modeling (PLS-SEM) to investigate the UTAUT model's applicability in explaining Mobile Payment System (MPS) adoption. The analysis was based on a sample of 310 Gen Z respondents, who were selected using convenience sampling, allowing for an in-depth examination of the relationships between the variables. Within the context of the Pakistani banking landscape, the findings demonstrate an explanatory power of 45.5%. Moreover, the results indicate that Performance Expectancy (PE), Effort Expectancy (EE), Social Influence (SI), Facilitating Conditions (FC), and CFR are all significant predictors of MPS adoption intention (BI), exerting a positive influence on Users' Behavior (UB). The results show that affordability is a critical consideration for Gen Z users in Pakistan when it comes to mobile payment solutions. Prioritizing affordability enables banks to effectively target and serve Gen Z users. By combining social media marketing with gamification, banks can make mobile payments more appealing to Gen Z users by highlighting affordability and user-friendly design.

Keywords: Generation Z, UTAUT framework, customer financial resources, behavioral intention, use behavior, mobile payment system, Pakistani banking sector

1. Introduction

The widespread adoption of smartphones has revolutionized financial activities, enabling individuals to make payments, shop, and manage budgets with ease [1]. The advent of smart payment technology has further expanded the scope of smartphones,

providing access to various payment services, including payment transactions, money transfers, and account balance inquiries, thereby facilitating MPS [2]. According to Hassaan and Yaseen, [3], MPS exhibits key features, including intelligence, connectivity, mobility, and temporal-spatial flexibility, which collectively contributes to enhanced convenience for customers. This convenience enables customers to perform various financial activities *via* mobile phones, reducing processing times and enhancing hedonic pleasure [2]. Moreover, MPS provides consumers with a user-friendly interface through specialized apps, allowing service providers to innovate and differentiate themselves through novel product offerings and services [3]. By leveraging MPS, service providers can enhance their competitive advantage in an increasingly saturated market [4].

Pakistan has the eighth largest mobile phone user base globally, with 178 million cellular subscribers covering 83.09% of the population [5]. Despite the availability of MPS options from various financial organizations, a substantial portion of the population still prefers traditional payment methods [3, 6]. This preference for traditional methods is reflected in Pakistan's high cash circulation rate of 40% (as of 2020), which is substantially higher than those of its regional counterparts, such as India and Bangladesh, where the rate falls below 15% [5]. Although MPS are gaining traction in Pakistan, they remain in their early stages, offering vast growth potential [3, 7]. Therefore, further research is necessary to identify and understand the key factors influencing individuals' intentions to adopt MPS [3, 7], providing valuable insights for developing effective strategies to promote adoption and maximize the benefits of MPS [3].

The current Information Systems (IS) literature indicates that financial resources play a pivotal role in digital payment adoption, underscoring the need for further research to investigate this relationship in greater depth, particularly within the mobile payment context [8, 9]. Scholarly work has increasingly focused on understanding the determinants of technology adoption, resulting in the development of comprehensive frameworks that illuminate user behavior and acceptance [3, 8, 10]. Scholars advocate for the application of an extended UTAUT framework to investigate the multifaceted factors influencing MPS adoption, providing valuable insights that can inform and direct future research endeavors [10, 11].

Notably, despite Generation Z's (Gen Z) significant presence in the population, limited research has explored the factors influencing their intention to adopt MPS [12, 13]. In Pakistan, Gen Z (born between 1995 and 2010) has grown up with the internet and are highly skilled in using technology [13]. Gen Z is well-equipped to navigate digital platforms and leverage social media for global connections and knowledge sharing [13]. Furthermore, their early exposure to technology has profoundly shaped their communication styles and behaviors [12, 13]. Indeed, Pakistan's Gen Z plays a vital role in the adoption of MPS, driven by their technological proficiency, substantial population size, and digital-centric behaviors [12]. This demographic's early exposure to technology has cultivated a strong inclination toward fintech solutions [12]. As a significant and expanding segment, Gen Z represents a crucial market for mobile payment providers, warranting targeted attention. Their familiarity with digital platforms and social media suggests a natural preference for cashless transactions, aligning seamlessly with their lifestyle and consumption patterns [12]. Moreover, technology has profoundly shaped their financial habits, predisposing them to adopt seamless payment methods [3, 12]. Indeed, a substantial knowledge gap persists concerning the factors that drive mobile payment adoption among Gen Z, underscoring

the necessity for further research to inform and guide policymakers and stakeholders in the fintech industry [3, 11].

Thus, this study aims to elucidate the key factors influencing individuals' BI to adopt MPS, specifically extending the UTAUT framework by incorporating CFR. Building on this framework, our research reveals that CFR plays a vital role in promoting mobile payments among Gen Z in Pakistan by providing digital financial tools, enhancing financial literacy, and increasing access to financial services [8]. Consequently, Gen Z is empowered to make convenient mobile payments that seamlessly align with their digital lifestyle. Furthermore, leveraging CFR enables mobile payment providers to effectively target young users, promote a cashless economy, and support financial stability.

This study offers significant implications for MPS providers, enabling them to develop customer-centric strategies that enhance the experiential outcomes. Building on these implications, the findings provide actionable guidance for MPS executives seeking to leverage smart mobile technology to drive service excellence. Furthermore, this research contributes to the advancement of IS literature by offering pioneering insights into the evolving landscape of MPS. Indeed, the findings can help researchers better understand customer behavior and the adoption of innovative mobile payment systems.

2. Literature review

2.1 An overview MPS adoption among Pakistan's Generation Z

The advent of online payment platforms in Pakistan in 2009, facilitated by the proliferation of cellular networks, has played a crucial role in advancing mobile payment systems [6]. The rapid growth of Pakistan's e-commerce sector has underscored the importance of MPS, which has become a vital catalyst for economic development. Branchless banking has gained momentum primarily due to this advancement, which has received substantial support from a range of financial institutions [6]. Leading MPS platforms, such as Upaisa, EasyPaisa, and JazzCash, provide user-friendly apps that enable seamless transactions and account management [3, 6, 14]. These platforms benefit both users and service providers by offering convenient financial access, improved services, cost reductions, and increased sales [7, 10]. Moreover, the shift to MPS has positively transformed traditional banking, expanded economic opportunities, and contributed to socioeconomic progress [8]. Pakistan's young population (51.7%), which is highly familiar with digital technologies, increase their likelihood of adopting mobile payment solutions [13]. Previous studies indicate a growing preference among younger generations for mobile payment technologies, particularly in developing countries [3, 11]. Therefor this study examines the key drivers of MPS adoption among Gen Z in Pakistan. By identifying these factors, the research aims to uncover opportunities for enhancing financial inclusion and fostering sustainable economic growth.

2.2 UTAUT model

Venkatesh et al. [15] proposed the UTAUT model, which consists of four key constructs including PE, EE, FC, and SI. These constructs predict users' BI to adopt

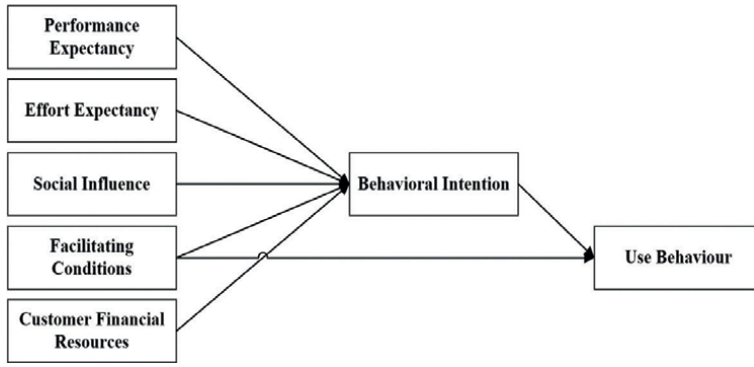


Figure 1.
Research Model adapted by Venkatesh et al. [15]. The proposed framework provides a theoretically grounded structure for examining the effects of exogenous variables on behavioral intention and use behavior.

technology. This study extends the UTAUT model by incorporating CFR to investigate the factors influencing individuals' intention to use MPS (see **Figure 1**). The financial costs associated with MPS, including equipment costs, transaction fees, and bank charges, affect an individual's ability to afford these services [8, 9]. Financial constraints and affordability issues can hinder the widespread adoption of new innovations [9]. Therefore, understanding the impact of CFR on MPS adoption is crucial, particularly in developing nations where household incomes are low [8, 9]. The UTAUT model provides a valuable framework for analyzing technology adoption, serving as a solid foundation for this investigation. By understanding these factors, MPS providers can improve their services and increase adoption rates.

3. Research hypothesis formulation

3.1 Performance expectancy (PE)

PE refers to the degree to which an individual believes that using a technology will enhance their efficiency, productivity, or overall task performance [15]. In the context of mobile payments, it reflects users' perception that adopting such systems will save time, simplify transactions, and provide greater convenience compared to traditional payment methods [10, 11, 16]. Indeed, previous research shows that PE is a salient predictor of MPS adoption [3, 7]. Hence, it is hypothesized that:

H1. *PE is positively associated with BI.*

3.2 Effort expectancy (EE)

EE is defined as the degree to which an individual perceives ease of effort connected with using new technology [17]. Davis et al. [18] found that simplicity and user-friendliness are vital factors that promote the adoption of new technologies. The requirement for specialized skills and knowledge in using MPS [19] highlights the significance of EE in influencing users' intentions to use technology [20]. By applying the UTAUT model in recent studies, various authors have validated a significant relationship between EE and an individual's intention to adopt MPS [3, 7]. Hence, it is hypothesized that:

H2. *EE is positively associated with BI.*

3.3 Social influence (SI)

SI refers to the degree to which an individual feels pressured by their social network to use technology [15, 21]. The opinions of family and friends can influence an individual's intention to use MPS [3]. Research has consistently shown that SI is a significant predictor of technology adoption intentions [3, 7]. Hence, it is hypothesized that:

H3. *SI is positively associated with BI.*

3.4 Facilitating Conditions (FC)

FC is the perception of the availability of organizational and technical resources and support to facilitate the effective use of a technology [15, 21]. MPS require a set of technical structures and skills, such as installing apps and knowledge about mobile services and their security-related features [16]. Therefore, FC play a crucial role in providing a strong foundation for MPS use. Extant research has consistently shown that FC plays a crucial role in MPS adoption, influencing both adoption intentions and usage behavior [3, 10]. Hence, it is hypothesized that:

H4. *FC is positively associated with BI.*

H5. *FC is positively associated with UB.*

3.5 Customer financial resources (CFR)

CFR associated with using MPS determine the extent to which individuals can afford to access and utilize MPS [8] This includes expenses such as equipment costs and transaction fees [16]. Limited financial resources hinder the widespread adoption of MPS [9]. As MPS evolve, improvements in device affordability, user-friendly interfaces, and network infrastructure are likely to overcome financial barriers, driving wider adoption. [3]. However, high technology costs may limit MPS adoption among consumers with restricted financial resources, reducing practical benefits and increasing usage difficulties [3, 9]. Hence, it is hypothesized that:

H6. *CFR is positively associated with BI.*

3.6 Behavioral intention (BI)

BI is a widely studied concept in technology acceptance, representing an individual's cognitive readiness to use specific technology [22]. Research consistently confirms that BI precedes actual behavior [21]. Theoretical models, such as the Theory of Planned Behavior (TPB), Technology Acceptance Model (TAM), and UTAUT, support the intention-usage relationship [15, 23, 24]. Empirical studies on MPS adoption have also found a positive relationship between BI and UB [3, 7]. Hence, it is hypothesized that:

H7. *BI is positively associated with UB.*

4. Research methodology

4.1 Data collection and sampling strategy

This research examines the salient factors shaping the intentions and behaviors of Pakistani Gen Z individuals in adopting MPS, providing insights into their adoption decisions. A quantitative survey methodology was employed, wherein 310

participants were recruited *via* convenience sampling, comprising current MPS users from Generation Z residing in Pakistan's prominent metropolitan cities (Islamabad, Karachi, and Peshawar). Prior to participation, informed consent was obtained from each respondent, and survey instruments were administered through face-to-face interactions. There were a majority of male participants (57.4%). Most of the participants (41.0%) had master's degrees and were from higher education levels. The demographic characteristics of the participants are comprehensively outlined in **Table 1**. The survey instrument was developed based on existing research, with minor modifications to suit the current context (see **Table 2**). The survey assessed intentions and behaviors using a seven-point Likert scale, supplemented by five multiple-choice questions that captured demographic information, including age range, gender groups, education status, city of residence, and frequency of MPS use in the past year.

5. Results

5.1 Data analysis tools and techniques

For 20 years, first-generation statistical techniques were widely used in social sciences research. However, their weaknesses have been overcome by second-generation

Demography		**Frequency**	**Percentage (%)**
Gender	Female	132	42.6
	Male	178	57.4
City	Islamabad	110	35.5
	Karachi	102	32.9
	Peshawar	98	31.6
Education level	Matric	53	17.1
	Intermediate	46	14.8
	Bachelor's degree	62	20.0
	Master's degree	127	41.0
	Others	22	7.1
Age group	14–16	33	10.6
	17–19	58	18.7
	20–22	66	21.3
	23–25	80	25.8
	26–28	73	23.5
Frequency of MPS use in the past 1 year	1–10	69	22.3
	11–20	75	24.2
	21–30	59	19.0
	31–40	50	16.1
	Above 40	57	18.4

Table 1.
Demography of participants.

Constructs	Key measurement items	Sources
PE	Utilizing MPS increases my likelihood of successfully completing tasks that are important to me	Venkatesh et al. [21]
	Utilizing MPS improves my task performance	
	Utilizing MPS enables me to complete tasks more efficiently	
EE	I find it easy to learn how to use MPS	Venkatesh et al. [21]
	MPS provides a clear and intuitive user experience for me	
	MPS is easy for me to use	
	Acquiring skill in using the MPS comes easily to me	
SI	Individuals who are important to me recommend the use of MPS	Venkatesh et al. [21]
	Individuals who are familiar to me recommend the use of MPS	
	Most people around me use MPS	
FC	I have access to the necessary resources for using MPS	Venkatesh et al. [21]
	I have the necessary knowledge to use MPS effectively	
	MPS is compatible with other technologies I use	
	Support from others is accessible when I face difficulties with MPS	
CFR	I perceive the annual MPS fees to be excessively costly	Nguyen et al. [9]
	I perceive the MPS transaction fees to be excessively high	
	I find the cost of MPS to be excessively high	
BI	I intend to utilize MPS as a future payment method	Venkatesh et al. [21]
	I intend to consistently utilize the MPS in my daily transactions	
	I intend to consistently utilize the MPS for future transactions	
UB	I utilize the MPS	Oliveira et al. [25]
	I frequently utilize MPS to manage my accounts	
	I utilize MPS as main source to make transfer	

Notes: *EE = effort expectancy; MPS = mobile payment system; UB = use behavior; BI = behavioral intention; SI = social influence; CFR = customer financial resources; PE = performance expectancy; FC = facilitating conditions.*

Table 2.
A brief look at measurement items and their origins.

techniques like SEM [26]. This study uses PLS-SEM, a powerful data analysis technique suitable for empirical research. PLS-SEM assesses reliability, validity and causal relationships among constructs, making it an attractive alternative to traditional SEM methods. Its ability to handle small sample sizes and examine cause-and-effect relationships among multiple constructs makes it an ideal choice for this study [27].

5.2 Measurement model evaluation

The assessment of measurement models is a multifaceted process, comprising three distinct levels [28]. Initially, internal reliability consistency is established through the evaluation of Composite Reliability (CR), with acceptable values ranging from 0.70 to 0.95 and Cronbach's alpha (α), which should exceed 0.7 (see **Table 3**) [28]. Subsequently, convergent validity is estimated *via* Average Variance

Constructs	Cronbach's alpha	CR	AVE
BI	0.723	0.724	0.643
CFR	0.757	0.759	0.673
EE	0.779	0.794	0.600
FC	0.755	0.769	0.670
PE	0.715	0.718	0.638
SI	0.767	0.780	0.681
UB	0.733	0.736	0.652

Table 3.
The constructs' validity and reliability.

Extracted (AVE), with a threshold of 0.50 and outer-loadings of indicators, which should surpass 0.50 (See **Table 3** and **Figure 2**) [28]. Finally, discriminant validity is assessed based on the Heterotrait-Monotrait ratio (HTMT), with values below 0.85 deemed acceptable (see **Table 4**) [29, 30].

5.3 Structural model evaluation

This study examined the hypotshesized relationships between constructs and their impact on customers' BI and UB. As shown in **Table 5** and **Figure 3**, the results indicate that all constructs had a significant impact on both BI and UB, p-values ≤0.10 [26].

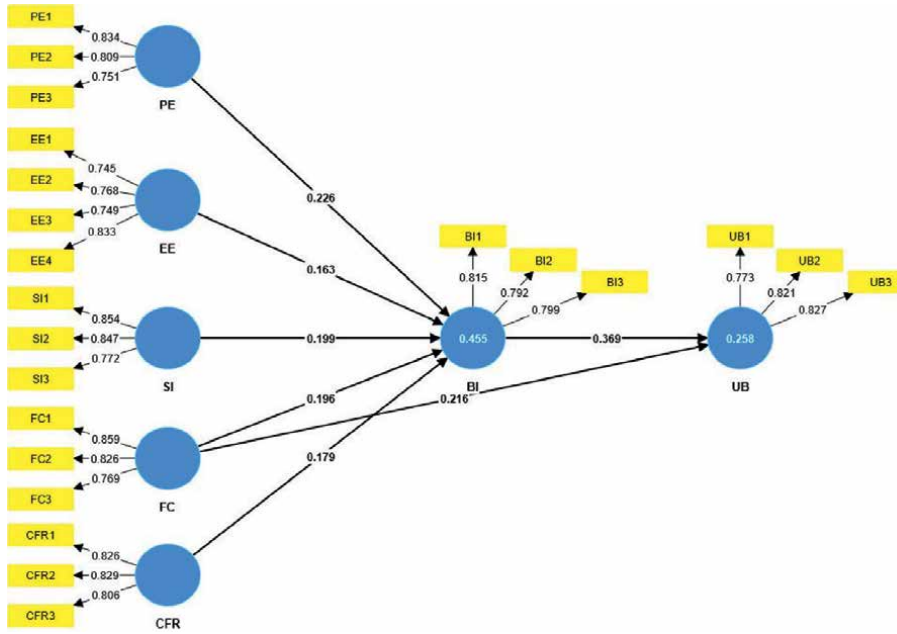


Figure 2.
R square, path coefficient, and outer-loadings indicators. The proposed figure offers a theoretically robust structure for investigating the impact of external factors on behavioral intention and usage behavior, leveraging metrics such as R-squared, path coefficients, and outer loadings to analyze and interpret the results.

	BI	CFR	EE	FC	PE	SI	UB
BI							
CFR	0.594						
EE	0.604	0.402					
FC	0.630	0.447	0.425				
PE	0.718	0.510	0.607	0.562			
SI	0.610	0.372	0.492	0.426	0.467		
UB	0.644	0.403	0.388	0.518	0.565	0.357	

Notes: UB = use behavior; EE = effort expectancy; SI = social influence; FC = facilitating conditions; BI = behavioral intention; CFR = customer financial resources; PE = performance expectancy

Table 4.
HTMT correlations ratio.

Association between predictors	VIF	t-value	Standard deviation	f^2	p-value	Significant
BI→UB	1.283	7.067	0.052	0.143	0.000	Yes
CFR → BI	1.263	3.539	0.051	0.047	0.000	Yes
EE → BI	1.398	3.249	0.050	0.035	0.001	Yes
FC → BI	1.324	3.537	0.056	0.053	0.000	Yes
FC → UB	1.283	3.786	0.057	0.049	0.000	Yes
PE → BI	1.491	4.060	0.056	0.063	0.000	Yes
SI → BI	1.285	4.287	0.046	0.057	0.000	Yes

Notes: UB = use behavior; BI = behavioral intention; EE = effort expectancy; PE = performance expectancy; CFR = customer financial resources; SI = social influence; FC = facilitating conditions; VIF = variance inflation factor; f^2 = f square.

Table 5.
Structural model estimates, comprising VIF and f^2 values for collinearity assessment.

The Effect Size (f^2) was computed [31] and the Variance Inflation Factor (VIF) values (< 3) indicate the absence of collinearity issues (see **Table 5**) [32, 33]. The R square (R^2) values demonstrated the substantial predictive accuracy for BI (0.455) and the moderate predictive accuracy for UB (0.258) (see **Table 6**). Furthermore, the blindfolded approach revealed significant predictive relevance, as indicated by Cross-Validated Redundancies (CVR) and Cross-Validated Communalities (CVM) exceeding zero for all endogenous variables (See **Table 6**) [34].

5.4 Hypothesis testing

The study employed PLS-SEM, a sophisticated statistical method, to test the research hypotheses. The results confirmed the effectiveness of the extended UTAUT model in predicting the adoption of MPS, consistent with the outcomes of previous research [3, 7–9]. The analysis reveals that PE ($\beta = 0.514$, $p < 0.000$), EE ($\beta = 0.452$, $p < 0.001$), SI ($\beta = 0.453$, $p < 0.000$), FC ($\beta = 0.465$, $p < 0.000$), and CFR ($\beta = 0.440$, $p < 0.000$) have positive effect on BI. The results further showed a positive effect of FC ($\beta = 0.385$, $p < 0.000$) and BI ($\beta = 0.467$, $p < 0.000$) on UB.

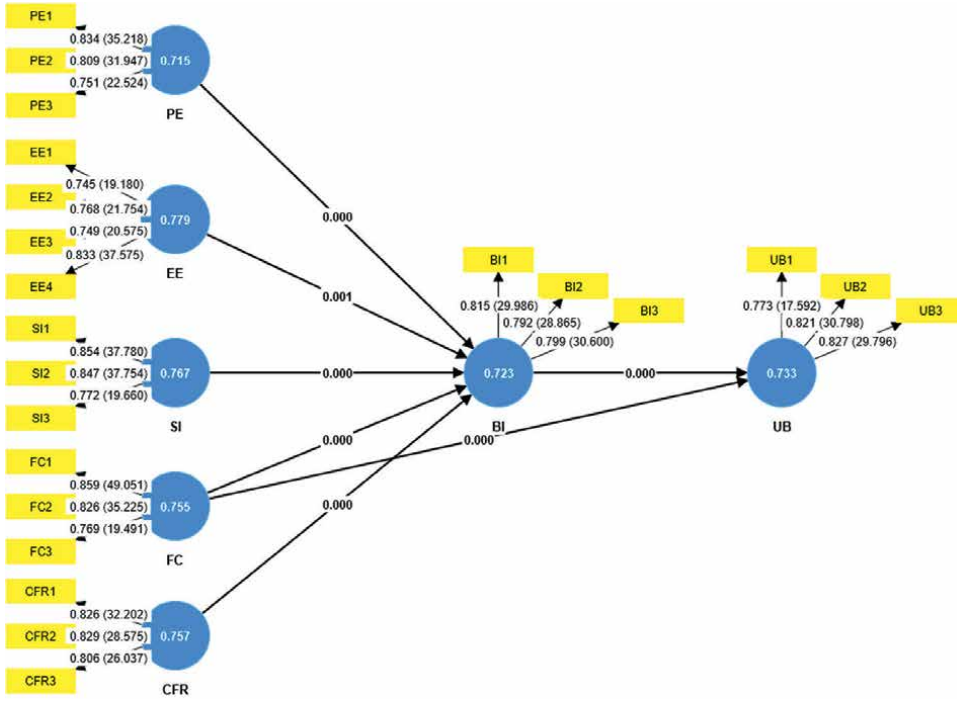


Figure 3.
P-values, T-values and Cronbach's alpha. The proposed figure presents a theoretically sound approach to studying the impact of external factors on behavioral intention and usage behavior, leveraging statistical analysis through P-values, T-values, and Cronbach's alpha.

Constructs	R^2	R^2 Adj	CVC	CVR
BI	0.455	0.446	0.289	0.281
UB	0.258	0.253	0.308	0.162

Notes: BI = behavioral intention; UB = use behavior; CVM = cross-validated communalities; CVR = cross-validated redundancies; R^2 = R square; R^2 Adj = R^2 adjusted.

Table 6.
Predictive relevance, R square Adj, and R square.

6. Discussion

The study aimed to investigate the key factors influencing the acceptance and use of MPS among Generation Z by extending the UTAUT with CFR. The findings of the study demonstrate that UTAUT is a robust framework [35] that significantly enhances our understanding of MPS adoption. Theoretically, the results indicate that Generation Z exhibited significantly positive responses to the measured factors, providing empirical support for the study's conceptual model. The findings of this study indicate that MPS performance positively influences Generation Z's intention to adopt and use MPS in real-life scenarios.

Indeed, the positive relationship between PE and BI towards adopting MPS among Generation Z is driven by their desire for speed, convenience, and seamless digital experiences. As digital natives, Gen Z prioritizes efficiency and ease of use, making

MPS an attractive option [12]. The perceived utility of MPS, including features like one-click payments and real-time transaction tracking, aligns with their tech-savvy behaviors and preferences [13]. This finding supports the UTAUT and highlights the importance of emphasizing time-saving features and user-friendly interfaces in MPS marketing strategies to appeal to Gen Z's needs and preferences. Indeed, consistent with prior research, the majority of studies applying the UTAUT model have found that PE has a significant positive impact on BI [19, 36–38].

Furthermore, the study reveals a positive relationship between EE and BI toward adopting MPS among Generation Z. This finding suggests that Gen Z's intention to adopt MPS is significantly influenced by their perception of how easy it is to use these systems [20]. The findings are supported by existing research [3, 7, 19, 38], confirming a strong positive relationship between EE and BI. Given their digital nativeness and familiarity with technology, Gen Z values user-friendly interfaces and seamless interactions, which, in turn, enhances their willingness to adopt MPS [19]. This relationship underscores the importance of designing MPS that are intuitive, easy to navigate, and require minimal effort, thereby catering to Gen Z's expectations for effortless digital experiences.

Also, the study highlights a positive relationship between FC and BI as well as UB toward adopting MPS among Generation Z [15, 21]. This suggests that Gen Z's adoption intentions are influenced by the availability of resources and support that facilitate MPS use, such as internet access, mobile devices, and technical assistance [16]. As a digitally connected cohort, Gen Z expects seamless integration of MPS with existing digital ecosystems, and favorable facilitating conditions enhance their confidence in using these systems [6]. Consistent with prior research [3, 10], the findings demonstrate that users are more likely to adopt MPS when they possess the necessary resources, facilities, and skills to utilize it effectively. Therefore, MPS providers can enhance acceptance by offering customer support services, such as 24/7 call centers and skilled staff to assist customers.

Notably, the study reveals a positive relationship between SI and BI toward adopting MPS among Generation Z. The finding is supported by previous research [3], which also indicated that SI plays a crucial role in shaping users' behaviors and decisions. This finding indicates that Gen Z's adoption intentions are shaped by the opinions and behaviors of their social circle, including friends, family, and peers [39]. As a cohort heavily influenced by social media and online communities, Gen Z is likely to adopt MPS if they perceive it as a socially accepted and popular trend [3, 7]. This highlights the importance of leveraging social proof, influencer marketing, and peer-to-peer recommendations to promote MPS adoption among Gen Z, as well as creating a sense of community around MPS use.

Consistent with previous research [8, 9], the findings highlights a positive relationship between CFR and BI toward MPS among Generation Z. The research emphasizes the significance of CFR in enabling MPS adoption [9], covering a broad spectrum of costs including equipment expenses and transactional fees. The substantial financial costs associated with MPS pose a significant barrier to their widespread adoption and utilization [8, 9]. The findings emphasize that MPS providers should offer intuitive financial management tools, flexible payment options, and transparent fee structures to align with Generation Z's financial preferences and behaviors.

The study confirms a positive relationship between BI and UB toward adopting MPS among Generation Z, aligning with previous research [3, 7–11, 16]. BI reflects an individual's willingness to engage in a specific behavior, such as adopting a particular technology. According to Venkatesh et al. [15], consumer behavior research examines

two key dimensions: the factors influencing technology adoption and the reasons behind continued usage. While some studies focus on pre-adoption intentions, others explore post-adoption behaviors, including sustained usage patterns [40]. IS literature consistently identifies BI as a key predictor of UB [15, 21], indicating that individuals with stronger intentions are more likely to follow through with the intended action [40]. In the context of MPS, customers with high adoption intentions are more inclined to use these services long-term [22]. Empirical studies further support this relationship, demonstrating a significant link between BI and actual SBS usage [22, 38]. The finding of this study highlights the importance of understanding and addressing Gen Z's needs, preferences, and concerns to foster positive intentions and drive actual adoption and continued use of MPS, ultimately contributing to the growth of digital payment ecosystems.

7. Theoretical contributions

This study seeks to understand the factors influencing Generation Z's intention to use MPS. By synthesizing MPS research within the FinTech literature, it enhances our understanding of how Pakistan's Generation Z adopts financial technology innovations. A more nuanced comprehension of Generation Z's engagement with FinTech will address the current paucity of research validating the UTAUT model.

The findings highlight the significant roles of EE, SI, and FC in shaping Generation Z's intention to adopt MPS, thereby validating the UTAUT framework. Additionally, the study examines the impact of the extended construct of CFR on MPS adoption. Indeed, empirical research on MPS adoption among Pakistan's Generation Z remains scarce [12].

This study bridges this gap by investigating the limited acceptance of MPS in Pakistan. Extending the UTAUT model [15], this study provides a comprehensive analysis of the factors driving MPS adoption among Generation Z in a developing economy context. By addressing the research objectives and questions, the study makes significant theoretical contributions, filling critical knowledge gaps while offering practical insights for researchers and practitioners [3, 8].

8. Managerial implications

The study provides valuable insights for MPS providers, highlighting key factors influencing Generation Z's adoption and usage of MPS. By understanding these factors, MPS providers can make informed decisions to enhance service quality, maximize technological investments, and ensure a worthwhile return on investment.

First, the findings indicate that PE has a positive relationship with BI to adopt MPS among Generation Z. This offers valuable insights for businesses, financial institutions, and marketers to develop targeted following strategies:

- *Highlight benefits:* Emphasize the benefits of MPS such as speed, convenience, and efficiency in marketing campaigns to appeal to Gen Z's desire for seamless digital experiences.

- *Demonstrate value:* Clearly demonstrate the value proposition of MPS, such as time-saving features, rewards, and real-time transaction tracking, to Gen Z users.

- *Targeted marketing:* Develop targeted marketing strategies that speak to Gen Z's preferences and needs, showcasing how MPS can fit into their digital lifestyles.

- *Training and support:* Provide adequate training and support to ensure Gen Z users can effectively use MPS and realize their benefits.

Second, the positive relationship between EE and BI to adopt MPS among Generation Z provides actionable insights for businesses and marketers. Based on the findings, the following strategies can be employed:

- *Simplify user experience:* Design MPS with intuitive interfaces and easy-to-use features to reduce user effort and enhance adoption.

- *Clear instructions:* Provide clear, concise instructions and tutorials to help Gen Z users understand and navigate MPS.

- *User-friendly design:* Prioritize user-friendly design to minimize complexity and frustration, ensuring a seamless payment experience.

- *Feedback mechanisms:* Implement feedback mechanisms to help users understand transaction processes and outcomes, reducing anxiety and uncertainty.

Third, the findings show that SI drives BI to adopt MPS among Generation Z. This offers valuable guidance for businesses and marketers, informing the following strategic approaches:

- *Influencer marketing:* Partner with social media influencers and thought leaders to promote MPS and increase adoption among Gen Z.

- *Social proof:* Highlight user testimonials, reviews, and ratings to demonstrate social acceptance and build trust in MPS.

- *Word-of-mouth:* Encourage satisfied users to share their experiences with friends and family, leveraging word-of-mouth marketing.

- *Social media campaigns:* Develop engaging social media campaigns that showcase the benefits and popularity of MPS among Gen Z.

- *Peer-to-peer recommendations:* Design MPS that facilitate peer-to-peer recommendations and referrals, harnessing social influence to drive adoption.

Fourth, the significant role of FC in shaping Gen Z's BI to adopt MPS provides key insights for businesses and marketers, highlighting the following strategies:

- *Mobile optimization:* Ensure MPS are optimized for various mobile devices and platforms to facilitate seamless transactions.

- *Technical support:* Provide reliable technical support and customer service to address Gen Z's concerns and issues with MPS.

- *User resources:* Offer accessible resources, such as FAQs, tutorials, and guides, to help Gen Z users understand and use MPS effectively.

- *Compatibility:* Ensure MPS are compatible with various devices, operating systems, and other technologies used by Gen Z.

- *Infrastructure development:* Develop an advanced MPS infrastructure that prioritizes speed, security, and reliability to support Gen Z's digital-native behavior and facilitate seamless transactions.

Fifth, the influence of FC on Gen Z's MPS adoption and use highlights key takeaways for businesses and marketers, including:

- *Infrastructure investment:* Design and upgrade digital payment systems, including mobile networks, cybersecurity, and app performance, in a way that directly aligns with Generation Z's preferences and habits.

- *Security measures:* Implement robust security measures to protect Gen Z users' transactions and data, building trust and confidence in MPS.

Sixth, the influence of CFR on Gen Z's adoption of MPS highlights important considerations for businesses and marketers, including the following:

- *Financial integration:* Integrate MPS with various financial services, such as digital wallets and budgeting tools, to cater to Gen Z's financial management needs.

- *Flexible payment options:* Offer flexible payment options, such as installment plans or rewards programs, to accommodate Gen Z's financial preferences and behaviors.

- *Financial literacy:* Provide educational resources and tools to help Gen Z users manage their finances effectively and make informed decisions about MPS usage.

Seventh, the role of BI in driving Gen Z's MPS usage behavior offers valuable guidance for businesses and marketers, highlighting the following:

- *User engagement:* Encourage user engagement through incentives, rewards, or loyalty programs to motivate Gen Z to translate their intention into consistent MPS usage.

- *Ongoing support:* Provide ongoing support and resources to address any concerns or issues Gen Z users may encounter, ensuring continued MPS usage.

9. Conclusion

This study provides valuable insights into the factors influencing Generation Z's adoption and use of MPS in Pakistan. By extending the UTAUT with CFR, the research offers a comprehensive understanding of the key drivers of MPS adoption among digital natives. The study reveals that PE, EE, FC, SI, and CFR significantly

impact Gen Z's BI to adopt MPS. Moreover, BI is a strong predictor of actual UB. The research contributes to the existing literature on technology adoption and provides practical insights for MPS providers, policymakers, and marketers. The findings highlight the importance of designing user-friendly interfaces, offering flexible payment options, and leveraging social proof to promote MPS adoption among Gen Z. This study offers a nuanced understanding of Gen Z's MPS adoption in Pakistan, providing valuable insights for stakeholders seeking to promote digital financial inclusion and drive the growth of mobile payment ecosystems.

10. Study limitations and future research directions

This study has several limitations that should be considered. Firstly, the Generation Z survey was confined to three major Pakistani cities: Islamabad, Karachi, and Peshawar. Although this sample provided valuable insights into Generation Z's characteristics, future research should expand to include other metropolitan areas, such as Lahore, Multan, and Faisalabad. Additionally, this study employed a cross-sectional survey design. While the proposed antecedents are theoretically justified, future research would benefit from a longitudinal approach to better understand the evolution of mobile payment adoption among Pakistan's Generation Z, considering cultural, familial, and religious influences. Given Pakistan's collectivist society, future studies could explore how social influence (e.g., family opinions, peer networks) and trust perceptions (e.g., Sharia-compliance concerns, data privacy considerations) impact sustained adoption versus abandonment patterns. Further investigation of behavioral outcomes, such as fluctuations in e-wallet top-up amounts, transaction frequency during religious festivals (e.g., Eid), or regional usage disparities, could reveal how local traditions and socioeconomic factors influence practical adoption. Comparative studies between urban and rural areas might further illuminate infrastructural and cultural barriers. These insights would enable fintech firms to tailor their services to Pakistani Generation Z's unique socioreligious context, ensuring alignment with both familial expectations and Islamic financial principles (e.g., interest-free transactions).

Author details

Muhammad Hassaan[1], Asif Yaseen[2*], Khawar Naheed[2] and Sania Usman[2]

1 Department of Business and Public Administration, Emerson University, Multan, Pakistan

2 Department of Commerce, Bahauddin Zakariya University, Multan, Pakistan

*Address all correspondence to: asifyaseen@bzu.edu.pk

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Chapter 10

Marketing and Business Models of Credit in the Banking System: The Role of Mortgage Loan, People's Business Credit, and Productive Microcredit-Women in MSMEs in Indonesia

Jono Mintarto Munandar, Widi Adyanto, Rabiatul Adwiyah, Rizki Sejat and Annisaturrahmah Maulida

Abstract

Service marketing has many strategies. Among the popular service marketing sectors are banks, schools, hotels, expeditions, and restaurants. Banking strategies need to focus on four aspects: place, personnel, productivity capacity, and process. These strategies are important to implement in the credit system. Credit strategies in banking are influenced by several factors, depending on the situation and type of credit. In this case, the credit system is divided into three types: credit related to housing, credit related to people's businesses, and credit related to productive women. The three types of credit were analyzed using the Analytical Hierarchy Process (AHP) method, with varying numbers of respondents across each credit type. The analysis revealed key findings regarding the factors influencing marketing, the main actors involved, the intended goals, and the alternative strategies adopted. The study presented in this chapter was conducted in Bogor and Bima, Indonesia. This paper is expected to provide information related to marketing strategies in the banking world.

Keywords: bank, credit, Indonesia, marketing, MSMEs

1. Introduction

The banking sector has a strategic role in supporting economic growth through various financial products, especially credit. Credit is the main instrument used to improve people's standard of living while encouraging business growth, especially micro, small, and medium enterprises (MSMEs) [1]. In 2009, the total number of MSMEs in Indonesia reached 49.8 million, of which approximately 95.7% were micro-enterprises, including household businesses, street vendors, and various other

types of informal businesses [2]. Until now, the number of MSMEs has continued to increase to reach 64.2 million, around 99.62% of which are micro-enterprises [3]. At this scale, it also absorbs the most labor and supports improving people's standard of living, estimated at 91.8 million people (97.3%) of the total employment opportunities [2]. Until now, the MSME sector still absorbs the most labor, namely 96.9% [3].

MSMEs in Indonesia not only contribute to the absorption of a very large workforce but also contribute greatly to the gross domestic product (GDP) [4]. The contribution of MSMEs to the national GDP reached Rp. 2121.3 trillion (47.11%) of the total GDP, the contribution of exports reached IDR 142.8 trillion (20%) of the total non-oil and gas exports, and the physical investment of MSMEs reached IDR 462.01 trillion (46.9%) [2]. Until 2025, the contribution of MSME exports to national GDP continues to increase to reach 60.5%, the contribution of MSMEs to non-oil and gas exports only reaches 15.6%, and the total national MSME investment increases to reach 60% [3].

However, MSMEs still face various obstacles, especially in accessing formal financial services such as bank credit. Of the total number of MSME units—reaching 49.8 million spread across all regions in all business sectors—only around 39 percent, or 19.4 million, have obtained bank credit, while the rest have not been touched by banking institutions at all [5]. Until 2023, the portion of MSME credit to total bank credit in Indonesia is only around 20% [6].

Credit is one of the main banking products designed to meet the various needs of the community and the business world. Mortgage loans serve as a solution for the community to have decent housing more affordable. On the other hand, people's business credit is designed to provide capital support to MSMEs that are eligible but do not have adequate collateral. Productive microcredit complements the two types of credit by providing financial access to low-income groups, especially women micro-entrepreneurs. Women are often the backbone of the family economy, so the existence of productive microcredit has a significant impact on empowering the community's economy.

Competition in the banking sector is increasingly complex with the presence of foreign banks and technological developments that drive digital transformation in financial services. This requires banks to develop marketing strategies that are more innovative, adaptive, and oriented to customer needs. A deep understanding of market conditions, customer preferences, and opportunities and challenges in marketing credit products is the key to success in winning the competition. In addition, community-based approaches, such as personal selling and local promotions, are becoming increasingly relevant in reaching market segments that have not been touched by conventional banking services.

In addition to the competitive aspect, the socio-economic conditions of the community also affect the effectiveness of credit marketing. In Indonesia, economic disparities between regions and low levels of financial literacy are additional challenges for banks in expanding the reach of credit services. Therefore, the marketing strategy designed must be able to answer the specific needs of various segments of society, from urban to rural communities and from individuals to micro-entrepreneurs.

This study aims to identify marketing strategies that can be applied to improve public access to credit services, expand the reach of banking services, and support the development of MSMEs as the backbone of the national economy. Thus, this study is expected to contribute to the formulation of relevant and effective credit marketing policies while strengthening the role of the banking sector in supporting national economic stability and growth.

This study analysis was conducted on secondary data. The data were based on credit marketing in the Indonesian banking system by highlighting three main types of credit,

namely Mortgage Loan at Bank X Bogor Branch. People's Business Credit at Bank Negara Indonesia (BNI), a state-owned limited liability company (PT), Bima branch, and productive microcredit at PT BPR (Bank Perkreditan Rakyat) Parasahabat Bogor, a rural bank located in Bogor. These studies use the analytical hierarchy process (AHP) method to process data and strengthen the results of the study. Based on such results, it was then analyzed by using the Business Model Canvas (BMC).

2. Credit marketing strategy in banking system

Regarding marketing, banking credit programs adopt various strategies, depending on the product type and target market. This chapter explores three commonly used credit products to illustrate how different marketing approaches are applied in practice. These include: mortgage loans, people's business credit, and productive microcredit. While each case highlights a distinct strategy—such as personal selling or market development—the comparisons provide insight into how banks can adapt their marketing approaches across formal, semiformal, and informal lending segments.

2.1 Mortgage loan

The overall determination of the mortgage strategy follows the stages starting from identifying the factors, actors, and objectives, and finally determining alternatives.

The analysis began by identifying the key factors involved in formulating the promotion strategy for Bank X's mortgage loan product. From the results of observations and focus group discussions (FGD) with six employees of Bank X's Bogor branch management, supported by literature studies, internal and external factors of the company were obtained. Internal factors include product characteristics, segmentation, targeting, positioning (STP), and human resources (HR). While external factors of the company are consumer characteristics (potential debtors), market characteristics, and the level of competition.

1. *Product characteristics*. Product characteristics can be translated as the type (nature) of mortgage products offered to consumers. The more appropriate the type (nature) of mortgage loan products sold is to what prospective consumers need, the more in demand the product will be. The characteristics of the product entered by Bank X are mortgage loans for medium-sized houses, including a minimum of type 45/95. The price of the house that is used as collateral is estimated by Bank X to be at least IDR 125 million. The reason Bank X focuses on this type of product is because of the company's management policy, which wants a middle-to-upper market target so that it can minimize the risk of bad debts. Product strategy planning must consider several things, namely: situation analysis, determining product objectives, determining market/product targets, determining budgets, determining product strategies, and evaluating strategy implementation. After this is carried out, it is certainly expected that mortgage products can be well received.

2. *Segmentation, targeting, positioning (STP)*. The STP concept is very important. Segmentation is carried out by banks to identify and form separate groups of prospective mortgage customers who may need separate mortgage products or

marketing mixes. The segment applied by Bank X Bogor Branch for mortgage loan products is multisegment marketing. Bank X Bogor management selects two or more market segments and prepares separate marketing mixes for each segment. This strategy can provide potential benefits, such as increased sales volume, profit, larger market share, and economies of scale in marketing. However, there is a negative side, namely the emergence of quite large costs for product design and promotion. Determining the target market (targeting) is the act of selecting one or more customer segments that will be the focus of the company's promotional activities. The target market for Bank X Bogor Branch mortgage loan is prospective debtors who are over 18 years old, with a minimum of 2 years of work experience and a minimum income of IDR 3 million per month. Positioning is the act of building and communicating the positive value of a Bank X mortgage loan in the market. The positioning carried out is by providing convenience and speed in terms of the credit process, which is supported by Bank X's mortgage loan slogan, namely "Three Days of Credit Approval."

3. *Human resources*. Human resources are a very important factor as a driver and implementer of a strategy that has been made. A strategy needs to be supported by creative and innovative human resources so that the strategy can run effectively. Bank X Bogor Branch has had transparent and integrated human resource management (HRM). This HRM includes the processes of recruitment, development, and coaching of HR, which are regulated by the Human Resources Division of Bank X Center. The process of recruiting Bank X employees has been standardized. Every new employee at Bank X will go through a trial period and training for the first year. This aims for each employee to know their field of work and adapt to the company culture. In addition, to maintain the quality of employees, Bank X provides regular education and training programs.

4. *Consumer characteristics*. The consumer segment targeted for sales of Bank X's mortgage loan products in the Bogor Branch is divided based on demographic factors, namely in terms of age (age above 22 years), in terms of income (min. Rp. 3 million/month), in terms of employment (civil servants and private/BUMN/self-employed), and in terms of length of service (min. 2 years of work experience). These requirements are applied by Bank X to avoid and minimize the occurrence of bad debts (non-performing loans). Bank X's target consumers are the middle-to-upper class. With this strategy, it is expected to provide several potential benefits, such as increased sales volume, profit, and larger market share, as well as economies of scale in marketing. However, there are also risks and costs, including promotional tool design costs, promotion costs, and marketing research costs.

5. *Market characteristics*. The market entered by Bank X Bogor Branch can be seen in three main things, namely: (1) the geographical area of the market, which includes Bogor City, consisting of the areas of South Bogor, East Bogor, North Bogor, Central Bogor, West Bogor, and Tanah Sareal; (2) market concentration is focused on the people of Bogor City; and (3) there is strong market potential for housing in Bogor City, particularly among middle-class consumers, with house prices ranging from 100 to 200 million rupiah.

6. *Competition level*. The level of competition in the banking industry will affect how a strategy is formulated. The strategy chosen must take into account the

situation and conditions that occur in the market. The activities carried out by competitors can be used as material for thought to balance competitor strategies. The increasingly tight competition will continue to encourage Bank X Bogor Branch to be more creative in designing promotional programs.

Strategy selection analysis. After analyzing and identifying the strategy formulation factors, the next step is to conduct strategy selection. Strategy selection is related to aspects obtained from related sources. Strategy selection analysis is divided into three, namely: actors, objectives, and strategic alternatives.

1. *Actors.* The most influential actors in the decision-making of choosing a mortgage loan promotion strategy for Bank X, Bogor Branch, are the Branch Manager, Business Development Officer, and Consumer Finance Manager.

2. *Objectives.* The main objective of Bank X Bogor Branch's mortgage loan product promotion activities is to increase sales. With increased sales, the company's profits will also increase, and opportunities to expand and strengthen the position of the housing credit market will be more open. Another objective to be achieved is to maintain a positive image of Bank X in the eyes of the wider community, one of its missions, namely understanding customer needs and establishing sustainable relationships with stakeholders.

3. *Alternative strategy*. Alternative strategies for promoting mortgage loans at Bank X Bogor Branch include a promotional mix consisting of: (1) Alternative A: Focus on advertising activities, including electronic media, print media, brochures, banners, pennants, and so on; (2) Alternative B: Focus on sales promotion activities, such as providing bonuses, shopping vouchers, or merchandising; (3) Alternative C: Focus on publicity activities, namely activities related to publicizing Bank X Bogor Branch mortgage loan products, establishing good relations with various Bank X Bogor Branch publics, forming a good corporate image, and handling or eliminating rumors, stories, and unfavorable events; (4) Alternative D: Emphasize personal selling activities, namely by involving reliable and communicative marketers in carrying out promotional activities; (5) Alternative E: Focus on direct marketing activities and direct sales activities, including sending letters, direct mail, and opening housing exhibition stands.

Analysis of alternative selection of mortgage loan promotion strategy. The processing of primary data began with a consistency check of the weighting judgments provided by respondents using Expert Choice. The individual weights were then aggregated into a composite matrix, which was subsequently analyzed using the AHP method in Microsoft Excel 2003 to produce both horizontal and vertical processing results. The horizontal analysis explained the relationships and influence levels between elements within and across hierarchy levels, while the vertical analysis became the foundation for determining strategy priorities. The results of vertical processing at Bank X Bogor Branch, covering levels 2 (factor elements) to 5 (alternative promotion strategies), are shown in **Table 1**.

Among the available promotional strategies, personal selling is identified as the top priority by the companies, with a score of 0.236. The very tight competition between banks in selling mortgage loan products now requires the management of Bank X to further increase personal selling to prospective direct debtors and sales developers.

Cluster	Aspect	Total average	
		Score	Ranking
Factor	Market characteristic	0.189	2
	Product characteristic	**0.203**	1
	Segmenting, targeting, positioning	0.169	4
	Consumer characteristic	0.141	5
	Competition level	0.174	3
	Human resources	0.124	6
Actor	Branch manager	0.264	3
	Consumer finance manager	**0.408**	1
	Business development officer	0.327	2
Objectives	Increasing sales of Bank X's mortgage products	**0.608**	1
	Maintaining the image (brand image) of Bank X	0.391	2
Alternative	Increasing advertising activities	0.219	2
	Increasing sales promotion activities	0.207	3
	Increasing publicity activities	0.136	5
	Increasing personal selling activities	**0.236**	1
	Increasing marketing and direct sales activities	0.201	4

Table 1.
Results of processing the hierarchy of mortgage loan promotion strategies of Bank X, Bogor Branch.

This aligns with Kotler and Keller [7], which emphasizes that in highly competitive markets—especially for high-value or risky products—personal selling becomes a crucial component of the promotion mix, helping firms maintain their market position through individualized customer interaction. This implies that Bank X Bogor Branch needs to increase the intensity of personal selling activities to cooperative developers.

The increase in personal selling activities that can be recommended is by: (1) Providing sales commissions (rewards) to sales developers who have directed prospective mortgage loan debtors to use the services of Bank X Bogor Branch. Rewards can be in the form of cash, shopping vouchers, or merchandise (umbrellas, wall clocks, mugs); (2) Increasing the role of sales executives as intermediaries in selling mortgage loans by increasing and changing the wage/salary scheme and only giving it if prospective mortgage loan debtors make credit bindings at Bank X Bogor Branch. This system is expected to increase the motivation of sales executives in making sales; (3) Increasing the intensity of soliciting activities (visits) to developer partners in cooperation with Bank X Bogor Branch. This aims to improve better relations.

Practical implications for managers. Given the high competition in mortgage loan products, Bank X Bogor Branch management should intensify personal selling efforts targeting prospective debtors and sales developers. Recommended strategies include providing sales commissions, revising the compensation scheme for sales executives to be performance-based, and increasing visits to developer partners to foster better relationships. To successfully implement these strategies, Bank X is advised to provide training that enhances the personal selling skills of field staff. Additionally, an appropriate budget should be allocated to cover sales commissions, promotional rewards (such

as vouchers and merchandise), and operational costs related to partnership visits. Allocating these resources will help motivate the sales team and strengthen collaboration with developer partners, ultimately improving mortgage loan disbursement.

This case study highlights the importance of personal selling strategies in promoting mortgage loan products, particularly to strengthen relationships with developer partners and boost sales amid intense market competition. While mortgage loans focus on the formal housing sector, the next case study examines marketing strategies for credit programs targeting micro, small, and medium enterprises (MSMEs), which face different market characteristics and challenges in accessing capital.

2.2 People's business credit

The determination of the overall people's business credit strategy follows stages starting from Strengths, Weaknesses, Opportunities, Threats (SWOT) identification; SWOT matrix analysis; assessment of alternative SWOT strategy decisions; and finally, analysis of alternative strategy selection.

Identification of SWOT of people's business credit program at PT BNI Tbk Bima branch through FGD. The results obtained from the analysis of the internal and external environmental conditions of BNI people's business credit at the Bima branch revealed several strengths and weaknesses in the company, as well as opportunities and threats faced by marketing people's business credit products.

1. *Strength*. Strength describes what a company has that can provide a competitive advantage. Based on the results of the analysis conducted, several strengths were obtained that were owned by PT BNI Tbk Bima branch, including: (1) Good relations with business partners; (2) Speed of credit decision-making; and (3) Extensive networking.

2. *Weaknesses*. Weaknesses describe things that a company does not have, but other companies do. Based on the results of the analysis that has been carried out, several weaknesses were obtained in PT BNI Tbk Bima branch, including: (1) Bad debts are a burden on the implementing bank; (2) There is no uniform understanding of the people's business credit program, both by bank officers in the field and the community.

3. *Opportunities*. Opportunities are factors that come from the company's external environment. If the company can utilize these opportunities well, it can generate profits for the company. From the results of the analysis that has been carried out, several opportunities were obtained that can be utilized by PT BNI Tbk Bima branch, including the following: (1) A large number of MSMEs, while many have not yet received capital; (2) Contribution of MSMEs to GDP in Indonesia.

4. *Threats*. Threats are factors originating from outside the company that must be addressed to reduce the detrimental impact on the company. Based on the analysis that has been done, several threats faced by PT BNI Tbk Bima branch were obtained, as follows: (1) Competitor growth; (2) Risk of external moral hazard; (3) National economic growth.

SWOT matrix analysis. The SWOT matrix is compiled based on the results of identifying the company's internal and external factors that describe the strengths

Internal	Strength (S)	Weaknesses (W)
External	1. Good relationship with business partners 2. Speed of credit decision-making 3. Extensive networking	1. Bad debts become a burden on implementing banks 2. There is no uniform understanding of the people's business credit program, both by officers of the Bima branch of BNI Tbk Bank in the field and the community
Opportunity (O)	**Strengths–Opportunities (SO) strategy**	**Weaknesses–Opportunities (WO) strategy**
1. A large number of MSMEs, while many still have not received capital 2. Contribution of MSMEs to GDP in Indonesia	1. Market penetration strategy (S1, S2, O1, O2) (0.491, 0.228, 0.421, 0.259) 2. Market development (S1, S2, S3, O2) (0.491, 0.228, 0.079, 0.259)	1. Expanding the reach of service areas for providing people's business credit (W2, O1, O2) (0.097, 0.421, 0.259) 2. Conducting evaluation and monitoring together with the policy committee and related departments every month (W1, W2, O1, O2) (0.097, 0.104, 0.228, 0.421)
Threat (T)	**Strengths–Threats (ST) strategy**	**Weaknesses–Threats (WT) strategy**
1. Risk of external moral hazard 2. Competitor growth 3. National economic growth	1. Human resource development and training (S2, T2,) (0.228, 0.077) 2. Customer differentiation of people's business credit program (S3, T1, T2, T3) (0.079, 0.117, 0.077, 0.110)	1. Development of people's business credit products with life and health insurance features (W1, T2) (0.097, 0.077) 2. Continuing joint socialization, with coordination by the Secretary to the Vice President (Setwapres) and the Coordinating Minister for the Economy (W1, W2, T1, T2) (0.097, 0.104, 0.117, 0.077)

Table 2.
People's business credit SWOT matrix.

and weaknesses of the company, as well as the opportunities and threats faced by the company. The SWOT matrix can be seen in **Table 2**.

The strategies resulting from the SWOT matrix include the following.

1. *S-O strategy (strengths-opportunities): Market penetration strategy*. PT BNI Tbk Bima Branch considers whether the micro-business credit program can achieve deeper market penetration by providing or channeling more micro-business credit to its current customers without changing the form of its products. For example, PT BNI Tbk Bima branch can increase the distribution of micro-business credit at the sub-branch offices in the current market conditions, so that its customers can more easily access financing/capital for their businesses. Improvements in the promotion system, interest rates, and services can encourage potential customers to access financing/capital more often at the PT BNI Tbk Bima branch. In this case, the customers in question are MSME customers who are feasible but not yet bankable, and their partners are the government and linkage institutions (BPR and cooperatives). The resulting strategy is strengthened by using the speed of making credit decisions, good relationships with partners, and extensive networking. With these strengths, the PT BNI Tbk Bima

branch has been able to position its products in the eyes of customers by providing fast service for credit applications submitted by customers, so that they will not switch to competitors. Then, the PT BNI Tbk Bima branch also positions its products in the eyes of its partners by establishing good relationships. This can be used to get new potential debtors and increase the company's income.

2. *Strategi S-O (strengths-opportunities): Strategi market development.* PT BNI Tbk Bima branch is thinking about the possibility of market development, namely by identifying and developing new markets for micro-enterprise credit products. What can be done is to approach customers more closely to review the demographic market, such as customers of the elderly micro-enterprise credit program. Furthermore, the company can open a new market, namely by opening a new BNI branch office/cash office by marketing the current micro-enterprise credit product. This will make it easier for MSMEs to access and apply for micro-enterprise credit more often. The approach taken is not only to customers but also to business partners. The approach to customers and business partners must be carried out more intensively, considering that these parties are directly involved in marketing the micro-enterprise credit program. This approach will later become a strategy for PT BNI Tbk Bima branch to develop its business market. This strategy is produced by using all the strengths that have been identified to capture opportunities in the form of the large number of MSMEs, while many still have not received capital, and the contribution of MSMEs to GDP in Indonesia. All the strengths possessed by PT BNI Tbk Bima branch are a strong foundation and are supported by the opportunity of a large number of MSMEs, while many still have not received capital. This will make it easier for the company to develop market share.

3. *Strategi S-T (strengths-threats)*. The resulting S-T strategy is the development and training of human resources to win the competition and survive in it. In terms of human resources, intensive training should be provided on handling the risk of external moral hazard, which can increase knowledge in responding to cases that must be resolved immediately, so that credit approval decisions can be made quickly. Another strategy that can be implemented is customer segmentation, for instance by grouping them into MSMEs and cooperatives. This strategy is carried out by utilizing the position of the people's business credit program as a government program, where the credit interest rate is set and determined by the government.

4. *Strategi W-O (weaknesess-opportunities).* The resulting W-O strategy is to expand the reach of PT BNI Tbk's people's business credit product services at the Bima branch by opening sub-branch offices in places that have not been reached. Another strategy is that the company can conduct evaluations and monitoring together with the policy committee and related departments every month considering the weakness of bad credit that is a burden on the implementing bank. This is done by taking advantage of the opportunity that the number of MSMEs is large, but many of them have not received capital.

5. *Strategi W-T (weaknesess-threats).* The strategy resulting from W-T is that the company can develop people's business credit products, namely by adding life and health insurance features that are tailored to the needs of MSMEs. This will help increase the average number of marketing efforts for people's business

credit programs at PT BNI Tbk Bima branch. Another strategy that can be done is to continue joint socialization and coordination with the Secretary of the Vice President and the Coordinating Minister for the Economy to face threats in the form of growth in competitors from similar companies that may make innovations to the people's business credit program.

Alternative decision assessment of strategy generated in SWOT using Bayes technique. Bayes method is a technique used to analyze in make the best decision from several alternatives generated in the SWOT matrix. Bayes' procedure is used to determine the recapitulation of the results of the assessment of the suitability of alternative strategies generated in the SWOT matrix with the existing criteria. The criteria were obtained from the results of interviews with experts related to the marketing of the people's business credit program at PT BNI Tbk Bima branch.

To obtain the weights of these criteria, the pairwise comparison method was employed using Saaty's scale of 1–9, where experts assessed the relative importance of each criterion against others. The scale includes both direct values (e.g., 1, 3, 5, 7, 9) and reciprocal values (e.g., 1/3, 1/5, 1/7) to express the intensity of preference. These comparisons were compiled into a comparison matrix, and eigenvalue calculations were performed to derive the priority weights. Subsequently, these criterion weights were multiplied by the corresponding values of the alternative strategies identified through the SWOT analysis, resulting in an overall score for

Cluster	Aspect	Score	Ranking
Criteria	C1: Speed of accessing the KUR program	0.342	1
	C2: Credit repayment period	0.177	2
	C3: Low interest rate/margin	0.140	3
	C4: Easy requirements	0.098	4
	C5: Service to KUR program customers	0.074	5
	C6: Credit ceiling	0.061	6
	C7: Easy and uncomplicated procedures	0.056	7
	C8: Building good trust	0.049	8
Alternative	AL1: Market penetration	**3.713**	4
	AL2: Market development	**4.074**	2
	AL3: Expansion of the reach of KUR service areas	3.640	5
	AL4: Conducting evaluations and monitoring with the policy committee and related departments every month	2.812	8
	AL5: Human resource development and training	3.487	6
	AL6: Differentiation of KUR program customers	3.418	7
	AL7: Development of KUR products, with life and health insurance features	**4.234**	1
	AL8: Continuing joint socialization, with coordination by the presidential secretary and the coordinating minister for the economy	**3.779**	3

Table 3.
Calculation of alternative assessment decisions for marketing strategies for people's business credit programs at PT BNI Tbk Bima branch using the Bayes technique.

each alternative. These scores were then ranked to determine the most preferred strategies based on quantitative and qualitative integration. The strategies generated from several alternative strategies in the SWOT analysis using Bayes technique calculations are shown in **Table 3**.

Alternative assessments for each criterion use a hedonic scale, namely one (very poor) to five (very good), for these criteria. Using the Bayes formulation, the strategies selected to enter the AHP structure are strategies 7, 2, 8, and 1, namely: (1) developing KUR products with life and health insurance features; (2) market development; (3) continuing joint socialization, with coordination by the Presidential Secretary and Coordinating Minister for the Economy; and (4) market penetration. These selected strategies were then analyzed using the AHP method to determine their implementation priorities based on specific evaluation criteria. Thus, AHP serves to quantitatively refine and strengthen the strategic alternatives previously identified through the SWOT analysis.

Analysis of alternative marketing strategy selection for people's business credit program at PT BNI Tbk Bima branch using AHP method. All elements that have been identified are then arranged into an AHP structure that will be assessed by experts. Experts

Cluster	Aspect	Score	Ranking
Factor	F1: Competitor growth	0.236	2
	F2: Bad debts become a burden on implementing banks	0.193	3
	F3: Risk of moral hazard	**0.237**	1
	F4: National economic growth	0.154	5
	F5: Contribution of MSMEs to GDP in Indonesia	0.180	4
Actor	A1: Branch manager	**0.382**	1
	A2: Business marketing supervisor	0.170	2
	A3: Marketing manager	0.163	3
	A4: Brand quality assurance	0.139	5
	A5: People's business credit program customers	0.146	4
Objectives	P1: Increase company revenue and profit	**0.300**	1
	P2: Increase customer loyalty	0.134	5
	P3: Maintain market share	0.172	3
	P4: Synergize business activities with environmental sustainability	0.153	4
	P5: Establishing good relations with business partners and the community	0.241	2
Alternative	AL1: Market development	**0.351**	1
	AL2: Development of people's business credit products, with life and health insurance features	0.192	4
	AL3: Market penetration strategy	0.208	3
	AL4: Continuing joint socialization, with coordination by the secretary of the presidential election and the coordinating minister for the economy	0.243	2

Table 4.
Results of processing the marketing strategy hierarchy for the people's business credit program at PT BNI Tbk Bima branch.

involved in the assessment of this structure include PT BNI Tbk Bima branch, namely, branch managers, brand quality assurance, business marketing supervisors, marketing managers, and people's business credit program customers. Experts who assess the structure in this study have different views and assessments, so the combination of expert assessments will produce an objective assessment. The combination of constituent elements are combined in a complete hierarchy, as shown in **Table 4**.

The main marketing strategy for the people's credit program that can be applied is market development (0.351). It is undeniable that MSMEs still face significant challenges in accessing capital. Marketing the people's credit program through market development is successful because the target market is broad. In addition, this marketing strategy requires a budget that is not too large and only requires trust in the prospective customers of the people's credit program.

Practical implications for managers: Given that market development is the main marketing strategy for the People's Business Credit, management at PT BNI Tbk Bima branch should focus on expanding the target market to reach more MSMEs who currently face difficulties accessing capital. The broad target market allows for scalable outreach efforts without requiring a large budget, relying heavily on building trust with prospective customers. To implement this strategy effectively, it is recommended to allocate resources for community engagement activities and awareness campaigns. Additionally, training staff in customer relationship management and trust-building techniques is crucial to enhance the program's accessibility and reputation. Budgeting should cover promotional materials, outreach events, and staff development to support sustained market expansion.

While the previous case emphasized the role of strategic promotion in mortgage products, this second case underlines the importance of market development and institutional coordination in supporting MSME-focused credit schemes like People's Business Credit. Building strong networks and managing risks, such as moral hazard, are central to People's Business Credit marketing success. The final case study will shift the focus to productive microcredit, highlighting direct promotional approaches such as personal selling in smaller-scale banking institutions.

3. Productive microcredit

The determination of the overall productive microcredit strategy follows the stages starting from SWOT identification, SWOT matrix analysis, and finally analysis of the selection of alternative marketing strategies using AHP.

Identification of SWOT at BPR Parasahabat Bogor. Based on the results of the analysis of the company's internal and external environmental conditions in marketing productive microcredit products, several strengths and weaknesses were identified in the company, as well as the opportunities and threats faced.

1. *Strength*. Strength describes something that a company has that provides a competitive advantage for the company. Based on the analysis that has been done, several strengths are obtained that the company has in marketing productive microcredit, namely: (1) Easy requirements without collateral; (2) Unique product characteristics; (3) Strategic location; (4) Speed of credit decision-making; (5) Use of a proactive technique that makes it easy and fast for customers to get service; (6) Experienced human resources in terms of product knowledge.

2. *Weaknesses.* Weaknesses reflect things that the company does not have, but other companies do. Weaknesses can also be internal constraints on the company in marketing products. Based on the results of the analysis that has been carried out, several weaknesses were identified in BPR Parasahabat Bogor, including: (1) Relatively high interest rates; (2) Loans must be made in groups; (3) Loan terms that are too fast; (4) Loan amounts that are too small.

3. *Opportunities*. Opportunities describe factors originating from the external environment that allow a company to grow, thus generating greater profits. From the results of the analysis that has been carried out, several opportunities were obtained that can be utilized by BPR Parasahabat Bogor, including the following: (1) Increasing credit development; (2) Increasing MSMEs development; (3) Increasing the number of women.

4. *Threats*. Threats are factors originating from outside the company that must be faced to reduce the detrimental impact on the company in the marketing activities of pension credit products. Based on the analysis that has been done, several threats faced by BPR Parasahabat Bogor were obtained, namely: (1) Brand image of strong competitors; (2) There are still customers who commit banking crimes; (3) Competitors who provide similar credit; (4) Unstable economic growth.

SWOT matrix analysis. By using the SWOT matrix, alternative strategies can be obtained by combining the company's main internal and external factors. The SWOT matrix produces four types of strategies, namely the SO strategy, the WO strategy, the ST strategy, and the WT strategy (**Table 5**).

The strategic alternatives derived from the SWOT analysis—encompassing SO, WO, ST, and WT strategies—were further evaluated using the AHP. This method was applied to rank the strategies according to pre-defined assessment criteria, thereby facilitating the identification of the most feasible and impactful options. Through this integration, AHP functions as a complementary tool that quantitatively validates and prioritizes the qualitative findings of the SWOT analysis.

Analysis of alternative marketing strategy selection with AHP. In the analysis of the productive microcredit marketing strategy of BPR Parasahabat Bogor, four things are interrelated and important to evaluate, namely: the factors that make up the marketing strategy, the actors who play a role in making the marketing strategy, the marketing objectives, and the alternative marketing strategies that may be implemented by the company. These four attributes will form the most appropriate marketing strategy to be applied to BPR Parasahabat Bogor. The results of processing the most appropriate marketing strategy can be seen in **Table 6**.

The most appropriate strategy implemented by the company based on the AHP analysis is to carry out a market development strategy by increasing promotions in the form of personal selling, with a value of 0.298 percent. This strategy is considered the most appropriate to be implemented in productive microcredit products. Promotions carried out with personal selling are considered more effective because employees can explain productive microcredit products in more detail. Meetings between PT BPR Parasahabat employees and prospective customers allow employees to immediately arouse the hearts of prospective debtors, and at that time, it is hoped that prospective customers can decide to become debtors.

With personal selling promotion, the company's strength in terms of product knowledge can be maximized, because the personal selling strategy is a strategy that

Internal	**Strength (S)**	**Weaknesses (W)**
External	1. Unique product characteristics, specifically for women and without collateral 2. HR experience in terms of product knowledge	1. The loan term is too fast, which is a maximum of 6 months 2. The loan amount is too small, a maximum of IDR 3,000,000-
Opportunities (O)	**SO strategy**	**WO strategy**
1. Increasing number of women 2. Increasing development of MSMEs	Carrying out market development strategies by increasing promotions in the form of direct selling to increase the number of customers (S1, S2, O1, O2)	Increase the loan amount and term of the borrower to attract more customers (W1, W2, O1, O2)
Threats (T)	**ST strategy**	**WT strategy**
1. Strong competitor brand image 2. There are still customers who commit banking crimes (moral hazard)	1. Providing special services to customers who have borrowed to maintain customer loyalty (S2, T1) 2. Increasing employee training to improve employee performance (S2, T2) 3. Conducting local promotions in the form of public relations to integrated health posts by providing free immunizations to improve the company's image (S1, T1)	1. Customers who have frequently taken out loans are given a longer loan period and a larger maximum loan amount (W1, W2, T1) 2. Strengthening the survey process by seeking customer information through neighborhood associations, residents' associations, and the environment around the customer's residence (W1, W2, T2)

Table 5.
Productive microcredit SWOT matrix.

interacts directly with end consumers. Experienced human resources can provide information, invite, and influence a prospective customer to participate in the product being implemented by the company. Good information provided by the company to prospective customers will make the customer indirectly promote the company to people around them about the advantages of the company compared to other companies. In the long term, to expand market share, the company can cooperate with commercial banks.

Practical implications for managers. Given that market development through personal selling is the most appropriate strategy for productive microcredit at PT BPR Parasahabat Bogor, management should prioritize enhancing direct, face-to-face promotion efforts. Personal selling enables employees to provide detailed explanations of the product, build trust, and immediately influence prospective debtors' decisions. To implement this strategy effectively, it is recommended to provide training that strengthens employees' product knowledge and interpersonal skills, enabling them to communicate the benefits clearly and persuasively. Management should also allocate a budget for personal selling activities, including incentives for employees to motivate sales efforts. Furthermore, fostering cooperation with commercial banks can be considered as a long-term approach to expand the market share and increase the program's reach. Allocating resources for partnership development and coordination will support sustainable growth in the productive microcredit segment.

Cluster	Aspect	Score	Ranking
Factor	F1: Unique product characteristics, specifically for women, and without collateral	0.19	2
	F2: HR who are experienced in terms of product knowledge	**0.38**	1
	F3: The loan term is too fast, which is a maximum of 6 months	0.07	6
	F4: The loan amount is too small, a maximum of IDR 3,000,000	0.08	4
	F5: The number of women has increased, which is 2.64 percent	0.09	3
	F6: The development of MSMEs has increased by 20.1 percent	0.05	7
	F7: Strong competitor brand image	0.08	5
	F8: There are still customers who commit crimes in banking (moral hazard)	0.04	8
Actor	A1: President director	**0.30**	1
	A2: Marketing head	0.20	2
	A3: Group loan head	0.19	3
	A4: Head of unit	0.18	4
	A5: Account officer	0.14	5
Objectives	P1: Increase credit distribution	**0.40**	1
	P2: Increase market share	0.34	2
	P3: Introduce and build a strong image	0.27	3
Alternative	AL1: Implement a market development strategy by increasing promotions in the form of personal selling to increase the number of customers	**0.30**	1
	AL2: Increase the maximum loan amount and loan term given to attract more customers	0.15	3
	AL3: Provide special services to customers who have borrowed to maintain customer loyalty	0.14	4
	AL4: Increase employee training to improve employee performance	0.06	6
	AL5: Conduct local promotions in the form of public relations to integrated health posts by providing free immunizations to improve the company's image	0.22	2
	AL6: Customers who have frequently borrowed are given a longer loan term and a larger maximum loan amount	0.10	5
	AL7: Tighten surveys on groups with confirmation from RT, RW, and people close to the area where the prospective customer lives	0.04	7

Table 6.
Results of processing the hierarchy of productive microcredit marketing strategies at BPR Prasahabat Bogor.

Together, these three case studies illustrate how different credit products within the banking system require tailored marketing strategies—from the broad, product-focused promotion of mortgage loans, to strategic market development in MSME financing, and, finally, to personalized, community-based approaches in microcredit. This comprehensive understanding aids banking managers in crafting effective credit marketing strategies across diverse customer segments and product types.

4. Credit marketing business model in banking system

The Business Model Canvas (BMC) is a management strategy designed to help companies plan their business based on value propositions, products, infrastructure, customers, and finances. BMC has several advantages, namely: (1) *Increases focus on important points of business planning*: BMC allows companies to systematically identify and fill in business planning elements according to the available blocks; (2) *Helps create a business model*: BMC is an effective strategic tool for clearly mapping the direction of the company's business; (3) *Saves time*: The use of BMC makes the business planning process faster and more efficient; (4) *Improves communication*: BMC makes it easier for teams to understand the company's business model, thereby improving the quality of communication between teams [8]. Created by Alexander Osterwalder in 2005, BMC consists of nine main blocks, namely: Value Proposition, Customer Segments, Channels, Customer Relationships, Revenue Streams, Key Activities, Key Resources, Key Partners, and Cost Structure. This business model will be used to observe the business structure of the following three types of banking businesses, specifically related to their business models and the strategic priorities that must be taken, namely: mortgage loans, people's business credit, and productive microcredit.

To better understand how business models are operationalized in the banking credit sector, the following case studies analyze three different credit products—mortgage loans, people's business credit, and productive microcredit—through the lens of the BMC framework.

4.1 BMC: Mortgage loan

The first case study focuses on Bank X Bogor Branch and its mortgage loan business. Using the BMC, we identify key areas to improve, such as marketing activities, customer relationships, and promotion channels, to increase mortgage sales and strengthen Bank X's position in Bogor.

Bank X is the second-largest bank in Indonesia in distributing mortgage loans, with a market share of around 10%. The Bank X Bogor Branch is located in Bogor, an extension of the head office that carries out banking activities to support national development, economic growth, and economic stability to improve public welfare. The number of employees in the Sales and Service Division of Bank X Bogor Branch is around 82, consisting of 72 permanent employees and 10 contract employees. The mortgage loan products offered are: (1) New and used (second) mortgages; (2) Multipurpose mortgages; (3) Renovation mortgages; (4) Takeover mortgages (**Table 7**).

From the analysis results, home ownership credit by PT Bank Cabang Bogor needs to be improved in elements including: (1) key activities, (2) customer relationships, and (3) channels. In key activities, it is necessary to consider increasing marketing and direct marketing activities, which function to convey product information directly to potential consumer targets, increase mortgage loan sales, build relationships with developers, and strengthen Bank X's image as a trusted provider of mortgage loan services. In the customer relationship element, it is necessary to increase personal selling activities, which aim to convey information and persuade developers and potential consumers to use Bank X Bogor's mortgage loan products.

For the channel element, advertising, sales promotion, and publicity activities need to be increased. Advertising aims to promote the name of Bank X nationally and increase sales at the Bogor Branch. Sales promotion is carried out by providing incentives to developers and potential consumers, such as sales rewards, shopping

Key partners	**Key activities**	**Value proposition**	**Customer relationships**	**Customer segments**
1. Property developer 2. Real estate agent 3. Property insurance provider	1. Direct marketing at development sites 2. Management of database of potential property buyers 3. **Increasing direct marketing and sales activities**	1. The ease of owning a home with an affordable credit scheme 2. Flexibility in tenor and competitive interest rates 3. Customer assurance *via* required insurance coverage	1. Personal selling services at developer locations 2. Financial consultation for property purchases 3. **Increase personal selling activities**	1. First home buyers 2. Upper middle class 3. Young families
	Key resources		**Channels**	
	1. Skilled marketing staff 2. Strategic relationships with property developers 3. Digital technology		1. Bank branches near developer locations 2. Property exhibitions 3. Digital banking for credit applications 4. **Increase advertising activities** 5. **Increase sales promotion activities** 6. **Increase publicity activities**	
Cost structure		**Revenue streams**		
1. Fixed cost: Branch operational costs, training costs for seminars, and self-development for employees 2. Variable cost: Branch operational costs, promotion costs at developer locations		1. Credit interest income 2. Administration fees		

Table 7.
Mortgage loan business model.

vouchers, and souvenirs, to encourage the selection of Bank X mortgage loan products. Meanwhile, publicity aims to explain the new terms or conditions of mortgage loan products, as well as build a positive image of Bank X and strengthen good perceptions among marketing developers and the public.

4.2 BMC: People's business credit

Following the examination of the mortgage loan business model, the focus now shifts to the business credit program targeted at micro, small, and medium enterprises (MSMEs). This segment plays a vital role in Indonesia's economy but faces unique challenges in accessing financing. The next case study explores how PT BNI Tbk Bima branch manages and strategizes its people's business credit program to address these challenges and enhance its market position.

PT BNI Tbk Bima branch is one of BNI's branch offices that markets the people's business credit program. People's business credit is a form of credit intended for entrepreneurs who are eligible for financing but do not yet meet bankable criteria, such as businesses that have only been running for less than 3 years, do not have legal documents such as a Business Location Permit, Trade Business Permit, or Company Registration Certificate, and do not have adequate additional collateral as credit collateral. The business sectors served are agriculture, hunting, and agricultural facilities; industry; trade, restaurants, and hotels; electricity, gas, and water; transportation, warehousing, and communications; business services; and social services.

Based on (**Table 8**), in the people's credit program, fundamental improvements need to be made to the following elements: (1) key activities, (2) customer relationships, and (3) customer segments. In the key activities element, it is necessary to develop people's credit products with life and health insurance features, which aim to protect debtors as the main consumers, thereby increasing the sense of security, trust, and attractiveness of people's credit products. In the customer relationship element, it is necessary to continue socialization together with coordination by the Secretary of the Vice President and the Coordinating Minister for the Economy. This step will make it easier for PT BNI Tbk Bima branch to market the people's credit program and increase competitiveness with other banks that also offer similar programs.

In the customer segment element, a market development strategy needs to be implemented to expand the marketing of the people's credit program, considering that there are still many MSMEs that face obstacles in accessing capital easily. This strategy is effective because the target market is broad, requires a minimal budget, and relies on the trust of prospective customers in the people's credit program. In addition, a market penetration strategy needs to be implemented to retain customers so that they do not switch to competitors while increasing market share through promotions and customer loyalty.

4.3 BMC: Productive microcredit

Building upon the discussion of people's business credit, the final case study examines a more specialized credit product aimed at empowering women microentrepreneurs. PT BPR Parasahabat Bogor's productive microcredit program targets women's groups with collateral-free loans designed to foster business growth and social support within communities. The following analysis highlights key strategic elements that require enhancement to optimize the program's impact and outreach.

Key partners	**Key activities**	**Value proposition**	**Customer relationships**	**Customer segments**
1. UMKM training institution 2. Cooperatives office 3. Small business association	1. MSME feasibility assessment 2. Financial literacy campaign 3. Business Monitoring 4. **Development of people's business credit products, with life and health insurance features**	1. High collateral-free financial support 2. Fast process to help MSMEs working capital and investment	1. Financial literacy education for MSMEs 2. Business Assistance 3. Ongoing relationships through business monitoring 4. **Continuing joint socialization, with coordination by the presidential secretary and the coordinating minister for the economy**	1. Eligible MSMEs but do not have sufficient collateral 2. Small business actors in the trade, agriculture, and service sectors 3. **Market development** 4. **Market penetration strategy**
	Key resources		**Channels**	
	1. Strategic relationship with cooperative services and MSMEs associations 2. Credit feasibility assessment staff		1. Bank Branch 2. Mobile Application 3. Education in MSME Community 4. MSMEs Seminar	
Cost structure		**Revenue streams**		
1. Fixed cost: Technology investment, Branch operational costs in MSME areas 2. Variable cost: Educational campaign costs, Branch operational costs in MSME areas		1. Credit interest *income* 2. *Credit app*lication administration fee		

Table 8.
People's business credit business model.

Key partners	Key activities	Value propositions	Customer relationships	Customer segments
1. Posyandu 2. Women's cooperative 3. Microfinance institution	1. Local promotion 2. Training of marketing personnel 3. Monitoring micro credit at the community level 4. **Developing the market with personal selling promotion to increase customers** 5. **Increasing employee training to improve performance** 6. **Tightening surveys by confirming neighborhood associations, residents' associations, and people close to potential customers.**	1. Microcredit access for women's economic empowerment 2. Reducing dependency on loan sharks 3. Community empowerment 4. **Increasing loan limits and terms to attract more clients** 5. **Providing larger loan terms and amounts for clients who borrow frequently**	1. Community-based relationships through local promotions 2. Financial literacy training 3. Micro-business assistance 4. **Providing special services for existing customers to maintain loyalty**	1. Women micro-entrepreneurs 2. Low-income communities 3. Local communities in rural areas
	Key resources		**Channels**	
	1. Relationships with local communities 2. Field staff who understand community needs 3. Microcredit technology		1. Local promotion at posyandu 2. Outreach service 3. Microcredit application *via* mobile phone 4. **Conducting local promotion at posyandu with free immunization to improve company image**	
Cost structure		**Revenue streams**		
1. Fixed cost: Field staff training costs 2. Variable cost: Local promotion costs, bad debt risk management costs		1. Microcredit interest income 2. Credit administration costs		

Table 9.
Productive microcredit business model.

Women's Micro Credit is a collateral-free credit facility from BPR Parasahabat Bogor, specifically intended for women aged 18–55 years with micro businesses that have been running for at least 2 years. This credit is given to groups of women consisting of 10–30 members, who know each other and live close together. Productive microcredit is not available to individuals, as a BPR strategy to facilitate monitoring in the event of arrears or bad debts through other group members. Women are chosen as debtors because they are considered more resilient, care about their families, and have stronger social ties than men (**Table 9**).

From the analysis results, productive microcredit by BPR Parasahabat Bogor needs to be improved in elements including: (1) key activities, (2) value propositions, (3) customer relationships, and (4) channels. In the key activities element, market development through personal selling promotions needs to be done to increase the number of customers. This strategy is effective in introducing productive microcredit products in detail and building trust through face-to-face interactions. In addition, visiting customers directly can increase their satisfaction by facilitating transactions and services. To support this effort, employee training is needed to improve performance and tighten the survey process for prospective customers with confirmation from neighborhood associations, residents' associations, and people closest to them in their residential areas.

In the value propositions element, an increase in the loan limit and term is needed to attract more customers. Customers who have borrowed frequently also need to be given benefits in the form of a longer loan term and a larger maximum loan amount as a form of appreciation and a loyalty incentive. In the customer relationship element, special services are needed for old customers to maintain their loyalty. Meanwhile, in the channels element, local promotions through integrated health posts by offering free immunizations can strengthen the company's image. This strategy supports the company's goal of introducing productive microcredit products while building a strong and positive image in the eyes of customers.

5. Key marketing components of credit products: A comparative overview

The following table (**Table 10**) summarizes and compares the key marketing factors, primary stakeholders, marketing objectives, and strategic actions identified in each of the three credit products discussed in previous sections. This comparative overview is intended to highlight both shared and unique elements across mortgage loans, people's business credit, and productive microcredit, offering a concise reference for strategic analysis.

The personal selling strategy has proven to be an effective approach in marketing banking products in Indonesia. A study by Ref. [9] demonstrated that personal selling significantly contributed to increasing sales of subsidized mortgage products at Bank Tabungan Negara (BTN) Syariah Bandung. Similarly, Ref. [10] examined personal selling strategies at Bank Central Asia (BCA) for mortgage products, identifying a step-by-step process used by marketing officers to attract and retain customers, from prospect management to closing transactions. Additionally, Ref. [11] described the success of Bank BTN's "Super Untung" promotional program through the systematic implementation of personal selling, involving prospecting, relationship building, and after-sales service. These studies collectively confirm that personal selling not only improves sales effectiveness but also strengthens long-term relationships between banks and their customers.

No	Product	Marketing factors	Actors	Objectives	Final strategies
1	Mortgage loan	Product characteristic	Consumer finance manager	Increasing sales of Bank X's mortgage products	**Increasing personal selling activities**
		Market characteristic	Business development officer	Maintaining the image (brand image) of Bank X	Increasing advertising activities
		Competition level	Branch manager		Increasing sales promotion activities
		Segmenting, targeting, positioning			Increasing marketing and direct sales activities
		Consumer characteristic			Increasing publicity activities
		Human resources			
2	People's business credit	Risk of moral hazard	Branch manager	Increase company revenue and profit	**Market development**
		Competitor growth	Business marketing supervisor	Establishing good relations with business partners and the community	Continuing joint socialization, with coordination by the secretary of the presidential election and the coordinating minister for the economy
		Bad debts become a burden on implementing banks	Marketing manager	Maintain market share	Market penetration strategy
		Contribution of MSMEs to GDP in Indonesia	People's business credit program customers	Synergize business activities with environmental sustainability	Development of people's business credit products, with life and health insurance features
		National economic growth	Brand quality assurance	Increase customer loyalty	

No	Product	Marketing factors	Actors	Objectives	Final strategies
3	Productive microcredit	HR who are experienced in terms of product knowledge	President director	Increase credit distribution	**Implement a market development strategy by increasing promotions in the form of personal selling to increase the number of customers**
		Unique product characteristics, specifically for women, and without collateral	Marketing head	Increase market share	Conduct local promotions in the form of public relations to integrated health posts by providing free immunizations to improve the company's image
		The number of women has increased which is 2.64 percent	Group loan head	Introduce and build a strong image	Increase the maximum loan amount and loan term given to attract more customers
		The loan amount is too small, a maximum of IDR 3,000,000	Head of unit		Provide special services to customers who have borrowed to maintain customer loyalty
		Strong competitor brand image	Account officer		Customers who have frequently borrowed are given a longer loan term and a larger
		The loan term is too fast, which is a maximum of 6 months			Increase employee training to improve employee performance
		The development of MSMEs has increased by 20.1 percent			Tighten surveys on groups with confirmation from RT, RW, and people close to the area where the prospective customer lives

Table 10.
Comparative summary of key marketing elements across credit products.

In addition to personal selling, market development has emerged as a complementary strategy to expand customer bases and meet evolving consumer preferences. One practical implementation of the market development strategy in Indonesian banking is through product innovation and demographic-based segmentation. Bank Syariah Indonesia (BSI), for instance, focuses on developing sharia-compliant digital banking services tailored to modern customer needs, such as mobile banking and responsive customer service, to expand its market reach [12]. Similarly, Bank Negara Indonesia (BNI) applies market development by targeting specific demographic segments, especially millennials, through customized financial products and services aligned with their digital preferences. This approach is particularly relevant in highly competitive urban areas such as Manado, where understanding consumer behavior is crucial to gaining market share [13].

In Indonesia, the socio-economic and regulatory landscape significantly influences the choice of marketing strategies in the banking sector. Limited digital literacy, particularly in rural areas, often necessitates more personal and direct engagement with prospective borrowers. As such, personal selling becomes a more effective approach compared to purely digital channels. This is reinforced by initiatives such as the *Strategi Nasional Keuangan Inklusif (SNKI)* and regulations from the Financial Services Authority (OJK), including OJK Regulation No. 76/POJK.07/2016, which emphasize community-based financial education and face-to-face engagement to promote financial inclusion. Similarly, Bank Indonesia's *Blueprint Sistem Pembayaran Indonesia 2025* outlines the importance of hybrid strategies that combine digital innovation with on-ground outreach, especially for underserved populations.

Conflict of interest

The authors declare no conflict of interest.

Author details

Jono Mintarto Munandar*, Widi Adyanto, Rabiatul Adwiyah, Rizki Sejat and Annisaturrahmah Maulida
IPB University, Bogor, Indonesia

*Address all correspondence to: jonomu@apps.ipb.ac.id

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Section 5

Risk and Capital under Supervision: Credit, Counterparty, Operational and Resilience

Chapter 11

Perspective Chapter: The Creditworthiness Assessment – Looking Forward between Fintech and EBA Guidelines

Alessandro Berti

Abstract

The chapter will examine both the changes that have already occurred and those currently unfolding with regard to creditworthiness evaluation. In Europe, but not exclusively, there is growing awareness that artificial intelligence can certainly play a significant role in banking operations; however, the issue of customer relations and the bank-business relationship has not yet been fully addressed. The Fintech phenomenon, together with the new rules imposed by the European Banking Authority (EBA Guidelines on Loan Origination and Monitoring), risks leading to credit rationing for small- and medium-sized enterprises, thereby disrupting the efficient allocation of resources. New tools have been mandated for banks to ensure a more accurate assessment of creditworthiness, while at the same time, new opportunities for accessing the credit market are being offered by digitalization and Fintech. However, this process may not necessarily be slow and gradual, as it will involve both the human capital of banks and the financial culture of businesses. The aim will therefore be to understand, starting from some considerations on credit risk assessment, the impact of Fintech innovations, new banking regulations, and corporate crises on business financing, as well as to explore possible solutions to prevent credit rationing and improve bank-firm relationships.

Keywords: banking, relationship banking, customer relationship, creditworthiness, Fintech, prudential supervision, guidelines EBA-loan origination and monitoring (LOM), credit risk, insolvency, SMEs

1. Introduction

Credit risk has always represented the primary risk for commercial banks. Any attempt to diversify portfolios, unless it fundamentally transforms the business model

of the lending institution, ultimately brings theoretical considerations back to the diligent or negligent evaluation of creditworthiness [1].

This was the case, for instance, in the subprime mortgage crisis, which, while a financial crisis involving the issuance and circulation of junk securities, originated in negligent creditworthiness assessments of borrowers. These evaluations were based on the collateral value rather than on borrowers' cash flow capabilities to meet obligations as they fell due.

In Europe, the predominant approach for a long time has been a guarantee-based practice in customer relationships, which sought to balance the costs of individual credit operations with the need to protect creditors' interests through the acquisition of collateral. Only the major financial crisis that began in 2008 and ended in 2018 led regulatory authorities and banks themselves to adopt greater prudence and diligence [2] in the evaluation of credit risk [3].

This chapter discusses creditworthiness assessment in light of recent innovations [4] brought by Fintech tools [5], new regulations issued by the European Banking Authority (EBA Guidelines on Loan Origination and Monitoring, 2021), and the potential consequences for credit rationing, especially for small- [6] and medium-sized enterprises (SMEs). The primary change introduced by the adoption of the EBA-LOM Guidelines has been, in effect, to focus on preventing the downgrading of credit exposure rather than mitigating its effects once a corporate crisis has materialized. This shift has been achieved through a more detailed and comprehensive preventive analysis, alongside a deeper forward-looking assessment of creditworthiness. As a result, all companies must not only understand but also effectively explain their historical and projected performance based on business plans grounded in credible and prudent assumptions. The practical enforcement of the EBA Guidelines may pose substantial risks for small- and medium-sized enterprises (SMEs), as it could prompt credit rationing [7] practices linked to a more conservative risk appetite among lending institutions. At the same time, firms—particularly SMEs—continue to exhibit a persistent deficit in financial literacy, which, within the current regulatory and legal framework, risks becoming a critical vulnerability. The framework is further shaped by the transposition into member states' national laws of the Insolvency Directive (2019) on corporate crises, which aims to anticipate, mitigate, and, where possible, prevent the effects of corporate distress. These changes have a significant impact on the dynamics of the bank-business relationship and, as such, should be evaluated from a perspective that considers the adjustments they impose on both the attitudes [8] and behaviors of key actors in customer relationships. This chapter, in examining the key issues related to creditworthiness assessment and the innovations introduced by Fintech and the EBA-LOM Guidelines, will compare both the traditional tools predominantly used by banks in the past and the new metrics mandated by the EBA, highlighting their key differences. Within the framework of these metrics, the increasing use of Fintech tools is also addressed, although the effectiveness of these tools in credit assessment may be compromised by the quality of the databases available to banks. Finally, the chapter will emphasize how the new regulatory and legal environment forces both banks and businesses, especially SMEs [9], to enhance the quality of their relationships, shifting toward a more intensive relationship banking model.

2. Credit risk assessment: Introductory considerations

Credit risk essentially refers to the risk that an unexpected change in a borrower's creditworthiness leads to an equally unexpected decrease in the value of the credit

exposure. This assessment is relatively straightforward in the case of individuals (such as consumer credit or mortgage credit) but becomes much more complex when evaluating businesses.

In consumer credit, whether purpose-specific or not, Fintech-based tools such as scoring models and automated models have long been used to measure credit risk using a few, simple variables: consumer income, past credit behavior, current and anticipated commitments, and potential effects of sensitivity analysis on future compliance with assumed obligations. In this context, consumer credit and mortgage loans are particularly suited to evaluation through mathematical models, which help minimize operational costs, especially those related to employing credit analysts. The high suitability of these credit products for low-unit-cost distribution has certainly emphasized the role of Fintech tools, facilitating the distribution and sale of third-party products, and thereby increasing service revenues over credit intermediation revenues.

In business credit, however, assessing risk and determining creditworthiness requires a significantly more complex evaluation [10], with an evident trade-off between the desire to reduce the unit cost of credit approval and the accuracy and precision of the evaluation. This involves examining historical and prospective financial statements, information from both internal and external sources, and preventive measures against moral hazard from businesses. It is worth noting that lending is inherent to banking activity, and banks are almost naturally inclined to lend money both due to their role in financial systems and because interest margins historically account for the majority of their intermediation margins. Business loans are riskier and, therefore, more profitable, making it logical for banks to support businesses in meeting their financial needs, also within a predefined Risk Appetite Framework and strategic choices aimed at better defining their business model.

It should be noted, in light of the forthcoming discussion, that meeting entrepreneurial needs has not always been a priority for banks. In a multi-banking credit model, where financial needs are addressed only on a pro-rata basis, the accurate assessment of financing requirements is a secondary factor, as risk is assumed in a segmented way, and it is essential to reduce the unit costs of credit evaluation. At the same time, the current state of business evaluation does not permit a perfect distinction between good and bad borrowers (**Figure 1**), leaving a share of businesses—potentially excellent or highly risky—within a gray area. The gray area in **Figure 1** represents a possible big source of significant revenues for the bank but

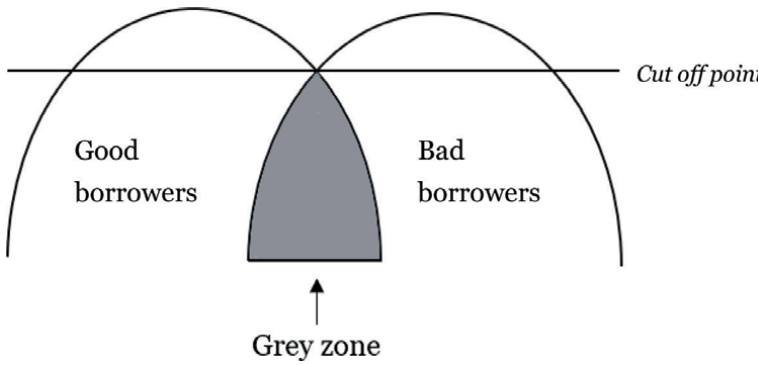


Figure 1.
The gray zone as the effect of not perfect distinction between borrowers.

also of substantial losses. It must therefore be assessed with great care, which entails considerable costs, particularly in terms of staff training and the analytical tools employed. Obviously, the size of the gray area depends on the level of risk appetite the bank has chosen to adopt, and the selected cut-off point that defines it is known only to the bank. As a result, the firm may be subject to credit rationing without being aware of the underlying reasons. Only a bank de-risking choice can reduce this area, but at the cost of losing many good potential customers, lowering the cut-off level (**Figure 2**). As of now, mathematical models and Fintech solutions have yet to provide definitive answers in this regard. This aligns with the fact that business management is not an exact science but a social science and that individual behaviors cannot always be constrained within model-generated frameworks.

Naturally, it is difficult to imagine, at the present time [11], that artificial intelligence (AI) could independently assess the creditworthiness of a company requesting a loan without relying on the experience of a trained and prepared credit analyst, who is particularly accustomed to examining financial statements with skepticism. It is therefore believed that AI could reduce the time and methods of the pre-assignment phase, namely the collection of the database, without, however, being able to fully replace human intervention in the decision-making synthesis.

Raising the cut-off point leads to a reduction in the bank's risk exposure, but also to a decline in revenues. This trade-off may induce moral hazard, as restricting lending to only the most creditworthy firms results in lower income, which in turn may necessitate cost-cutting measures. From this perspective, the use of AI tools can be potentially very risky if not guided and monitored by human intelligence and by well-trained, experienced analysts.

Finally, risk measurement and creditworthiness assessment are activities for which a complete replacement of human intervention with model-based or Fintech tools is not feasible. Aware of the risks associated with excessive reliance on AI in lending activities, the European Banking Authority (EBA) has mandated the establishment of safeguards related to model risk, to ensure that AI does not produce dysfunctional outcomes in relation to intended objectives. Model risk must therefore be continually monitored and periodically reassessed to confirm that decisions made with AI support are both accurate and effective for lending operations.

Prior to the implementation of the EBA-LOM Guidelines, banks employed highly simplified methodologies for assessing creditworthiness. These typically involved checking the debt/equity ratio, verifying the existence of a positive net income, and ensuring compliance with certain financial ratios—most notably, the current ratio, which was required to be positive and above one. It is readily apparent that no substantive investigation was conducted into the actual reliability of current assets, which could be freely manipulated in the presence of uncollectible receivables or merely accounting-based inventory values.

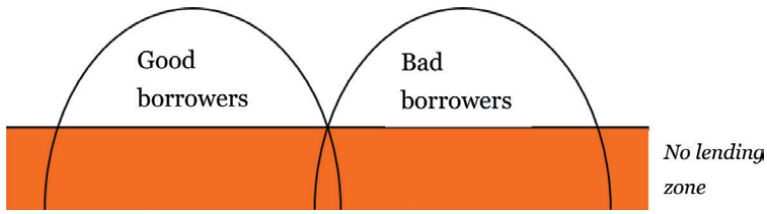


Figure 2.
Raising cut-off effects: credit crunch.

2.1 Comparative financial analysis: Company XYZ (2025)

The company under analysis has reported a net loss in its 2025 financial statements. In order to avoid disclosing this negative result to financing banks and external stakeholders, management decided to apply an accounting policy aimed at improving the net income. Specifically, the value of inventories was increased by €30,000, thus artificially enhancing the operating margin and final result.

The following comparative table illustrates the company's financial position and performance before and after the application of the accounting policy (**Table 1**).

Statement items	**Without policy adjustment**	**With policy adjustment**
INCOME STATEMENT		
Revenues	€2,000,000	€2,000,000
Operating costs	€1,950,000	€1,920,000
EBITDA	€50,000	€80,000
Depreciation	€20,000	€20,000
EBIT	€30,000	€60,000
Financial expenses	€40,000	€40,000
Net profit (loss)	€(10,000)	€20,000
STATEMENT OF FINANCIAL POSITION – ASSETS		
Property, plant, and equipment	€780,000	€780,000
Trade receivables	€290,000	€290,000
Inventories	€200,000	€230,000
Total assets	€1,270,000	€1,300,000
STATEMENT OF FINANCIAL POSITION – EQUITY & LIABILITIES		
Share capital	€620,000	€620,000
Trade payables	€230,000	€230,000
Short-term bank borrowings	€130,000	€130,000
Medium-term bank borrowings	€300,000	€300,000
Net profit (loss)	€(10,000)	€20,000
Total equity and liabilities	€1,270,000	€1,300,000
KEY FINANCIAL RATIOS		
Current ratio	136%	147%
Debt/equity ratio	0.70	0.67
CASH FLOW STATEMENT		
Net profit (loss)	€(10,000)	€20,000
Depreciation	€20,000	€20,000
Cash flow from operating activities	€10,000	€40,000
Change in net working capital	€(90,000)	€(120,000)
Free cash flow	€(80,000)	€(80,000)

Statement items	Without policy adjustment	With policy adjustment
Change in financing needs	€(80,000)	€(80,000)
Change in sources	€80,000	€80,000

Table 1.
A comparative financial analysys.

2.2 Summary interpretation

The application of the accounting policy leads to:

- A reversal of the net loss into a net profit of €20,000.
- An increase in total assets and equity.
- An improved current ratio and debt/equity profile.
- However, the free cash flow remains unchanged, as the inventory increase is a non-cash adjustment and negatively affects working capital: plus, although the overall cash flow remains negative and increased reliance on bank financing is necessary, the current ratio has improved.

3. AI in lending: Reflections on EBA's KPIs and metrics

AI's role in bank lending is not entirely new. For many years, banks have utilized automated models to digitize credit procedures and applied the so-called trend analysis to predictively identify any irregularities in borrowing behaviors that might signal impending corporate crises. However, the drawback of these models has always been their predictive ability: they only detect potential crises after the company has been granted credit, thus failing to prevent uncreditworthy businesses from entering the banking system [12, 13]. The delayed introduction of AI into credit processes is largely attributable to banks' need to manage a high volume of non-performing loans, which reached peak levels in 2015 before gradually declining. Prompted by regulatory pressure, banks have subsequently prioritized more rigorous preventive selection processes to avoid accumulating deteriorated or high-risk assets on their balance sheets. In this sense, the guidelines within EBA's Loan Origination and Monitoring (LOM) document aim to emphasize proactive, rather than reactive, credit management [14].

In recent years, the adoption of artificial intelligence (AI) in the banking industry has significantly transformed traditional approaches to credit scoring. Financial institutions increasingly deploy AI-driven tools to enhance predictive accuracy, operational efficiency, and regulatory compliance in credit risk assessment. The principal AI methodologies and tools employed include the following:

1. Machine learning algorithms:

   Supervised learning models are widely used to evaluate credit risk based on historical data. Among the most effective algorithms are:

- *Logistic regression and decision trees*—foundational models still employed for their interpretability.
- *Random forests and gradient boosting machines* (e.g., *XGBoost, LightGBM, and CatBoost*)—ensemble methods that offer superior accuracy and robustness in complex datasets.
- *Support vector machines (SVMs)*—effective in high-dimensional spaces and commonly applied for classification tasks in risk modeling.

2. Deep learning frameworks:

   Neural networks, particularly *deep neural networks (DNNs)* and *recurrent neural networks (RNNs)*, are used to model non-linear and temporal patterns in borrower behavior. These models are implemented using platforms such as *TensorFlow, PyTorch, and Keras*.

3. Natural language processing (NLP):

   NLP techniques facilitate the extraction of insights from unstructured data sources, including credit reports, social media content, and customer service interactions. Tools such as *spaCy, NLTK, and BERT-based models* support semantic analysis and sentiment evaluation to complement traditional credit indicators.

4. Alternative data analytics:

   AI systems process non-traditional data, such as mobile phone usage, e-commerce activity, utility payments, and psychometric data, to assess individuals lacking formal credit histories. Companies such as *Zest AI, Kreditech, and LenddoEFL* specialize in integrating alternative data into credit scoring models.

5. Explainable AI (XAI):

   Given the regulatory imperative for transparency, banks increasingly incorporate explainability frameworks to interpret complex model decisions. Popular tools include:

   - *SHapley Additive exPlanations (SHAP)*
   - *Local Interpretable Model-Agnostic Explanations (LIME)*
   - *IBM Watson OpenScale, which provides bias detection and model interpretability for enterprise AI applications.*

6. Credit scoring platforms and vendors:

   Several Fintech providers and AI platforms offer end-to-end solutions for credit evaluation, including:

   - *FICO (integrating ML-based models with traditional scoring systems)*
   - *Zest AI (AI-powered underwriting)*

- *Upstart (utilizing ML to expand access to credit)*
- *Experian Ascend (big data analytics and ML-driven credit decisioning)*

Through the integration of these tools, at least in theory, banks can not only enhance their credit decision-making processes but also extend financial inclusion, reduce default risk, and comply with evolving regulatory frameworks.

Currently, AI tools in credit processes seem still limited to data entry, with automated systems gathering financial, economic, and asset data through optical character recognition. While AI can enhance the data entry phase, reading and interpreting balance sheets, particularly in Europe, still poses challenges. Once the financial statements are processed and reclassified, they require review by an expert analyst to ensure that heterogeneous items are not mistakenly grouped, and especially to prevent internal and external fraud, as prescribed by EBA's LOM guidelines. In defining metrics for creditworthiness assessment, the EBA has introduced a structural monitoring tool, an approach previously underutilized both in prudential supervision frameworks and in managing non-performing loans within bank balance sheets. Essentially, the EBA has provided banks with specific tools, or key performance indicators (KPIs), which must be used during the creditworthiness evaluation process.

AI also plays a role in the credit process through the development of internal rating models, which the Capital Requirements Regulation (CRR3) intends to extend to all types of businesses, enhanced with ratings issued by External Credit Assessment Institutions (ECAIs). However, ratings alone are not designed to assess either creditworthiness or a company's financial needs; they primarily measure client risk, often based solely on trend analysis, if available, central risk information, or debt/equity ratios.

It is already common practice for balance sheets to be reclassified with AI tools that also generate the necessary KPIs for creditworthiness assessment. Often, these tools produce a synthetic score for the company under review, the reliability of which remains questionable, given that scores are assigned based on variables defined at the discretion of the external AI provider. In any case, an effective assessment of a client's repayment capacity and the appropriate size of the bank's financial intervention cannot be undertaken by a machine but rather requires a skilled credit analyst. Similarly, it is challenging to envision AI tools adequately compensating for the frequent lack of financial knowledge among businesses, particularly concerning the preparation of forecast reports, that are now essential under the EBA's prescribed metrics. In short, AI can provide valuable support in all preparatory phases leading up to credit approval but does not yet offer tools capable of reliably distinguishing good from bad borrowers or accurately determining creditworthiness.

Corporate financial statements are available in numerous databases, including those maintained by entities required to receive and archive annual corporate accounts. It is therefore likely, and indeed already occurring, that opaque, non-transparent, and sometimes manipulated balance sheets are not properly reclassified but merely transposed into the analytical models used within the credit process.

In this entire process, several key elements are lost:

1. The firsthand knowledge of those who would have performed the data entry, yet did not, and thus cannot recognize issues present in many financial statements, especially those of SMEs.

2. The opportunity to correct, except in cases of truly critical or necessary intervention, any posting or interpretative errors in financial statement items.

3. The ability to prevent fraud through the detection of improperly recorded items in financial statements, which, if unchecked or inserted in misleading ways, could lead decision-makers to erroneous assessments.

Additionally, the subsequent process of verifying and reviewing what AI has performed in the credit process risks lengthening the time and increasing the costs of due diligence, counteracting the initial intentions.

Conversely, the need for human analytical evaluation could be almost completely eliminated if the bank were to raise the cut-off level, as shown in the **Figure 2**. By doing so, applicants within the "gray area" would be entirely excluded, with clear implications for both risk and profitability, both of which would be significantly impacted. Raising the cut-off point would, on the one hand, avoid the risks associated with gray areas but, on the other, exclude potential borrowers, leaving the bank with only the lowest-risk, and thus, least profitable customers. In other words, by reducing its risk appetite, the bank may find it less necessary to monitor model risk, as well as to involve as many decision-makers within the institution, leading to evident cost savings.

It is equally clear that, due to the known opacity of financial communication among SMEs, these companies could be subject to credit rationing, as discussed in the following section.

4. EBA-LOM guidelines and credit rationing

As is well known, the EBA-LOM Guidelines [15] document has established three deadlines for the implementation of its provisions. First, as of June 30, 2021, all new credit applications submitted from that date forward were to comply with the guidelines criteria. By June 30, 2022, the financial statements of all borrowers became subject to the new rules for the purposes of credit monitoring and risk management. As of June 30, 2024, every bank in the European Union is expected to be fully compliant with the provisions established by the EBA.

The impression, though not substantiated by evidence, is that the EBA aimed to introduce the guidelines gradually to avoid disproportionately impacting SMEs, whose financial statements and quality of financial reporting are still far from acceptable standards.

It is worth noting that the EBA Guidelines address both the banks' allocation policies and the tools used to evaluate creditworthiness, prioritizing cash flow sustainability over collateral, even real assets. Appendix 2 of the EBA document specifies the data and information required for creditworthiness assessment, listing guidelines for all types of enterprises, regardless of size.

For micro-enterprises, SMEs, and large companies alike, certain key elements are emphasized, which may indeed be pivotal and potentially lead to credit rationing. These include:

- Purpose of the loan,

- Income and cash flow,

- Financial position and commitments, including pledged assets and potential liabilities,
- Business model and, if applicable, corporate structure,
- Business plans supported by financial projections,
- Real collateral (for secured loans),
- Other risk mitigation factors (guarantees, etc.).

It is important to emphasize that no size distinctions are made between different types of firms (only the construction and shipping sectors are treated separately), and all firms are required to provide financial projections. The investigation into financial needs (the purpose of the loan) remains the top priority, directly supported by the analysis of income and cash flows. Furthermore, banks must maintain "an accurate, comprehensive view of the client that enables them to assess the prospective repayment ability."

Moreover, if there is a likelihood that the customer will face financial difficulties (an assessment evidently left to the bank) in meeting the obligations arising from the loan contract, banks must request reliable documentation that includes realistic projections of the business's ability to remain solvent. Banks may also use information obtained from third parties (consultants, auditors, experts, etc.).

The most significant requirement, however, is that "real collateral should not be a dominant criterion for loan approval: (...) real collateral should be considered the institution's secondary recourse in the event of default or a significant credit deterioration, rather than as the primary source of repayment."

The specific requirements for SMEs related to the customer's financial position analysis are of particular note: In this context, banks must consider the following factors:

- Current and projected net financial position (NFP), including balance sheets, sources of repayment capacity, capital structure, working capital, income, and cash flow;
- Leverage, dividends, investments, and cash conversion rate;
- Probability of Default (PD) based on credit scoring or internal ratings.

The EBA's emphasis highlights both quantitative and qualitative aspects, particularly requiring banks to evaluate the business model and corporate strategy of clients, especially in relation to the loan's purpose. Banks must also assess the client's knowledge, experience, and ability to manage business operations, activities, and investments tied to the loan contract, as well as the feasibility of the business plan and related financial projections in alignment with the specific characteristics of the client's industry.

For loans to small and micro-enterprises, as well as to medium and large firms, it will be necessary to provide:

- Information on the purpose of the loan and, where applicable, evidence of the loan's purpose;

- Financial statements and accompanying notes, both on a single-entity and consolidated basis (balance sheet, income statement, cash flow) for a reasonable period, along with certified or audited accounts if applicable;
- Aging reports for receivables;
- Business plans for both the client and the loan's purpose;
- Financial projections (balance sheet, income statement, cash flow);
- Evidence of tax payments and tax liabilities;
- Data from credit registries or credit offices containing at least information on financial liabilities and payment arrears;
- Capitalization rate (net operating income/market value), applicable only to publicly traded companies;
- Asset quality;
- Total debt service coverage ratio (EBITDA/total debt service);
- Cash debt coverage ratio (net cash flow from operating activities divided by the average current liabilities maturing within a specified period).

For loans to micro-enterprises, SMEs, and large firms, banks must consider the Equity Ratio (equity/total assets), long-term Debt-to-Equity Ratio, EBITDA, Debt Yield (net operating income/loan amount), Interest-bearing Debt/EBITDA, and Enterprise Value (for listed companies only, equivalent to the sum of the market value of ordinary shares, preferred shares, debt, and minority interests, minus cash and investments).

Certainly, below is the revised academic version of your paragraph, now supported by appropriate references that align with academic standards in banking and finance literature:

In summary, the principal innovations introduced by the EBA Guidelines on Loan Origination and Monitoring (EBA-LOM) may be synthesized as follows:

1. A pronounced shift toward the primacy of cash flow-based lending, whereby the borrower's capacity to generate sustainable operating cash flows is prioritized over the availability of collateral [15, 16].
2. A substantially broader and deeper information framework, requiring both historical financial analysis and, more critically, forward-looking assessments, in order to better capture the firm's prospective risk profile [15, 17].
3. Increased emphasis on the business model and entrepreneurial capabilities of the borrower, including the evaluation of strategic coherence and the adequacy of organizational and governance structures [15, 18].
4. A renewed focus on the role of working capital and asset quality, particularly in terms of the capacity of balance sheet items to support future earnings, revenue

generation, and liquidity—an essential condition for ensuring business continuity [19, 20].

5. An explicit call to avoid undue delays in recognizing signs of borrower distress, thereby promoting a more timely and proactive approach to credit risk monitoring and loan loss provisioning [21, 22].

6. Finally, the EBA also emphasizes the concept of loan sustainability—both in the short term and in the medium to long term—through the use of two key indicators: the Debt Service Coverage Ratio (DSCR) and the Net Financial Position to EBITDA ratio.

Faced with the list provided here, which is not exhaustive but only illustrative, it is evident that the well-known gap in financial literacy characterizing SMEs risks becoming a significant factor in credit rationing unless banks intervene, while adhering to the guidelines, to facilitate financial communication [23].

Ironically, AI has not yet been engaged in this area to help ease the transition from old practices to the new requirements set by the EBA. As a result, while AI is used internally within banks to process and manage loan applicant information, it is not utilized in client interactions and not to replace the essential relationship between the bank and the client but to streamline and standardize it.

4.1 Best practices and AI

It is worth noting that during data collection, banks can support clients struggling to provide all the necessary information [24], for instance, financial projections that may be needed, particularly when a loan application involves investments aimed at altering the firm's working capital. Such efforts could be supported by industry associations and accounting professionals assisting companies to standardize the criteria and presentation methods for credit applications.

These considerations suggest that certain banks may be more responsive to client needs and may be more inclined to assist clients in adapting to the new credit application requirements. This could lead to two potentially complementary outcomes: on one hand, banks with a stronger focus on relationship banking could gain a competitive advantage over the rest of the banking sector, which remains committed to the transaction banking model. On the other hand, if some banks decide to apply EBA criteria less rigidly, this could lead to client polarization, attracting less prepared clients to these institutions. Such banks would inherently assume higher risk levels within their loan portfolios—more prone to deterioration in the medium term but potentially more profitable in the short term.

The consequences for businesses, especially smaller ones, risk manifesting in excessively prudent evaluations that will inevitably lead to credit rationing, either in the form of reduced credit limits or through increased applied rates. However, the issue of effective financial communication cannot remain confined to the topic of rating assignment but should, above all, enable an accurate assessment of creditworthiness through a judgment on the nature, quality, and sustainability of financial needs.

A central question concerns the methods by which banks evaluate creditworthiness for the firms they support. There is a risk that the growing push toward digitalization might expedite the credit process inappropriately, relegating creditworthiness assessments (both the necessity and amount) to models and using ratings solely as a basis for

pricing. This could unfairly penalize smaller firms whose simplified financial statements lend themselves to being treated, equally simplistically, by automated models.

Currently, there is no indication that supervisory authorities intend to apply the rules contained in the EBA-LOM Guidelines *stricto sensu*. The potential effects of credit rationing will also depend on the extent to which banks are genuinely willing to fully apply the metrics set out by the EBA, as well as on the supervisory policies EBA adopts to monitor their effective implementation.

On the other hand, it is unreasonable to expect businesses, particularly SMEs, to adapt to the new regulatory framework without a preceding process of financial education focusing on corporate financial management.

Regarding best practices in financial communication, it is essential to clarify that communication is not equivalent to merely providing information. In the case of a publicly traded company, the information provided to the market is mandatory and prescriptive, leaving no doubt as to what must be included in quarterly reports or other obligatory documents. What distinguishes effective communication, however, is how information is handled and conveyed. For instance, while all companies required to prepare complete financial statements must also prepare a cash flow statement following international accounting standards, few provide accompanying commentary. In other words, while information is presented in compliance with the law, communication does not enable the average reader of the financial statements, unless they possess specific expertise, to understand the nature, quality, and duration of the company's financial needs or the purpose of preparing the cash flow statement, especially given that most SMEs rely on bank credit rather than equity financing, following Myers' well-known pecking order [25].

Thus, financial communication is the collection of information directed externally that serves to update stakeholders' knowledge of the firm's ability to generate wealth over time through the efficient use of working capital. Stakeholders primarily include suppliers, credit insurers, and banks.

Since business risks and changes in the operating environment can sometimes produce outcomes that differ from expectations, there are three possible approaches:

1. To manipulate or conceal data that reflect underwhelming performance, or to enhance them only from an accounting perspective (e.g., through the classic inventory adjustment);

2. To favorably interpret data that might not otherwise support positive assessments;

3. To avoid discussing unfavorable data altogether and minimize commentary on the remaining information.

These considerations may lead to the believe that the quantity of information improves financial communication, but this is not the case. Effective financial communication starts from adequate explanations of the business model and additional relevant details.

A realistic observation is that corporate financial statements contain what the preparers intend them to include (for instance, in the explanatory notes, an entry like "other payables" simply states "other payables") and that all stakeholders, as outsiders, do not have access to internal insights. Proper financial communication should therefore adhere to several basic rules:

a. Provide historical financial documents promptly, with the utmost timeliness;

b. Explain the rationale behind adopting specific accounting principles and the resulting impact on EBITDA and EBIT;

c. Outline the strategic approach to management;

d. Explain decisions regarding working capital management (especially concerning inventory and the use of trade credit);

e. Present the outlook for the next 2–3 years, using projected financial statements and justifying the assumptions behind them;

f. Connect operational profitability, use of invested capital, structural and cyclical financial needs, and adopted financial structure using reclassified financial statements in a standardized format;

g. Proactively explain, in documents sent to banks, suppliers, and credit insurers, the data that are known to be of interest to them.

The understanding that certain data, if omitted or inadequately presented, will still be requested and/or independently calculated by financial stakeholders should discourage the omission or inadequate presentation of such data. For example, if the ratio of NFP to EBITDA is increasing, explaining the rationale behind the indebtedness (e.g., for new investments) could render the increase acceptable and sustainable.

Finally, some financial statements include ratios—often generated automatically from long-standing practices—such as ROE, quick ratio, current ratio, structural margin, and others, which add little value and primarily serve to fill pages. It would be better to exclude such indicators, some of which, like ROE, are altogether misleading for stakeholders. In this regard, an effective financial education program could advocate calculating these indicators, while also providing explanatory notes on their basis and composition.

A separate discussion, which can only be addressed briefly within this chapter, concerns the evaluation of ESG factors in the assessment of credit risk [26]. Many authors focus on the raw ESG information used by rating agencies rather than the scores assigned by these agencies. This approach ensures independence from different rating schemes and allows the results to be applicable to non-rated corporations. Several empirical studies (e.g., [27]) have examined the relationship between ESG ratings and corporate performance, as well as creditworthiness. The studies find positive links between ESG ratings and financial performance, stock returns, and lower credit spreads. There is evidence that incorporating ESG factors into the credit rating process improves the prediction of borrowers' financial performance and default risk. Credit rating agencies recognize the importance of ESG factors in assessing credit quality and have started considering ESG risks in their evaluations. The UNPRI Statement on ESG in credit risk and ratings emphasizes the relevance of ESG factors for creditworthiness assessment. Despite this evidence, there is still a lack of a comprehensive credit risk model that explicitly incorporates ESG dimensions as determinants of default risk.

5. The role of banks in preventing credit rationing: AI and standardization of credit databases in banks

Given that banks themselves determine their risk appetite and Risk Appetite Framework (RAF) in relation to the business model selected within their strategic planning, it is easy to envisage that banks will need to carefully choose the productive sectors, geographical areas, and even supply chains within which to operate. While banks are not required to disclose their strategies to clients, partially sharing credit allocation choices could help clients gain, at least a superficial understanding of the new rules of a game they do not know. It is fair to say that many professionals and advisors supporting business clients have neglected to adequately inform them about recent regulatory changes, from the Insolvency Directive to the EBA Guidelines [28].

AI could assist banks in standardizing and thereby making more accessible a database framework essential for credit acquisition and initiating credit processing [29]. This could take the form of a dedicated page on the bank's website that includes all necessary fields for uploading required documents, with an explanation that without these documents, the request evaluation cannot begin. It is equally important that businesses understand the provision in the EBA-LOM Guidelines, which states that the bank's decision-makers must decide based on the most up-to-date information available at the time of assessment, which implies the examination of historical financial statements, recent forecasts, and at least three-year economic and financial projections. Proposing a standardized framework for the database needed to obtain credit would help companies better prepare to comply with the requirements of the Insolvency Directive, thus aiming to prevent insolvency and facilitate the adoption of measures to restore business continuity.

There is certainly another approach to avoid credit rationing, which involves forward-looking analysis, by making companies more informed about the content of the EBA-LOM Guidelines on this matter. Economic and financial planning, especially in countries where a more conservative approach has long been adopted, is relatively unfamiliar even to banking analysts. Within the entrepreneurial sector, particularly among SMEs, there is a genuine lack of knowledge of the technical tools necessary both to achieve solid and reliable management control and to produce credible economic and financial projections that demonstrate business continuity and debt sustainability.

Banks could, therefore, work to develop the knowledge of managers and owner-managers of SMEs to share with them the tools and methods for drafting economic and financial forecasts, as well as an appropriate approach to analyzing past performance. Additionally, they could provide insights into the main metrics that the EBA mandates in the creditworthiness assessment process. Since this assessment has become more objective with the issuance of the EBA-LOM Guidelines, there is a little risk of creating a conflict of interest. On the contrary, it can be legitimately argued that increasing the managerial literacy of entrepreneurs not only benefits them but also helps banks better understand their performance and prospects. In practice, businesses, particularly SMEs, often demonstrate a limited understanding of the rules introduced by the EBA and, more generally, frequently lack the capacity to comply with them even when they are aware of their existence. Greater sharing of assessments and evaluations by banks regarding the businesses they finance, far from constituting a conflict of interest, could help reduce the risk profile of these firms and enable a more efficient allocation of resources.

6. The impact of digital transformation on the bank business relationship

The bank business relationship has increasingly become characterized by depersonalization, driven both by the widespread adoption of credit ratings by major banks and by the need to control cost-income ratios through reductions in operational costs, particularly staffing. The implementation of ratings—exempting smaller banks and excluding SMEs—has paradoxically allowed these relationships to endure, specifically with smaller enterprises. Ratings have often been used as shortcuts for assessing creditworthiness, with less focus on examining the nature, quality, and duration of the business's financial needs, which has not contributed to a more mature and informed bank-business relationship. For retail clients, while relationships may still be based on personal knowledge, they also frequently rely on guarantees, often through state-backed credit guarantee consortia. Although this structure has likely mitigated severe financial crises for SMEs, it has not encouraged banks to improve the quality of their credit assessment processes, as public guarantees provided an easy exit route for difficult situations.

Digital transformation has eliminated [30] numerous positions tied to repetitive, easily replicable tasks, not only cashiers but also roles related to credit processes, such as data entry, document transmission, and the evaluation of standard operations like mortgage or personal loan applications. Final judgment on credit applications remains securely anchored in human intervention, requiring synthesis from experienced, reliable analysts; even when banks use automated models for credit assessments [31], the EBA mandates model risk controls that can only be effectively performed by expert personnel.

However, while digital data collection will likely diminish the direct relationship between banks and businesses—given the ease of accessing client data regardless of the client's diligence or involvement (as seen in databases that consolidate and reclassify business financials)—human intervention remains crucial in the analysis and creditworthiness assessment stage. Nevertheless, it will be limited to preserve the impartiality and independence of decision-makers, as mandated by the EBA.

The risk, therefore, lies in the likelihood that more banks will adopt standardized digital processes for information requests, allowing business owners or their advisors to submit data remotely. This approach would accelerate the database completion phase but could also reduce face-to-face interactions between banks and clients, confining them mostly to collaboration on financial projections as part of the business plan.

Regarding this last point, the issue of limited financial literacy among SMEs may present an opportunity to redefine the traditional dynamics of the bank-business relationship.

Often, the customer relationship follows a pattern that begins with a credit request, sometimes disconnected from an analytical understanding of the firm's actual financial needs, followed by requests for historical information and guarantees. Despite the clear improvements introduced by the IFRS9 accounting standard, banks' monitoring activities have so far remained closely tied to performance analysis results, without engaging in corrective actions directly with clients, such as providing feedback, identifying weaknesses, clarifying risk factors, or explaining the key metrics that the financial institution must necessarily examine.

Possessing a complete accounting database allows banks to digitize the prospective evaluation process easily, as it only requires inserting assumptions—possibly even

adverse ones—about the evolution of key variables to generate forecasted balance sheets that the client may not have previously seen or understood. The client's lack of financial knowledge, particularly in terms of managing business cash flows, makes this scenario plausible, pushing banks to rely on their own projections, doubting the client's forecasts or not trusting their technical abilities.

An additional point of reflection involves assessing companies in distress within a European regulatory landscape profoundly altered by the Insolvency Directive and its national implementations.

A preliminary, surface-level analysis of a crisis's causes should allow for determining whether the crisis is temporary (perhaps due to an economic downturn causing payment delays and lengthening the cash cycle) without undermining the business's core stability, or if it is structural, requiring industrial interventions to modify and enhance a business model that is evidently no longer competitive.

This distinction between crisis types has immediate consequences for financial reporting. A temporary liquidity crisis does not necessitate major changes in working capital valuation criteria, whereas a business crisis affecting the model's viability impacts both fixed and net working capital assets significantly. Discussion on this topic is often "tainted" by a corporate crisis culture that focuses on symptoms (lack of liquidity) rather than causes, offering solutions—often encouraged by banks—that merely postpone the issue through consolidation of unsecured debt into secured debt, extended payment terms, and acquisition of additional collaterals, particularly public ones that are more easily liquidated than real assets.

This theoretical "contamination" and its practical application have led to the pursuit of ineffective solutions, with companies striving to avoid a credit crunch and banks seeking more valid guarantees, while cautious of violating principles of fairness and good faith should they withdraw support from insolvent companies. This has led companies to produce "bankable" financial statements, often the product of significant accounting policies aimed at altering earnings, and banks to secure new, more reliable guarantees while continuing credit relationships that would warrant closer scrutiny, effectively delaying the recognition of losses.

If the cause of a business crisis is economic, whether exogenous or endogenous, the impact will be immediately reflected in the income statement, affecting profitability. In this case, an in-depth examination is required to determine whether the crisis affects the EBIT level (indicating a failure to achieve operational breakeven) or, more critically, the EBITDA level, where it becomes evident that the added value is insufficient to cover labor costs. Although these are both industrial issues of varying severity, they each call into question the company's fundamental viability, often necessitating interventions that structurally alter working capital. It is difficult to imagine that the financial statements would remain unaffected, not only in terms of interim results but also regarding asset valuation, whether technical, material, or intangible, as well as financial assets. Asset valuations will necessarily reflect the need for a restructuring plan involving equity as well. The absence of recovery plans or concrete prospects for improvement will inevitably impact working capital assessment in its various components, which has become inadequate to generate projected revenue and cash flows.

If the crisis starts from financial issues, it presents similar symptoms to an economic or industrial crisis, such as liquidity shortages, though the root cause is different. Delayed or missed payments from one or more clients may put the company at risk only if revenues are heavily concentrated—as in subcontracting. Otherwise, it is a

matter of assessing whether conditions exist for redefining the monetary cycle and its timing within a set of management actions reflecting an essentially sound operation.

Adhering to best practices for adequate organizational, administrative, and accounting structures is the only way, in both cases, to produce reliable, clear, and accurate interim and final financial statements and to anticipate and prevent potential difficulties. Here, too, banks could support clients by providing them with knowledge tools, beginning with a set of necessary information for a thorough and comprehensive creditworthiness assessment.

7. Conclusions

The potential negative impact of digitalization—a possibility far from remote given the points highlighted above—could only be mitigated by the behavior of those who will make the greatest use of it within the client relationship, namely the banks. Should banks choose to adopt creditworthiness assessment models based entirely or predominantly on AI—not only for data entry or data collection but especially in making lending decisions—it is likely that SMEs would be most adversely affected, given their managerial shortcomings in financial matters. Conversely, a constructive approach to using AI as a tool to enhance understanding of businesses' needs and circumstances could significantly benefit customer relationships, provided that banks also invest in adequately trained and skilled human resources for credit risk analysis and assessment. Ultimately, digitalization can positively impact the bank-business relationship by significantly improving:

- Access to databases on historical performance.
- Establishment of a standardized protocol to help businesses better understand their KPIs.
- Online simulation capabilities for three-to-five-year financial projections, incorporating key sustainability indicators.
- Digital support along with educational programs for financial planning techniques to strengthen client relations.

The solutions proposed in this chapter can therefore involve AI to varying degrees, encouraging businesses to take greater responsibility in providing comprehensive historical information and fostering necessary collaboration on future business plans.

For example, if a business seeks support for a major investment plan, the evaluation database could be structured as follows: complete financial statements for the past 3 years, including cash flow statements; a recent trial balance (no older than 2 months from the credit request submission date); and a three-year financial plan focused on projected ICR, free cash flow, and sustainability indicators for short- and medium- to long-term debt (DSCR and NFP/EBITDA).

It is therefore essential to develop a greater propensity for financial communication, particularly among SMEs, which would enable banks to maintain a complete and up-to-date database, without which a decision on creditworthiness cannot be made. At the same time, assistance from banks in developing financial literacy within

businesses will undoubtedly facilitate overcoming the information asymmetries that still characterize the bank-business relationship.

Understanding customer satisfaction remains critically important, not only in quantitative terms but also in qualitative dimensions. This can be achieved through the administration of surveys and the active involvement of trade associations. Such efforts could be translated, for instance, into a periodic report summarizing the qualitative aspects of client relationships, as was previously undertaken by the British Bankers Association, many years ago. This would enable all stakeholders to deepen their mutual understanding, fostering a partnership-oriented approach. It is also evident that such exchanges would carry a competitive advantage for those banks—of which there are many—that aim to offer retail clients services and products tailored to their actual needs. Through these tools, it will be possible to enhance the qualitative level of the bank-business relationship, steering it toward greater mutual awareness and alignment.

Certainly, as nothing occurs automatically, it will be essential—particularly during the initial implementation phase of the EBA-LOM Guidelines—for financial advisors supporting businesses, especially SMEs, to be adequately prepared to act as facilitators of a new and more effective relationship between banks and enterprises. Only mutual trust can establish transparent and long-term relationships. In this period of significant change, it is unrealistic to expect businesses to navigate this process alone. Conversely, within a framework of agreements involving banks, business associations, and representatives of financial advisory associations, it would be feasible and realistic to envision the achievement of standardized practices for financial communication, with agreed timelines and improved mutual understanding. If implemented, such measures could not only foster a stronger entrepreneurial culture but also significantly mitigate the potential rationing effects discussed in the previous chapter.

Author details

Alessandro Berti
Urbino Carlo Bo University, Urbino, Italy

*Address all correspondence to: alessandro.berti@uniurb.it

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Chapter 12

Innovative Approaches to Counterparty Credit Risk Management: Machine Learning Solutions for Robust Backtesting

H. Semih Yildirim

Abstract

This chapter explores the application of machine learning (ML) in enhancing backtesting processes for counterparty credit risk (CCR) management. Traditional backtesting frameworks, while foundational, often fail to address the complexities of modern financial systems due to their reliance on static assumptions and limited adaptability. By leveraging ML's capabilities, such as high-dimensional data processing, dynamic recalibration, and scenario-based stress testing, the proposed framework addresses critical gaps in predictive accuracy and exposure validation. A comprehensive application of this framework is included, illustrating its effectiveness in areas such as improving real-time monitoring, dynamically recalibrating risk models, and integrating scenario-based stress testing to validate Expected Positive Exposure (EPE) profiles and assess tail risks. Challenges related to data quality, model transparency, and integration with legacy systems are critically evaluated, alongside strategies to align ML methodologies with regulatory requirements. While emphasizing the central role of backtesting in CCR management, the chapter also considers the broader implications of integrating ML for improving systemic resilience and operational efficiency. By combining advanced ML techniques with established risk management principles, this chapter provides actionable insights for financial institutions, regulators, and researchers seeking to modernize CCR backtesting in an evolving financial landscape.

Keywords: counterparty credit risk (CCR), machine learning (ML), risk backtesting, predictive risk modeling, regulatory compliance

1. Introduction

The 2008 financial crisis exposed critical weaknesses in counterparty credit risk (CCR) management, underscoring its central role in maintaining global financial stability. CCR—the risk that a counterparty might fail to fulfill its contractual

obligations—can lead to significant financial losses and amplify systemic risks. The collapse of Lehman Brothers vividly demonstrated how the failure of a single entity could disrupt interconnected counterparty relationships, destabilizing global markets. Similar vulnerabilities were evident in the near-collapse of institutions like Bear Stearns, AIG, Fannie Mae, and Freddie Mac, where exposures were often incorrectly treated as risk-free. These misjudgments not only contributed to widespread losses but also revealed fundamental flaws in how counterparty risk was modeled and managed. Events such as the European sovereign debt crisis in 2012 further highlighted the need for rigorous validation techniques, as deteriorating sovereign debt strained the solvency of major financial institutions.

In the aftermath of these crises, backtesting became a cornerstone of CCR management, providing banks and regulators with tools to refine risk calculations and enhance resilience. Regulatory frameworks, such as Basel III, introduced higher capital reserves and mandated backtesting practices for internal model methods (IMM) [1, 2]. Backtesting plays a critical role in assessing whether CCR models provide accurate forecasts, comparing predicted exposures with actual outcomes under varying market conditions. However, significant challenges remain. Traditional backtesting frameworks, heavily reliant on static assumptions and linear methodologies, struggle to capture the complexities of CCR, particularly in scenarios involving long-term contractual relationships or non-linear dependencies [3]. For example, derivative contracts often exhibit high sensitivity to interconnected market variables, creating dynamic interactions that traditional statistical models fail to address effectively [4]. These limitations are further compounded by increasing regulatory demands for transparency and explainability, requiring risk models to be not only accurate but also interpretable and defensible.

Existing literature underscores the urgent need for innovation in CCR backtesting methodologies [5]. Traditional backtesting principles from market risk models often fall short when applied to CCR, with researchers emphasizing the importance of tailored approaches that account for non-linear exposures and long-term dynamics. Calls to integrate risk factor evolution models with backtesting frameworks reflect a growing consensus on the need for holistic and practical methods to validate CCR models effectively [6]. While these studies provide valuable theoretical insights, practical guidance on leveraging emerging technologies like machine learning (ML) in backtesting remains limited. ML offers a transformative potential to address these gaps, excelling in processing high-dimensional datasets, identifying non-linear relationships, and adapting to evolving market conditions. For example, ML can refine predictive accuracy by dynamically incorporating real-time data and recalibrating model parameters based on emerging risk patterns [7–10].

This chapter presents a conceptual framework that bridges the gap between traditional backtesting practices and emerging ML methodologies in CCR. By harnessing ML's strengths—its ability to analyze complex data, model intricate relationships, and adapt dynamically—the proposed framework enhances the precision, scalability, and robustness of backtesting processes. Importantly, this integration is grounded in established financial principles, ensuring both practical applicability and regulatory alignment. The framework equips financial institutions with tools to validate CCR models effectively, empowers regulators to refine standards through transparent and interpretable models, and inspires researchers to explore new opportunities for innovation in backtesting.

The implications of this framework are substantial. For financial institutions, ML offers tools to modernize backtesting practices, equipping them to validate

CCR models with greater precision and adaptability in volatile markets. Regulators can benefit from ML's transparency and interpretability, enabling them to refine risk management standards. Researchers can use this framework as a foundation to expand ML's applications in backtesting CCR. This chapter begins by introducing foundational CCR concepts, delves into relevant ML methodologies, and presents a comprehensive ML-based framework for CCR backtesting. It concludes with an analysis of emerging trends, challenges, and future opportunities for advancements and applications in this critical domain.

2. Counterparty credit risk and regulatory landscape

CCR refers to the risk of financial loss if a counterparty fails to meet its contractual obligations before the contract's maturity. Unlike traditional credit risk, CCR is inherently dynamic, with exposures fluctuating due to changes in market conditions that affect the contract's mark-to-market (MtM) value. This variability complicates risk assessment and is especially pronounced in over-the-counter (OTC) derivatives, securities financing transactions, and other bilateral agreements, where exposures can shift rapidly in response to external events [11]. The 2008 financial crisis brought CCR into sharp focus, illustrating how interconnected financial systems could amplify the effects of counterparty defaults, leading to widespread instability. These cascading effects revealed the pressing need for rigorous backtesting frameworks to validate models and ensure their robustness under dynamic market conditions.

In the wake of the crisis, regulatory reforms reshaped CCR management, placing backtesting at the forefront of institutional and regulatory strategies. Frameworks like Basel III emphasized the importance of backtesting internal model methods (IMM), requiring institutions to validate predictions against real-world outcomes to ensure accuracy and reliability [2]. Backtesting became central to calculating critical risk metrics, including Value-at-Risk (VaR) for market risk capital charges and Expected Positive Exposure profiles for CCR management. By enforcing stringent validation requirements, these reforms aimed to bolster financial system resilience and enhance institutions' ability to navigate systemic risks. This emphasis gained urgency during subsequent crises, such as the European sovereign debt crisis of 2012, which further exposed weaknesses in traditional CCR models when sovereign debt pressures threatened institutional solvency.

CCR modeling involves a suite of interconnected components designed to assess and quantify potential exposures. Expected Positive Exposure (EPE) represents the time-weighted average of potential future exposures, while Potential Future Exposure (PFE) quantifies the maximum exposure at a specified confidence level. Effective Expected Positive Exposure (EEPE), used for regulatory capital calculations, reflects a more conservative approach under Basel III guidelines. These metrics are fundamental to backtesting frameworks, providing benchmarks for comparing model predictions against actual outcomes under varied market scenarios [12].

Effective backtesting of CCR models requires a comprehensive approach that integrates multiple components. This process involves generating EPE profiles through four core elements: (1) Risk Factor Evolution (RFE), which simulates changes in market variables like interest rates and volatilities; (2) Pricing models, which determine the value of derivative instruments; (3) Collateral models, which account for the mitigating effects of collateral; and (4) Netting and aggregation models, which evaluate overall exposures across portfolios. A holistic backtesting strategy evaluates

the combined influence of these models to ensure robustness and alignment with real-world dynamics [3]. However, practical challenges often arise due to data limitations and model sensitivities, such as the disproportionate impact of small changes in risk factor volatility compared to adjustments in derivative pricing models.

Despite significant regulatory advancements, traditional CCR management frameworks face notable challenges in backtesting. Static assumptions in many models fail to capture the evolving, path-dependent nature of CCR. Exposure distributions are frequently misrepresented, particularly in response to changes in macroeconomic variables or counterparty behaviors. Additionally, CCR lacks the standardized backtesting methodologies available in market risk management, such as those used for VaR. This lack of standardization impedes consistency across institutions and complicates model validation efforts. Furthermore, stress testing methods, often calibrated to historical data, struggle to anticipate extreme tail risks during periods of unprecedented market disruption. Fragmented data systems and integration challenges further undermine the interplay between risk factor evolution, pricing models, and collateral frameworks, limiting backtesting effectiveness [13].

Emerging methodologies aim to address these limitations, offering opportunities for transformative improvements in CCR backtesting [14–17]. Dynamic backtesting frameworks evaluate entire exposure distributions rather than focusing solely on specific percentiles, providing a more nuanced view of model reliability. Machine learning (ML) techniques, such as gradient boosting and neural networks, are increasingly employed to identify complex relationships between market variables, improving the precision and scalability of backtesting efforts. Scenario-based stress testing, enabled by ML, allows institutions to assess model resilience under diverse hypothetical conditions, such as concurrent market shocks and counterparty defaults. Real-time analytics further enhance backtesting by dynamically recalibrating models as new data emerges, ensuring alignment with volatile markets.

In conclusion, the evolution of CCR backtesting frameworks reflects a growing commitment to improving model reliability, institutional resilience, and regulatory alignment. By integrating advanced techniques such as machine learning and dynamic validation, financial institutions can address the inherent limitations of traditional models, meet the increasing demands of regulatory compliance, and effectively manage the complexities of modern financial systems.

3. Machine learning in risk management

Modern financial markets demand innovative approaches to risk management, exposing the limitations of traditional models in handling the complexities of CCR. Legacy systems, often reliant on static assumptions and linear methodologies, struggle to account for the dynamic nature of risk exposures and the interdependencies inherent in financial systems. Machine learning offers transformative tools for CCR backtesting, enabling institutions to validate models more effectively by capturing non-linear relationships, processing high-dimensional datasets, and adapting to rapidly changing market conditions. ML enhances critical backtesting processes such as validating exposure distributions, dynamically recalibrating predictions, and refining scenario-based stress testing.

Traditional backtesting frameworks often fail to address the evolving nature of counterparty exposures, particularly in scenarios involving long-term contracts or dynamic market variables. By integrating ML techniques, financial institutions can

improve predictive accuracy, EPE profiles, and evaluate risk factor evolution models under stress scenarios. These advancements align backtesting practices with the complexities of real-world CCR management, enhancing institutional resilience and compliance.

3.1 Data-driven approaches: Supervised and unsupervised learning

Supervised learning plays a central role in ML-based CCR backtesting, particularly for validating exposure metrics such as EPE. Algorithms like Random Forests and Gradient Boosting Machines analyze structured datasets, capturing nuanced relationships between market variables and counterparty behaviors. For instance, supervised learning models can assess how shifts in interest rates and volatilities impact EPE profiles, improving the accuracy of exposure predictions during volatile market conditions [18]. These models are especially valuable during stress testing, where traditional methodologies often fail to capture the compounding effects of interconnected risks.

Unsupervised learning complements supervised techniques by uncovering systemic dependencies and anomalies in exposure patterns. Clustering algorithms, for example, segment counterparties based on shared characteristics, enabling risk managers to identify high-risk groups for closer scrutiny. Similarly, anomaly detection methods highlight deviations in exposure distributions, flagging vulnerabilities that might otherwise go unnoticed. These insights help refine backtesting models, ensuring that systemic and idiosyncratic risks are accurately reflected in exposure calculations [8].

3.2 Dynamic adaptation through reinforcement and deep learning

Reinforcement learning (RL) introduces adaptability into CCR backtesting by dynamically optimizing exposure thresholds based on real-time feedback. For example, RL frameworks can recalibrate counterparty exposure limits as market conditions evolve, ensuring robust model predictions during periods of heightened volatility or unexpected market shocks [19]. This capability is critical for managing tail risks, such as liquidity crises or simultaneous counterparty defaults, where static backtesting models often fall short.

Deep learning further enhances backtesting by handling complex datasets and uncovering non-linear dependencies. Recurrent Neural Networks (RNNs) and Long Short-Term Memory (LSTM) networks are particularly valuable for analyzing time-series data, such as the evolution of derivative exposures across multiple market cycles. These models can identify long-term trends in counterparty behaviors, improving backtesting accuracy and robustness. Hybrid approaches that integrate deep learning with econometric models, such as GARCH, provide a balanced approach by combining interpretability with predictive precision [20].

3.3 Strengths, limitations, and applications in CCR backtesting

The integration of ML into CCR backtesting transforms how financial institutions validate and refine risk models. By leveraging ML's capacity to process high-dimensional datasets and uncover non-linear relationships, institutions can conduct more comprehensive exposure distribution validations, ensuring that backtesting results align with observed market behaviors. ML frameworks also improve stress-testing

methodologies, enabling the simulation of diverse scenarios, from incremental interest rate hikes to extreme tail events, providing a more holistic view of model performance under adverse conditions [18].

Despite these strengths, challenges persist. Data quality remains a critical concern, as biases or gaps in historical datasets can distort predictions, reducing the robustness of backtesting outcomes. Addressing these issues requires rigorous data preprocessing, fairness-aware algorithms, and robust data governance protocols to ensure consistency and accuracy across backtesting workflows. The computational demands of ML frameworks, particularly for large-scale simulations and real-time calibration, necessitate significant infrastructure investments, including distributed computing and GPU acceleration [20].

Explainability remains a central challenge in regulatory environments. Complex ML models, often seen as "black boxes," complicate transparency expectations. Tools like SHAP and LIME have emerged as critical enablers of interpretability in this context [21]. For a deeper explanation of explainability tools and adaptive recalibration, see Section 4.2.4.

Emerging applications highlight ML's potential to further advance CCR backtesting. Dynamic exposure validation, real-time scenario analyses, and advanced stress-testing frameworks are just a few areas where ML can align institutional practices with the demands of modern financial markets. As ML methodologies continue to evolve, they promise to enhance the precision, scalability, and adaptability of CCR backtesting frameworks, paving the way for more resilient and effective risk management practices [22].

4. A machine learning framework for backtesting counterparty credit risk

Effective backtesting is a cornerstone of counterparty credit risk management, providing institutions with the tools to validate predictive models, assess robustness, and ensure regulatory compliance. However, traditional backtesting frameworks, while foundational, often fall short in today's dynamic and interconnected financial markets. These frameworks rely on static assumptions, linear methodologies, and historical datasets, which limit their ability to capture evolving risk patterns and counterparty behaviors.

This section introduces an ML-based backtesting framework designed to address these limitations. By leveraging the adaptability, precision, and scalability of machine learning, the framework bridges the gap between conventional approaches and the demands of complex financial ecosystems. It reimagines backtesting as a dynamic, data-driven process capable of adapting to real-time market changes and offering actionable insights into risk exposure and model performance.

Central to this framework is its ability to align cutting-edge computational methods with well-established financial principles. This balance ensures that financial institutions can modernize their backtesting processes while retaining regulatory compliance and operational feasibility. By incorporating capabilities such as real-time recalibration, advanced scenario analysis, and enhanced interpretability, the framework provides a comprehensive roadmap for improving backtesting accuracy and resilience in CCR management.

The subsections ahead delve into the framework's design, key components, and practical implementation. They illustrate how this innovative approach transforms backtesting into a more agile, precise, and scalable process, equipping institutions to meet the challenges of evolving counterparty risks with confidence and efficiency.

4.1 Overview of the framework

The growing complexity of modern financial markets demands a paradigm shift in how backtesting for CCR is conducted. Traditional backtesting frameworks, rooted in static assumptions and retrospective analyses, struggle to address the dynamic interplay of market variables, counterparty behaviors, and macroeconomic volatility. These limitations have become increasingly pronounced as financial systems grow more interconnected and sensitive to systemic risks, such as those highlighted during the global financial crisis. Financial institutions require tools that not only validate models effectively but also adapt to rapidly changing conditions.

The proposed ML-based backtesting framework bridges the gap between traditional methods and emerging industry practices. It builds on foundational principles while incorporating advanced machine learning techniques to address critical limitations in accuracy, adaptability, and scalability. By leveraging machine learning's ability to process high-dimensional datasets, uncover non-linear relationships, and adapt dynamically to market conditions, the framework introduces a robust solution to modern CCR challenges. By aligning with real-world banking needs and regulatory requirements, the framework offers a practical solution to the unique challenges of backtesting in CCR management.

The framework also incorporates modular architectures that enable seamless integration with legacy systems. This modularity allows financial institutions to adopt advanced features incrementally without disrupting existing workflows. APIs ensure interoperability, facilitating smooth data exchanges across diverse systems. For example, an API can connect the ML framework to an existing risk management system to automatically update exposure distributions based on the latest market data. Governance mechanisms are built into the framework, enabling continuous monitoring and refinement of backtesting processes, ensuring models remain robust over time. Dynamic feedback loops further enhance this adaptability by allowing the framework to identify discrepancies in predictions and recalibrate accordingly.

Additionally, the framework emphasizes scalability to handle increasing data complexity and computational demands. Distributed computing and cloud-based architectures ensure that large datasets, such as those encompassing multi-regional portfolios, can be processed efficiently in real time. This scalability ensures institutions can meet the demands of modern financial markets without compromising performance.

In essence, this ML-based backtesting framework represents a forward-looking yet practical approach to CCR management. It integrates academic advancements in machine learning with operational insights from real-world banking, empowering institutions to validate risk models, meet regulatory demands, and adapt to evolving market conditions with confidence and precision. By blending innovation with practicality, the framework not only addresses current limitations in CCR backtesting but also positions institutions to navigate future challenges in an increasingly dynamic financial landscape.

4.2 Framework components

The framework's modular design integrates advanced computational techniques tailored for backtesting CCR models. Each component is constructed to address the unique challenges of validating model predictions, assessing risk exposures, and improving predictive accuracy. By focusing on the rigorous demands of backtesting,

these components ensure that the framework is precise, reliable, and adaptable to dynamic financial environments.

4.2.1 Data preprocessing and feature engineering

Data preprocessing and feature engineering serve as the foundation for ensuring accurate backtesting outcomes. High-quality data is essential for evaluating the reliability of ML predictions against historical and hypothetical scenarios. This phase focuses on transforming raw data into a clean, structured, and standardized format that supports robust model training and validation.

A critical step in preprocessing is identifying and managing outliers—extreme values that could distort backtesting performance. Extreme values, such as a counterparty default probability of 90% in a dataset where most values hover between 2% and 5%, can significantly skew evaluation metrics. Techniques like interquartile ranges (IQRs) and Z-scores are commonly employed to identify and handle these anomalies by either correction or removal. Automated outlier detection tools streamline this process, ensuring consistent treatment across large datasets. Missing values, such as gaps in a counterparty's historical financial performance, are another key challenge. Advanced imputation techniques like k-nearest neighbors (KNN), mean or median substitution, or predictive modeling are often used to ensure data completeness. For instance, missing credit ratings can be inferred based on correlated variables like debt-to-equity ratios or macroeconomic indicators.

Features with varying scales, such as financial ratios and volatility metrics, require normalization or standardization to ensure that all inputs contribute equitably during model training. For example, without standardization, a feature measured in millions might dominate another expressed as a percentage. Techniques that normalize or standardize data improve consistency across all features, enhancing the model's predictive performance.

Feature engineering further enhances the utility of datasets by deriving new variables tailored to backtesting needs. Examples include rolling debt-servicing capacities, stress-scenario flags, or exposure growth rates, which provide richer insights into counterparty risk patterns. These engineered features help uncover nuanced trends critical for assessing model robustness in a backtesting context. For instance, a derived feature capturing the maximum exposure during a defined stress period can highlight counterparty vulnerabilities under extreme conditions.

Preserving temporal relationships in the data is essential for validating predictions against real-world trends. Time-series preprocessing techniques, such as creating lagged feature sets or rolling averages, ensure that the sequence of events is accurately represented. Capturing exposure trends over rolling windows allows the framework to evaluate how past conditions influence future outcomes. Lagged variables also enable the model to incorporate dependencies between historical and future behaviors.

High-dimensional datasets, while comprehensive, often introduce unnecessary complexity. Dimensionality reduction techniques like Principal Component Analysis (PCA) can isolate the most relevant information while minimizing computational overhead. Alternatively, feature selection methods like Recursive Feature Elimination (RFE) or Information Gain can prioritize variables that contribute most significantly to model predictions, improving efficiency without sacrificing accuracy. For example, PCA can distill hundreds of market indicators into a smaller set of components that retain at least 90% of the original dataset's variance, ensuring that essential insights are preserved.

To ensure the success of preprocessing, evaluation metrics such as Variance Inflation Factor (VIF) can be used to detect multicollinearity among features. Similarly, the Explained Variance Ratio can measure how much information is retained after dimensionality reduction, while the percentage of missing data resolved provides insight into the effectiveness of imputation techniques. These metrics help validate the preprocessing steps and ensure alignment with the framework's objectives of accuracy and efficiency.

Features engineered during preprocessing, such as stress indicators or rolling averages, directly influence downstream processes like model training and validation. For instance, integrating exposure growth rates into the backtesting workflow enhances the model's ability to evaluate risk dynamics under varying scenarios. However, trade-offs such as reduced interpretability after PCA must be carefully managed, particularly to ensure alignment with regulatory compliance.

By transforming raw, messy data into a streamlined resource, data preprocessing and feature engineering ensure that the framework operates efficiently and delivers precise and meaningful backtesting results.[1] This meticulous preparation supports not only accurate validations but also the scalability of the framework, enabling it to handle increasing volumes and complexities of data. Such preparation empowers financial institutions to trust the robustness of their CCR models and make informed decisions based on reliable predictions.

4.2.2 Model training and selection

The process of training and selecting models is pivotal in ensuring the effectiveness of CCR backtesting. This phase involves assembling a specialized toolbox that validates exposure predictions and tests models under diverse market conditions. The ultimate goal is to ensure that the selected models align with the complexities of counterparty credit risk while meeting the operational demands of backtesting frameworks. A structured workflow is essential to achieve this balance, combining clear objectives, algorithm selection, and performance evaluation.

The first step in model training and selection is defining clear objectives and metrics to evaluate performance. Models may be designed to predict default probabilities, forecast exposure profiles, or evaluate risks under stress scenarios. Success metrics vary depending on the task, with accuracy and ROC AUC (Receiver Operating Characteristic Area Under the Curve) often used for classification models and RMSE or MAE for regression tasks. Calibration curves are also valuable for assessing how well predicted probabilities align with actual outcomes. With objectives clearly defined, the next step is to select algorithms suited to the dataset and problem. Gradient Boosting Machines (GBMs) are particularly effective for structured datasets, where they excel at identifying non-linear relationships and feature interactions. For sequential data, like exposure trends over time, Recurrent Neural Networks (RNNs) or Long Short-Term Memory (LSTM) networks are more appropriate, offering the ability to process temporal dependencies. In some cases, hybrid models

[1] Popular tools like Python's Scikit-learn and Pandas offer efficient implementations for these preprocessing tasks. Scikit-learn includes functionality for imputation (KNNImputer), normalization (StandardScaler), and dimensionality reduction (PCA), while Pandas provides versatile methods for handling missing values, creating lagged variables, and merging datasets. PyOD is another library that specializes in outlier detection.

provide a compelling solution, combining traditional econometric approaches, such as GARCH for volatility forecasting, with ML algorithms to balance transparency and predictive power.

Training begins with baseline models like logistic regression or decision trees. These simpler models serve as benchmarks, offering a reference point for assessing the value added by more advanced methods. They are also useful for identifying data issues, such as multicollinearity or imbalanced datasets. Advanced models are then trained to improve predictive accuracy and capture complex patterns in the data. Hyperparameter tuning is an essential component of this process, optimizing parameters like learning rates and tree depths using methods such as grid search, random search, or Bayesian optimization. Regularization techniques like L1 or L2 are also applied to prevent overfitting, particularly in high-dimensional datasets. Automated tools can streamline comparisons across models, enabling the selection of the most effective algorithm.

Evaluating model performance requires rigorous testing with in-sample and out-of-sample data to ensure generalizability. Metrics such as RMSE and MAE assess prediction errors for continuous variables, while ROC AUC evaluates the discriminative power of classification models. Calibration curves are particularly useful for CCR backtesting, as they measure the alignment of predicted probabilities with observed outcomes. Comparing baseline models with advanced algorithms allows practitioners to quantify the benefits of increased model complexity and ensure these gains justify any added computational or interpretability trade-offs.

Stress-testing models under synthetic scenarios is a critical aspect of evaluation. Bootstrapping techniques generate new datasets by recombining existing records, creating realistic variations that test model robustness. Generative Adversarial Networks (GANs) can simulate extreme conditions, such as prolonged market downturns or simultaneous interest rate hikes and credit downgrades, ensuring the models are resilient under diverse scenarios. These stress tests not only highlight potential weaknesses but also guide refinements to model parameters before deployment.

Real-world challenges often complicate the training process. Overfitting, for instance, can be mitigated through cross-validation, dropout layers for neural networks, and regularization techniques. Imbalanced datasets are another common issue, requiring resampling methods like SMOTE or the use of weighted loss functions to address skewed class distributions. Synthetic data generation is especially useful when historical data lacks diversity. Bootstrapping and GANs are effective tools for expanding training datasets, enabling models to handle rare but high-impact events more effectively.

The outputs from this phase feed directly into validation and deployment processes. Validation ensures that trained models perform well across different conditions, while deployment integrates them into the backtesting framework for dynamic, real-time predictions. This seamless transition from training to deployment ensures that the models remain aligned with the broader objectives of CCR management and adapt continuously to evolving market conditions.[2]

[2] Popular tools for implementing these techniques include Python's Scikit-learn for baseline models and hyperparameter tuning, XGBoost and LightGBM for training GBMs, and TensorFlow or PyTorch for deep learning models like LSTMs and GANs. PyCaret simplifies comparisons and optimizations across multiple models.

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4.2.3 Backtesting and validation

Backtesting and validation are critical components of CCR management, ensuring that machine learning frameworks can reliably predict real-world outcomes and adapt to diverse financial scenarios, including extreme market conditions. These processes systematically bridge theoretical predictions with practical results, laying the foundation for effective risk management and regulatory compliance. A structured approach to backtesting, incorporating rolling windows, stress-testing scenarios, and robust metrics evaluation, is essential for building a resilient and trustworthy framework.

The first step in effective backtesting is defining clear metrics and targets to assess model performance. Metrics such as RMSE and MAE are widely used to measure prediction accuracy for continuous variables like exposure profiles, while ROC AUC evaluates the classification models' ability to distinguish between defaulting and non-defaulting counterparties. Calibration curves complement these metrics by assessing how closely predicted probabilities align with observed outcomes, offering valuable insights into model reliability. For example, a calibration curve might reveal whether a model consistently underestimates risks during periods of heightened market volatility, providing a basis for parameter adjustments or feature enhancements.

Rolling window validation is a practical method to evaluate model performance over sequential time periods, ensuring that predictions remain reliable as market conditions evolve. For instance, a rolling 12-month window allows practitioners to test predictions for each month using data from the preceding year, capturing temporal patterns and identifying performance consistency across changing conditions. This technique not only highlights potential weaknesses in the model's predictive capabilities but also ensures alignment with real-time market dynamics. Dynamic validation further enhances this process by continuously comparing ongoing predictions with actual outcomes. This enables the framework to identify discrepancies, recalibrate parameters, and incorporate additional risk factors as needed, maintaining adaptability in the face of evolving financial landscapes.

Stress testing is a cornerstone of the backtesting process, evaluating how models perform under severe market conditions. Hypothetical scenarios, such as a sudden 15% equity market drop, a 200-basis-point interest rate hike, or a counterparty-specific default triggered by macroeconomic shocks, provide a robust basis for assessing model resilience. By simulating these scenarios, the framework identifies high-risk counterparties, quantifies potential portfolio losses, and offers actionable insights for mitigating systemic vulnerabilities. Tail-risk validation goes a step further, examining the framework's ability to manage rare but catastrophic events. For example, the COVID-19 pandemic underscored the importance of tail-risk analysis by revealing vulnerabilities in sectors like travel and hospitality. Simulating comparable scenarios, such as prolonged geopolitical conflicts or severe supply chain disruptions, allows institutions to assess potential losses and make strategic adjustments, such as diversifying counterparty portfolios or revising exposure limits.

Synthetic data generation plays a critical role when historical data is insufficient to capture rare or extreme events. Techniques like bootstrapping create realistic variations by recombining existing records, while Generative Adversarial Networks simulate complex scenarios, such as prolonged market downturns or sector-specific shocks. These approaches expand the dataset, enabling models to handle rare events more effectively and ensuring comprehensive stress-testing coverage. The outputs of stress testing and tail-risk validation are then integrated into the backtesting framework, informing dynamic recalibrations and enabling real-time updates to model predictions.

Finally, rigorous backtesting ensures a seamless transition from validation to deployment. Once models are validated, they are integrated into the backtesting framework, where they continuously update predictions based on new data and market conditions. Discrepancies identified during validation feed directly into model training, allowing for iterative improvements and greater alignment with real-world outcomes.[3] Institutions can also leverage these processes to meet regulatory requirements, such as Basel III standards, while optimizing portfolio resilience through actionable insights.

4.2.4 Explainability, adaptability, and transparency

Building trust and ensuring compliance are pivotal in implementing a machine learning framework for CCR backtesting. Transparency becomes even more crucial in this context, where the reliability of predictions significantly influences risk assessments and regulatory reporting. The framework achieves this by integrating explainable AI (XAI) tools and interactive dashboards, which make complex decision-making processes interpretable for both technical teams and non-technical stakeholders. These tools provide clarity and actionable insights, ensuring alignment with regulatory demands while enhancing operational effectiveness.

Explainability tools like SHAP and LIME are essential for breaking down model predictions into understandable components. SHAP is used to provide global explainability across the dataset, identifying how specific variables contribute to predictions in aggregate. For instance, in forecasting Expected Positive Exposure (EPE) for a counterparty, SHAP can highlight the influence of factors such as market volatility, credit ratings, or collateral adjustments. If exposure increases under a stress scenario, SHAP might reveal whether the shift stems from systemic liquidity shocks or a counterparty's deteriorating credit profile. This global view supports model validation, contextual risk assessment, and regulatory justification.

LIME, by contrast, is designed for local explainability—offering case-specific insights by isolating the most influential features for individual predictions. For example, if a predicted default diverges sharply from the observed outcome, LIME can help determine whether the error was driven by unexpected interest rate changes or collateral devaluation in that instance. These micro-level insights help analysts refine features and improve prediction fidelity.

In our framework, SHAP was fully implemented for both global and local analysis, while LIME is discussed as a complementary tool that institutions may optionally adopt to enhance single-instance interpretability in audit-sensitive or regulatory contexts.

Interactive dashboards further elevate transparency by transforming complex datasets into accessible visualizations. These dashboards provide real-time access to metrics like prediction accuracy, sensitivity analyses, and longitudinal performance trends. Risk managers can use them to explore heatmaps that display exposure variations across counterparties under different stress scenarios or timeline charts tracking prediction errors over multiple backtesting cycles. Dashboards can also integrate

[3] For implementing these techniques, Python libraries such as Scikit-learn and Numpy offer efficient tools for rolling validation, metrics evaluation, and synthetic data generation. TensorFlow and PyTorch are well-suited for creating stress-testing scenarios using GANs, while Matplotlib can visualize calibration curves and sensitivity analyses.

predictive indicators, such as early warning signals for counterparty defaults, enabling institutions to proactively adjust exposure limits or collateral requirements. By offering customizable views tailored to the needs of diverse users, dashboards bridge the gap between advanced analytics and actionable insights, fostering meaningful engagement among risk managers, executives, and regulators.

Embedding explainability and transparency tools into the framework ensures alignment with regulatory compliance requirements. Regulators often demand clear justifications for model predictions, particularly when discrepancies occur between predicted and actual exposures. By generating transparent audit trails, the framework can demonstrate how each prediction was derived, linking outcomes to quantifiable factors like market conditions or collateral fluctuations. During an audit, for instance, the framework might attribute a counterparty's exposure spike during a stress test to specific changes in credit spreads or macroeconomic conditions. These explanations not only satisfy regulatory expectations but also strengthen confidence among internal stakeholders and external partners, ensuring that decision-making processes remain defensible and accountable.

The implementation of XAI tools and dashboards requires a structured approach to ensure their effectiveness. The framework must first prepare the model outputs by generating the necessary intermediate data, such as feature importances or predicted probabilities, for interpretation. SHAP can then be deployed to provide global explanations, identifying the dominant factors influencing risk across the portfolio, while LIME offers granular insights into individual predictions. Outputs from these tools should integrate seamlessly into dashboards, enabling dynamic exploration of variable contributions and prediction factors. Dashboards must be designed with flexibility in mind, offering customizable views to accommodate the differing needs of stakeholders such as risk managers, regulatory officers, and executives. Interoperability with existing risk management systems ensures that these tools enhance, rather than disrupt, existing workflows.

Beyond transparency, the framework offers dynamic adaptability through real-time recalibration. Unlike static risk models that rely on fixed assumptions, this ML-based system continuously ingests new data and updates exposure predictions accordingly. For example, if market volatility suddenly spikes or counterparty credit spreads widen, the framework responds instantly by adjusting forecasts—empowering risk managers to act quickly and accurately. This adaptability enhances the relevance of backtesting outcomes in fast-changing environments.

Evaluating the effectiveness of XAI tools and dashboards is crucial for continuous improvement. Feedback from stakeholders on the clarity and usefulness of explanations can guide refinements to both tools and their implementation. Metrics such as the accuracy of predictive indicators or the quality of insights derived from audit trails provide objective measures of their impact. Addressing challenges such as integrating dashboards with legacy systems or processing large datasets efficiently is also essential to ensure that the framework operates smoothly in diverse operational environments.

To ensure alignment with Basel III regulatory frameworks, the explainability and transparency features embedded in the ML-based framework directly support supervisory expectations. SHAP-based explainability enables traceable and interpretable outputs required under the Internal Models Method (IMM). Continuous monitoring via dashboards and audit trails supports the ongoing performance validation demanded by Pillar 2 internal oversight. Additionally, the framework's scenario-based stress testing aligns with Pillar 1 and Pillar 2 capital adequacy requirements, helping institutions assess resilience to both market-wide and idiosyncratic shocks.

Collectively, these components promote regulatory compliance while strengthening institutional readiness for supervisory review.

These combined elements—explainability and adaptability—not only enhance compliance with Basel III regulations but also support operational resilience. They allow risk managers to understand and justify model behavior under diverse scenarios while ensuring that risk assessments stay current and responsive.

By embedding explainability, adaptability, and transparency into the backtesting framework, this ML-based approach ensures that predictions are not only accurate but also interpretable, responsive, and defensible. This integration bridges the gap between sophisticated analytics and practical application, enabling financial institutions to optimize risk strategies, meet regulatory requirements, and build resilience in a dynamic market landscape.

4.2.5 Integration and scalability

For a ML framework dedicated to CCR backtesting, integration and scalability are essential to ensure operational effectiveness and long-term adaptability. Seamlessly integrating with existing risk management systems while scaling to accommodate the growing complexity of exposure data is critical for meeting evolving regulatory and operational demands. The modular design of the framework enables components to be updated, replaced, or expanded without disrupting overall functionality. This flexibility ensures that updates, such as the incorporation of new backtesting techniques or regulatory requirements, can be implemented incrementally and with minimal operational disruption. For example, if regulators introduce additional stress-testing scenarios involving sector-specific risks, the framework can integrate these adjustments seamlessly without requiring a complete overhaul.

Integration with legacy systems is achieved through APIs and middleware, which bridge the gap between the ML framework and pre-existing infrastructures. APIs facilitate the translation of data and commands between backtesting tools and older systems, ensuring compatibility and uninterrupted functionality. Middleware, on the other hand, enables the smooth transfer of data across components like pricing models, risk factor simulations, and reporting tools. For instance, middleware can allow the framework to ingest exposure data generated by older systems, process it alongside modern risk metrics, and produce updated backtesting results that integrate seamlessly into existing workflows. This interoperability ensures that financial institutions can enhance analytical capabilities while retaining their established technology infrastructure.

Scalability is another cornerstone of the framework, addressing the substantial computational demands of backtesting, particularly during periods of market stress. Distributed computing and GPU acceleration are leveraged to process large datasets efficiently, enabling real-time analysis even during high-pressure events such as market crashes or geopolitical disruptions. For example, a global financial institution managing counterparties across multiple regions can simultaneously analyze exposure distributions, run stress tests, and evaluate currency-specific risks across its portfolio, ensuring timely and accurate backtesting outcomes. The ability to process these scenarios in real time ensures that institutions can meet regulatory reporting timelines and respond effectively to emerging risks.

Cloud-based solutions and distributed architectures further enhance scalability by dynamically allocating computational resources to match workload demands. During periods of heightened activity, such as interest rate hikes or liquidity shortages, the framework's elastic scaling capabilities ensure uninterrupted performance by

automatically allocating additional resources where needed. This real-time responsiveness allows risk managers to access up-to-date insights and make informed decisions without delays, even under challenging market conditions. The framework's adaptability also ensures it remains future-proof, capable of incorporating advanced methodologies and metrics as they emerge. For example, as dynamic exposure distribution validation becomes a standard for backtesting, or as new metrics like Expected Shortfall (ES) are introduced, the framework can integrate these advancements seamlessly.

The integration and scalability processes are evaluated through a structured approach to ensure their effectiveness. Legacy system compatibility is assessed by identifying existing system components and designing APIs and middleware that facilitate smooth data exchanges. The framework's scalability is monitored using metrics such as latency, throughput, and resource utilization efficiency, which measure its performance under varying workloads. Testing workflows with simulated datasets or dummy data helps validate the integration of new components, ensuring that they function as expected before deployment.

Common challenges in integrating ML frameworks with legacy systems include handling data inconsistencies and managing the costs associated with scaling cloud-based resources. Standardizing data formats and implementing APIs that support multi-format translations can address inconsistencies, while cost management strategies, such as scheduled resource allocation or workload prioritization, can optimize expenses in cloud environments. These solutions ensure that the framework operates efficiently and remains financially sustainable.

By embedding modularity, seamless integration, and scalable architectures, the ML-based framework becomes an indispensable tool for CCR backtesting.[4] It empowers financial institutions to navigate modern regulatory challenges, process vast volumes of data, and operate effectively in dynamic financial environments. The ability to integrate advanced tools and adapt to future demands ensures that the framework remains robust and reliable, supporting resilience and precision in CCR management.

Despite the framework's modular architecture and cloud-native design, several integration challenges must be acknowledged. Legacy IT infrastructure often limits the seamless deployment of containerized ML systems, especially when existing platforms lack compatibility with modern APIs. Data silos and inconsistent ownership across departments further complicate real-time access and centralization efforts. Additionally, compliance and legal teams may resist automation or algorithmic decision-making due to perceived risks around auditability and regulatory interpretation. Financial constraints, including the high cost of cloud storage or GPU-based computation, may also delay full implementation in some institutions. Addressing these barriers requires close coordination across technical, legal, and business units to align risk, cost, and compliance objectives.

4.3 Application to simulated bank data

Managing counterparty credit risk requires a robust backtesting framework capable of addressing the complexities of modern financial systems. Traditional backtesting

[4] For integration and scalability, tools like Flask or FastAPI can facilitate API development, while cloud platforms such as AWS, Azure, or Google Cloud provide scalable computing resources. Middleware solutions and GPU acceleration frameworks like NVIDIA CUDA enhance processing efficiency for high-demand scenarios.

methods, constrained by static assumptions and historical data, often fail to capture the dynamic and evolving nature of financial markets. A machine learning-based framework offers a transformative solution by enabling precise model validation, adaptability to changing market conditions, and compliance with stringent regulatory requirements. The successful implementation of such a framework involves a structured, step-by-step process that integrates data preparation, operationalization, deployment, and continuous monitoring, supported by actionable metrics and collaboration among stakeholders.

4.3.1 Step 1: Data integration and preparation for backtesting

The process begins with data preparation, where diverse datasets are consolidated into a unified platform. Structured data, such as market prices, credit ratings, and interest rate curves, serves as the backbone for modeling exposure and validating predictions. Integrating unstructured data, including regulatory filings, news reports, and counterparty-specific updates, provides critical qualitative insights that complement traditional metrics. For instance, news indicating a counterparty's financial distress can act as an early warning signal, enhancing predictive capabilities. Centralized Extract, Transform, Load (ETL) pipelines are essential at this stage, extracting raw data from multiple sources, transforming it into standardized formats, and loading it into a centralized data warehouse. Automated quality checks within the ETL process identify and address anomalies, such as missing values or outliers, ensuring data reliability. For example, if a dataset contains an abnormally high exposure value due to a data entry error, automated checks can detect and correct the issue, providing accurate inputs for the framework. Data completeness metrics, such as the percentage of missing values resolved, can be used to assess the effectiveness of this phase.

4.3.2 Step 2: Operationalizing data for backtesting scenarios

Operationalizing the framework requires seamless integration with existing workflows and systems, facilitated by APIs and middleware. APIs enable the dynamic exchange of data and commands between the framework and legacy systems, ensuring compatibility and uninterrupted functionality. Middleware supports interoperability by facilitating smooth data flow between components, such as pricing models, risk factor simulations, and reporting tools. For example, middleware can enable the framework to process data from legacy systems that calculate EPE, dynamically recalibrating exposure distributions based on updated risk factors. Scenario generation is automated to simulate stress-testing conditions, such as simultaneous interest rate hikes and equity market drops. These scenarios not only validate the model's robustness against historical patterns but also test its ability to anticipate vulnerabilities under forward-looking conditions. Stress-testing results can be assessed using metrics like error rates and exposure prediction accuracy to evaluate how well the framework performs under extreme scenarios.

4.3.3 Step 3: Deploying the framework for live backtesting

Deployment transitions the framework from development to operational use, leveraging distributed computing and GPU acceleration to handle the computational demands of large-scale simulations. These technologies allow real-time validation of exposure distributions and dynamic stress testing, ensuring performance even during volatile market conditions. A modular architecture supports deployment by

enabling financial institutions to incorporate updates without disrupting workflows. For example, if regulators introduce new requirements for climate-related financial risks, the framework can seamlessly integrate additional metrics and algorithms to comply with these standards. Deployment success can be measured through system latency and throughput metrics, ensuring the framework maintains responsiveness and accuracy under varying workloads.

4.3.4 Step 4: Continuous monitoring and feedback for backtesting models

Continuous monitoring and feedback mechanisms are integral to maintaining the framework's accuracy and reliability. Automated dashboards provide real-time visualizations of key metrics, including prediction accuracy, exposure coverage, and system performance. Dynamic feedback loops enable the framework to refine its predictions by comparing outputs with actual exposure outcomes and recalibrating parameters based on observed discrepancies. For example, if the model consistently underestimates defaults during periods of heightened volatility, feedback mechanisms adjust risk factors and parameters to improve predictive accuracy. Monitoring also includes ongoing stress-testing to assess the framework's resilience against emerging risks, such as cascading defaults or sudden market freezes. Dashboards facilitate collaboration by providing customizable views for risk managers, compliance officers, and executive leadership, ensuring insights are actionable and tailored to their respective needs.

Implementing a machine learning-based framework for CCR backtesting requires collaboration among various stakeholders. IT teams play a critical role in setting up ETL pipelines, maintaining APIs, and managing middleware to ensure seamless data integration. Risk managers validate model outputs and interpret dashboard insights, using them to refine exposure limits and adjust risk strategies. Compliance officers ensure the framework aligns with regulatory requirements during development, deployment, and updates. By defining clear roles and fostering collaboration, institutions can streamline implementation and maximize the framework's effectiveness.

5. Comprehensive example: Implementing the ML-based backtesting framework

This section presents a comprehensive example that demonstrates the application of the proposed ML-based backtesting framework for counterparty credit risk to a simulated banking environment. A multinational bank seeks to modernize its risk management processes, addressing challenges such as fragmented data, inconsistent formats, and the need for real-time stress-testing. This step-by-step example illustrates how the bank consolidates its data, trains predictive models, integrates explainability tools, and continuously refines outputs to improve risk assessment and compliance. All results are based on synthetically generated data that simulate realistic counterparty credit risk scenarios. Models were trained and evaluated using this synthetic dataset, and the results are intended to be illustrative rather than derived from real-world applications. Each component directly reflects the conceptual elements outlined in Section 4.2, offering a practical and generalizable blueprint for implementation.

As shown in **Figure 1**, the implementation unfolds in six stages: data centralization and feature engineering, model training and evaluation, application of explainability tools, stress-testing and scenario analysis, deployment and integration, and continuous monitoring.



Figure 1.
Implementation flow chart.

5.1 Step 1: Centralizing and standardizing data

The first step in implementing the ML-based backtesting framework involves addressing the fragmented and inconsistent data landscape across the bank's global operations. The bank's data sources span a mix of structured datasets—such as historical exposure profiles, counterparty credit ratings, and market indices—and unstructured data, including analyst notes, financial news articles, and regulatory filings. Stored in siloed systems, these datasets often lack uniformity and contain anomalies that limit their usability for machine learning applications.

To resolve these challenges, the bank deploys an ETL pipeline. This automated pipeline is designed to centralize data from disparate sources, standardize formats, and clean inconsistencies. During the extraction phase, raw data is pulled from various departments and systems across the organization. In the transformation phase, missing values in counterparty credit ratings are addressed through statistical imputation techniques, ensuring the dataset is complete. Anomalies in exposure values, such as a $1.5B entry mistakenly logged instead of the correct $150 M, are flagged and corrected, while negative exposure values are replaced with the mean exposure value to maintain validity. Finally, in the loading phase, the cleaned and standardized data is stored in a centralized repository, creating a single, reliable source of truth for the ML framework.

The simulated data results demonstrated clear improvements in data quality. Data completeness rose from 94% to 100%, and two major outliers that could have skewed predictions were successfully corrected. **Figure 2** illustrates the impact of the ETL pipeline, highlighting these enhancements and its effectiveness in preparing data for analysis.

By consolidating and standardizing its data, the bank established a robust foundation for training predictive models, conducting reliable backtesting, and generating actionable insights. This foundational step ensured the success of subsequent phases

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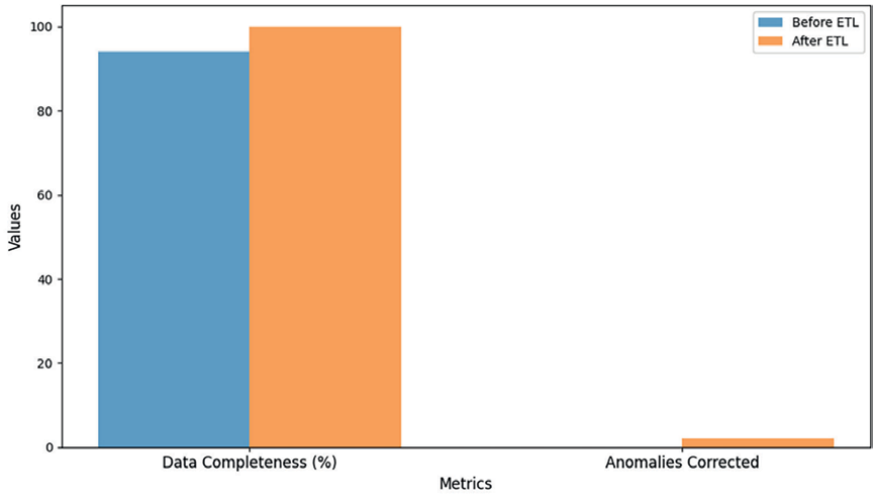


Figure 2.
Data quality metrics before vs. after ETL.

in the ML framework's implementation, reinforcing the importance of clean, high-quality data in modern risk management.

5.2 Step 2: Training and evaluating models

With the data foundation established, the bank trained three models—logistic regression, decision trees, and Gradient Boosting Machines—to predict counterparty default probabilities and Expected Positive Exposure.

Logistic regression served as a baseline model due to its simplicity and transparency, but its reliance on linear assumptions limited its ability to model complex relationships. Decision trees improved flexibility by identifying non-linear interactions, such as how thresholds in collateral devaluation and interest rates jointly influence default probabilities. However, decision trees showed a tendency to overfit in high-dimensional datasets. GBMs, on the other hand, emerged as the most effective model.

The predictive performance of the three models was evaluated using accuracy and RMSE as metrics. The results of the training and evaluation process are presented in **Table 1**.

The Gradient Boosting model outperformed the others, achieving the highest accuracy (92%) and the lowest RMSE (0.28). Its ability to capture non-linear relationships and complex interactions between features makes it particularly effective for CCR predictions.

While GBMs delivered the highest predictive accuracy and lowest RMSE in this study, the choice of model architecture depends heavily on institutional priorities and regulatory context. GBMs are particularly effective at capturing non-linear interactions and complex dependencies among features such as credit rating downgrades and sector exposure. However, this performance comes at the cost of greater computational complexity and reduced transparency compared to simpler models.

Logistic regression, though less accurate in this case, remains valuable in highly regulated or audit-sensitive environments due to its inherent interpretability and ease of validation. Risk managers and compliance teams may prefer models whose decision logic is immediately understandable and justifiable during regulatory reviews. In

Model	Accuracy (%)	RMSE
Logistic regression	83.33	0.38
Decision tree	88.67	0.33
Gradient boosting	92.00	0.28

Table 1.
Comparison of models for predicting CCR exposures.

such contexts, simpler models may be favored despite marginally lower performance, especially when transparency and auditability are paramount. To address explainability concerns, SHAP was applied to the GBM in the next step to analyze feature contributions.

5.3 Step 3: Gaining insights through explainability tools

To improve transparency and regulatory compliance, the bank used SHAP to analyze the Gradient Boosting Model. This method revealed the impact of individual features on predictions, highlighting key variables influencing counterparty default probabilities. These insights help risk managers prioritize interventions. As described in **Table 2**, the dataset included the following key input features:

Each feature represents a key risk factor that contributes to the model's predictions, ensuring the dataset comprehensively captures both quantitative and

Feature	Description	Relevance
1. Credit rating	Counterparty's creditworthiness (AAA = best, D = default).	Directly impacts default probability calculations and exposure limits.
2. Market volatility	Fluctuations in financial markets (e.g., stock indices, commodity prices).	Affects mark-to-market valuations and collateral requirements.
3. Collateral valuation	Percentage changes in collateral value securing obligations.	Mitigates exposure but introduces liquidity risk during market stress.
4. Interest rates	Central bank or market rate trends influencing borrowing costs.	Impacts discount rates for future exposures and funding costs.
5. Debt-to-income ratio	Counterparty's leverage: total debt relative to income/revenue.	Signals financial fragility and default risk.
6. Sector exposure	Portfolio exposure to high-risk sectors (e.g., energy, real estate).	Concentrated sector risks amplify systemic vulnerabilities.
7. Liquidity reserves	Liquid assets available to counterparty to mitigate financial stress.	Determines capacity to meet short-term obligations during crises.
8. GDP growth rate	Macroeconomic conditions influencing default probabilities.	Links counterparty risk to broader economic cycles.
9. Payment delinquencies	Number of late payments in credit history.	Predicts future default behavior and creditworthiness.
10. Netting arrangements	Agreements to offset exposures with counterparties.	Reduces gross exposure but depends on legal enforceability.

Table 2.
Key features in counterparty credit risk management.

qualitative aspects of CCR. The SHAP feature impact plot in **Figure 3**, based on simulated data, revealed the following key insights[5]:

The most influential factor was *payment delinquencies*, where repeated missed payments significantly elevated default probabilities—entities with three or more delinquencies faced up to a 25% higher risk than those with clean histories. *Interest rates* also emerged as a major contributor, particularly for borrowers with floating-rate obligations, as even a 1% rise was linked to a 10% increase in default likelihood. At the macroeconomic level, *GDP growth rate* played a vital role; downturns or recessions amplified systemic risk by reducing counterparties' income-generating capacity.

Among qualitative risk indicators, *credit ratings* proved essential for risk stratification, with lower-rated entities (e.g., BB) showing double the default risk of top-rated (AAA) peers. Industry exposure patterns also mattered: counterparties heavily concentrated in volatile sectors like energy or real estate were flagged as high-risk due to *sector exposure* effects. In stressed environments, *collateral valuation* shifts—such as a 10% decline—translated into moderate increases in default probability, while limited *liquidity reserves* further weakened resilience under financial pressure.

Additionally, *market volatility* affected speculative portfolios, driving up risk during unstable periods. Though less prominent, structural features such as *netting arrangements* offered modest mitigation by reducing gross exposures when enforceable. Lastly, *debt-to-income ratios*, while ranked lower, still signaled vulnerability, as excessive leverage modestly raised default risk. Collectively, these variables provided a multidimensional view of counterparty creditworthiness, enabling more targeted and proactive risk interventions.

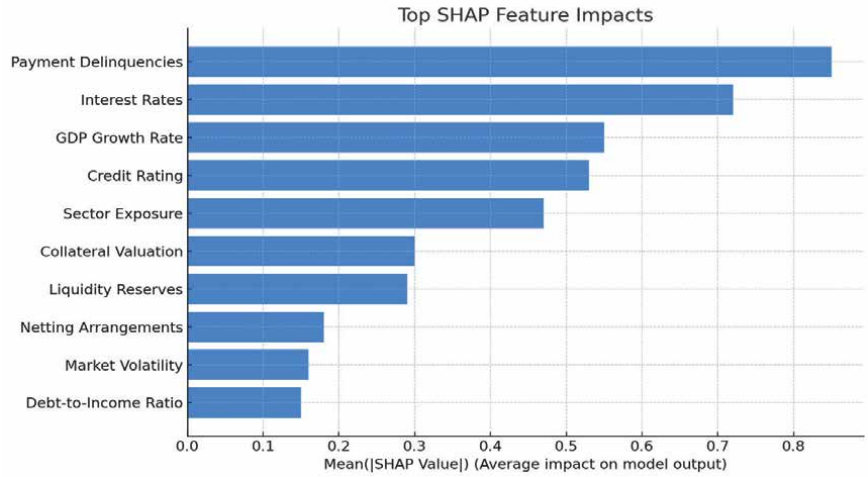


Figure 3.
SHAP feature impact chart for gradient boosting model.

[5] The selected features and their rankings in the SHAP analysis broadly align with real-world practices in counterparty credit risk management. However, the exact rankings and numerical impacts (e.g., a 1% increase in interest rates leading to a 10% higher default probability) are approximations generated from synthetic data. Real-world datasets might yield different rankings or impacts.

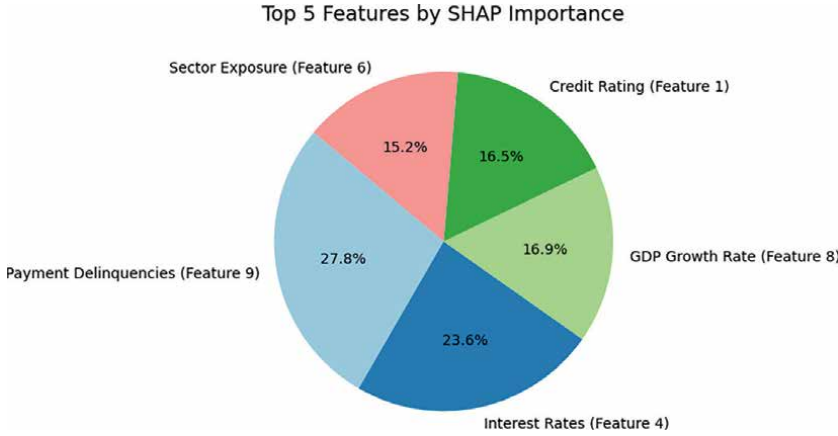


Figure 4.
Top five features by SHAP importance.

In addition to the bar chart, **Figure 4** provides a proportional breakdown of the top five features, offering another perspective on their contributions to the model's predictions. According to the pie chart, Payment Delinquencies contribute nearly 28% of the total predictive power, followed by Interest Rates at 23.6% and GDP Growth Rate at 16.9%. Credit Rating and Sector Exposure round out the top five, collectively accounting for 31.7% of the predictive importance. Together, the bar and pie charts reveal complementary insights, with the bar chart emphasizing overall feature impact and the pie chart providing a proportional analysis of the dominant drivers.

The SHAP analysis, visualized through the bar chart and pie chart, provided actionable insights that significantly enhanced the bank's risk management strategies. Key drivers of default probabilities, such as Payment Delinquencies and Sector Exposure, were identified as high-priority features for intervention. Counterparties with frequent delinquencies were flagged as high-risk, leading the bank to enforce stricter exposure limits and implement higher collateral requirements. Similarly, entities with substantial exposure to volatile sectors, such as energy and real estate, were prioritized for stress testing and subjected to sector-specific risk controls.

Macroeconomic factors, including GDP Growth Rate and Market Volatility, highlighted the importance of scenario-based risk assessments. The analysis revealed that a decline in GDP growth posed significant sector-wide vulnerabilities, while increased market volatility heightened default risks, particularly for speculative portfolios. These insights guided the development of stress-testing scenarios, enabling the bank to evaluate and mitigate systemic risks effectively.

The impact of Interest Rates further underscored the necessity of monitoring floating-rate borrowers and highly leveraged counterparties. The bank identified at-risk entities and implemented pre-emptive measures, such as debt restructuring and interest rate hedging, to reduce exposure and enhance portfolio resilience.

By leveraging the high predictive accuracy of the Gradient Boosting model alongside SHAP's explanations, the bank developed a comprehensive and actionable risk management framework. These analyses empowered risk managers to clearly understand the key drivers of counterparty vulnerabilities and take proactive steps to mitigate emerging risks. The integration of advanced analytics and interpretability ensured the framework not only aligned with regulatory requirements but also strengthened the bank's ability to navigate dynamic financial environments.

5.4 Step 4: Stress-testing and scenario analysis

The bank conducted an extensive set of validation scenarios and stress-testing exercises to confirm the robustness and applicability of the SHAP findings. These tests not only validated the predictive accuracy of the Gradient Boosting model but also provided actionable insights to enhance the bank's CCR management strategies.

5.4.1 High-delinquency counterparty stress test

Using insights from Feature 9 (Payment Delinquencies), the bank simulated a scenario where counterparties experienced a 40% increase in payment delinquencies, mimicking the effects of an economic downturn. The results revealed an 18% increase in default probabilities, with EPE rising by 14% across the affected counterparties. In response, the bank introduced targeted measures, such as stricter exposure limits and higher collateral requirements, to mitigate risks among these high-delinquency counterparties.

5.4.2 Sector-specific exposure analysis

The SHAP analysis underscored the importance of Feature 6 (Sector Exposure). The bank simulated a 15% decline in real estate values to assess the impact on counterparties with significant exposure to this sector. The stress test highlighted an 11% increase in default probabilities and a 12% reduction in collateral recovery rates. These findings prompted the bank to revise exposure limits for real estate-linked counterparties and enhance sector-specific monitoring protocols to manage risk effectively.

5.4.3 Macroeconomic scenario stress testing

Features 8 (GDP Growth Rate) and 2 (Market Volatility) emerged as key macroeconomic indicators in the SHAP analysis. To test their combined impact, the bank modeled a scenario involving a 4% drop in GDP growth and a 25% spike in market volatility. The results projected a 9% loss in portfolio value, with sectors like energy and manufacturing facing heightened vulnerabilities. As a mitigation strategy, the bank developed contingency plans, such as enhanced monitoring and targeted diversification efforts, to address macroeconomic risks.

5.4.4 Interest rate sensitivity analysis

Interest Rates (Feature 4) and Debt-to-Income Ratio (Feature 5) were identified as critical drivers of counterparty risk. The bank simulated a 150-basis-point increase in interest rates to assess the sensitivity of floating-rate borrowers. The stress test revealed a 17% increase in default probabilities among highly leveraged counterparties. Consequently, the bank introduced proactive measures, including debt restructuring programs and interest rate hedging strategies, to safeguard at-risk counterparties.

5.4.5 Collateral stress test

To evaluate the role of Feature 3 (Collateral Valuation), the bank simulated a 20% drop in collateral values. The test revealed a 13% increase in default probabilities for

counterparties with limited collateral coverage. In response, the bank implemented dynamic collateral management practices, including real-time collateral monitoring and enhanced recovery strategies, to mitigate potential losses.

5.4.6 Netting arrangements scenario

Feature 10 (Netting Arrangements) highlighted the residual risks of over-relying on netting agreements. The bank simulated a scenario where certain netting arrangements became 30% less effective due to operational inefficiencies. This exercise revealed an underestimation of risks, particularly for counterparties with high reliance on these agreements. As a corrective measure, the bank diversified its risk mitigation strategies by introducing alternative contractual protections.

5.4.7 Scenario-based risk interactions

To analyze compounded risks, the bank modeled a combined scenario involving a 4% GDP decline, a 20% increase in market volatility, and a 100-basis-point rise in interest rates. The combined stress test revealed an amplified 28% increase in default probabilities across the portfolio. These results highlighted systemic vulnerabilities, prompting the bank to implement coordinated risk reduction strategies across its business units, such as tighter underwriting standards and enhanced diversification efforts.

5.4.8 Validation against historical events

The Gradient Boosting model's outputs were benchmarked against historical events, such as the 2008 financial crisis and the COVID-19 pandemic. By comparing predicted outcomes with actual results, the bank confirmed the model's ability to replicate past events accurately. For instance, the model effectively captured the spike in defaults during these crises, reinforcing its credibility and predictive robustness.

Through these validation and stress-testing exercises, the bank not only refined its CCR strategies but also demonstrated the practical value of SHAP-driven insights in mitigating both systemic and counterparty-specific risks. By translating quantitative findings into targeted actions, the bank successfully strengthened its ability to navigate complex and volatile financial environments.

5.5 Step 5: Deploying the framework

The bank successfully deployed its Gradient Boosting-based framework into live operations, leveraging distributed computing and middleware integration to optimize performance and recalibration efficiency. This step was a critical milestone in operationalizing the machine learning framework, enabling faster and more accurate risk management during volatile market conditions.

The deployment validated the framework's ability to outperform traditional methods in recalibration speed and accuracy under stress scenarios. For example, in a simulated interest rate hike of 150 basis points, the framework recalculated default probabilities and exposure metrics for thousands of counterparties. As illustrated in the recalibration speed comparison bar chart (**Figure 5**), the new framework completed recalibration in 70 minutes, compared to 125 minutes for the baseline system—a 44% improvement. This efficiency ensured that risk managers received actionable insights in near real-time, enhancing their ability to respond promptly to emerging risks.

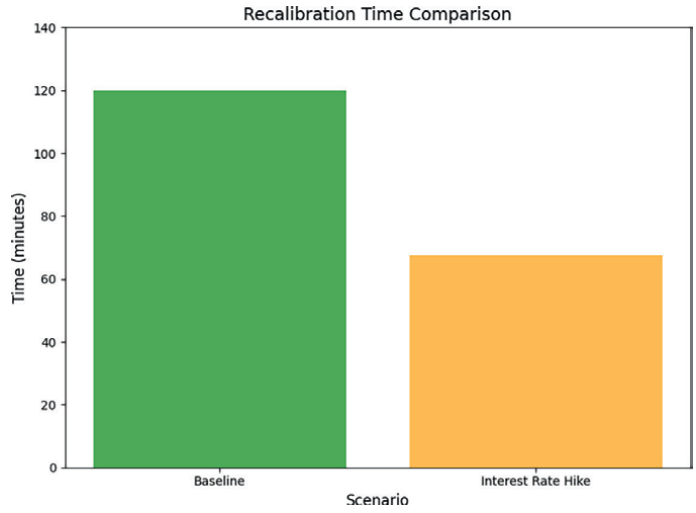


Figure 5.
Recalibration time comparison.

The analysis of default probabilities further demonstrated the framework's precision in stress scenarios. The default rate analysis bar chart in **Figure 6** shows that under normal conditions, the baseline default rate was 12.5%. Following the simulated interest rate increase, the enhanced framework identified a heightened default rate of 16.3%, effectively capturing the increased risk associated with floating-rate borrowers and leveraged counterparties. These findings allowed the bank to implement targeted interventions, including adjusting exposure limits and revising collateral requirements for high-risk counterparties.

Middleware integration played a pivotal role in ensuring seamless communication between the machine learning framework and the bank's legacy systems. This integration enabled real-time synchronization of recalculated metrics across operational

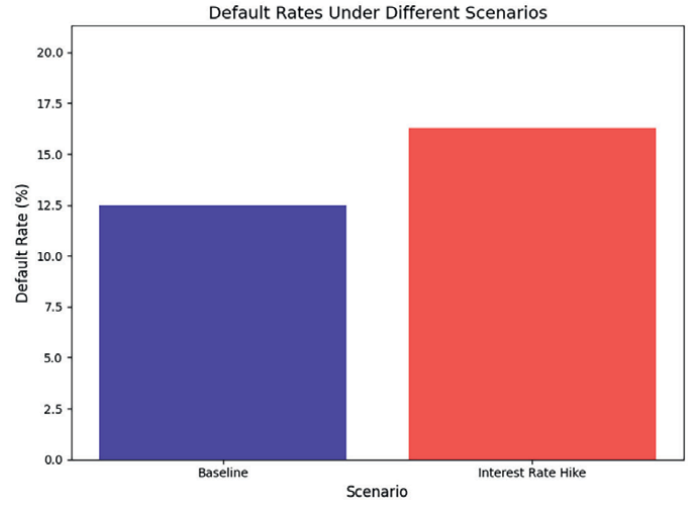


Figure 6.
Default rates under different scenarios.

platforms. For example, during the simulated stress scenario, the framework dynamically updated default probabilities and exposure adjustments on dashboards used by risk managers, maintaining workflow continuity and operational alignment.

The performance metrics pie chart in **Figure 7** highlights the framework's overall impact, with recalibration speed improvements accounting for 92% of its operational benefits and the ability to capture increased default rates contributing 8%. These metrics underscore the comprehensive improvements in the bank's risk management capabilities, emphasizing the framework's value in addressing systemic and counterparty-specific risks effectively.

By successfully deploying the framework, the bank demonstrated its readiness to harness advanced analytics for real-world applications. The improved recalibration efficiency, precise risk predictions during stress conditions, and seamless integration with existing systems collectively marked a transformative step in the bank's risk management approach. These achievements showcased the bank's ability to proactively navigate complex financial environments with resilience and precision.

5.6 Step 6: Monitoring and continuous improvement

The bank implemented interactive dashboards to monitor the performance of its risk management framework and facilitate continuous improvements. Over 6 months, these dashboards provided real-time insights into key metrics, enabling risk managers to track prediction accuracy, evaluate stress-test results, and assess data quality improvements.

The dashboards tracked prediction accuracy trends, highlighting fluctuations in model performance over time. As shown in the **Figure 8**, monthly prediction accuracy ranged from 85% to 92%, with a notable peak in April at 92% followed by a temporary dip in May to 89%. This drop prompted further recalibrations, leading to a recovery in prediction accuracy to 91% by June.

Stress-test results visualized on dashboards revealed sector-specific impacts under various scenarios. As shown in the **Figure 9**, the Real Estate default rate exhibited a significant increase, rising from 10% in January to 14% in May before slightly declining to 13% in June, indicating growing vulnerabilities in this sector. In contrast, the

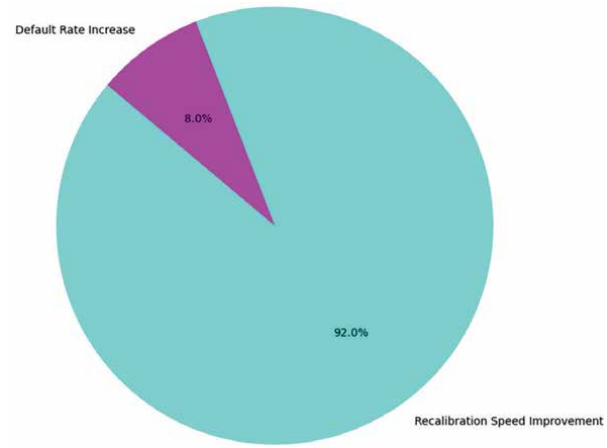


Figure 7.
Performance metrics: framework vs. baseline.

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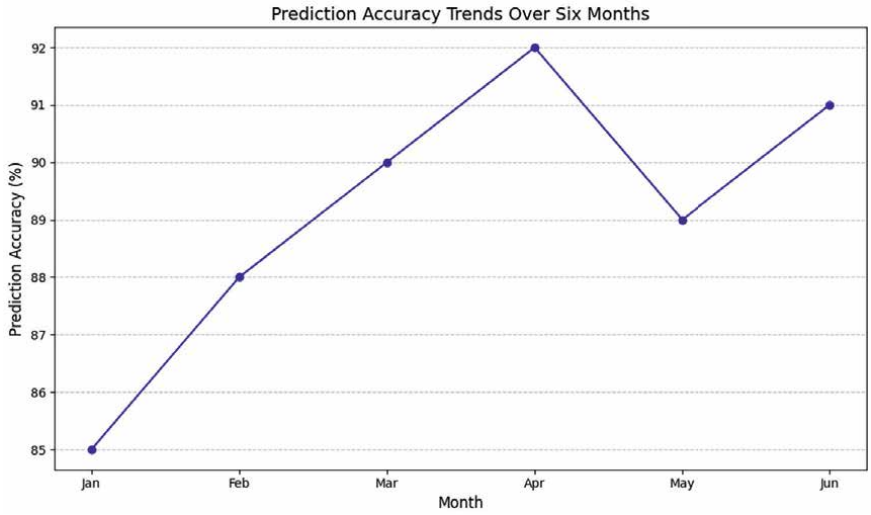


Figure 8.
Prediction accuracy trends over 6 months.

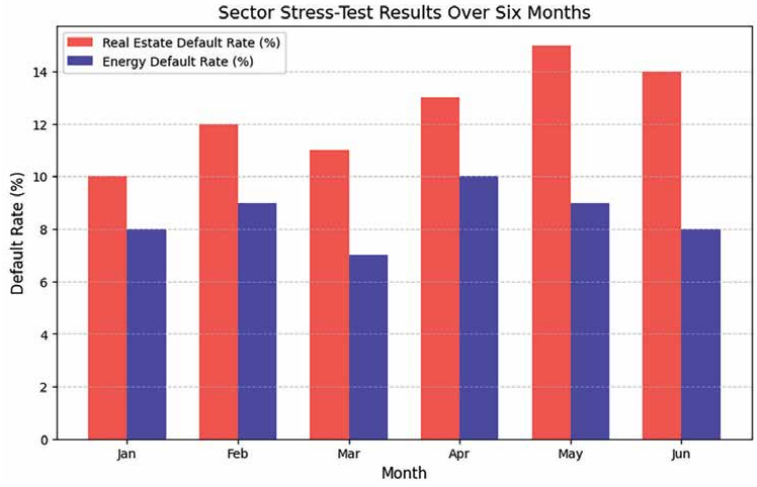


Figure 9.
Sector stress-test results over 6 months.

Energy default rate remained relatively stable throughout the 6 months, fluctuating between 8% and 9%. These insights enabled risk managers to implement targeted measures, such as adjusting exposure limits for the Real Estate sector and reinforcing collateral requirements to mitigate potential risks.

The dashboards tracked data quality metrics, showcasing continuous improvements in preprocessing and data integrity. As illustrated in **Figure 10**, anomaly reduction improved steadily from 70% in January to 90% in June, while data completeness increased from 95% to nearly 100% over the same period. These advancements ensured that the framework operated with high-quality inputs, minimizing errors and significantly enhancing the reliability of risk predictions.

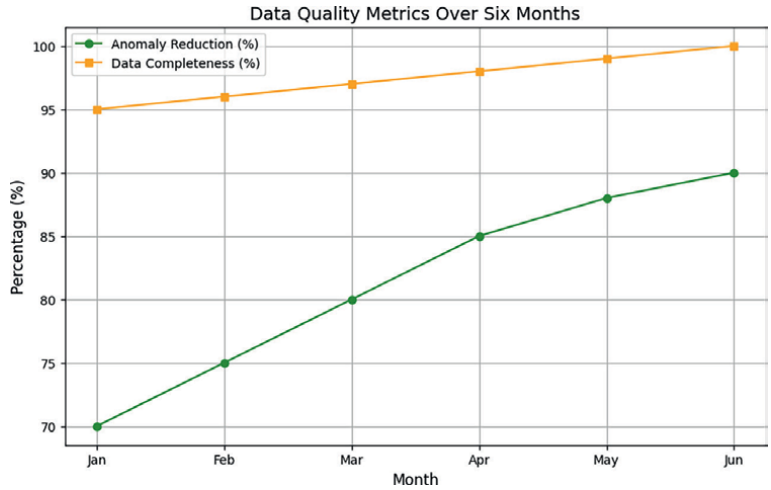


Figure 10.
Data quality metrics over 6 months.

The interactive dashboards provided critical insights into sector-specific vulnerabilities during stress-testing scenarios. The heatmap of sector-wide default rates (as shown in **Figure 11**) highlighted the evolving risk exposure in the real estate and energy sectors over a 6-month period. This visualization proved invaluable in analyzing the impact of macroeconomic shocks, such as a 15% GDP decline and a 30% spike in market volatility, on key industries.

In the real estate sector, default rates rose steadily from 10.5% in January to 12.0% in June, underscoring its susceptibility to macroeconomic shifts and declining asset valuations. Risk managers responded by revising exposure limits and enforcing stricter collateral requirements for vulnerable counterparties in this sector. The energy sector demonstrated greater resilience but still saw a gradual increase in

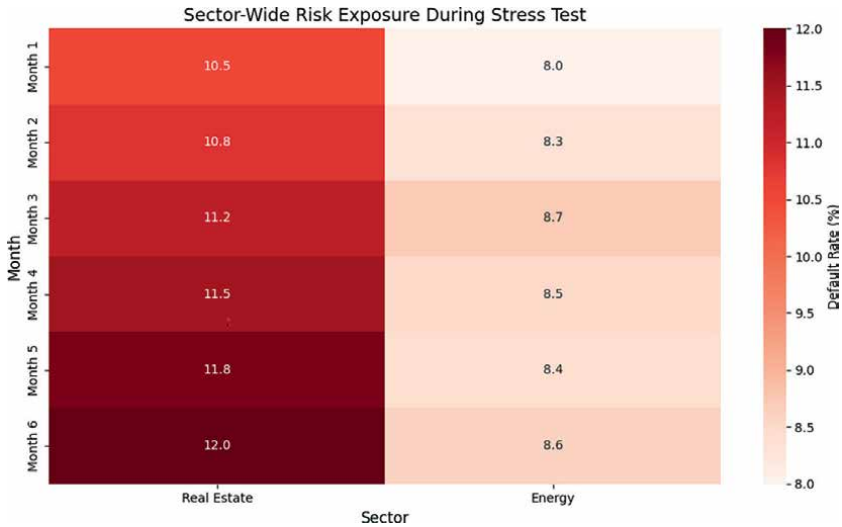


Figure 11.
Sector-wide risk exposure during stress test.

default rates from 8.0% to 8.6%, prompting enhanced monitoring of entities with heightened exposure to market volatility.

By integrating this sector-specific analysis into the dashboard's capabilities, the bank adopted a proactive approach to managing risk at both the counterparty and portfolio levels. These dynamic insights, supported by real-time feedback loops, empowered decision-makers to continuously refine their strategies, ensuring the resilience and adaptability of their CCR framework.

Risk managers relied on interactive dashboards to identify counterparties with deteriorating risk profiles, with real-time updates flagging entities whose default probabilities exceeded thresholds, enabling pre-emptive actions such as renegotiating loan terms or reducing exposure. The framework's dynamic feedback loops recalibrated models with new data, adjusting exposure predictions to reflect trends like rising interest rates, ensuring accurate and timely risk metrics. By integrating real-time monitoring with continuous improvements, the bank maintained operational efficiency, adaptability, and resilience, addressing immediate risks while evolving seamlessly to meet changing market conditions.

In conclusion, the adoption of the machine learning-based framework delivered transformative improvements to the bank's counterparty credit risk management. Data quality improved significantly, with completeness reaching 100% and anomalies resolved effectively, creating a strong foundation for predictive modeling. The Gradient Boosting model achieved high accuracy (92.1%) and a low RMSE (0.26), outperforming traditional models. Stress-testing times were reduced by 44%, enabling recalibrations within 70 minutes, compared to 125 minutes previously. SHAP analysis provided actionable insights into risk drivers, such as delinquency rates and macroeconomic factors, informing targeted interventions and sector-specific strategies. Middleware integration ensured real-time updates across dashboards, enhancing operational efficiency, while explainability tools guaranteed regulatory compliance and transparency. Overall, the framework strengthened CCR management practices, equipping the bank to address risks proactively and adapt to dynamic financial environments with greater precision and efficiency.

6. Challenges, emerging trends, and the road ahead

The integration of machine learning into backtesting for counterparty credit risk (CCR) represents a paradigm shift in financial risk management. These frameworks enable real-time recalibration, more accurate exposure validation, and scenario-based stress testing—addressing key limitations of static, rule-based models. However, realizing their full potential requires overcoming significant adoption barriers, leveraging emerging technologies, and aligning with evolving regulatory expectations.

6.1 Key challenges in ML-based CCR backtesting

Despite its promise, ML-driven backtesting faces several institutional and technical obstacles. A foundational issue is data quality: fragmented, incomplete, or biased datasets undermine model performance and reliability. Legacy systems often lack the infrastructure to centralize and standardize data, making real-time integration difficult. Addressing these concerns requires robust preprocessing pipelines, governance protocols, and fairness-aware methodologies. For example, ensuring that EPE calculations reflect underrepresented industries or regions can mitigate skewed outcomes.

Another critical challenge is model interpretability. While complex algorithms like GBM or deep learning models boost predictive accuracy, they often operate as black boxes—creating barriers to regulatory compliance and stakeholder trust. In stress-testing contexts, institutions must clearly explain why specific exposures are flagged as high-risk. Tools like SHAP (used extensively in this framework) help bridge this gap by offering transparent attribution of prediction outcomes, while LIME remains a viable option for localized, single-instance explanations.

Technological integration adds a further layer of complexity. Legacy IT systems often lack the capacity to support dynamic model validation or high-frequency stress simulations. Scalable infrastructure, such as distributed computing and GPU acceleration, is essential. Middleware and APIs facilitate seamless embedding of ML frameworks into existing workflows, enabling institutions to adjust exposure limits in near real time.

Bias in historical data also poses risks, as entrenched systemic patterns can distort future predictions. Financial institutions must employ fairness-aware modeling and dynamic recalibration techniques to adapt to evolving conditions. Moreover, interdisciplinary collaboration across data science, risk management, and compliance teams is essential to ensure the technical soundness and practical viability of these solutions.

6.2 Innovations and the road ahead for CCR backtesting

Machine learning is fundamentally reshaping how counterparty credit risk (CCR) is assessed and managed. Recent innovations highlight the dual promise of enhanced performance and strategic agility. Explainability tools like SHAP and LIME have become foundational in aligning predictive models with regulatory expectations, offering both global and local insights into model behavior. These tools serve as essential bridges between algorithmic complexity and stakeholder transparency.

Real-time analytics is emerging as a game changer. By ingesting live financial and macroeconomic data, ML-based frameworks can dynamically recalibrate exposure estimates, increasing predictive relevance in volatile markets. This adaptability ensures that institutions can respond to sudden shifts—such as geopolitical shocks or monetary policy changes—with updated, accurate risk assessments.

Additional technologies are expanding the backtesting toolkit. Federated learning allows institutions to collaborate on systemic risk modeling without sharing raw data, preserving privacy while enhancing model diversity. Natural language processing (NLP) further enriches predictive systems by extracting risk-relevant signals from unstructured sources like news articles or regulatory reports—offering qualitative insights to support scenario testing.

Hybrid modeling blends the strengths of machine learning with traditional statistical methods. For instance, GARCH models offer interpretable volatility forecasts, while ML algorithms capture non-linear relationships and evolving dependencies. Together, they enable more robust and transparent risk validation frameworks.

The next wave of innovation in CCR backtesting will be driven by five strategic priorities that span technology, governance, and cross-sector collaboration:

Data governance: High-quality, standardized, and ethically sourced data is foundational. Institutions must develop robust protocols for ingestion, integration, and validation, supported by secure infrastructures that enable shared insights while maintaining data privacy.

Scalable infrastructure: Real-time recalibration and multi-scenario stress testing demand cloud-native, distributed architectures. Leveraging GPU acceleration and

parallel computing will be essential to support large, heterogeneous portfolios under dynamic market conditions.

Interoperability: Seamless integration of ML frameworks into legacy systems remains a core challenge. Modular APIs and middleware solutions can bridge this gap, embedding advanced analytics within existing workflows without disrupting mission-critical operations.

Explainable AI and regulatory alignment: As regulatory expectations continue to evolve—particularly under Basel III's IMM, Pillar 2, and stress-testing frameworks—ML models must not only be accurate but also auditable and interpretable. Advancements in explainable AI will be central to ensuring compliance and institutional trust.

Cross-sector collaboration: Partnerships between academia, regulators, and financial institutions are critical for driving innovation. Collaborative efforts can accelerate development of benchmarks, ethical AI standards, and methodologies for emerging domains such as climate risk, systemic fragility, and macroprudential oversight.

Emerging technologies like quantum computing, federated learning, and sustainability-linked stress metrics may further expand the analytical scope of CCR models. Preparing for this evolution will require not just technical agility, but also resilient governance structures and a commitment to continuous adaptation.

By aligning with these priorities, institutions can unlock the full potential of ML-based backtesting—delivering more transparent, adaptable, and forward-looking frameworks for managing counterparty credit risk in an increasingly complex financial landscape.

6.3 Practical implementation takeaways for ML-based CCR backtesting

Machine learning frameworks represent a transformative evolution in counterparty credit risk (CCR) backtesting—moving beyond the limitations of static models toward scalable, adaptive, and explainable architectures. By embedding non-linear modeling, real-time recalibration, and regulatory alignment at the core of the framework, institutions gain actionable insights and enhanced preparedness for market stress and systemic shocks. Key takeaways include:

Non-linear modeling advantage: ML models capture complex interactions between variables—such as the combined effects of collateral valuation, credit ratings, and macroeconomic trends—that traditional models often overlook.

Regulatory alignment via explainability: Explainable AI tools like SHAP help bridge the transparency gap between algorithmic complexity and supervisory expectations, aligning the framework with Basel III IMM and Pillar 2 validation requirements.

Dynamic recalibration: Real-time updates to exposure forecasts ensure relevance amid shifting financial conditions, supporting proactive responses during volatile or crisis scenarios.

Integration challenges: Operational barriers—including legacy infrastructure, data silos, and cost constraints—continue to hinder large-scale deployment. These must be addressed through strategic investment and cross-functional collaboration.

Regulatory readiness: ML frameworks can enhance auditability and compliance when combined with interpretable models, XAI tools, and robust validation infrastructure.

Looking ahead, the success of CCR backtesting will hinge on institutions' ability to integrate performance, interpretability, and regulatory confidence. Cutting-edge technologies like NLP, federated learning, and hybrid modeling are set to enhance

analytical capabilities, particularly in emerging areas such as climate risk and macroprudential supervision. As machine learning frameworks evolve, the focus will be on balancing innovation with transparency, ensuring that data-driven models are robust, explainable, and effective in navigating intricate financial environments.

Author details

H. Semih Yildirim
School of Administrative Studies, York University, Toronto, ON, Canada

*Address all correspondence to: yildirim@yorku.ca

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Chapter 13

Measurement of Operational Risk Regulatory Capital in the Banking Sector: Developed Vs. Emerging Economies

Medhat A. Hassanein, Mohammed Bouaddi and Talha Karim

Abstract

This study examines operational risk as a fundamental risk faced by banks in emerging and developed economies. We explored several models to specify the marginal and joint distributions of operational losses that reflect the loss frequencies and the severity distribution(s), using international data published by a group of banks in developed and emerging economies. Our results reveal that a uniform approach to modeling operational risk in both types of economies may lead to banks' overestimation or underestimation of capital losses. This would result in either the opportunity cost of holding excessive capital to mitigate operational losses or the additional cost resulting from underestimating the capital required.

Keywords: operational risk, capital charge, value at risk, copula, Basel III, emerging economies, developed economies

1. Introduction

Operational losses in the financial industry have garnered the attention of academics, practitioners, and regulators since the late 1990s [1]. Operational risks can lead to severe financial losses and, in some cases, the collapse of financial institutions. In 2017, the Brazilian Development Bank (BNDES) lost £1.8 billion after faulty transactions between a BNDES subsidiary and another firm. Similarly, in Japan, Shoko Chukin Bank lost £1.75 billion owing to unrealistic sales targets for employees, which resulted in the falsification of documents for small business loans. ScoieteGenerale lost £856 million, linked to the Libyan Investment Authority, to a fraudulent and corrupt scheme managing its sovereign wealth funds. Finally, Deutsche Bank lost $550 million to a bank in Iceland because of questionable investment advice during the global financial crisis [2].

The nature of operational risk differs between credit and market risks. According to Chernobai et al. [3], operational risk losses include various aspects such as loss data with only a positive sign, delays between the time of an event and its loss detection/accumulation, and a considerably right-skewed, heavy-tailed distribution.

Furthermore, operational risk data comprises continuous and discrete data, with dependencies varying between business units and event types. According to Sturm [4], banks have agreed to employ the operational risk framework recommended by the Basel Committee on Banking Supervision (BCBS) [5]. The BCBS [6] defines operational risk as "the risk of loss resulting from inadequate or failed internal processes, people, and systems or from external events." This definition includes legal risk but excludes strategic and reputational risks. According to the BCBS [7], "a capital charge for operational risk should cover unexpected losses due to operational risk. Provisions should cover expected losses." Therefore, an operational risk capital charge is obligatory to provide a buffer against operational risk losses.

Unlike other risk types, operational risks and their associated losses are commonly characterized by heavy-tailed distributions, a significant number of small losses, and few large losses; that is, low frequency and high severity losses are the crucial components of operational risk management ORM and capital allocation [8]. This is evident in the global banking industry. By contrast, ORM primarily focuses on low-severity/-high-impact events rather than central projections or tendencies [9].

According to Abdymomunov and Ergen [10], significant modeling risk arises if the model used to measure operational risk does not account for tail loss dependence. Operational losses are triggered by various types of events, which are then collectively modeled. Consequently, the assumptions and the strength of a bank's dependence on losses affect capital calculations. Therefore, if an incorrect model that does not account for strong tail loss dependence is used, the total required capital will be underestimated. Tail dependencies in losses require regulators to use this information to determine a suitable model to capture these dependencies, ensuring the model's accuracy.

Therefore, it is crucial to select a model that accounts for the complexity of operational risk data. Applying a standardized model across different markets creates inconsistent results because of differences in data due to the prevailing market environment. Unlike developed economies, emerging economies do not employ complex derivative transactions or financial products; thus, the nature of their operational losses differs significantly.

Compared to developed economies, emerging economies face significant research gaps in operational risk management, mainly due to structural differences and methodological limitations compared to developed economies. Operational risk profiles in emerging economies fluctuate dramatically in time. Nevertheless, most frameworks apply a uniform and homogenous approach. Therefore, personalized risk measurement methodologies accounting for structural differences with developed economies are needed.

When it comes to emerging economies, there is a sharp sensitivity to overestimation or underestimation of operational risk capital requirements due to structural and regulatory challenges. These issues emerge from differences in risk profiles and economic conditions compared to developed markets. On one hand, standardized approaches developed for developed markets habitually fail to capture the unique operational risk dynamics of developing economies due to higher fraud rates, weaker governance, and less mature infrastructure. On the other hand, operational losses in developing markets exhibit stronger interdependencies between fraud and system failures for example, which are not fully captured by standardized models. Ignoring these dependencies can lead to overestimation. In addition, a decline in real GDP during a crisis may lead to an underestimate of capital required when risks are actually high. Also, operational risk in developing economies is more influenced by

sectoral factors (agriculture and manufacturing) and governance quality that are not adequately included in standardized models.

To differentiate between developed and emerging economies[1], this study employs both the International Monetary Fund's (IMF) World Economic Outlook and classifications by the United Nations. The IMF World Economic Outlook classifies the global economy into two major groups: advanced and emerging, and developing economies. However, this classification is not based on strict criteria; rather, it has been developed over time with a focus on simplifying the data analysis to provide data that are both reasonable and meaningful. Countries including Anguilla, Cuba, Montserrat, and the Democratic People's Republic of Korea, which are not IMF members, are excluded because they are not monitored by the IMF. Moreover, Somalia is not included as an emerging or developing economy owing to data limitations. The United Nations uses the World Economic Situation and Prospects (WESP) dataset, which classifies the global economy into three groups: developed, transition, and developing economies. First, the dataset distinguishes between fuel-importing and fuel-exporting economies within transition and developing economies. Second, countries are categorized into high-, upper-middle-, lower-middle-, and low-income groups based on their gross national income (GNI).

Uniform approaches for modeling operational risks overlook significant tail loss dependencies. Discarding the advanced measurement approach (AMA) and adopting a standardized methodology would lead to the mismeasurement of the required operational risk capital.

This study aims to demonstrate that using a standardized model for all banks worldwide does not lead to precise capital calculations. This can lead to an overestimation or underestimation of the required capital, tying up funds that could otherwise generate income or be reallocated to hedge against other risk types. The modeling of operational risk capital depends on loss data and distribution selection. An error in the input or distribution can lead to a radical change in required capital. This is reflected in Basel's choice to oblige all banks in both developed and emerging economies to use the same modeling technique, despite the major differences in the nature of operational risk losses between economies.

The contribution of this study is to demonstrate that applying AMA in emerging and developed economies by testing a set of statistical models or specifying the distribution of losses leads to different capital requirements owing to differences in the prevailing markets. Our results are consistent with and support those of Peters et al. [11], who present similar conclusions using an approach tested to measure the operational risk regulatory capital. They demonstrate significant problems in operational risk modeling using any uniform approach, including risk insensitivity, capital superadditivity, and instability. Therefore, they advocate for the AMA and its standardization to avoid heterogeneity problems across banks rather than a complete shift to any uniform approach that would eliminate the AMA entirely. Eliminating AMA could lead to biased results, benefiting only large banks in developed economies with significant operational risk losses, while allowing banks in emerging economies to decrease their required capital for operational risks.

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[1] For the country classification, we used the United Nations World Economic Situation and Prospects and the IMF World Economic Outlook: https://www.un.org/en/development/desa/policy/wesp/wesp_current/2014wesp_country_classification.pdf
https://www.imf.org/external/pubs/ft/weo/2016/02/weodata/groups.htm#da

The remainder of this chapter is organized as follows. Section 2 presents a literature review, Section 3 analyzes the data, and Section 4 explores an empirical investigation. Section 5 summarizes the results and Section 6 presents the findings, concluding the article.

2. Literature review

The Basel Committee primarily aims to improve both the soundness and stability of the global banking system by strengthening risk management practices and instituting risk-sensitive capital requirements to avoid catastrophic losses that previously occurred. According to Nystrom and Skoglund [12], Barings's insolvency and the Allied Irish Bank's loss of $750 million were due to rogue trading, and the Lloyd Banking Group and Barclays were involved in fraudulent actions that led to losses of €5.9 billion and €4 billion, respectively. Such losses occurred because of weak ORM, thus presenting an opportunity for fraudulent action [13].

Ames et al. [14] posit that unlike other risks, operational risk tends to exhibit heavy tails, and the available datasets are neither as comprehensive nor as accessible as those for other risks. Therefore, the models are insufficiently robust to explain why minor changes in the data can have a significant impact on the model's results, leading to instability in the operational risk capital requirement.

Operational risk models are broadly classified into top-down and bottom-up approaches [15]. Chernobai et al. [3] state that top-down approaches quantify operational risk without identifying events or causes of loss. However, bottom-up approaches quantify operational risk at a micro-level by identifying internal events, which are then incorporated into the overall capital charge calculation.

According to Jednak and Jednak [16], the advantage of bottom-up approaches over top-down ones lies in their ability to explain the mechanisms behind the reform of operational risk within an institution. The implementation of these models is hindered by limited historical operational loss data. However, banks can adopt bottom-up models if they have robust databases [3].

According to Ames et al. [14], the Basel II Accord has three main approaches to calculating operational risk regulatory capital. The first is the basic indicator approach (BIA), the second is the standardized approach (TSA) and the third is the AMA. BIA and TSA are top-down modeling approaches, whereas AMA is a bottom-up modeling approach [15]. BIA is simple and uses only one factor, which is 15% of the average annual gross income. Under TSA, each standard business line has a different gross income percentage. The AMA is the most advanced and complex approach, generating a more accurate calculation of operational risk faced by banks. Banks using the AMA can employ their internal models, provided they meet the accuracy standards of the Basel II eight business lines based on the seven relevant event types [11].

Subject to regulatory approval and following the AMA approach, banks can quantify their operational risk using an internally developed model that incorporates the four data elements (tools/sources) specified in the BCBS [17]: internal loss data, relevant external data, scenario analysis, and factors reflecting the business environment and internal control factors (BEICFs) [18–20]. Loss data (internal and external), key risk indicators (KRIs), risk and control self-assessment (RCSA), and scenarios are extensively used in risk identification and management processes. External data can also be used as direct inputs for capital calculations, but only after extensive development [21].

Basel II requires banks to categorize their loss data based on a risk matrix of 56 cell combinations (i.e., eight business lines by the seven event types) [18]. The number of cell combinations can be increased by expanding the business line and loss event type classification from a one-level to a three-level hierarchical tree structure, where each business line node has a branch of event types attached. For simplicity and because of a lack of data, banks tend to quantify their operational risks at different levels and exclude risk cells that are irrelevant to their business [22].

According to Prokopenko and Bondarenko [23], collecting data is challenging. They propose several solutions, including team-building events, automation, bonus and penalty systems, data verification, and periodic revision. Banks face several issues, such as a small internal data sample, the need for rescaling when integrating external and internal data samples into a single model, the requirement for the operational risk losses to fit the correct statistical distribution, and the underreporting of internal losses [24].

Brechmann et al. [25] suggest that the Basel BIA does not reflect real operational loss capital because it generates 38% less capital than a realistic dependence model. This incentivizes banks to use realistic and advanced models. However, banks under BIA and TSA use simple models to estimate their capital requirements. Because of the modeling complexity and inability to compare AMA models across different banks, the BCBS decided to revert to the simplest approach by removing all internal models and using a uniform approach model [11].

In March 2016, Basel introduced a fourth approach that was finalized in December 2017, recognizing a uniform approach aimed at reducing the direct link between modeling activity and required capital. Regulators argue that models are fragile and that the lack of AMA standardization across banks makes it difficult to compare the end results. In 2020, all three approaches were phased out, and only a uniform approach was in effect, which is the standardized measurement approach (SMA) [14].

According to the Basel Committee (2016), the SMA is a uniform approach that combines bank-specific operational loss data with business indicators (BIs), which are a basic financial statement proxy for operational risk exposure. BIs comprise the same components as profits and losses found in the gross income (GI) composition. In October 2014, Basel revised the BIs to avoid penalizing certain business models, such as those based on high interest margins and those based on the distribution of products bought from third parties. The Basel analysis revealed that operational loss exposure increased (more than proportionally) with the BIs. Consequently, the Committee revised the marginal coefficients for the BIs and increased them under any uniform approach. Basel emphasizes that, to have an accurate SMA model, banks must have an internal database loss that follows policies and procedures.

Furthermore, the primary reason for replacing AMA with the Basel Committee's model, SMA, in 2016 was to implement a "one size fits all" model across all banks and avoid complex modeling techniques. Migueis [26] highlights key weaknesses that led to the replacement of the AMA with the SMA, also referred to as the new standardized approach (NSA), as reported by Basel in January 2019: Many practitioners perceive AMA as a complex and unnecessary approach that lacks value in real business decisions and comparability across banks. Consequently, in March 2016, the Basel Committee issued a consultative document replacing the AMA with the SMA or NSA, a system that would base capital calculation on a fully standardized formula.

According to Migueis [26], AMA estimates the 99.9th percentile of the annual distribution of operational losses. However, Basel does not specify how this should be accomplished, allowing each bank flexibility in calculating this using a combination of

main data elements such as external loss data, internal loss data, scenario analysis, and BEICFs. Six aspects are considered for replacing AMA with SMA: robustness, comparability, risk sensitivity, stability, simplicity, usefulness in risk management, and advancement of quantification techniques.

Robustness and comparability are enhanced by using a standardized approach with a given formula for estimating the required capital, which decreases the potential of model manipulation and minimizes decisions left to the practitioner's judgment. Consequently, the SMA is more robust than the AMA because the AMA does not specify how data elements should be combined or how to use the correct family distribution to estimate the operational loss distribution at the 99.9th percentile. This leads to significant differences in capital estimations between banks. Conversely, the SMA is robust because it applies a standardized formula to historical internal losses and financial statement metrics. Additionally, the standard formula of the SMA is easily compared, unlike AMA, which is difficult to compare across banks. However, if differences in data collection under the SMA are not accounted for, comparability will be difficult for both the SMA and AMA [26].

Risk sensitivity: The AMA did not specify how banks should model the 99.9th percentile of the operational risk annual loss distribution, allowing banks to tailor the model to be more risk sensitive to a specific data element, potentially decreasing their capital requirement. A similar problem exists in the SMA, as relying on historical internal losses and financial statement metrics does not reflect a bank's risk profile. In addition, the removal of major data elements that existed under the AMA, such as BEICFs and scenario analysis from capital calculations, has curtailed the forward-looking perspective in capital calculations [26].

Stability and simplicity: Because AMA primarily relies on internal losses, any significant loss can impact capital estimates, particularly the estimation of the 99.9th percentile of loss. Moreover, using external data can cause significant variations in the risk sensitivity of the estimated capital. Consequently, AMA is not a stable approach. In addition, AMA involves numerous data elements and complex modeling techniques. Under the SMA, stability is ensured using a 10-year historical data loss to calculate the required capital. This eliminates variances and guarantees stability. The SMA is a simple approach that uses a standard formula [26].

Usefulness for risk management and advancement of quantification: Bankers argue that AMA is of limited use beyond regulatory capital estimation because its estimation is based on the 99.9th percentile of past losses. Reliance on past losses eliminates the need for dynamic forward-looking models. Moreover, the 99.9th percentile is an extreme tail percentile useful for pricing and other day-to-day risk decisions. However, because SMA is a top-down approach, it lacks the option of studying risk at a granular level, which produces no motive for risk management to develop advanced quantification techniques [26].

This shift from the AMA to the SMA adopts a top-down approach that decreases operational risk losses to one unit of measurement. Assuming that losses that are heterogeneous in nature and can all be aggregated simply eliminates the concept of risk sensitivity analysis. Therefore, the BCBS SMA does not achieve its primary objective of measuring the sensitivity of operational risk capital. This is because the capital estimated under any uniform approach is neither stable nor related to the bank's risk profile, potentially encouraging risk-taking behaviors that may cause financial instability [11].

Under the Basel AMA, significant emphasis is placed on the use of the four main loss data types when calculating capital. These loss data types include the external loss

data, internal loss data, BEICF, and scenario analyses. However, the shift to a new SMA excludes three types of data and uses only the internal loss data. For example, standardization must be considered by requiring statistical robustness, using the loss distribution approach (involving all four types of data loss), and detailed reports on the modeling assumptions and techniques [11].

Compared to the simpler approaches, the capital reserves under the AMA approach are expected to be more relevant to the bank's actual risk profile (i.e., capital is held in proportion to the amount of operational risk involved in its activities). Consequently, capital requirements are typically lower under any uniform approach, thereby incentivizing banks to invest in robust operational practices and risk management [9, 15, 18, 27].

According to a PWC report [28], the banking industry has criticized the Basel models that measure operational risks. The elimination of the concept of business lines made it more difficult for banks to achieve better risk management by assessing the risk-based performance of each business line. The shift to the new SMA uses five different categories, ranging from 10–30%, based on the BI approach [5]; however, it does not show how to capture massive variations in banks' business models. By contrast, the BCBS [29] reports that SMA 5 employed three categories. Notably, it does not explain how a uniform approach can differentiate between banks that have improved their control environments and those that have high-quality ORM practices.

According to Sands et al. [30], risk-weighted asset (RWA) is one of the three major components of a bank's risk-based capital ratio. RWA is the denominator of the Common Equity Tier 1 (CET1) capital ratio[2]. According to BCBS [31], "CET1 is the highest quality of regulatory capital, as it absorbs losses immediately when they occur." The RWA of operational risk represents 15.6% of the 30 Globally Systemically Important Banks (GSIB) [5].

Sands et al. [30] mention that the BCBS's latest update on the estimation of operational RWA shifts from reliance on complex internal models to standardized modeling. Under the uniform approach, a significant increase in operational risk losses leads to an increase in RWA. Consequently, management cannot reduce the operational risk RWA except by decreasing the RWA of the market or credit risk. Therefore, a uniform approach causes a negative loss of absorbency for banks, leading to further challenges for those operating under such a uniform approach. Specifically, it does not provide the bank with an incentive to improve ORM. Moreover, the ability to compare risk-based capital ratios across banks will not improve because of variability and a lack of consistency in the derivation of the operational RWA under both the uniform approach and AMA. A uniform approach may provide comparability by appearance rather than real comparability across banks. This is because under the uniform approach, two banks could have equivalent operational RWA while facing different levels of risk and vice versa.

Mignola et al. [32] examine the impact of the shift from AMA to SMA through a case study simulation. They state that this shift undermines the accurate measurement of the operational risk in banks, as SMA fails to capture different risk profiles, resulting in inaccurate capital calculation. Cohen [33] mentions that the SMA cannot capture granular risk levels. SMA is a "one- size-fits-all type of model," which means one equation applies to all banks with different risk profiles. This completely ignores idiosyncratic characteristics such as lines of business, asset classification, and other

[2] $\textit{Common Equity Tier 1 (CET 1)} = \frac{\textit{Adjusted Common Equity (adjusted for deductions for tax credits and expected losses}}{\textit{(Credit RWA+Market RWA+Operational RWA)}}$

individual bank characteristics. The only details captured by the SMA are the bank's profits and operational losses. Cohen [33] supports the view that SMA fits all banks and makes comparability applicable; however, AMA should not be eliminated. The modeling data can be improved by focusing on fewer details, reducing the noise in the modeling results, generating one overall dominating trend, and adjusting the confidence level from the 99.9th percentile.

Mignola et al. [32] reveal three main points that highlight the weakness of SMA over AMA, apart from the fact that SMA is easier to compare across banks. First, the SMA is risk insensitive, does not change with the bank risk profile, and cannot differentiate between different risk profiles across banks. This is because SMA does not grow in proportion to the operational losses; therefore, it is said to be risk insensitive, unlike AMA. Second, the SMA is directly linked to bank income, which is imperfectly correlated with historical losses. According to a recent survey, there are wide variations between the income level generated by banks and operational loss data. Because SMA banks with similar risk profiles can have different capital levels, the SMA loses its main advantage, which is comparability. Third, SMA can lead to over-or underestimation of operational risk capital since it is not linked to any risk measure, unlike AMA, which is linked to the 99.9th percentile value at risk (VaR) of the annual operational loss distribution. The SMA can be linked to various confidence levels, beginning from the 99th to 99.9999th percentiles. This proves that the SMA does not differentiate between different risk profiles.

Because operational losses are typically presented by a heavy-tailed loss distribution, the SMA is expected to have the following characteristics: First, assuming that two banks have the same expected loss (EL), a bank with a low frequency-high intensity loss profile should have more capital than a bank with a high-frequency and low-intensity loss profile. Second, if the two banks have risk factors, the bank with high EL should hold more capital than the one with low EL. After conducting a case-study simulation, the SMA failed to follow these two characteristics. The main component of the SMA is the business size rather than the loss profile. Increasing the loss component (LC) by 100% does not exceed the increase in the final SMA figure by 33% (assuming no change in the BI). Therefore, if neither BI nor the risk factors remain unchanged, any change in LC would be directly linked to a change in EL. This indicates that as EL increases, SMA decreases, which is contrary to the first characteristic mentioned above [32].

Mignola et al. [32] conclude that SMA is considered a deterioration in two aspects. First, it measures risk sensitivity. Second, it fails to establish a link between capital requirements and managerial actions. For instance, assume two banks with similar loss profile and size: One bank invests in improving the existing legal environment, controls, and resources, while the other makes no such improvements. Under the SMA, both banks have the same capital requirements. However, under AMA, the first bank is likely to have a reduced risk profile through improvements and lower required capital.[3]

This study aims to estimate the capital required for operational risk using several models for both developed and emerging economies. There are two key components: loss frequency and loss severity distributions of the historic operational loss data. Actuarial models can differ based on the type of loss distribution with respect to

[3] A comparative table showing different operational risk measurement approaches (AMA vs. SMA) can be found in the Appendix (**Table A1**).

empirical loss distribution models and parametric loss distribution models. Operational risk capital is measured by the VaR of the aggregated one-year losses.

For example, three actuarial models can be used simultaneously to measure a bank's operational risks [34]. Alternatively, an autoregressive moving average/generalized autoregressive conditional heteroskedasticity (ARMA/GARCH) model can be applied to the losses below a high threshold, while the generalized Pareto distribution can fit the data exceeding it [3]. This is the approach adopted in our model, which employs both the bottom-up and top-down approaches. These models show that using a standardized model for all banks in emerging and developed economies leads to an under-or overestimation of required capital, highlighting the main objective of this study.

3. Data

In this study, we use the "SAS Operational Risk Global Data" related to the operational risk losses in banks in developed and emerging economies. There are eight business lines and seven event types that constitute 56 risk categories,[4] as shown in **Table 1**.

As shown in **Table 1**, under the Basel II and subsequent frameworks banks are mandated to categorize their activities into eight distinct business lines and seven event types. Each business line echoes a different area of banking operations related to the exposure to operational risk. The goal of this classification is to ensure that operational risk capital requirements are sensitive to the specific risks inherent in each type of banking activity.

We used the global SAS data on operational risk from 1971 to 2017. The total number of reported events are 16,468, of which 15,471 and 997 are from developed and emerging economies, respectively.[5] The items with significant and recent data for

Business lines	**Event types**
Corporate Finance	Internal Fraud
Trading & Sales	External Fraud
Retail Banking	Employment Practices and Workplace Safety
Commercial Banking	Clients, Products & Business Practices
Payment and Settlements	Damage to Physical Assets
Agency Services & Custody	Business disruption and system failures
Asset Management	Execution, Delivery & Process Management
Retail Brokerage	

Table 1.
Operational risk matrix (Basel classification).

[4] This table presents the considered eight business lines and seven event types of operational risk as suggested by Basel, which reflects the 56 options.

[5] For detailed access inquiries, contact SAS directly through their website: https://www.sas.com/en_nz/customers/bank-of-india-eGRC.html

both developed and emerging economies include the business line "Trading & Sales" and the event types "Clients, Products & Business Practices" and "Damage to Physical Assets" which account for 57% of the total number of events in emerging economies. Business lines and event types are selected based on the number of events declared and available in the SAS system. **Table 2** demonstrates that business line "Trading & Sales" and the event types "Clients, Products & Business Practices" and "Damage to Physical Assets" have the highest number of events in developing countries. In addition, to preserve the efficiency of the model's parameter estimates, we restrict our analysis to these types of events. Economic data on developing countries are recognized by their scarcity, specifically, in the banking sector.Clients, Products and Business Practices" and "Damage to Physical Assets" account for 41.98% and 17.43%, respectively, contributing to 59.41% of the total number of events in developed countries. Emerging economies account for 28.77 and 11%, respectively, amounting to 39.77% of the total number of events.

We select the marginal distributions of operational severities and frequencies for every intersection of event types and business lines, as well as their joint distribution (copula) using the Vuong test. We utilize the Akaike information criterion and the Anderson-Darling test for the same purpose. Subsequently, we approximate the total loss distribution using Monte Carlo simulations, through which we estimate the global VaR with a 99.9% confidence level.

4. Modeling methodology

We refer to Pretorius [35], "The superiority of one frequency function over another depends rather on the success with which that function can be applied to graduate data than on the manner in which it originated."

This insight highlights that a model with good properties should not be complicated or sophisticated. Specifically, it should be flexible, enabling practitioners to generate stylized data. Therefore, a model must be more flexible while containing a finite number of good interpretable parameters while remaining tractable and simple for estimating and predicting the variables or key indicators such as the risk of exceeding a certain threshold value. We pursue these desirable properties to model the severity and frequency of operational risk losses.

Operational risk is a compound process because it depends on two random variables: the size or severity of the risk and the number or frequency of events. Severity is a continuous variable, and frequency is a discrete variable.

The loss distribution approach is a common model used to measure operational risk losses. It assumes that the number of events (frequency) of internal operational losses and the severity (s) of a single loss are independent random variables and that the individual losses are independent and identically distributed. The total loss is given by $L = \sum_{i=1}^{f} Si$, and the total loss distribution on function (H) is given by

$$H(l) = pr(L < l) = \sum_{n=0}^{+\infty} \Pr(f = n) F_n(S). \quad (1)$$

where F_n is the n-fold convolution of the severity distribution F. As our loss data are heavily tailed (subexponential), a simple closed-form approximation of the upper quantile of the total loss (L) derived by Böcker and Kluppelberg [36] exists:

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Count of events	**Event category**							
Business line	**Internal Fraud**	**External Fraud**	**Employment Practices**	**Clients, Products**	**Damage to Physical Assets**	**Business Disruption**	**Execution**	Total
Corporate finance	73	42	1	27	2	0	0	145
Trading and sales	75	33	15	287	105	10	2	527
Retail Banking	6	0	0	9	0	0	0	15
Commercial banking	1	2	0	8	0	0	1	12
Payment and settlement	16	0	0	7	0	1	0	24
Agency Services & Custody	5	2	0	0	1	0	0	8
Retail Brokerage	80	55	0	44	6	0	0	185
Asset Management	3	0	2	6	0	0	0	11
Total	259	134	18	388	114	11	3	927

Table 2.
Count of events for developing countries.

$$H(1) \approx 1 - E(f)(1 - F(s)) \cdot \tag{2}$$

In this case, the quantile of (L) is given by

$$q_a \approx F^{-1}\left(1 - \frac{1-\alpha}{E(f)}\right) \cdot \tag{3}$$

VaR is equal to the quantile (q_a) when α is close to 1. In the subsequent subsections, we present the different distributions of severity (s) and frequency (f) used to estimate the operational risk capital required for developed and emerging economies.

4.1 Severity modeling

To model the severity of operational risks, we use univariate distributions to capture the heavy-tailed distribution of operational risk losses: We consider the following distributions: Exponential, Weibull, Gamma, Log-normal, Exponentiated-Exponential, Exponentiated-Weibull, and Pareto. **Table 3** presents the density for each distribution and the derived VaR.

4.2 Frequency modeling

The frequency data of the operational risk is a type of count data. The standard framework for modeling the outcome variable includes the Poisson and negative binomial models.

The Poisson model is expressed as follows:

$$\Pr(F = f) = \frac{\exp(-\mu)\mu^f}{\Gamma(f+1)} . \mu > 0 . f = 0.1.2 \cdots \tag{4}$$

where F represents the frequency, and μ denotes the mean. The variance in this model is equal to the mean ($\sigma^2 = \mu$). The basic Poisson model assumes that the variance in an outcome is equal to the mean, which is of limited use in empirical analyses. However, count data are often over-dispersed relative to the Poisson distribution. One frequent manifestation of overdispersion is that the data may originate from different sources (e.g., different populations). This is the case with the frequency of operational risk data. Another alternative is the negative binomial model. This model complements more conventional models for overdispersion that concentrate on modeling the variance-mean relationship correctly.

The negative binomial model is expressed as follows:

$$\Pr(F = f) = \frac{\Gamma(\eta + f)}{f!\Gamma(\eta)} (1 - \pi)^{\eta} \pi^f . \eta > 0.0 < \pi < 1 f = 0.1.2. \cdot \cdot \tag{5}$$

If a distribution is used for regression, it is more appropriate to express the probability mass in terms of the mean. Therefore, if we substitute $\mu/(\eta + \mu)$ for π, the probability mass becomes

$$\Pr(F = f) = \frac{\Gamma(\eta + f)}{f!\Gamma(\eta)} \left(\frac{\eta}{\eta + \mu}\right)^{\eta} \left(\frac{\mu}{\eta + \mu}\right)^{f} \eta > 0 . \mu > 0 . f = 0.1.2 \cdots \tag{6}$$

Distribution	Density	VaR
Exponential	$f(s.\mu) = \frac{1}{\lambda}\exp\left(-\frac{s}{\lambda}\right).s \geq 0.and\ \lambda > 0.$	$VaR_\alpha(S) = Q(\alpha.\mu) = \mu(-\ln(1-\alpha)).0 < \alpha < 1.and\ \lambda > 0.$
Weibull	$f(s.\lambda.k) = \frac{k}{\lambda}\left(\frac{s}{\lambda}\right)^{k-1}\exp\left(-\left(\frac{s}{\lambda}\right)^{k}\right).s \geq 0.\lambda > 0\ and\ k > 0.$	$VaR_\alpha(S) = Q(\alpha.\lambda.k) = \lambda(-\ln(1-\alpha))^{\frac{1}{k}}.0 < \alpha < 1.\lambda > 0\ and\ k > 0.$
Gamma	$f(s.\lambda.k) = \frac{1}{\lambda^k\Gamma(k)}s^{k-1}\exp\left(-\frac{s}{\lambda}\right).s \geq 0.\lambda > 0\ and\ k > 0.$	$VaR_\alpha(S) = Q(\alpha.\lambda.k) = \gamma^{-1}(\alpha.\lambda.k).0 < \alpha < 1.\lambda > 0\ and\ k > 0.$ $\Gamma(a) = \int_0^{+\infty} t^{a-1}\exp(-t)dt.\gamma(\lambda.k.x) = \int_0^x \frac{\exp\left(\frac{-s}{\lambda}\right)s^{k-1}}{\lambda^k\Gamma(k)}ds$
Log-normal	$f(s.\lambda.\mu) = \frac{1}{\sqrt{2\pi\lambda}s}\exp\left(-\frac{1}{2}\frac{(\ln(s)-\theta)^2}{\lambda^2}\right).s > 0.\lambda > 0\ and\ \theta$	$VaR_\alpha(S) = Q(\alpha.\lambda.k) = \exp\left(\lambda\Phi^{-1}(\alpha)+\theta\right).0 < \alpha < 1.\lambda > 0\ and\ \theta$
Exponentiated-Exponential	$f(s.\lambda.k) = \frac{k\left[1-\exp\left(\frac{-s}{\lambda}\right)\right]^{k-1}\exp\left(\frac{-s}{\lambda}\right)}{\lambda}.s \geq 0.\lambda > 0\ and\ k > 0$	$VaR_\alpha(S) = Q(\alpha.\lambda.k) = \lambda\left(-\ln\left(1-\alpha^{\frac{1}{k}}\right)\right).0 < \alpha < 1.\lambda > 0\ and\ k > 0$
Exponentiated-Weibull	$f(s.\lambda.k) = \frac{k\theta\left[1-\exp\left(-\left(\frac{s}{\lambda}\right)^k\right]^{\theta-1}\exp\left(-\left(\frac{s}{\lambda}\right)^k\right)s^{k-1}}{\lambda^k}.s \geq 0.\lambda > 0.\theta > 0\ and\ k > 0$	$VaR_\alpha(s) = Q(\alpha.\lambda.k) = \lambda\left(-\ln\left(1-\alpha^{\frac{1}{\theta}}\right)\right)^{\frac{1}{k}}.0 < \alpha < 1.\lambda > 0.\theta > 0\ and\ k > 0$
Pareto	$f(s s_m.\lambda.k) = \frac{ks_m^k\left(\frac{s}{\lambda}\right)^{-k-1}}{\lambda}.s \geq s_m > 0.\lambda > 0\ and\ k > 0$	$VaR_\alpha(S) = Q(\alpha.\lambda.k) = \lambda s_m(1-\alpha)^{\frac{1}{k}}.0 < \alpha < 1.s_m > 0.\lambda > 0\ and\ k > 0$

Table 3.
Density for each distribution and derived VaR.

The negative binomial distribution is particularly appropriate for modeling operational risk event frequency in banks owing to its ability to handle overdispersion, which is a common feature of real-world loss data where variance exceeds the mean. Banks in emerging economies may lack extensive historical loss data. In such a situation, the negative binomial performs better than Poisson as it accounts for periods of low losses and abrupt spikes. Another advantage is that, in Basel frameworks banks are required to model tail risks accurately in which case the negative binomial can do better in capturing the tail behavior and rare but severe events (large frauds, etc.). In addition, the negative binomial distribution enhances stress testing by allowing simulation of extreme but plausible loss frequencies linked to systemic risks (cyberattacks, geopolitical disruptions, etc.).

4.3 Dependence modeling: Copula

To model the dependence between different types of losses, we use the Gumbel and Clayton copulas. The Gumbel copula captures upper-tail dependence, whereas the Clayton copula models lower-tail dependence. If small losses occur more often than larger ones, the Clayton copula is appropriate. If large losses occur more frequently than small losses, then the Gumbel copula is preferred.[6]

4.4 Model selection and estimation

We use the maximum-likelihood estimator to estimate our models of severity and frequency processes. Specifically, the inference function for the margin (IFM) method is used to estimate the parameters. The IFM approach follows a two-step approach introduced by Shih and Louis [41]. In the first step, the marginal parameters are estimated separately, and in the second step, the dependence parameters are estimated.

We utilize the Vuong test to select an appropriate model for frequency, severity, and copula. The Vuong test is a likelihood-ratio-based test used for model selection. This statistic compares the likelihoods of two models. These models can be nested, non-nested, or overlapping. The statistic verifies the null hypothesis that two competing models are equally close to the true data-generating process, against the alternative that only one model is closer (see Vuong [42] for further details). Furthermore, we use the Akaike information criterion to classify the models based on their loss of information, with the preferred model being the one with the lowest value for this criterion. Additionally, we conduct a nonparametric test to determine whether the data come from the proposed distribution. Specifically, we use the Anderson-Darling test to assess the specification for the considered distributions.

5. Results

To measure the dependence among losses, we use the Pearson, Spearman's rank, and Kendall's rank correlation coefficients. While the first correlation captures linear dependence, the last two correlations capture nonlinear dependence. For the two marginal operational losses, **Table 4** reports the three types of dependency measures and their corresponding p-values (in parentheses).

[6] For more details about copula, see [37–40].

Correlation	Linear	Spearman	Kendall
Developed	0.4467 (0.0195)	0.7106 (0.0000)	0.5328 (0.0001)
Emerging	0.0033 (0.9868)	0.4768 (0.0119)	0.3908 (0.0073)

Table 4.
Correlations.

Furthermore, **Table 4** demonstrates that the linear correlation for emerging economies is −0.33%. For developed economies, it is 44.67% and significant. These results suggest that the linear independence hypothesis can be a valid assumption for banks in emerging economies, implying that using any uniform approach, as recently introduced by Basel, could lead to an increase in required regulatory capital. However, Spearman's and Kendall's rank correlation coefficients for emerging economies are 47.68 and 39.08%, respectively. These correlation coefficients for developed economies are statistically significant at 71.06 and 53.28%, respectively. This indicates that using a uniform approach instead of the AMA for developed economies would generate lower regulatory capital for banks. These results emphasize that the dependence on the operational losses is nonlinear, thereby rejecting the independence hypothesis.

We also test the assumption that the correlation is equal to unity, and this hypothesis is strongly rejected by the data for all types of correlations. Thus, the complete dependence assumption, as suggested by Basel in the AMA, is inadequate for modeling the relationship between different types of losses. Thus, the assumption that different risks are positively dependent is inaccurate. This demonstrates that copulas provide a more representative framework for dependence modeling and that the independence assumption is inaccurate.

Tables 5–8 present the Vuong test results for specifying the marginal distributions of the two different operational losses. The results indicate that the Exponentiated-Weibull is the best candidate for modeling severity losses in developed economies, whereas the Log-Normal is preferred for emerging economies.

This is consistent with the results of the Akaike criterion and the Anderson-Darling test presented in **Tables 9–12**.

Tables 13 and **14** present that, using the Vuong test, the Gumbel copula is the best fit for capturing dependence in developed economies, and the Clayton copula is the best choice for emerging economies.

These results corroborate the results of the Akaike criterion and Anderson-Darling test presented in **Tables 15** and **16**.

For the frequency distribution, for both emerging and developed countries, the Akaike criterion and the Anderson-Darling test select a negative binomial, as presented in **Tables 17–20**.[7]

Significant difference exists between the two copulas: The Clayton copula exhibits lower tail dependence, and the Gumbel copula captures upper tail dependence. In

[7] The Anderson-Darling test statistic can sometimes be small for some models, making the test inconclusive. However, this result is well understood because the non-parametric tests generally require large samples to achieve more influence and reduce bias compared with the parametric tests, such as Vuong.

	Exponential	**Weibull**	**Gamma**	**Log-Normal**	**Pareto**	**Exponentiated-Exponential**	**Exponentiated-Weibull**
Exponential	—	Weibull	Gamma	Log-Normal	Exponential	Exponentiated-Exponential	Exponentiated-Weibull
Weibull	—	—	Weibull	Log-Normal	Weibull	Weibull	Exponentiated-Weibull
Gamma	—	—	—	Log-Normal	Gamma	Gamma	Exponentiated-Weibull
Log-Normal	—	—	—	—	Log-Normal	Log-Normal	Exponentiated-Weibull
Pareto	—	—	—	—	—	**Exponentiated-Exponential**	Exponentiated-Weibull
Exponentiated-Exponential	—	—	—	—	—	**—**	**Exponentiated- Exponential**
Exponentiated-Weibull	—	—	—	—	—	—	—

Table 5.
Developed: business line: trading & sales/event type: clients, products & business practices.

	Exponential	**Weibull**	**Gamma**	**Log-normal**	**Pareto**	**Exponentiated-exponential**	**Exponentiated-Weibull**
Exponential	—	Weibull	Gamma	Log-Normal	Exponential	Exponentiated-Exponential	Exponentiated-Weibull
Weibull	—	—	Weibull	Log-Normal	Weibull	Weibull	Exponentiated-Weibull
Gamma	—	—	—	Log-Normal	Gamma	Gamma	Exponentiated-Weibull
Log-Normal	—	—	—	—	Log-Normal	Log-Normal	Exponentiated-Weibull
Pareto	—	—	—	—	—	**Exponentiated-Exponential**	Exponentiated-Weibull
Exponentiated-Exponential	—	—	—	—	—	—	**Exponentiated-Exponential**
Exponentiated-Weibull	—	—	—	—	—	—	—

Table 6.
Developed: business line: trading & sales/event type: damage to physical assets practices.

	Exponential	**Weibull**	**Gamma**	**Log-Normal**	**Pareto**	**Exponentiated-Exponential**	**Exponentiated-Weibull**
Exponential	—	Weibull	Gamma	**Log-Normal**	Pareto	Exponentiated-Exponential	Exponentiated-Weibull
Weibull	—	—	Weibull	**Log-Normal**	Weibull	Weibull	Exponentiated-Weibull
Gamma	—	—	—	**Log-Normal**	Gamma	Gamma	Exponentiated-Weibull
Log-Normal	—	—	—	—	**Log-Normal**	**Log-Normal**	**Log-Normal**
Pareto	—	—	—	—	—	Exponentiated-Exponential	Exponentiated-Weibull
Exponentiated-Exponential	—	—	—	—	—	—	Exponentiated-Weibull
Exponentiated-Weibull	—	—	—	—	—	—	—

Table 7.
Emerging: business line: trading & sales/event type: clients, products & business practice.

	Exponential	**Weibull**	**Gamma**	**Log-Normal**	**Pareto**	**Exponentiated-Exponential**	**Exponentiated-Weibull**
Exponential	—	Weibull	Gamma	**Log-Normal**	Pareto	Exponentiated-Exponential	Exponentiated-Weibull
Weibull	—	—	Weibull	**Log-Normal**	Weibull	Weibull	Exponentiated-Weibull
Gamma	—	—	—	**Log-Normal**	Gamma	Gamma	Exponentiated-Weibull
Log-Normal	—	—	—	—	**Log-Normal**	**Log-Normal**	**Log-Normal**
Pareto	—	—	—	—	—	Exponentiated-Exponential	Exponentiated-Weibull
Exponentiated-Exponential	—	—	—	—	—	—	Exponentiated-Weibull
Exponentiated-Weibull	—	—	—	—	—	—	—

Table 8.
Emerging: business line: trading & sales/event type: damage to physical assets.

	Anderson-Darling Statistic	Akaike
Exponential	135.6565	12205.91
Weibull	2.311741	11786.49
Gamma	8.572192	11833.36
Log-Normal	1.018559	11759.7
Pareto	29.26322	11911.95
Exponentiated-Exponential	9.886807	11839.75
Exponentiated-Weibull	1.034691	11762.53
(Business line: Trading and sales/event type: Damage to physical assets).		

Table 9.
Marginal: Anderson-Darling test and Akaike criterion, Emerging economies.

	Anderson-Darling Statistic	Akaike
Exponential	1526.534	270977.6
Weibull	121.9547	266741.4
Gamma	255.7549	267644.2
Log-Normal	20.3355	265633.4
Pareto	1210.815	273541.5
Exponentiated-Exponential	285.5045	267781.9
Exponentiated-Weibull	11.76942	265590.4
(Business line: Trading and sales/event type: Damage to physical assets).		

Table 10.
Marginal: Anderson-Darling test and Akaike criterion, developed economies.

	Anderson-Darling Statistic	Akaike
Exponential	63.9200	4815.225
Weibull	3.1750	4653.13
Gamma	6.1698	4672.619
Log-Normal	1.2922	4634.195
Pareto	12.15908	4690.947
Exponentiated-Exponential	6.513094	4674.169
Exponentiated-Weibull	1.945219	4634.623
(Business lines: trading and sales/event type: clients, products, and business practices).		

Table 11.
Marginal: Anderson-Darling test and Akaike criterion, Emerging economies.

	Anderson-Darling Statistic	**Akaike**
Exponential	327.5706	32900.93
Weibull	32.1438	32101.34
Gamma	58.6899	32269.43
Log-Normal	11.8317	31887.47
Pareto	121.8443	32549.48
Exponentiated-Exponential	63.5005	32290.31
Exponentiated-Weibull	5.5957	31849.09

(Business lines: trading and sales/event type: clients, products, and business practices).

Table 12.
Marginal: Anderson-Darling test and Akaike criterion, Developed economies.

	Normal	**Clayton**	**Gumbel**
Normal	—	Clayton	Gumbel
Clayton	—	—	Gumbel
Gumbel	—	—	—

Table 13.
Copula-developed market.

	Normal	**Clayton**	**Gumbel**
Normal	—	**Clayton**	Gumbel
Clayton	—	—	**Clayton**
Gumbel	—	—	—

Table 14.
Copula-emerging market.

	Anderson-Darling Statistic	**Akaike**
Gaussian Copula	1.2018	106.1774
Clayton copula	0.6455	−8.133466
Gumbel Copula	0.8922	−7.152300

Table 15.
Copula: Anderson-Darling test and Akaike criterion emerging.

emerging economies, losses show a high degree of dependence for small losses and exhibit independence when there are large losses, whereas the opposite is true for developed economies. This supports our research hypothesis that banks in different markets cannot apply the same methodology to measure operational risks because of

	Anderson-Darling Statistic	Akaike
Gaussian Copula	26.5543	95.29025
Clayton copula	0.9312	−17.09323
Gumbel Copula	0.7524	−17.56574

Table 16.
Copula: Anderson-Darling test and Akaike criterion developed.

	Anderson-Darling statistic	Akaike
Poisson	0.0242	145.556
Negative-Binomial	0.0064	104.2360
(Business line: Trading and sales/event type: Damage to physical assets).		

Table 17.
Frequency: Anderson-Darling test and Akaike criterion, emerging economies.

	Anderson-Darling Statistic	Akaike
Poisson	0.2598	8512.0446
Negative-Binomial	0.0003	477.2543
(Business line: Trading and sales/event type: Damage to physical assets).		

Table 18.
Frequency: Anderson-Darling test and Akaike criterion, developed economies.

	Anderson-Darling Statistic	Akaike
Poisson	0.0321	624.6632
Negative-Binomial	0.0101	146.4304
(Business lines: trading and sales/event type: clients, products, and business practices).		

Table 19.
Frequency: Anderson-Darling test and Akaike criterion, emerging economies.

the differences in the nature of the data. However, this may result in differences between the level of capital and money markets in both economies. Therefore, using a standardized model proposed by Basel would result in an inaccurate capital calculation, overestimating the operational risk capital in emerging economies while underestimating the operational risk capital in developed economies.

We define the relative percentage error (underestimation or overestimation) in the VaR forecast as:

$$RPE = \frac{AM - OM}{OM} \times 100 \tag{7}$$

	nderson-Darling Statistic	**Akaike**
Poisson	0.259807	801.1519
Negative-Binomial	0.000322	255.8277

(Business lines: trading and sales/event type: clients, products, and business practices).

Table 20.
Frequency: Anderson-Darling test and Akaike criterion, Developed economies.

	Developed	**Emerging**
Gaussian	59.45%	6.00%
Clayton	62.64%	0
Gumbel	0	12.31%
Complete Dependence	3.97%	17.67%
Independence	26.45%	0.63%

Table 21.
VaR Results.

where *AM* represents the actual model, and *OM* represents the optimal model. If the RPE is negative, the actual model underestimates the VaR by the given percentage. Moreover, if the RPE is positive, the actual model overestimates the VaR. **Table 21** indicates the VaR results for the different models, where columns 2 and 3 report the results for developed and emerging economies, respectively. As shown in **Table 10**, the last two rows show the results of the perfect dependence and independence models included in Basel's AMA.

These results indicate that the independence model underestimates VaR and the complete dependence model overestimates VaR. Nonetheless, the complete dependence model overestimates VaR by 3.97% for developed economies, compared with 17.67% for emerging economies. Conversely, the independence model underestimates VaR by 26.45% for developed economies and 0.63% for emerging economies. This is consistent with the correlation results in **Table 4**, where the correlations are significantly higher for developed economies compared with emerging economies.

Given the above results, the study looked at different ways to estimate how much capital a bank could lose in a worst-case scenario due to operational problems like fraud, system failures, or human error. Assuming that different types of risk are unrelated is not realistic in the real world. On the other side, assuming that all risks occur together leads to an approach that is overly cautious. There is no single model that provides a perfect estimate for every situation. Some models are too optimistic, while others are too pessimistic, and the best model may depend on the country and its specific circumstances. This means banks, especially in developing countries, need to be careful about which models they use to measure operational risk.

From the contour plot in **Figure 1** and given our empirical results, it is revealed that the Gumbel copula is suitable to capture the upper tail dependence which is critical to better capturing the clustering of extreme losses. On the other side, the figure shows that the Clayton copula is more adapted to capture the clustering of small losses happening in the lower tail. That is, Clayton copula is more adapted to situations

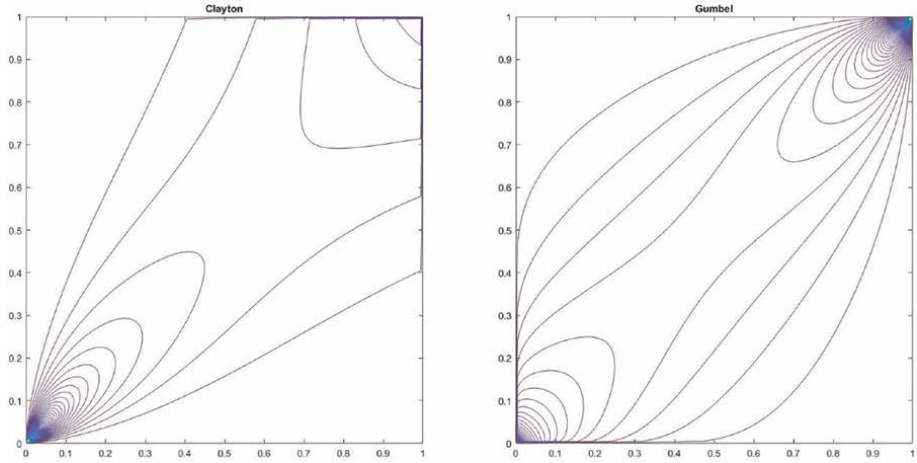


Figure 1.
Contour plot of Clayton and Gumbel copulas (Kendall's Tau correlation of 0.5).

where small losses are realized jointly and simultaneously while the Gumbel copula is relevant in modeling joint spikes (joint extreme losses). Therefore, using the Gumbel copula in the case of emerging economies, where the big losses are rare, leads to an overestimation of capital at risk while adopting Clayton copula in the case of developed economies, where big losses are realized jointly and frequently leads to underestimation of capital at risk.

5.1 Limitations and further improvements

In the absence of available of detailed panel data on operational risk available for research, we used SAS database that includes publicly reported operational losses above a certain threshold (typically USD 100,000) leading to underrepresentation of smaller losses and incidents typical to small-sized banks. This translates into a skewed dataset. Another limitation of our study is related to scale bias, a consequence of data aggregation of losses from institutions of varying sizes and regions. This can twist operational risk estimates when applying a given model to banks of a different size. The SAS data may also suffer from homogeneity in internal control and risk management practices across different banks. The data may also suffer from a scarcity of severe events that were not reported.

5.2 Possible improvements

As an extension and improvement of our findings, it will be very important to include qualitative and quantitative factors, both macro and specific. It will also be essential to develop methods to fine-tune the differences in internal control and risk culture among reporting institutions where qualitative indicators are central.

6. Conclusion

From **Table 21**, Column 2, Rows 2 and 3 show that adopting the Gaussian or Clayton copula instead of the Gumbel copula underestimates VaR by 59.45 and

62.64%, respectively, for developed economies. Conversely, if we use the Gaussian or Gumbel instead of the Clayton copula, the VaR is overestimated by 6 and 12.31%, respectively, for emerging economies. This is possibly due to differences in the risk profiles of banks in different economies.

This study highlights that the estimation of operational risk capital cannot be uniformly applied across all banks under the new Basel regulation. The main finding of our study is that a uniform approach, such as the one based on Basel's complete dependence model, may lead to an overestimation or underestimation of capital. Our results also suggest that adopting the same approach for all banks across emerging and developed economies is not recommended because of the differences in the nature of operational risk losses in each economy.

Our results are consistent with and support those of Peters et al. [11], who present similar conclusions using an approach tested to measure operational risk regulatory capital. They demonstrate that significant problems result in operational risk modeling using any uniform approach, such as risk insensitivity, capital superadditivity, and instability. Therefore, they advocate AMA and its standardization to avoid heterogeneity problems across banks rather than a complete shift to any uniform approach that would eliminate the AMA entirely. Eliminating AMA could lead to biased results, benefiting only large banks in developed economies that experience large operational risk losses.

The proposal to shift to a uniform approach does not address the primary issues of operational risk owing to its qualitative nature and business lines. It is further recommended that the standardized approach needs only a revisit and consultation process to have a homogeneous standard to compare and assess reliability across different banks in different markets. Sands et al. [30] state that no uniform approach can successfully protect the economy from the negative externalities created by operational risk losses. In recent years, banks have faced significant losses due to operational risks. The externalities resulting from bank losses, such as decreased trust in the financial system and credit risk provisions, have been significant. No uniform approach has addressed the concerns raised under the AMA. In fact, it has only marginally improved some aspects that the standardized approach did not address, neglecting other aspects such as risk sensitivity. Three main aspects must be considered when attempting to correctly estimate operational risk capital, as no uniform approach properly addresses. In the first aspect, capital should be deployed against operational RWA. The second aspect must concern the scale of losses from operational risk, and the third should focus on the future risks facing the banking system.

In conclusion, no uniform approach accounts for tail loss dependence, which may lead to a significant underestimation of aggregated operational risks. Therefore, model risks may also occur. Empirical evidence indicates a relatively strong dependence among tail losses in large banks. This outcome provides evidence of systemic risks due to the concurrent incidence of operational risk tail losses across large banks [10].

Our empirical analysis shows that banks in developed economies experience operational losses that occur simultaneously when the magnitude is substantive rather than small. Conversely, in emerging economies, strict rules are adopted to protect banks from extreme losses. Our results also indicate that a concrete specification of the dependence structure among various categories of risk is crucial for reducing errors in the measurement of required capital.

As practical insights and recommendations, developing economies' banks should invest in decision support systems to better identify, measure, and mitigate operational risk. Increasing investment in these systems is the main key to directly reduce operational risk exposure. In addition, banks in developing economies should collect, clean, and

maintain Internal Loss Databases because calibrating internal losses using external data can lead to underestimation or overestimation of required capital. On one side, underestimation of capital at risk exposes banks to a lack of liquidity risk and other risks (reputational risk, for example). On the other side, overestimation of capital at risk prevents banks from investing additional capital and get extra return. In addition, maintaining good quality Internal Loss Databases will align the emerging economies banks' databases system with the new Basel framework (Basel III/SMA) for risk capital estimation. Banks should arrange to build comprehensive internal loss data, even though they are not immediately required for regulatory capital estimation, as this will constitute a solid foundation of comprehensive operational risk management and enhances risk sensitivity. Rather than viewing Basel compliance as a box-ticking exercise, banks in emerging economies should strengthen Governance and Risk Culture enhance transparency and disclosure and use Basel as a Catalyst for broader risk management improvements.

Future research should focus on developing operational risk measurement models that include heterogeneity rather than uniformity in modeling to capture specific structure of risk profile across banks and countries/regions. Moreover, operational risk models should be general enough to be both robust to sectorial disparities and more practical for data-constrained environments typical of emerging economies.

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Conflict of interest

None

Appendix

Aspect	AMA	SMA
Methodology	Bank-specific internal models with scenario analysis, external data, and Business Environment Factors	Formula-based: Combines Business Indicators (BI) and Loss Multiplier (bank-specific loss history)
Risk Sensitivity	High (theoretically), but criticized for variability and model complexity	Lower risk sensitivity due to reliance on financial proxies (e.g., BI) and aggregated loss data

Aspect	AMA	SMA
Complexity	Highly complex, requiring advanced statistical models and governance frameworks	Simplified, standardized calculation with no internal modeling
Data Requirements	Extensive: Internal/external loss data, scenario analysis, and qualitative factors	Limited: BI (income-based metric) and 10-year internal loss history
Capital Calculation	Tailored to bank-specific risk profile, but led to inconsistent RWA outcomes	Formula-driven: Capital = BI Component × Loss Multiplier
Regulatory Impact	Withdrawn in 2017 due to lack of comparability and excessive model flexibility	Mandated post-2017 to improve consistency, but criticized for over-penalizing large banks
Procyclicality	Less procyclical (forward-looking scenarios)	More procyclical: BI ties capital to income, which declines during crises when risks rise

Table A1.
Comparison between AMA and SMA approaches to operational risk modeling.

Author details

Medhat A. Hassanein[1*], Mohammed Bouaddi[1] and Talha Karim[2]

1 The American University in Cairo, Egypt

2 Commercial International Bank – CIB, Egypt

*Address all correspondence to: medhaths@aucegypt.edu

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Chapter 14

To What Extent Can Profit and Cost Efficiencies Help Banks to Survive during the Crisis? An Empirical Evidence from Pre- and Post-War Syria

Mazen Diwani

Abstract

This chapter explores how bank efficiency during normal times (2009:Q1–2012:Q4) influenced risk and profitability during the Syrian crisis (2013:Q1–2018:Q4). Using data from private commercial banks, the analysis divides the study period into two phases: the "Normal Period" (2009:Q1–2012:Q4) and the "Crisis Period" (2013:Q1–2018:Q4). The findings reveal that cost efficiency increased banks' risk during the crisis but also enhanced their profitability during this challenging period. Conversely, profit efficiency reduced banks' risk during the crisis. However, profit efficiency negatively impacted profitability during the crisis, indicating that bank managers prioritized low-risk, high-revenue strategies before the crisis. These results suggest that cost efficiency provided banks with the resilience needed to maintain profitability under crisis conditions. In contrast, the negative relationship between profit efficiency and profitability during the crisis highlights the cautious approach taken by bank managers in the pre-crisis period, which limited the banks' ability to generate profits when faced with economic instability. By examining these dynamics, the chapter sheds light on the complex role of efficiency in shaping banks' performance during times of crisis and underscores the importance of strategic management decisions during stable periods to navigate future challenges effectively.

Keywords: cost efficiency, profit efficiency, Bank performance and risk, financial crisis, Syrian banking sector

1. Introduction

This chapter explores the role of bank efficiency during stable periods in determining bank survival and performance during crises, focusing on the Syrian war (2012–2018). Crises often reveal the consequences of poor decision-making in preceding normal times [1], a phenomenon termed "institutional memory loss" [2]. Managers and loan officers may fail to anticipate or address problems effectively

during periods of stability. The chapter poses the key question: to what extent does efficiency in normal times influence banks' ability to withstand crises? Syria, characterized by prolonged war and geopolitical instability, offers an ideal case study. Once a middle-income economy dependent on agriculture, industry, oil, and tourism, Syria's economic infrastructure has been devastated by conflict, sanctions, and currency depreciation. These factors have severely impaired its banking sector.

The findings aim to provide insights not only for Syria but for other politically unstable regions, particularly within MENA, where similar crises could arise. The chapter addresses gaps in the literature by examining bank performance through multiple efficiency estimation methods, such as the Distribution-Free Approach (DFA) and Stochastic Frontier Analysis (SFA). This dual approach builds on previous work (e.g., [3]) by assessing whether different methods yield varying impacts on bank performance. By examining how pre-crisis efficiency affects survival during crises and comparing efficiency estimation methods, this chapter contributes to understanding bank resilience and encourages further research on this critical issue.

The main empirical results are summarized as follows. First, I find that a higher cost efficiency during normal times increases banks' risk during the subsequent crisis, while profit efficiency tends to decrease bank risk during the subsequent crisis. A possible explanation is that cost efficiency may better mandate management quality, while profit efficiency may partially reflect temporary high returns during normal times from low-risk investments that are reversed during the subsequent crisis. Second, I find that cost efficiency, during normal times, may help banks' management to increase their profitability through the subtle management channel. This is because high revenues during normal times are associated with decreased risk during the subsequent crisis. Thus, profit efficiency during normal times may partially reflect engagement in high expected return-low-risk activities, which were due to engagements of banks in Syria in financing syndicated loans for multi-national companies, in which the Syrian government was also a partner in these financing deals. The remainder of the chapter is organized as follows. Section 2 outlines the necessity of linking efficiency with banks' performance in the literature. Section 3 develops our testable hypotheses. Section 4 outlines the methodologies for estimating efficiency and modeling its impact on banks' performance. Section 5 provides a description of the dataset used in this study. Section 6 reports the empirical results. Section 7 is devoted to testing the robustness of our models, and Section 8 highlights the policy implications for banks beyond the Syrian case. Finally, Section 9 concludes.

2. Literature review

The impacts of cost and profit efficiencies on bank performance are a rarely investigated relationship in the literature, and previous studies either focus on the relationship between the two in normal times or how it changes in the crisis, therefore, I organized this review considering three important points: first, identify the framework for which how the study of cost efficiency is beneficial to the performance of banks; second, identify the framework for which how the study of profit efficiency is beneficial to produce a sophisticated measure of financial performance which takes many of the heterogeneity among banks. Finally, I need to establish the ground for the use of more than one approach in measuring efficiency and justify this approach by borrowing from the literature.

One of the most important elements of quantitative research in recent years has been the concept of "frontier efficiency or X-efficiency". It measures deviations in performance from that of "best-practice" firms on the efficient frontier. Following the work of Berger and Mester [4], the cost efficiency of a bank is defined as the estimated cost required to produce the bank's outputs if the bank was as efficient as the best-practice bank in the sample. Therefore, cost efficiency measures how close a bank's cost is to that of a best-practice or most efficient bank producing the same output that faced the same input prices and environmental conditions. Financial institutions characterized as being "cost inefficient" have been found to exhaust—on average considerable portion of costs, to be an intensive source of performance problems than either scale or product mix inefficiencies, and to have a strong empirical association with higher probabilities of failures over several years following the observation of substantial inefficiency [5]. The majority of recent studies in the literature assert the existence of an "association" between "how cost-efficient" a bank is and "how well" it performs subsequently. This is because regulators of commercial banks may need to have some expert knowledge on whether the observed managerial inefficiency (in normal times) could raise the probability of financial institution failure substantially in the crisis that follows [5–10]. The well documented applications of cost efficiency—or frontier efficiency—with respect to many regulatory issues on the performance of the banking sector have been evident in topics such as mergers and acquisitions (e.g., [3, 11–16]), deregulation and financial disruption (e.g., [7, 12, 17–20], institution failure, risk, problem loans, and management quality (e.g., [21–24]), banks' policies in terms of its branching base (e.g., [25–29]), productivity growth of banks (e.g., [30–34], and market structure and concentration (e.g., [35–43]). In relating performance to cost efficiency, Berger and Humphrey [17] emphasize that the failure of most banks is caused by a significant number of problem loans, a low capital position, a weak or negative cash flow, and poor management quality. It might be foreseeable that banks would exhibit low cost efficiency before failure and that management quality would be positively related to efficiency. Both of these priors are supported in studies that have examined these issues.

It was shown that banks that display low efficiency reported more defaults than institutions with higher efficiency levels [22, 23], and this relationship was evident several years ahead of eventual failure [21]. Additionally, DeYoung [14] shows that management quality, as measured by regulatory agency assessments, is positively related to cost efficiency, which Granger causes reductions in problematic loans consisting of past due and non-accrual [44]. As a result, the predictive power of efficiency measures depends on the accuracy of the models for predicting defaults; therefore, efficiency measures may represent a useful addition to current modeling efforts by regulatory agencies [21]. Profit efficiency is a concept that comprises revenues as well as costs. Profit efficiency measures how close banks' profits are to a best-practice or most efficient bank given the same conditions. In this chapter, I employ the "alternative profit efficiency" measure, which is based on how much a bank earns relative to what would be earned by a best-practice bank that produced the same output and faced the same input prices and environmental conditions. Some of the studies that focus on profit efficiency employ an alternative profit function in which the firm maximizes profits given output quantities, rather than taking output prices as exogenous (e.g., [45–47]. The alternative profit function, in most cases, yields qualitatively almost identical results to the standard profit function. The alternative profit function may be beneficial when one or more of the assumptions underlying the standard cost and profit efficiency models are violated by the data (e.g., competitive imperfections and unmeasured

differences in product quality). Most of the studies which are concerned with efficiency analysis of financial institutions have focused on cost efficiency, while the estimation of profit and revenue efficiency has been an area only recently attracting interest. The techniques utilized in the estimation of profit efficiency are essentially the same ones applied in the cost efficiency, but the data are different. Profit efficiency is concerned with both cost and revenue efficiency, but only under certain conditions would it be likely that the former will equal the sum of the latter [17]. This is due to the assumption that cost (revenue) efficiency is based on the idea that the observed level of output (input use) is already profit maximizing, which may or may not be the case in practice. Besides, there might exist some differences in the quality of some financial services that are not captured in the output measures. This may make high-quality producers appear to be cost-inefficient because of the extra expenses associated with producing the higher-quality output. Such a problem may be improved by the use of a profit function because high quality should be rewarded in the marketplace by extra revenues that offset the extra expenses [17, 48]. The need to estimate a profit function for banks stems from the fact that banking, being a multi-product industry, is a service sector for which it is difficult to specify a unique production frontier. For instance, English et al. [49] argue that profit efficiency is essentially the mirror image of cost inefficiency since it incorporates errors in the choice of output mix or the one that has too little output, etc. Also, Sensarma [50] argues that in the absence of proper knowledge of the production technology of banks, it may be preferable to instead estimate cost and profit efficiencies which rely on the estimated cost and profit functions of a bank.

Despite intense research efforts on efficiency analysis (cost and/or profit), there is no consensus on the best method or set of approaches for measuring frontier efficiency, and the choice of the underlying methodology may affect the policy conclusions that are drawn from the analyses [5]. For instance, Casu and Girardone [7] assert that by using multiple frontier techniques, the robustness of the results can be tested, this is what is referred to in the literature as "methodological cross-checking". This is evident as Lovell and Schmidt [51] suggest that approaches to measuring efficiency differ in many ways, however, the two most significant differences occur in (i) the method used to determine the shape and placement of the relevant frontier, and (ii) in the interpretation given to deviations from the frontier. In estimating the X-frontier, the non-parametric approach differs from the parametric approach. The two approaches utilize different mechanisms to envelop data more or less using dissimilar assumptions for random noise and flexibility in the structure of the efficient frontier. Dong et al. [52] emphasize that the choice of a suitable estimation method (approach) has been quite controversial because both parametric and non-parametric techniques have their own merits, and the true level of efficiency is unknown. Again, the "methodological cross-checking" was advocated by many researchers (e.g., [5, 53–55]). These authors argue that it is not necessary to have a consensus on which is the best method for measuring frontier efficiency. Alternatively, they speak favorably of a checking process that utilizes more than one approach to assess the robustness of results. This methodological cross-checking brings forth to obtaining useful information and diagnosis for regulatory authorities and the decision-makers. Therefore, I chose to obtain cost (profit) efficiency, in this chapter, by applying two methods within the family of parametric approaches[1]. In the study of Assaf et al. [3], only the

[1] It is not the scope of this chapter to justify our choice for the parametric approach rather than the non-parametric ones; instead, future research might be fruitful to make such a contribution in this domain.

distribution-free approach (FDA) is used for the estimation of efficiency, and only one scenario is assumed for the inefficiency (i.e., time-varying). Also, the authors utilize the Fourier flexible functional form to estimate the cost and alternative profit functions in estimating bank-specific efficiency measures which are used subsequently in panel estimations of the effects of bank efficiency on bank performance. My contribution is quite different from the approach followed by Assaf et al. [3]: first, instead of using one methodology to estimate efficiency (i.e., DFA), I use two different methodologies: Stochastic Frontier Analysis (SFA) and Free Distribution Approach (FDA) to estimate cost and profit efficiencies during normal times; second, I aim to examine how the use of two methodologies (as opposed to using only one) leads to different impacts of the estimated efficiencies on bank risk-taking the subsequent crisis; third, I have assumed two scenarios (compared to using only one scenario) for the estimation of inefficiencies: the first is a time-invariant inefficiency, the second is a time-varying inefficiency. Finally, when considering the choice of a functional form for the estimation of cost and alternative profit functions, I use the transcendental logarithmic (translog) function. Murray and White [56] were the first to use the translog function, and since then, the translog functional form has become the standard form to estimate bank efficiency.

Some recent studies—including Assaf et al. [3]—argue that the Fourier Flexible (FF) functional form provides a better approximation than the translog functional form for banking data located far from the mean scale and product mix of the given bank [3, 6, 57]. To justify my choice of the translog production function, I based my choice on Berger and Mester [4] who find that the results from both the translog and FF functional specifications are essentially the same and the improvement obtained in the goodness of fit from using the FF functional form appears to be trivial. Furthermore, in the FF specification, additional parameters are prerequisites for the Fourier trigonometric terms, and this calls for more degrees of freedom compared to the translog functional form. Moreover, the FF specification is more difficult to apply in our empirical research since the number of observations in my sample is relatively small. For the above reasons, and unlike the FF specification used in Assaf et al. [3], I employ the translog functional form to derive our efficiency estimates.

3. Hypotheses development

In sections 3.1 & 3.2, I aim to investigate how cost and profit efficiencies reported in bank activity during normal times may affect the level of risk-taking for our sample banks during the subsequent crisis period.

3.1 Cost efficiency channels

During normal times, "NT", high-cost efficiency of banks can impact their performance during the subsequent crisis, "CT". Positive impacts can be recognized through the Subtle management channel:

3.1.1 High-cost efficiency (in normal times) → positive impacts (in crisis times)

Studies such as Berger and DeYoung [44], Kwan and Eisenbeis [53], and Williams [58] show if the management of a bank that is "subtle" at depressing costs during

normal times and is also "subtle" at managing its portfolios, then its high-cost efficiency may be associated with lower risk and higher profitability during the subsequent crisis. This results in *Hypothesis A: Higher cost efficiency during normal times has a positive impact, providing better performance in terms of lower risk and higher profitability for banks during the subsequent crisis.* Meanwhile, negative impacts act through the Skimping channel:

3.1.2 High-cost efficiency (in normal times) → negative impacts (in crisis times)

The "skimping" channel was pioneered by Berger and DeYoung [44], who argue that bank management that assigns less of resources to screening and monitoring loan applications would lead to the situation where banks are achieving high-cost efficiency during normal times. This "skimping" channel will work on improving cost efficiency during normal times and may not be detected until the point where the credit portfolio is performing poorly; this point only becomes evident during the subsequent crisis. This leads to *Hypothesis B: Higher cost efficiency during normal times results in negative impacts reflected by a worse performance for banks (higher risk and lower profitability) during the subsequent crisis.*

3.2 Profit efficiency channels

Profit efficiency is likely to operate through the same two channels as cost efficiency does, and this is because profit efficiency includes the impacts of costs as well as revenues. Therefore, the subtle management channel may work out for profit efficiency since managers who are performing well at managing costs are not expected to perform poorly at managing revenues. Likewise, the skimping channel may also be relevant to profit efficiency as long as revenues during normal times are not significantly adversely affected by skimping. This might happen because even tacky loans may perform well outside of the crisis period. According to Assaf et al. [3], during normal times, the profit efficiency of banks may improve or worsen bank performance during the subsequent crisis. Improving bank performance —Positive impacts—can be recognized through the Value creation (preservation) channel:

3.2.1 High-profit efficiency (in normal times) → positive impacts (in crisis times)

A bank can enhance its charter value and accumulate it through time due to the high expectation of future profits (during the subsequent crisis), which might be generated by the current high-profit efficiency. Another way that a bank can enhance its charter value (due to the current high-profit efficiency) is by achieving low profitability (during the subsequent crisis) associated with a low level of risk, which keeps its value from being eroded. Studies such as Marcus [59], Keeley [60], Demsetz et al. [61], and Hellmann et al. [20] argue that banks with higher charter value (implying a creation in value), which is generated by another source (i.e., market power), act prudently to protect this value. Assaf et al. [3] argue that the same logic would apply to high-profit efficiency. Therefore, banks with high normal-times profit efficiency are expected to behave more cautiously and be more likely to survive, have relatively low risk, and relatively high or low levels of profitability during the subsequent crisis, conditional on whatever preserves the charter value of a bank. This leads to *Hypothesis C: Higher profit efficiency during normal times results in a*

positive impact reflected by better performance for banks (lower risk associated with low or high profitability) during the subsequent crisis. Conversely, deteriorating bank performance—Negative impacts—act through the Excessive risk channel:

3.2.2 High-profit efficiency (in normal times) → negative impacts (in crisis times)

By engaging in more risky investments and accumulating excessive risk, banks may achieve high-profit efficiency during normal times due to the higher returns on high-risk investments when the circumstances are normal. Taking on excessive risk during normal times may turn into higher failure probabilities, higher risk, and lower profitability for banks during the subsequent crisis. This is doomed to happen when high-risk investments suffer losses. This leads to *Hypothesis D: Higher profit efficiency during normal times results in a negative impact reflected by a worse performance for banks (higher risk associated with higher or lower profitability) during the subsequent crisis.* Therefore, what characterizes this channel is that a bank achieves low profitability or high profitability associated with high risk, which ultimately leads to bank failure/bankruptcy in the following crisis, whereas, in the value creation/preservation channel, a bank can either achieve high profitability or low profitability conditional on being associated with a low level of risk. Hence, in the study, I assume that the level of risk achieved is the key identifier between the creation/preservation channel and the excessive risk channel.

4. Methodology

In this chapter, the methodology is based on three stages. In the *first* stage, I estimate the cost and profit efficiencies for the sample banks in the normal period (i.e., 2009:Q1 to 2012:Q4). In the *second* stage, I estimate the profitability and risk measures for the sample banks in the crisis period (i.e., 2013:Q1 to 2018:Q4). In the *third* stage, cost and profit efficiencies—from the first stage—will be used to investigate the extent to which profitability and risk measures—from the second stage—are explained; in other words, we need to understand whether efficiency can help banks to survive during war times, which is the central theme of this chapter.

4.1 Stage one: Estimating bank efficiency

I measure cost and profit efficiency instead of technical efficiency. According to Kosmidou et al. [62, 63], technical efficiency is narrower, focusing solely on resource use, while cost efficiency incorporates both technical and allocative efficiency. Profit efficiency is broader, considering both costs and revenues [11]. Cost efficiency relates to cost minimization, defined by Isik and Hassan [64] as the ratio of a bank's minimum possible cost to its observed cost. A score of 0.75 indicates 75% resource efficiency. Profit efficiency, focusing on profit maximization, measures a bank's actual profit relative to the most efficient bank [65], with a score of 0.65 implying a 35% profit loss. Profit efficiency has two versions: standard profit efficiency (SPE) and alternative profit efficiency (APE). SPE assumes competitive markets, while APE, developed by Humphrey and Pulley [47], accounts for imperfect competition and market power [4]. Berger and Mester [4] argue that APE is preferable when

assumptions for SPE, such as homogeneous output quality and competitive markets, do not hold. APE's application has expanded over the past 20 years (e.g., [66, 67]). Bank efficiency is assessed using parametric (e.g., stochastic frontier analysis (SFA), thick frontier approach (TFA), and distribution-free approach (DFA)) or non-parametric methods [68] (e.g., Data Envelopment Analysis (DEA) [69], Free Disposable Hull Analysis (FDHA)). Parametric approaches, which specify a functional form, are used here, employing DFA and SFA to estimate cost and profit efficiencies.

4.1.1 Cost efficiency

In general, a cost function could be expressed as:

$$C = C(p, y, z, u, \varepsilon) \tag{1}$$

where: C is the bank cost; p is the vector of input prices (prices of total borrowed funds, physical capital, etc.); y is the vector of outputs quantities (total loans, other earning assets, etc.); z is the vector of fixed bank parameters (bank capital, fixed assets, off-balance items, etc.); u represents the inefficiency term that captures the difference between the efficient level of cost for given output levels and input prices and the actual level of cost; ϵ is the random error term. I use the transcendental logarithmic (translog) functional form to measure the cost function and estimate bank-specific efficiency measures. For the translog cost function COSEFF = lnTC, I estimate Eq. (2):

$$\begin{aligned} COSEFF = {} & \alpha_0 + \beta \ln (w_1/w_2) + \frac{1}{2}\kappa \ln(w_1/w_2) \ln(w_1/w_2) + \sum_{k=1}^{2} \gamma_k \ln(y_k/z) \\ & + \frac{1}{2}\sum_{k=1}^{2}\sum_{m=1}^{2} \gamma_{km} \ln(y_k/z) \ln(y_m/z) + \delta \ln z + \frac{1}{2}\tau \ln z \ln z \\ & + \sum_{k=1}^{2} \eta_k \ln(w_1/w_2) \ln(y_k/z) + \rho \ln (w_1/w_2) \ln z + \sum_{k=1}^{2} \varrho_k \ln(y_k/z) \ln z + \xi \end{aligned} \tag{2}$$

where: lnTC is the natural log of total costs; w_1 is the price of total borrowed funds; w_2 is the price of physical capital; y_1 is the total loans; y_2 is the other earning assets; ξ is the composed error term which consists of ($\ln \epsilon_c$ - $\ln u_c$), where $\ln u_c$ represents cost inefficiency, and $\ln \epsilon_c$ represents noise; β, κ, γ_k, γ_{km}, δ, τ, η_k, ρ, ϱ_k are the parameters to be estimated; z is the bank fixed parameter defined as equity capital. I include z in the model for several reasons. First, it controls for managerial risk preferences in solving maximization and minimization problems. To mitigate financial shocks, managers of a risk-averse nature might hold a higher level of equity than the level of cost-minimizing. Therefore, failure to control for risk preferences might lead to define, otherwise, a bank with optimal behavior, given its managerial risk preference, as an inefficient bank. Second, Berger & Mester [4] also note that the inclusion of equity in the model may control for the scale bias arising from differences in bank dependence on borrowed funds since large banks usually depend more on borrowed funds. Finally, costs and profits might be affected significantly by using equity, which (equity) constitutes an alternative to deposits in funding loans and investments. Since equity financing is

generally the most costly way of funding assets, neglecting the equity level will bias the efficiency scores in favor of banks with high dependence on equity.

The dependent variables and all the continuous explanatory variables have been divided by their respective sample means before taking logarithms. This normalization of variables permits the first-order parameters of the translog function to be directly interpreted as estimates of cost elasticities evaluated at the point of approximation[2]. I apply the standard symmetry restrictions to the translog function (i.e., $\gamma_{km} = \gamma_{mk}$). I normalize the cost, profit, and input price w_1 terms by the input price w_2 to ensure linear homogeneity. The only way to ensure linear homogeneity is through normalizing by one input price in the translog functional form so that doubling all input prices exactly doubles costs on the efficient frontier. To avoid the bank's scale bias, I normalize cost, profit, and output quantities by the fixed bank parameter equity capital z. This is to ensure that the banks in the sample are treated comparably, otherwise, the large banks would dominate the regressions. Additionally, normalization by the equity capital z helps with the economic interpretation of the profit function, given that the dependent variable is proportional to profits per Syrian pound of equity, or return on equity. These normalizations are fairly standard in the cost and profit function literature.

4.1.2 Profit efficiency

I consider the concept of profit efficiency, which implies that managers should not only consider reducing a marginal dollar of costs, but they also have to pay attention to raising a marginal dollar of revenues. Profit efficiency is a more general concept than cost efficiency because revenues and costs are considered in the profit function. Generally, a profit function could be expressed as:

$$P = P(p, \varphi, z, u, \varepsilon) \tag{3}$$

Following Assaf et al. [3] and Pulley and Humphrey [70], I assume that banks have some market power in output markets. Therefore, I chose to work with the alternative profit function (APE), which takes output quantities as given instead of taking output prices as given. This approach assimilates differences across banks in market power and their ability to exploit it [24]. In Eq. (3), φ is the vector of outputs' prices, which I utilize with quantities y. The general form of APE function is given by:

$$P = P(p, y, z, u, \varepsilon) \tag{4}$$

The APE requires a few changes in (2), in which the dependent variable becomes:

$$PROFEFF = \ln\left[\left(\frac{\pi}{w_2 z}\right) + \left|\left(\frac{\pi}{w_2 z}\right)^{min}\right| + 1\right] \tag{5}$$

Where $\left|\left(\frac{\pi}{w_2 z}\right)^{min}\right|$ is the absolute value of the minimum value of normalized profit; 1 is added so I can take the natural log of a positive number since minimum profits are usually negative; ($\ln u_\pi + \ln \epsilon_\pi$) is the composed error. Therefore, the translog profit function PROFEFF is estimated by Eq. (6), and for this, we specify:

[2] Since the average values of the variables are treated as the Taylor series expansion point.

$$PROFEFF = \acute{\alpha}_0 + \acute{\beta}\ \ln\ (w_1/w_2) + \frac{1}{2}\acute{\kappa}\ \ln(w_1/w_2)\ \ln(w_1/w_2) + \sum_{k=1}^{2}\acute{\gamma}_k\ \ln(y_k/z)$$
$$+\frac{1}{2}\sum_{k=1}^{2}\sum_{m=1}^{2}\acute{\gamma}_{km}\ \ln(y_k/z)\ \ln(y_m/z) + \acute{\delta}\ \ln z + \frac{1}{2}\acute{\tau}\ \ln z\ \ln z + \sum_{k=1}^{2}\acute{\eta}_k \qquad (6)$$
$$\ln(w_1/w_2)\ln(y_k/z) + \acute{\rho}\ \ln\ (w_1/w_2)\ \ln z + \sum_{k=1}^{2}\acute{\varrho}_k \ln(y_k/z)\ \ln z + \acute{\xi}$$

The variables in (6) are the same in (2) with only two differences: the first one being that $\acute{\beta}$, $\acute{\kappa}$, $\acute{\gamma}_k$, $\acute{\gamma}_{km}$, $\acute{\delta}$, $\acute{\tau}$, $\acute{\eta}_k$, $\acute{\rho}$, and $\acute{\varrho}_k$ are the parameters to be estimated in this model; the second difference is that $\acute{\xi}$ is the composed error term which consists of ($\ln u_\pi + \ln \epsilon_\pi$). **Table 1** reports the variables used in estimating bank efficiency (cost and profit).

By using the cost and alternative profit efficiency functions in (2) and (6), I have to distinguish between two scenarios. The first scenario assumes that technical inefficiency (u) is time-invariant and individual-specific. That is, the inefficiency levels may be different for different individuals, but they do not change over time [26]. This scenario

Variables	Notation	Definitions	Used In
Dependent variables			
Total costs	TC	Total costs include the costs of borrowed funds, deposits, wages and salaries, and other operating expenses	(2)
Total profits	π	Total bank net income	(6)
Independent variables/ Inputs & components			
Price of total borrowed funds	W_1	The ratio of total interest expenses on borrowed funds to total borrowed funds	(2) and (6)
Total interest expenses	INTEX	Interest paid on total deposits and interest on interbank borrowing	W_1
Total borrowed funds	TBF	Bank deposits and customers deposits	W_1
Price of physical capital	W_2	The ratio of other operating expenses to the book value of fixed assets (net of depreciation)	(2) and (6)
Other operating expenses	OOEX	The operating expenses less employees' expenses	W_2
Employees' expenses	EMPEX	Wages, salaries, and other benefits provided to employees	OOEX
Independent variables/ Outputs & components			
Total loans	Y_1	Net credit facilities for retail and corporate clients and loans to other banks	(2) and (6)
Other earning assets	Y_2	Cash balances at Central Bank of Syria (CBS), balances at other banks, deposits at other banks, financial assets for trading, financial derivatives, financial assets for sale, financial assets held until maturity, investments in subsidiaries	(2) and (6)
Equity capital	Z	Bank i's equity, to be used as a fixed parameter	(2) and (6)

Table 1.
Variables' description to be used in estimating Bank efficiency (Cost/Profit).

suggests that a unit that is inefficient (i.e., a bank) never learns over time. This might be the case in some situations where inefficiency is, for example, associated with managerial ability and there is no change in management for any of the banks during the period of the study or if the period of the panel is particularly short. I consider the first scenario for the Syrian banking sector since I only have 4 years (48 quarters) to estimate efficiencies (2009:Q1–2012:Q4), and I assume that no significant changes had occurred in the executive management of the respective banks included in the sample during this period. For this scenario, I utilize the fixed effect model, or as it is called, Schmidt and Sickles [71] [hereafter SS84] for the DFA and SFA.

The second scenario assumes that technical inefficiency (u) is time-varying. Choosing this scenario is attributable to the fact that decisions within the banks in our sample might be influenced by the changing conditions and regulations within the Syrian banking sector which might affect the overall way of operating for these banks, in addition to the fact that some banks—even with the unchanged top managements—may refer in their decisions to the subordinate teams in different departments which might be changing over time. For this scenario, I use the model of Cornwell et al. [18] [hereafter CSS90] for the DFA and Battese and Coelli [72] [hereafter BC92] for SFA.[3]

To avoid the extreme values of inefficiencies (u), I follow the methodology adopted by Berger and Mester [4] and truncate (winsorize) the extreme values of inefficiency. Specifically, those banks in the top and bottom 5% are allocated values of banks at the 95th and 5th percentiles, respectively. For each bank and each quarter, cost efficiency is estimated as the ratio of the minimum predicted cost to the actual predicted costs for that bank. Likewise, for each bank and each quarter, profit efficiency is estimated as the ratio of actual predicted profit to the maximum predicted profit for that bank. Afterward, cost (profit) efficiencies are ranked for each quarter in descending order of efficiency. I then average the ranks over all the quarters of the normal-times period (in the case of a time-varying inefficiency) to obtain a comparable measure to use in our regression models of bank performance in the subsequent crisis time. However, in the case of a time-invariant inefficiency, each bank would have the same cost (profit) efficiency each quarter, therefore, I do not take the average of the ranks over the quarters (since the rank for each bank in each quarter is fixed in this case). Efficiency ranks are preferred to levels due to the ability of the ranks to eliminate changes in the distributions of efficiency over time.

4.2 Stages two and three: The impact of bank efficiency in normal times on bank performance in crisis times

The main approach is to pool the data to treat the crisis period and its preceding normal period as a group. I focus on the Syrian crisis that occurred between 2013:Q1 and 2018:Q4. The normal period includes all the quarters that precede 2013:Q1, specifically, the normal period is set to occur between 2009:Q1 and 2012:Q4[4]. The dependent variables are measures of performance during the crisis, and the explanatory variables are measured during the normal period preceding this crisis. I chose 2009:Q1 as the starting point of our analysis to guarantee that our sample has all the

[3] The steps of applying SS84 (under Time-invariant inefficiency SFA & DFA), CSS90 (under Time-varying inefficiency DFA), & BC92 (under Time-varying inefficiency SFA) will be provided upon request.

[4] The onset of the Syrian war started in 2012 but it was not until the beginning of 2013 that the toll of war affected the various sectors of the economy, especially the banking sector.

available financials for all of the 11 private banks in Syria, hence, I managed to have a balanced panel. All dependent and independent variables (except estimates of cost and alternative profit efficiencies under time-invariant inefficiency) are averages of the quarterly values over the crisis (for dependent variables) or normal times (for independent variables). Following the methodology of Assaf et al. [3], I estimate the following two models:

$$\Pi_{i,ct} = f(COSEFF_{i,nt}, PROFEFF_{i,nt}, OBC_{i,nt}) \quad (7)$$

$$\text{Risk}_{i,ct} = f(COSEFF_{i,nt}, PROFEFF_{i,nt}, OBC_{i,nt}) \quad (8)$$

where: ct is the crisis period (2013:Q1–2018:Q4); nt indicates the normal period (2009: Q1–2012:Q4); $\Pi_{i,ct}$ is alternatively the Return on Assets (ROA) and Return on Equity (ROE) for bank i during ct; $\text{Risk}_{i,ct}$ is alternatively Ln(ZSCORE) and σROA for bank i during ct; $COSEFF_{i,nt}$ is the cost efficiency over nt; $PROFEFF_{i,nt}$ is the profit efficiency over nt; $OBC_{i,nt}$ is a set of control variables which includes: Capital (CAP): is the ratio between total equity and total assets for bank i. It measures the extent to which a bank is capable of absorbing potential losses and it is generally thought to be associated with better monitoring and reduced moral hazard incentives to take a risk [73–75]; Credit Risk (CR): is the ratio between non-performing loans and total loans for bank i; Liquidity (LIQ): is the ratio of total loans to total assets for bank i, is an important factor since, in periods of increased uncertainty, financial institutions may decide to diversify their portfolios and/or raise their liquid assets to reduce their risk [62, 76, 77]; Cash Holdings (CH): is cash holdings over total assets for bank i. High cash holding might lower liquidity risk for banks and could help them survive; however, higher cash holdings might be associated with more agency problems (e.g., [78]). I also included Bank Size (BS), which is the natural logarithm of total assets as a proxy of the size. Since larger banks are better diversified with higher survival chances, bank size is expected to have favorable effects on the future performance of banks. The need for risk measures is justified by the fact that within pre-crisis (i.e., normal time), banks which are exposed to riskier and more opaque portfolios might have a higher probability of failure, incur higher risk, and perform less in terms of lower profitability in the subsequent crisis period; the Herfindahl-Hirschman Index (HHI) defined as $\text{HHI}_{i,nt} = \sum_{i=1}^{n} \text{ms}^2_{i,nt}$ where $\text{ms}^2_{i,nt}$ represents the market share percentage of bank i during the normal time nt. Some studies suggest that franchise value might be reduced as a result of increased competition, which, in turn, increases insolvency risk and the likelihood of failure (e.g., Keeley [60]). However, other studies argue that increased competition reduces the likelihood of failure (e.g., Boyd and De Nicoló [79]). Others suggest that the relation between franchise value and competition may be non-monotonic (e.g., [80]).

Eqs. (7) and (8) are estimated using OLS. To address potential concerns that error terms may be heteroskedastic or correlated across quarters for each bank, I run all regressions adjusting the standard errors for heteroskedasticity and within-bank clustering. The literature on social learning, herd behavior, and neighborhood effects indicates that microeconometric panel datasets are likely to exhibit complex patterns of mutual dependence between the cross-sectional units (e.g., banks in our case)[5].

[5] For more details, see Feng and Seasholes [28], Trueman [41] and Welch [42], and Hirshleifer and Hong Teoh [38].

Additionally, since social norms and psychological behavior patterns typically enter panel regressions as unobservable common factors, complex forms of spatial and temporal dependence may even arise when the cross-sectional units have been randomly and independently sampled. To ensure that our panel is immune to cross-sectional dependence in the errors which may arise because of the presence of common shocks and unobserved components that ultimately become part of the error term, I use the estimator of Driscoll and Kraay [81], who proposed a non-parametric covariance matrix estimator that produces standard errors that are robust to general forms of spatial cross-sectional and temporal dependence.

To track the impacts of our key independent variables (COSEFF & PROFEFF), I run three separate regressions (under each scenario) in which the first one includes only COSEFF, the second one includes only PROFEFF, and finally, the third model includes both of COSEFF and PROFEFF. **Table 2** reports the variables used in Eqs. (7) and (8).

Variables	Notation	Definitions
Dependent variables		
Bank profitability	ROA	Return on assets (net income/total assets) of bank i averaged over the quarters within the crisis period (i.e., 2013:Q1–2018:Q4)
	ROE	Return on equity (net income/capital equity) of bank i averaged over the quarters within the crisis period.
Bank Risk	Ln (ZSCORE)	Defined as Log $[(\mu ROA_{i,ct} + \mu CAP_{i,ct})/\sigma ROA_{i,ct}]$; where $\mu ROA_{i,ct}$ is bank's mean ROA averaged over the quarters within the crisis period ct; $\mu CAP_{i,ct}$ is bank's mean capitalization (equity capital/assets) averaged over the quarters within the crisis period ct; and $\sigma ROA_{i,ct}$ is the volatility of ROA of bank i over crisis period ct.
	σROA	Defined as the volatility of ROA of bank i over crisis period ct
Key Independent variables		
Cost Efficiency	COSEFF	It is defined as "the cost efficiency ranks" over the normal time period prior to the crisis. This is obtained from running model (2) previously.
Profit Efficiency	PROFEFF	It is defined as "the profit efficiency ranks" over the normal time period prior to the crisis. This is obtained from running model (5) previously.
Control Variables //Other Bank Characteristics (OBC)//		
Capitalization	CAP	Defined as (Bank's equity/Total Assets) for each bank i
Credit Risk	CR	Defined as (Non-performing loans/Total Loans) for each bank i
Liquidity	LIQ	Defined as (Total loans/Total Assets) for each bank i
Cash Holdings	CH	Defined as (Cash holdings/Total Assets) for each bank i
Bank size	BS	Defined as Ln (Total Assets) for each bank i
Herfindahl-Hirschman Index	HHI	Defined as the sum of squared market shares of all banks in the sample: $\sum MS^2_i$

Table 2.
Variables to be used in estimating Bank Performance (Profitability/Risk).

5. Data[6]

The sample used is composed of 11 Syrian private and listed commercial banks[7] over the period 2009:Q1 to 2018:Q4. Data are collected from Syrian banks' annual reports and the websites of both Damascus Securities Exchange and the Syrian Securities and Exchange Commission. Due to the undisclosed financials in some years (as a consequence of the war), I use other sources such as the Central Bank of Syria, the Syrian Central Bureau of Statistics, the Statistical Abstract Database which is a joint database between the Syrian Central Bureau of Statistics and several Syrian ministries (Finance, Economy, Justice, Tourism, Agriculture, Communication). I adjust the data to be in real terms of the year 2009 using the GDP price deflator. I omit observations with missing or incomplete financial data on basic accounting variables such as total assets and equity, as well as those with no outstanding loans or deposits. Since not all banks have available information (quarterly) for the years preceding 2009, I started the sample in the year 2009 to obtain a balanced panel.

During the crisis, Return on Assets (ROA) increased due to profits generated by the devaluation of the Syrian Pound (SYP) against foreign currencies, allowing banks to profit from re-evaluating their foreign currency holdings [62]. Return on Equity (ROE) also rose, driven by two factors: (1) a temporary improvement in the SYP exchange rate between 2016 and 2017, which reduced equity values, and (2) the accumulation of loan loss provisions that further decreased equity, artificially inflating ROE. The crisis period showed increased risk, evident from a 3.4% rise in ROA volatility (σROA) and a 67.2% decline in Ln (ZSCORE), reflecting economic instability caused by the Syrian war (2013:Q1 onward). Regarding Time-Invariant Inefficiency, most cost and profit efficiency measures declined during the crisis, attributed to higher operating costs, staff expenses, and rising interest rates on interbank loans. As for Time-Varying Inefficiency, they improved when accounting for time-varying inefficiency, reflecting better cost management and resource utilization by banks. Under the CSS90 model, cost efficiency improved due to accumulated experience in credit risk management and "learning over time".

Before 2009, Syrian banks lacked a unified regulatory framework for credit risk management. Post-2009 reforms aligned banks with Basel Committee recommendations, including better credit risk assessment and early action on problem credits. These changes contributed to efficiency improvements under CSS90, which allows bank-specific inefficiency patterns, unlike the BC92 model. Capitalization (CAP) dropped by 45.7% due to SYP's devaluation against the USD, reducing the real value of bank assets and capital. However, Credit Risk (CR) increased due to loan defaults and higher provisions, prompting banks to reduce credit facilities. Also, Liquidity (LIQ) rose by 50.1% as banks shifted from loans to liquid investments to mitigate repayment uncertainty and Cash Holdings (CH) increased by 34.6% during the crisis. Finally, the measure for Competition (HHI) fell by 6.3%, indicating increased competition among Syrian banks as they compete for deposits and loans amid resource constraints caused by the war.

[6] Due to brevity, results and tables in sections 5, 6, and 7 can be provided upon request from the author.

[7] The sample constitutes 80% of the population of private banks in Syria.

6. Empirical results

In the following sections (6.1 & 6.2), the results will be presented in response to the two main questions that this chapter seeks to answer.

6.1 How does pre-crisis efficiency affect bank risk during a subsequent crisis?

Banks with high-cost efficiency during normal times (NT) take on higher risk during crises (CT), as evidenced by the coefficients of $COSEFFDFA_{i,nt}$ (−0.77, −0.79) and $\sigma ROA_{i,ct}$ (0.112). This aligns with the "skimping channel", where minimal resource allocation for loan screening during NT leads to elevated risk during CT [78]. In contrast, higher profit efficiency during NT results in reduced risk during CT, as shown by positive coefficients of $PROFEFFDFA_{i,nt}$ (0.44) and the negative coefficients (−0.20, −0.24) supporting the "value creation/preservation channel". Profit-efficient banks likely engaged in low-risk, high-return activities, such as financing multi-national projects backed by the Syrian government. Results from various models (SFA-SS84, DFA-CSS90, SFA-BC92) consistently show that higher cost efficiency during NT increases risk during CT (supporting Hypothesis B over A), while higher profit efficiency decreases it (supporting Hypothesis C over D). Variations in econometric specifications do not alter these findings.

6.2 How does pre-crisis efficiency affect bank profitability during a subsequent crisis?

When profitability is measured using $ROA_{i,ct}$, banks operating in a cost-efficient context during NT exhibit higher subsequent CT profitability, as shown by $COSEFFDFA_{i,nt}$ coefficients (0.08 & 0.148). Similarly, using $ROE_{i,ct}$, higher cost efficiency during NT leads to greater profitability ($COSEFFDFA_{i,nt}$: 0.121 & 0.093). This aligns with increased risk during CT due to higher NT cost efficiency. Private banks in Syria, allocating fewer resources to screening and monitoring during NT, experienced higher income, supporting the subtle management channel over the skimping channel and Hypothesis (A) over (B). Conversely, profit efficiency during NT ($PROFEFFDFA_{i,\mathbf{nt}}$) negatively impacts CT profitability $ROA_{i,\mathbf{ct}}$: (−0.21 & -0.30); $ROE_{i,\mathbf{ct}}$: (−0.092 & -0.037). Syrian banks with high-profit efficiency in NT took a prudent approach, resulting in lower risk and profits during CT, consistent with the value creation/preservation channel and Hypothesis (C) over (D). With time-varying inefficiency (DFA-CSS90), cost efficiency in NT negatively impacts CT profitability $COSEFFCSS_{i,\mathbf{nt}}$: (−0.169 & -0.166); insignificant for $ROE_{i,\mathbf{ct}}$. The entry of new competitors and cessation of lending during CT reduced efficiency advantages. Similarly, NT profit efficiency ($PROFEFFCSS_{i,nt}$) negatively affects CT profitability $ROA_{i,ct}$: (−0.0475 & -0.038); $ROE_{i,ct}$: (−0.0165 & -0.0162) supporting Hypothesis (C) over (D). Under SFA-BC92, results confirm that NT cost efficiency ($COSEFFBC92_{i,nt}$) decreases CT profitability (skimping channel), while profit efficiency ($PROFEFFBC92_{i,nt}$) does not significantly influence CT profitability. These findings highlight inconsistencies in cost efficiency's impact on profitability, contrasting its consistent effect on risk-taking. However, NT profit efficiency supports value creation/preservation, signaling Syrian banks' ability to survive crises while maintaining charter value.

7. Robustness checks

In the following subsections (7.1) & (7.2), I perform two robustness checks. In all cases, I use only the full specifications with both cost and profit efficiency and the broad set of controls, although most of the controls are not shown for brevity.

7.1 How does pre-crisis efficiency affect bank performance for state-owned banks during a subsequent crisis?

Up to this point, our banks' sample was composed of only private banks in Syria. Hence, the question of whether pre-crisis efficiency affects the performance of state-owned banks in a different manner than the case of private banks emerges as an important issue to examine. To perform this task, I apply the same approach followed for private banks on the only six state-owned banks that exist in Syria[8]; in other words, I examine two questions: how does pre-crisis efficiency affect the risk of state-owned banks during a subsequent crisis, and how does pre-crisis efficiency affect the profitability of state-owned banks during a subsequent crisis. The results suggest that all of our effects of cost efficiency on bank performance hold consistently during the subsequent crisis. As state-owned and private banks in Syria dramatically cut lending in the aftermath of the crisis, and as the lending activity is the main force behind the profitability of banks (both public and private), ceasing lending activities had an adverse impact on profitability when considering the time-varying inefficiency.

7.2 Testing the stability of the model

To estimate the impact of efficiencies (cost & profit) along with other control variables on banks profitability and risk, I divided my data into two subsets. The first one accounts for the normal times (NT) where our regressors were measured, the second subset accounts for the crisis period (CT) in which the performance indicators (profitability and risk) were measured, however, regressing one subset of the data (crisis period) on another one (normal period) might be defected because I am reducing the variability of our regressors when I consider only the normal period and this might affect the estimates of our dependent variables, hence, the more variation in the regressors allows us to more confidently pin down the relationship between Ln ($ZSCORE_{i,ct}$), $\sigma ROA_{i,ct}$, $ROA_{i,ct}$, and $ROE_{i,ct}$ on one side and $COSEFF_{i,nt}$, $PROFEFF_{i,nt}$, and $OBC_{i,nt}$ on another side in our regression Equations. Therefore, to test for the robustness of the results, I use the whole sample period for each of Eqs. (A1)–(A12) and introduce a crisis dummy (CD) which takes the value of 0 for the quarters 2009:Q1–2012:Q4 and 1 for the quarters 2013:Q1–2018:Q4, and I interact CD with all our regressors in these Equations. To see these changes, I re-write (A1)–(A12). (Reported Appendix B as Eqs. (B1)–(B12)). The results in all the set-ups confirm our original results which means that the regressors in the original Eqs. (A1)–(A12) do not suffer from lack of variability (due to the limited use of a subset of the whole sample), i.e., none of the key regressors (cost and profit efficiencies under different scenarios) or

[8] Syria, the government owns 6 banks which are: The Commercial Bank of Syria (the largest by far in terms of assets), Real-Estate Bank (the second largest bank in terms of its assets), Agricultural Cooperative Bank; Industrial Bank of Syria, Popular Credit Bank, and Saving Bank.

the control variables were moderated by the crisis period, hence, our estimates are validated when using the approach described in Section 4.

8. Policy implications beyond the Syrian case

The findings of this chapter underscore the crucial role of cost and profit efficiencies in shaping banks' resilience during crises. Cost-efficient banks can reduce operational expenses, which is critical in environments of declining revenues during crises. However, excessive cost-cutting may lead to risks if it undermines investments in risk management systems or human capital, leaving banks vulnerable to unexpected shocks. Profit efficiency, on the other hand, reflects the bank's ability to maximize revenue from its resources. High-profit efficiency enables banks to build stronger capital buffers, enhancing their ability to absorb losses during crises. Strategies that banks globally could adopt include diversifying revenue sources to reduce reliance on volatile income streams, leveraging financial technologies to improve service delivery and reduce costs without compromising quality, and implementing dynamic cost management to balance cost efficiency with sufficient investment in risk management and innovation.

The Syrian banking crisis provides insights relevant to other conflict-affected and emerging markets, where banks with higher efficiency levels, as seen during the Asian Financial Crisis (1997) and the Global Financial Crisis (2008), demonstrated greater resilience, underscoring the universal importance of maintaining operational and profit efficiency in turbulent environments. Similar to Syria, banks in Iraq [82] and Lebanon [83] faced reduced economic activity, heightened risks, and capital flight, with profit efficiency serving as a critical buffer by stabilizing revenue streams amid economic disruptions. For emerging markets, improving transparency, strengthening regulatory frameworks, and investing in crisis management systems are essential strategies to safeguard efficiency gains and enhance resilience under stress.

Efficient banks are better equipped to manage risks and prepare for crises, but balancing cost and profit efficiency is essential. While reducing costs enhances short-term profitability, excessive cost-cutting can compromise operational resilience, leaving banks vulnerable to risks such as fraud or regulatory penalties due to underinvestment in areas like cybersecurity and compliance. Conversely, high-profit efficiency improves financial stability and provides the flexibility to invest in innovation and risk management, enabling banks to adapt to changing conditions. To achieve this balance, bank managers should incorporate stress testing to assess the impact of crises on efficiency metrics, use profit efficiency gains to strengthen capital reserves for liquidity and solvency during downturns, and align efficiency goals with robust risk management strategies to ensure resilience without sacrificing cost savings.

9. Conclusions

The chapter highlights the critical role of cost and profit efficiencies in enhancing bank resilience during crises. Cost efficiency reduces operational expenses, but excessive cost-cutting can compromise risk management and operational resilience. Profit efficiency, on the other hand, strengthens capital buffers and reduces risk by maximizing revenue from resources, enabling banks to better absorb shocks. Strategies for enhancing efficiency include revenue diversification, leveraging financial technologies, and balancing cost management with risk management investments.

The Syrian banking crisis provides insights applicable to conflict-affected and emerging markets. Banks with higher efficiency levels, such as those observed during the Asian Financial Crisis (1997) and the Global Financial Crisis (2008), demonstrated resilience by stabilizing revenues amid reduced economic activity and heightened risks. Comparative examples from Iraq and Lebanon confirm the importance of transparency, regulatory frameworks, and crisis management systems for safeguarding efficiency gains and resilience under stress.

The research tested the impact of bank efficiency in Syria from normal times (2009–2012) on performance during the subsequent crisis (2013–2018), extending previous work by employing Stochastic Frontier Analysis (SFA) and Free Distribution Approach (FDA) under time-invariant and time-varying inefficiency scenarios. Findings show that cost efficiency during normal times increased risk in larger banks, supporting the "skimping channel" hypothesis, whereas profit efficiency reduced risk, supporting the "value creation/preservation" hypothesis. Cost efficiency contributed to profitability through subtle management under time-invariant inefficiency but had an adverse impact under time-varying inefficiency. Profit efficiency positively influenced risk and profitability through high-revenue, low-risk activities pre-crisis, although profits declined as the crisis unfolded.

Policy recommendations emphasize robust monitoring of cost-efficient banks, promoting cost efficiency while mitigating risks, and adopting stress testing, capital buffer strategies, and risk-aligned efficiency goals. Future research should leverage larger datasets, consider extended timelines beyond 2018 to assess reform impacts, and apply additional frontier techniques to enhance methodological robustness and insights into the Syrian banking sector's efficiency.

Appendix A. The impact of bank efficiency in normal times on bank performance (profitability and risk) in crisis times

When I account for bank profitability using ROA, the regression Sub-Equations under model (7) are:

$$ROA_{i,ct} = \delta_0 + \sum_{i=1}^{n} \delta_1 COSEFF_{i,nt} + \sum_{i=1}^{n} \delta_2 CAP_{i,nt} + \sum_{i=1}^{n} \delta_3 CR_{i,nt} + \sum_{i=1}^{n} \delta_4 LIQ_{i,nt} + \sum_{i=1}^{n} \delta_5 CH_{i,nt} + \sum_{i=1}^{n} \delta_6 BS_{i,nt} + \sum_{i=1}^{n} \delta_7 HHI_{i,nt} + \varepsilon_{i,nt} \quad \text{(A1)}$$

$$ROA_{i,ct} = \delta_0 + \sum_{i=1}^{n} \delta_1 PROFEFF_{i,nt} + \sum_{i=1}^{n} \delta_2 CAP_{i,nt} + \sum_{i=1}^{n} \delta_3 CR_{i,nt} + \sum_{i=1}^{n} \delta_4 LIQ_{i,nt} + \sum_{i=1}^{n} \delta_5 CH_{i,nt} + \sum_{i=1}^{n} \delta_6 BS_{i,nt} + \sum_{i=1}^{n} \delta_7 HHI_{i,nt} + \varepsilon_{i,nt} \quad \text{(A2)}$$

$$ROA_{i,ct} = \delta_0 + \sum_{i=1}^{n} \delta_1 COSEFF_{i,nt} + \sum_{i=1}^{n} \delta_2 PROFEFF_{i,nt} + \sum_{i=1}^{n} \delta_3 CAP_{i,nt} + \sum_{i=1}^{n} \delta_4 CR_{i,nt} + \sum_{i=1}^{n} \delta_5 LIQ_{i,nt} + \sum_{i=1}^{n} \delta_6 CH_{i,nt} + \sum_{i=1}^{n} \delta_7 BS_{i,nt} + \sum_{i=1}^{n} \delta_8 HHI_{i,nt} + \varepsilon_{i,nt} \quad \text{(A3)}$$

When I account for bank profitability using ROE, the regression Sub-Equations under model (7) are the same as Eqs. (A1)-(A3) except I alter ROA with ROE (The resulting Equations are (A4)-(A6). When I account for bank risk using Ln ($ZSCORE_{i,ct}$), the regression Sub-Equations under model (8) are the same as Eqs. (A1)-(A3) except I alter ROA with Ln ($ZSCORE_{i,ct}$) (The resulting Equations are (A7)-(A9). Finally, when I account for bank risk using $\sigma ROA_{i,ct}$, the regression Sub-Equations under model (8) are the same as Eqs. (A1)-(A3) except I alter ROA with $\sigma ROA_{i,ct}$ (The resulting Equations are (A10)–(A12)).

Appendix B. Robustness check: Testing the stability of the models

All the dependent and right-hand side variables in Eqs. (B1) to (B12) are taken for the whole sample (i.e., 2009:Q1–2018:Q4).

$$\begin{aligned} ROA_{i,ct} = \delta_0 &+ \sum_{i=1}^{n} \delta_1 COSEFF_{i,nt} + \sum_{i=1}^{n} \delta_2 CD_t.COSEFF_{i,nt} + \sum_{i=1}^{n} \delta_3 CAP_{i,nt} \\ &+ \sum_{i=1}^{n} \delta_4 CD_t.CAP_{i,nt} + \sum_{i=1}^{n} \delta_5 CR_{i,nt} + \sum_{i=1}^{n} \delta_6 CD_t.CR_{i,nt} + \sum_{i=1}^{n} \delta_7 LIQ_{i,nt} \\ &+ \sum_{i=1}^{n} \delta_8 CD_t.LIQ_{i,nt} + \sum_{i=1}^{n} \delta_9 CH_{i,nt} + \sum_{i=1}^{n} \delta_{10} CD_t.CH_{i,nt} + \sum_{i=1}^{n} \delta_{11} BS_{i,nt} \\ &+ \sum_{i=1}^{n} \delta_{12} CD_t.BS_{i,nt} + \sum_{i=1}^{n} \delta_{13} HHI_{i,nt} + \sum_{i=1}^{n} \delta_{14} CD_t.HHI_{i,nt} + \varepsilon_{i,nt} \end{aligned} \tag{B1}$$

$$\begin{aligned} ROA_{i,ct} = \delta_0 &+ \sum_{i=1}^{n} \delta_1 PROFEFF_{i,nt} + \sum_{i=1}^{n} \delta_2 CD_t.PROFEFF_{i,nt} + \sum_{i=1}^{n} \delta_3 CAP_{i,nt} \\ &+ \sum_{i=1}^{n} \delta_4 CD_t.CAP_{i,nt} + \sum_{i=1}^{n} \delta_5 CR_{i,nt} + \sum_{i=1}^{n} \delta_6 CD_t.CR_{i,nt} + \sum_{i=1}^{n} \delta_7 LIQ_{i,nt} \\ &+ \sum_{i=1}^{n} \delta_8 CD_t.LIQ_{i,nt} + \sum_{i=1}^{n} \delta_9 CH_{i,nt} + \sum_{i=1}^{n} \delta_{10} CD_t.CH_{i,nt} + \sum_{i=1}^{n} \delta_{11} BS_{i,nt} \\ &+ \sum_{i=1}^{n} \delta_{12} CD_t.BS_{i,nt} + \sum_{i=1}^{n} \delta_{13} HHI_{i,nt} + \sum_{i=1}^{n} \delta_{14} CD_t.HHI_{i,nt} + \varepsilon_{i,nt} \end{aligned} \tag{B2}$$

$$\begin{aligned} ROA_{i,ct} = \delta_0 &+ \sum_{i=1}^{n} \delta_1 COSEFF_{i,nt} + \sum_{i=1}^{n} \delta_2 CD_t.COSEFF_{i,nt} + \sum_{i=1}^{n} \delta_3 PROFEFF_{i,nt} \\ &+ \sum_{i=1}^{n} \delta_4 CD_t.PROFEFF_{i,nt} + \sum_{i=1}^{n} \delta_5 CAP_{i,nt} + \sum_{i=1}^{n} \delta_6 CD_t.CAP_{i,nt} \\ &+ \sum_{i=1}^{n} \delta_7 CR_{i,nt} + \sum_{i=1}^{n} \delta_8 CD_t.CR_{i,nt} + \sum_{i=1}^{n} \delta_9 LIQ_{i,nt} + \sum_{i=1}^{n} \delta_{10} CD_t.LIQ_{i,nt} \\ &+ \sum_{i=1}^{n} \delta_{11} CH_{i,nt} + \sum_{i=1}^{n} \delta_{12} CD_t.CH_{i,nt} + \sum_{i=1}^{n} \delta_{13} BS_{i,nt} + \sum_{i=1}^{n} \delta_{14} CD_t.BS_{i,nt} \\ &+ \sum_{i=1}^{n} \delta_{15} HHI_{i,nt} + \sum_{i=1}^{n} \delta_{16} CD_t.HHI_{i,nt} + \varepsilon_{i,nt} \end{aligned} \tag{B3}$$

When I account for bank profitability using ROE, the regression Sub-Equations are the same as Eqs. (B1)–(B3) except I alter ROA with ROE (The resulting Equations are (B4)–(B6)). When I account for bank risk using Ln ($ZSCORE_{i,ct}$), the regression Sub-Equations are the same as Eqs. (B1)–(B3) except I alter ROA with Ln ($ZSCORE_{i,ct}$) (The resulting Equations are (B7)–(B9)). Finally, when I account for bank risk using $\sigma ROA_{i,ct}$, the regression Sub-Equations are the same as Eqs. (B1)–(B3) except I alter ROA with $\sigma ROA_{i,ct}$ (The resulting Equations are (B10)–(B12)).

Appendix C. Measuring efficiency using time-invariant technical inefficiency (distribution free approach, DFA-SS84)

I first consider the case in which the technical inefficiency is assumed to be individual-specific and time-invariant. In this case, the unobservable individual effects of our panel model are the basis from which inefficiency is measured. The model may be written in the case of cost function as:

$$TC_{it} = f(x_{it};\beta) + \varepsilon_{it} \quad \text{(C1)}$$

$$\varepsilon_{it} = \epsilon_{it} + u_{it} \quad \text{(C2)}$$

where $u_i \geq 0$; i = 1, 2, … ., N; t = 2009:Q1, … ., T = 2012:Q4. Also, $f(x_{it};\beta)$ is a linear function of the variables in the vector x_{it}, and $u_i \geq 0$ is the time-invariant technical inefficiency of the bank i. The model in (C1) utilizes the panel feature of the data via u_i, which is specific to an individual and does not change over time. Additionally, (C1) can be estimated assuming either u_i is a fixed parameter (the fixed effects model) or a random variable (the random-effects model). None of these approaches require distributional assumptions on ui and are, thus, labeled as distribution-free approaches. For the time-invariant inefficiency under DFA, I utilize the fixed effect model, or as it is called, Schmidt and Sickles [71] [hereafter SS84]. From Eq. (2), and assuming that $Ln\left(\frac{TC}{w2\varepsilon}\right) = Y_{it}$, w is the vector of parameters in (2), and X_{it} is the vector of the terms of the translog cost function, I simplify Eq. (2) and the Fixed Effects model can then be written as:

$$LnY_{it} = (\alpha_0 - ln\, u_i) + X_{it}\omega + ln\, \varepsilon_{it} \quad \text{(C3)}$$

$$LnY_{it} = \alpha_i + X_{it}\omega + ln\, \varepsilon_{it} \quad \text{(C4)}$$

Σ

where $\alpha_i = (\alpha_0 - \ln u_i)$, $\ln u_i$ and thus $\alpha_i = 1, \ldots \ldots, N$ are assumed to be fixed parameters that are to be estimated along with the parameters vector ω in (C4). SS84 showed that I can apply standard FE panel data estimation methods (for example, the within estimator) to estimate the model in (C4) where α_i are treated as fixed and unobserved individual effects. The standard FE panel methods yield consistent estimates of ω, but $\hat{a}_i$ is a biased estimator of $\ln u_i$ because $\ln u_i > 0$ by construction. Nevertheless, after $\hat{a}_i$ is obtained, a simple transformation can be applied to recover $\ln \hat{u}_i > 0$, which is consistent as $T \to \infty$. Next, I transform the model in (C4) using the within transformation to eliminate α_i. The within transformation subtracts cross-sectional means of the data from each cross-section (i.e., replacing y_{it} by y_{it}-$\overline{y_i}$ and x_{it} by x_{it}-$\overline{x_i}$ where $\overline{y_i} = \frac{1}{T}\sum_t y_{it}$), thereby eliminating α_i. The resulting model in (C4) is then estimated by OLS, and the values of $\hat{a}_i$ are recovered from the mean of the

residuals for each cross-sectional unit. Since $\hat{a}_i$ are obtained, SS84 proposes the following transformation to be used:

$$\boldsymbol{Ln\hat{u}_i = \hat{a}_i - \min_i \{\hat{a}_i\} \geq 0, i = 1, N = 11} \quad \text{(C5)}$$

After that, I estimate bank-specific cost efficiency $\hat{TE}_i$ through DFA by the following:

$$\boldsymbol{\hat{TE}_i = \exp(-ln\,\hat{u}_i)} \quad \text{(C6)}$$

In the case of an alternative profit function, I apply the following changes:

$$\boldsymbol{\pi_{it} = f(x_{it};\beta) + \varepsilon_{it}} \quad \text{(C7)}$$

$$\boldsymbol{\varepsilon_{it} = \epsilon_{it} + u_{it}} \quad \text{(C8)}$$

Assuming that the dependent variable $\mathbf{ln}\left[\left(\frac{\pi}{w_2 z}\right) + \left|\left(\frac{\pi}{w_2 z}\right)^{min}\right| + 1\right] = \acute{q}_{it}$, $\boldsymbol{\psi}$ is a vector of parameters in (6), and G_{it} is the vector of the terms of the translog (alternative) profit function, accordingly, (C3) and (C4) become:

$$\boldsymbol{Ln\ Q_{it} = (\acute{\alpha}_0 - ln\ \acute{u}_i) + G_{it}\psi + ln\,\varepsilon_{it}} \quad \text{(C9)}$$

$$\boldsymbol{Ln\ Q_{it} = \acute{\alpha}_i + G_{it}\psi + ln\,\varepsilon_{it}} \quad \text{(C10)}$$

Applying the same steps in the translog cost function for (C9) and (C10), then (C5) becomes:

$$\boldsymbol{Ln\ \hat{\acute{u}}_i = \max_i \left\{\hat{\acute{a}}_i\right\} - \hat{\acute{a}}_i \geq 0, i = 1, N = 11} \quad \text{(C11)}$$

After that, I estimate bank-specific profit efficiency $\hat{\acute{TE}}_i$ through the DFA by the following:

$$\boldsymbol{\hat{\acute{TE}}_i = \exp\left(-ln\ \hat{\acute{u}}_i\right)} \quad \text{(C12)}$$

Appendix D. Measuring efficiency using time-invariant technical inefficiency (Stochastic Frontier Analysis, SFA-SS84)

A strong appeal for the Fixed Effects model presented in Appendix C is that it does not require distributional assumptions in estimating inefficiency from cost and profit functions. However, it is still possible to estimate Eq. (2) using Maximum Likelihood Estimator (MLE) by imposing distributional assumptions on ε_{it} and u_i. For the time-invariant inefficiency under SFA, I utilize SS84 as I did with the DFA. The likelihood function of the model is derived based on the distributional assumptions, and the parameters are estimated by maximizing the log-likelihood function [57]. Finally, inefficiency can be estimated using a variant of the JLMS approach [84]. As in (C1) and (C2), the MLE is written as:

$$\boldsymbol{Y_{it} = f(x_{it};\beta) + \varepsilon_{it}} \quad \text{(D1)}$$

$$\epsilon_{it} = \varepsilon_{it} - u_{it} : \varepsilon_{it} \backsim N\left(0, \sigma^2{}_{\epsilon}\right), u_i \backsim N^{+}\left(\mu, \sigma^2{}_{u}\right) \tag{D2}$$

According to Pitt and Lee [85] and Kumbhakar and Lovell [86], the likelihood function for the i[th] observation is:

$$Ln\, L_i = constant + ln\, \Phi\left(\frac{\mu_{i*}}{\sigma_*}\right) + \frac{1}{2}\sigma^2{}_* - \frac{1}{2}\left\{\frac{\sum_t \epsilon_{it}{}^2}{\sigma^2{}_{\varepsilon}} + \left(\frac{\mu}{\sigma_u}\right)^2 - \left(\frac{\mu_{i*}}{\sigma_u}\right)^2\right\} \tag{D3}$$
$$-Tln\sigma_{\varepsilon} - ln\, \sigma_u - ln\, \Phi\left(\frac{\mu}{\sigma_u}\right)$$

$$\mu_{i*} = \mu\sigma_{\varepsilon}^2 - \frac{\sigma_u^2 \sum_t \epsilon_{it}}{\sigma_{\varepsilon}^2 + T\sigma_u^2} \tag{D4}$$

$$\sigma^2{}_* = \frac{\sigma_{\varepsilon}^2 \sigma_u^2}{\sigma_{\varepsilon}^2 + T\sigma_u^2} \tag{D5}$$

The log-likelihood function of the model in (D1) is obtained by summing $\ln L_i$ over i, i = 1, … … , N. The MLE of the parameters is obtained by maximizing the log-likelihood function. After estimating the parameters of the model in (2), the inefficiency for each i can be computed from either the mean or the mode ([86], p. 104): In the case of the mean:

$$E(u_i|\epsilon_i) = \mu_{i*} + \sigma_* \left[\frac{\phi\left(\frac{-\mu_{i*}}{\sigma_*}\right)}{1 - \Phi\left(\frac{-\mu_{i*}}{\sigma_*}\right)}\right] \tag{D6}$$

And in the case of the mode:

$$M(u_i|\epsilon_i) = \begin{cases} \mu_{i*} \text{ if } \mu_{i*} \geq 0 \\ 0 \text{ otherwise} \end{cases} \tag{D7}$$

Both (D6) and (D7) are the extended JLMS estimators of inefficiency (104). In the case of an alternative profit function, I apply (C7) and (C8).

Appendix E. Measuring efficiency using time-varying technical inefficiency (distribution free approach, DFA-CSS90)

As the case with the time-invariant inefficiency models, time-varying models are classified as either Fixed (FE)- or Random (RE)-Effects type. In the FE models, the time-varying inefficiency term is non-stochastic (i.e., a parametric function of time), and for this chapter, I chose to apply the model of Cornwell et al. [18] [hereafter CSS90]. For the sake of the translog cost function, I recall from the SS84 model in (C3) and (C4) that the inefficiency term (confounded in the firm-specific effect) is time-invariant. To make it time-varying, CSS90 suggests replacing α by α_{it} where:

$$\alpha_{it} = \alpha_{0i} + \alpha_{1i}t + \alpha_{2i}t^2 \tag{E1}$$

Noting that the parameters a_{0i}, a_{1i}, and a_{2i} are bank-specific and t is the time trend variable. Since the number of cross-sectional units (N) is not large (i.e., 11 banks), I define N bank dummies and interaction of these dummies with time t and time squared t^2. These variables (the interaction of these dummies with time t and time squared t^2) along with the regressors (i.e., the $\acute{\boldsymbol{X}}_{it}$ variables utilized in the translog cost function in Eq. (C4)) are then used in the OLS regression. Because all the bank dummies are used, the intercept term in the regression has to be suppressed to avoid the exact multicollinearity problem. The coefficients associated with the bank dummies and their interactions are the estimates of $\boldsymbol{\alpha_{0i}}$, $\boldsymbol{\alpha_{1i}}$, and $\boldsymbol{\alpha_{2i}}$. These estimated coefficients can be used to obtain estimates of $\boldsymbol{\alpha_{it}}$. Therefore, if I represent the model as:

$$\boldsymbol{Y_{it}} = \boldsymbol{\alpha_{0i}} + \acute{\boldsymbol{X}}_{\boldsymbol{it}}\boldsymbol{\omega} + \boldsymbol{ln}\,\acute{\boldsymbol{\epsilon}}_{\boldsymbol{it}} \tag{E2}$$

$$\boldsymbol{ln}\,\acute{\boldsymbol{\epsilon}}_{\boldsymbol{it}} = \boldsymbol{ln}\,\boldsymbol{\epsilon_{it}} + \boldsymbol{\alpha_{1i}t} + \boldsymbol{\alpha_{2i}t^2} \tag{E3}$$

Accordingly, the form of the model in (E2) and (E3) looks like a standard panel data model, and I may apply a within estimator on (E2) and (E3) (similar to SS84) to obtain consistent estimates of $\hat{\boldsymbol{\omega}}$, and then the estimated residuals of the model become:

$$\boldsymbol{\epsilon_{it}} = \boldsymbol{Y_{it}} - \acute{\boldsymbol{X}}_{\boldsymbol{it}}\hat{\boldsymbol{\omega}} \tag{E4}$$

These residuals ($\boldsymbol{\epsilon_{it}}$) are then regressed on a constant, a time trend, and the square of the time trend for each i. The fitted values from these regressions provide estimates of α_{it} in (E1). Finally, $\hat{u}_{it}$ is obtained by:

$$\hat{\boldsymbol{u}}_{\boldsymbol{it}} = \hat{\boldsymbol{\alpha}}_{\boldsymbol{it}} - \hat{\boldsymbol{\alpha}}_{\boldsymbol{t}} \tag{E5}$$

$$\hat{\boldsymbol{\alpha}}_{\boldsymbol{t}} = \min_{\boldsymbol{i}} \{\hat{\boldsymbol{\alpha}}_{\boldsymbol{jt}}\} \tag{E6}$$

That is, for each t (which represents a quarter), I define the minimum and calculate efficiency relative to the best bank in that quarter. Because the minimum of $\hat{\boldsymbol{\alpha}}_{\boldsymbol{jt}}$ is likely to change over time, the same bank may not be efficient in every quarter. Intuitively, efficiency in this framework is relative to the best bank in the sample in a given quarter, and this may be represented by different banks in different quarters. Alternatively, if one defines the minimum over all i and t, then efficiency is relative to the best bank in the sample (defined over all time periods). In the case of an alternative profit function, I apply the following changes:

$$\hat{\boldsymbol{u}}_{\boldsymbol{it}} = \hat{\boldsymbol{\alpha}}_{\boldsymbol{t}} - \hat{\boldsymbol{\alpha}}_{\boldsymbol{it}} \tag{E7}$$

$$\hat{\boldsymbol{\alpha}}_{\boldsymbol{t}} = \max_{\boldsymbol{j}} \{\hat{\boldsymbol{\alpha}}_{\boldsymbol{jt}}\} \tag{E8}$$

Hence, for each t, I define the maximum and calculate efficiency relative to the best bank in that quarter. Because the maximum of $\hat{\boldsymbol{\alpha}}_{\boldsymbol{it}}$ is likely to change over time, the same bank may not be efficient in every quarter. I should emphasize that since t appears in the inefficiency function, it cannot appear as a regressor in $\acute{\boldsymbol{X}}_{\boldsymbol{it}}$ to capture technical change. Therefore, the model in (C3) and (C4) cannot separate inefficiency from technical change, and it would be of utmost importance to investigate this matter in a model that separates time-varying inefficiency from technical change for future research.

Appendix F. Measuring efficiency using time-varying technical inefficiency (Stochastic Frontier Analysis, SFA-BC92)

Considering that the following relationships exist:

$$Y_{it} = f(x_{it};\beta) + \varepsilon_{it} \tag{F1}$$

$$\epsilon_{it} = \varepsilon_{it} - u_{it} : \varepsilon_{it} \backsim N(0, \sigma^2{}_{\epsilon}), u_i \backsim N^{+}(\mu, \sigma^2{}_u) \tag{F2}$$

$$u_i = G(t)u_i \tag{F3}$$

Where G(t) > 0 is a function of time (t), I assume that the inefficiency u_{it} in (F2) is not fixed for a given individual; instead, it changes over time and also across individuals. Inefficiency in models (F1) and (F2) is composed of two distinct components: one is a non-stochastic time component G(t) and the other is a stochastic individual component u_i. It is the stochastic component u_i that utilizes the panel structure of the data in this model. The u_i component is individual-specific, and the G(t) component is time-varying and is common for all individuals. Given that $u_i \geq 0$, this is asserted by having a non-negative G(t). The econometric literature has given G(t) several specific forms; in this chapter, I apply the Battese and Coelli [72] (hereafter BC92) model which assumes that:

$$G(t) = exp\,[\gamma(t - T)] \tag{F4}$$

Where t is the beginning period of the sample (i.e., t = 2009:Q1); T is the terminal period of our sample (i.e., T = 2012:Q4). I specify the log-likelihood function of each cross-sectional observation i in generic form (for (F1)–(F3)), which is:

$$Ln\,L_i = constant + ln\,\Phi\left(\frac{\mu_{i*}}{\sigma_*}\right) + \frac{1}{2}\sigma^2{}_* - \frac{1}{2}\left\{\frac{\sum_t \epsilon_{it}{}^2}{\sigma^2{}_{\varepsilon}} + \left(\frac{\mu}{\sigma_u}\right)^2 - \left(\frac{\mu_{i*}}{\sigma_u}\right)^2\right\} - Tln\sigma_{\varepsilon} - ln\,\sigma_u - ln\,\Phi\left(\frac{\mu}{\sigma_u}\right) \tag{F5}$$

$$\mu_{i*} = \mu\sigma^2_{\varepsilon} - \frac{\sigma^2_u \sum_t \epsilon_{it}}{\sigma^2_{\varepsilon} + T\sigma^2_u} \tag{F6}$$

$$\sigma^2{}_* = \frac{\sigma^2_{\varepsilon}\sigma^2_u}{\sigma^2_{\varepsilon} + T\sigma^2_u} \tag{F7}$$

The log-likelihood function of the model in (F3) is obtained by summing ln L_i over i, i = 1, … …, N, which is maximized to get the ML estimates of the parameters. After estimating the parameters of the model in (F5), the inefficiency for each i can be computed from either the mean or the mode as in (D6) and (D7), respectively.

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Conflict of interest

The authors declare no conflict of interest.

Author details

Mazen Diwani
Northeastern University London, London, United Kingdom

*Address all correspondence to: meezdin86@gmail.com

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Section 6

Governance, Ethics and Alternative Banking Models

Chapter 15

Perspective Chapter: The Ethical Approach to Banking Activity

António Pedro A. Ferreira

Abstract

The current historical moment experienced by economic activity in general, and particularly by financial activity, induces the need to complement the search for the most appropriate legal-economic solutions with the development and consolidation of a new business culture, which revives the discussion on ethics in business and does not leave it to the convenience of each moment. The particular importance of business ethics in financial activity is identified from the perspective of financial markets, financial services, and financial management. Although this activity is subject to strict legal regulation, it is also clear that the foundations of this regulation are often supported by fundamental ethical content, such as equity in financial markets or the fiduciary duties of managers of financial organizations. Furthermore, the ethics of financial activity concern not only individual behavior but also the way in which financial markets and their institutions operate.

Keywords: ethics, financial activity, regulation, business culture, ethical banking

1. Introduction

The financial system, involving industries associated with banking, insurance, and securities operations, is the backbone of the global economy and serves as the basis for many other industries that depend, notably, on credit to function. Despite the various metrics used to estimate the size of the financial system and the variation in the results obtained, most estimates place financial services at about 20–25% of the global economy [1].

Historically, the success of the system has been evaluated solely by profits, but increasingly, the performance and role of financial services in society are being evaluated according to broader criteria, such as their social impact and the ethical conduct underlying them. The need for financial services to be conducted according to moral standards is indisputable, both because of the crucial role that financial activity plays in personal, economic, political, and social domains, and the opportunities for immense financial profits that might tempt people to act unethically [2].

This text intends to assess the current situation regarding the discussion of the ethical approach to banking activity, beginning by (i) framing the topic within business ethics, (ii) highlighting its relevance within this specific financial activity, (iii) contextualizing the regulatory and legislative contributions at the international level,

and (iv) analyzing the potentials of ethical banking initiatives, ultimately formulating general conclusions.

2. Business ethics and its relevance in banking activity

2.1 Ethics and corporate governance

Currently, the historical moment for economic activity, especially in finance, indicates the need to complement the search for suitable legal-economic solutions with the development of a new corporate culture that reignites the discussion on ethics in business [3–5]. We propose that business scandals have highlighted how ethical issues profoundly permeate the financial environment, making it vital to analyze activity from this new perspective. Conceptually, market economies need to rely on solid and competitive financial systems, which adequately perform their primary function of mediating financial resources[1] [6], sustained by the integrity of institutions and the continuity of markets. Thus, the need for reflection on the ethical approach to banking activity emerges[2] [7, 8].

Ethics, derived from the Greek "ethos," refers to character and human conduct, dealing with what is good and bad, as well as moral obligations [9]. Generally, ethics pertains to the acceptability and correctness of human behavior, with general ethical norms including truthfulness, honesty, and justice, applicable to all aspects of life, including business and finance [10]. Managing according to ethical criteria primarily aims to build reference images that become examples to follow, setting aside concerns about negative outcomes. The adoption of ethical criteria in the financial decision-making process allows for the definition of corporate value propositions that warrant better attention [11]:

- *Sustainability*, in that they constitute the foundation of a solid and enduring organization, whose legacy centers on the pursuit of prevailing normative and legal values in social life;
- *Building Trust*, creating bonds of loyalty between suppliers and consumers that, ultimately, always end up rewarding the effort expended;
- *Strengthening Team Spirit and Leadership Recognition*, sustaining excellence in the exercise of activity;
- *Raising Social Standards Defined by Laws and Regulations*, prompting social actors to act based on motivations beyond merely avoiding penalties for breaching specific norms;
- *Reputation and Awareness*, driving ethical behavior well beyond simple considerations of material gain, situating it within the context of values related to how each individual is perceived by their family, friends, and the community at large.

[1] About the risks posed by such mediation (credit risk, interest rate, and liquidity risk, as well as off-balance sheet operations), see António Pedro A. Ferreira [6].

[2] A list of the successive scandals, financial and non-financial, that have occurred in recent decades, can be seen in Marwa A. Bashawyah [7] and J. R. Boatright [8].

The last idea has garnered special attention, to the extent of becoming a reference of what could be called the enterprise's *bonus pater familias*, that is, the average entrepreneur, aware of their rights and responsibilities, who conducts their activity according to a value framework amicably accepted from a social viewpoint: "The businesspeople we interviewed set great store on the regard of their family, friends, and the community at large. They valued their reputations, not for some nebulous financial gain but because they took pride in their good names. Even more important, since outsiders cannot easily judge trustworthiness, businesspeople seem guided by their inner voices, by their consciences. … We keep promises because it is right to do so, not because it is good business" [12].

2.2 The importance of ethics in financial activity

Ethics assumes particular importance in financial activity, given its public relevance in allocating scarce capital and imposing market discipline [13]. As William C. Dudley, President and CEO of the Federal Reserve Bank of New York, has pointed out: "Although cultural and ethical problems are not unique to the finance industry, financial firms are different from other firms in important ways. First, the financial sector plays a key public role in allocating scarce capital and exerting market discipline throughout a complex, global economy. For the economy to achieve its long-term growth potential, we need a sound and vibrant financial sector. Financial firms exist, in part, to benefit the public, not simply their shareholders, employees, and corporate clients. Unless the financial industry can rebuild public trust, it cannot effectively perform its essential functions. For this reason alone, the industry must do much better" [14].

We argue that the modern banking system is defined by two essential activities (maintaining fractional reserves and transforming maturities), both facing ethical controversies [15].

Maintaining fractional reserves allows the amounts of money deposited in a bank account for safekeeping to be partially utilized to finance investment activities of the bank itself, which keeps only a small amount of the original deposit on guard, aiming to satisfy withdrawal requests. This leads to the situation where the depositor does not have their deposit fully available and secure, yet there is a significant probability of receiving their money promptly.

On the other hand, transforming maturities allows passive operations (deposits), inherently shorter-term, to be related to active operations (loans), which are necessarily longer-term. This is achieved through the careful use of the so-called laws of large numbers, a group of theorems contained within Probability Theory (the mathematical heart of the concept of risk), from which fundamental results arise [16].

Still, the legal and economic characteristics distinguishing the two practices generate distinct ethical analyses.

3. The key role of trust in banking activity

3.1 Recent banking crises: A quick overview

The financial system has faced successive crises that have shaken its foundations, with economic and social consequences [17]. In the case of crises related to the banking sector and using a broad definition of systemic banking crises, which

combines quantitative data with some subjective assessment of the situation, 1970 has been identified as the starting point of systemic banking crises around the world[3] [18, 19]. The origins of these crises have been associated with various causes, such as poor risk management, ineffective regulation and oversight, weak corporate governance, high levels of non-performing loans, low capital adequacy ratios, and monetary policy [20–24].

In the twenty-first century, two major crises have already been marked: the one in 2007–2008 and the one in 2023, which interestingly both originated in the USA: the first, due to the subprime crisis (which spread to Europe and was exacerbated by the sovereign debt crisis), largely caused by loose monetary policy and weak regulation, which encouraged and allowed banks to excessively leverage and transform maturities, leading to imbalances that prompted runs on banks [25, 26] - Lehman Brothers was a key example of this way of acting; the second shows how rising interest rates exposed hidden vulnerabilities within the financial system in the United States. As interest rates rose, banks recorded losses on their government bond portfolios, resulting in some regional banks facing unprecedented deposit outflows. These losses and deposit withdrawals triggered funding and liquidity issues in some banks, leading to the collapse of four banks: Silicon Valley Bank, Signature Bank, Credit Suisse, and First Republic Bank [27].

For the purposes of our topic, we will consider the examples of: Lehman Brothers in 2007–2008, and Silicon Valley Bank and Credit Suisse, in 2023:

3.1.1 Lehman Brothers (September 2008)

Several unethical procedures and practices are pointed to having contributed to the downfall of LB, marking one of the largest bankruptcies in US history [28, 29]:

- Risky mortgage-backed securities

LB heavily invested in mortgage-backed securities (MBS) during the housing bubble. These securities bundled high-risk subprime mortgages, which were often issued to borrowers with poor credit histories. The firm engaged in aggressive trading of these products, prioritizing short-term profits over the long-term implications of their riskiness.

- Misleading financial reporting

In the years leading up to its bankruptcy, LB employed accounting practices that obscured its true financial health. One notable technique was "Repo 105," which involved temporarily transferring assets to other institutions to reduce its leverage ratio on paper. This practice created a misleading impression of financial stability and allowed LB to appear less leveraged than it actually was, misleading investors and regulators.

[3] Cfr. [18]; for a broader perspective see Carmen M. Reinhart and Keneth Rogoff [19], who highlight how the misconception that destabilizing, systemic, multinational financial crises were a relic of the past was destroyed, at great social cost, by the 2007 global financial crisis, emanating from USA and Europe.

- Lack of transparency

LB often failed to provide clear and transparent information about its financial health and risk exposure. This lack of transparency made it difficult for investors and stakeholders to assess the firm's true condition, ultimately eroding trust. The complexity of the financial instruments they traded further obscured the risks involved.

- Inadequate risk management

The firm's risk management practices were grossly inadequate. LB underestimated the risks associated with its investments in subprime mortgages and did not have effective measures in place to mitigate those risks. As the housing market began to decline, the firm was ill-prepared to handle the resulting financial strain.

- Pressure for short-term gains

The corporate culture at LB emphasized short-term profits and aggressive growth strategies. This focus led to decision-making that prioritized immediate financial returns over ethical considerations and long-term sustainability. Employees faced intense pressure to achieve high performance metrics, often at the expense of sound judgment and ethical behavior.

- Failure to act on warning signs

Despite early warning signs of trouble in the housing market and financial sector, LB continued to pursue risky investments. The firm's leadership failed to recognize the severity of the impending crisis and did not take adequate steps to address the growing vulnerabilities.

3.1.2 Silicon Valley Bank (March 2023)

In the case of Silicon Valley Bank, it became apparent how a lapse in ethical behavior had deeply permeated the bank's organizational structure. Notably, this was evidenced by management's inability to appoint qualified board members; an imbalanced focus on social issues to the detriment of the fiduciary responsibility of managing the firm in the best interest of its stakeholders; and a minimal scope of its Code of Ethics, focusing almost exclusively on human resource risks while neglecting other more prevalent and imminent risks faced by the bank. Contrary to what has been argued that banks do not need an internal code, program, or ethical culture due to already being strongly regulated, the case of SVB underscored the necessity for an ethical organizational culture, regardless of the sector of activity and governmental oversight potentially in place[4] [30–32].

Several unethical practices and risk management failures contributed to its downfall:

[4] On the ethical issues raised by the insolvency of SVB see, v. g. Linda Ferrell and Ferrell [30]; Dave Epstein [31]; Mai Huynh [32].

- Inadequate risk management practices

SVB's risk management framework was insufficient for the unique challenges it faced. The bank primarily served startups and venture capital firms, which often operate in high-risk environments. However, SVB did not adequately assess the volatility of its customer base and the potential risks associated with a downturn in the tech sector.

- Concentration of deposits

SVB had a highly concentrated depositor base, heavily reliant on technology and life sciences companies. This reliance exposed the bank to significant risks, particularly when the tech industry began to experience contractions. The lack of diversification in its depositors meant that when these sectors faced challenges, a large number of customers withdrew funds simultaneously, leading to liquidity issues.

- Failure to prioritize fiduciary responsibilities

The management at SVB was criticized for prioritizing social and environmental issues over traditional fiduciary responsibilities. While companies often aim to align with broader societal goals, SVB's leadership appeared to place excessive focus on social matters at the expense of sound financial practices. This misalignment led to poor decision-making regarding the bank's operational integrity and financial health.

- Weak governance and oversight

The bank's governance structure failed to establish adequate checks and balances. There were concerns about the qualifications of the board members, and the oversight mechanisms in place were insufficient to monitor risk exposure effectively. This lack of strong governance contributed to management making reckless decisions without proper scrutiny.

- Mismanagement of interest rate risks

SVB invested heavily in long-term securities, such as government bonds, while interest rates were historically low. As interest rates rose sharply in early 2023, the value of these securities declined significantly. The bank did not adequately hedge against this interest rate risk, leaving it vulnerable when depositors began to withdraw their funds.

- Failure to address warning signs

Leading up to its collapse, there were several warning signs indicating financial distress, including rising interest rates and a slowdown in the tech sector. Despite these signals, SVB's management did not take proactive measures to strengthen its balance sheet or enhance liquidity. This failure to act on warning signs left the bank unprepared for the subsequent crisis.

3.1.3 Credit Suisse (March 2023)

In the case of Credit Suisse, despite its high capitalization, inconsistent strategic changes (aiming to reduce the investment banking side, lower profit volatility, and focus the business model primarily on asset management), successive scandals, and management errors, among other reasons, resulted in the loss of trust from customers, investors, and markets. The elevated level of fund withdrawals by customers jeopardized the bank's immediate solvency, leading to the acquisition of Credit Suisse by UBS in mid-March 2023 [33].

Several unethical practices contributed to its downfall:

- Risky investment practices

CS engaged in risky investment strategies, including significant exposure to high-risk assets. The bank's involvement in complex financial products and high-leverage investments increased its vulnerability to market fluctuations. This lack of prudent risk management led to substantial losses, particularly during market downturns.

- Failure to address repeated scandals

Over the years, CS has been embroiled in multiple scandals, including the 2015 currency manipulation case, the 2019 spying scandal involving former executives, and the collapse of the Greensill Capital and Archegos Capital funds in 2021. Each of these incidents raised serious ethical concerns about the bank's governance and compliance culture. Instead of addressing these issues, management often downplayed their significance, which eroded stakeholder trust.

- Inadequate oversight and governance

The bank's governance structure was criticized for being weak and ineffective. There were concerns about the board's independence and the qualifications of executives in key risk management and compliance roles. This lack of robust oversight allowed unethical practices to persist and went unchallenged, contributing to a culture of impunity;

- Misleading financial reporting

CS faced accusations of misleading investors regarding its financial health. For example, during the fallout from the Archegos scandal, the bank reported significant losses but failed to provide clear and transparent disclosures about the underlying risks and the extent of its exposure. This lack of transparency misled stakeholders and investors about the bank's true financial condition.

- Focus on short-term profits over long-term stability

The corporate culture at Credit Suisse prioritized short-term profits and aggressive growth strategies, often at the expense of ethical considerations and long-term stability. This approach led to decisions that favored immediate financial gains but compromised the bank's integrity and risk management practices.

- Inadequate response to regulatory scrutiny

CS faced ongoing regulatory scrutiny and criticism from authorities for its business practices. However, the bank's leadership often failed to implement necessary changes to address compliance deficiencies. This lack of responsiveness to regulatory feedback highlighted a disregard for ethical standards and accountability.

In conclusion, the three mentioned cases provide eloquent examples of how the combination of unethical practices jeopardizes institutional stability. We emphasize that these collapses serve as a stark reminder of the importance of ethical conduct, governance, and accountability in the financial industry.

3.2 A crisis of trust

We propose that the underlying issue in these financial crises can be traced back to a crisis of trust. Bank trust can be analyzed from several perspectives [34]:

i. In terms of the interaction between psychological expressions and economic aspects of human behavior. Trust is defined as an expectation of future behavior by another individual and is based on customers' assurance that the managers assisting them will take any necessary actions to ensure their benefit [35];

ii. From the perspective of risk control and minimization. Since all business operations are associated with a certain degree of risk, the choice of a business partner will be determined by customers' capacity to manage and adequately control potential business risks, resulting in the interaction between risk and trust transforming these elements into two sides of the same coin, meaning there cannot be one without the other. Particularly relevant are electronically implemented operations, though this applies across all other operations of financial institutions, as they are always associated with a certain level of risk[5] [36];

iii. In terms of clients' belief in establishing secure relationships with banks. The security of banking transactions has increasingly become a central concern for financial institutions, which play a fundamental role in facilitating electronic banking and, therefore, are prime targets for cyberattacks, through "... phishing schemes: 'e-thieves' steal confidential data such as passwords, credit card numbers, and user IDs from individuals, typically by setting up counterfeit websites designed to deceive them into submitting their personal credentials" [37].
The use of electronic banking is closely linked to clients' perceptions of safety, impacting their attitudes and behaviors [38]. Hence, trust in electronic banking services is generated by their security and reliability [39]. In this context, it cannot be overlooked that "The assessment that a major cyberattack poses a threat to financial stability is axiomatic - not a question of if, but when" [40].

3.3 Building banking trust

From the summary, we conclude that the foundation of banking trust results from multiple interrelated factors. We argue that the expectation of bank customers for

[5] Laura Burrows [36] highlighting, among the benefits of adequate banking risk management, the promotion of customer confidence, which increases customer retention and mitigates reputational risk.

necessary actions to safeguard their benefits relies on a selection determined by the counterparty's capacity to manage risks.

Additionally, it has traditionally been the case that banking trust has been built through face-to-face interactions. However, we propose that the accelerated development of online banking services demands new trust factors, such as maintaining "human" interactions (clients continue to wish to interact with trustworthy experts, even through electronic means), personalizing services (offering tailored recommendations and contextual contributions to clients that help them manage their finances effectively), or adopting radical transparency (involving providing clients with all relevant information regarding products and services available to them) [41].

The activity of banks should focus on the client, creating, maintaining, and developing the level of trust that is fundamental to fostering engagement and enhancing loyalty, which directly impacts the financial results of banks. Thus, trust is essential for banking success.

3.4 A paradigm shift: Improving the ethical behavior underlying the financial sector

While enhancing trust involves establishing better and broader regulatory frameworks, it remains evident that there is a crucial need for a paradigm shift to improve ethical behavior in the financial sector. We argue that despite strict regulation, financial activity continues to be a field for applying unwritten rules of ethical behavior.

This diversification requires that the theme of ethics in financial activity be approached from a tripartite perspective: the perspective of financial markets, the perspective of financial services, and the perspective of financial management [42].

Financial markets, supposedly operating in a fair and orderly manner, need to find the appropriate balance between correctness and efficiency, within an especially difficult framework given their vulnerability, for example, to unlawful commercial practices (fraud and manipulation) or contractual difficulties (formation, interpretation, and execution of contracts).

The delivery of financial services requires a careful respect for client interests, both in terms of a relationship that exhausts itself in the simple buying and selling of financial products and in a broader dimension that articulates financial entities and their clients in an agency relationship whenever the former acts on behalf of the latter. In that case, institutions have the obligation to avoid deceptive or abusive trade practices; in this regard, the obligation to avoid conflicts of interest is prominent.

Finally, financial management is confronted with the possible articulation between the fiduciary duty to conduct corporate affairs in a manner that maximizes shareholder profits and the duty to refrain from actions or omissions that compromise the adequate safeguarding of the interests of non-shareholder groups (stakeholders).

3.5 Agency theory and its ethical challenges

In this context, it is important to bear in mind that the relationship between managers and shareholders poses a source of conflict, identified as an agency problem within corporate governance [43]. Agency theory has been developed by economic science, where it is assumed that both agent and principal are motivated by their

own selfish interests seeking to maximize their respective gains in their relationship[6] [44, 46]. Then, "... the job of agency theory is to help us devise techniques for initially describing the conflict of principal-agent, and then controlling the situation so that the agent, acting from self-interest, does as little harm as possible to the principal's interests" [47].

Framed this way, agency theory raises a problem of a lack of values, as it does not seek to assess the correctness of behaviors aimed at maximizing profit, nor does it concern itself with defining what could be deemed a just remuneration assigned to the manager. The ideas of honesty and loyalty are thus disregarded by the agency relationship, given their structural incompatibility with the idea of rational maximization. Thus, it is understood that agency theory distances itself from the traditional agency concept, which is based on a set of moral values (such as truthfulness, loyalty, fidelity, and concern for others) that frame the traditional agent/principal relationship.

Consequently, it would seem impossible to ensure the proper functioning of a system that presents a genetic incongruity: on the one hand, it stimulates the individualistic maximization of profit, but on the other hand, it defines behavior rules so that agents continue to care for the interests of others. In fact, to do something for others within a system aimed at maximizing personal interests seems futile and senseless. This situation highlights an inconsistency at the heart of the system, since "... a system that has rules requiring agents to look out for others, while encouraging individuals to look out only for themselves, destroys the practice of looking out for others, i.e., it destroys agency" [45].

In the business context, agency theory has recast the traditional concept of the internal agency relationship into a structured contractual-type relationship, within which the principal can influence the agent's activity *via* an integrated system of incentives, motivations, and punishments. The loyalty of the agent is thus achieved at the cost of monetary rewards, penalties, or applicable legal commands, thus finding a feasible equilibrium to ensure the system's functioning.

3.6 The relationship between financial institutions and clients

However, we note that it becomes significantly more challenging to frame these same operating mechanisms in the agency resulting from the business contacts between financial institutions and their clients. Notably, the satisfaction of individual needs regarding financial services can only be adequately assured by specialized entities that possess the availability and proficiency that each of us lacks for that purpose. However, the delineation of the agency relationship established between financial entities and their clientele, in the same manner used for the relationship between managers and shareholders, proves quite difficult to materialize as the diversity of situations raises new problems: the clientele is not organized in the same manner as shareholder bodies, and generally lacks awareness of the existence of an agency

[6] It is worth mentioning that this idea of selfish interest has been supported, generally, in Adam SMITH's masterpiece, Wealth of Nations, published in London in 1776, where, for the first time, a free market economic solution is systematized as the most productive and beneficial to society. Even so, more careful analises have maintained that such reasoning is unjustified, since that work focuses, more broadly, on virtues such as prudence, equity and cooperation – in this sense Amartya Sen [44]; Patricia H. Werhane [45].

problem; the lack of information, on the other hand, hampers their capacity to monitor agent behavior.

For these reasons, it has been argued that "... what we have in our complex modern economic system is a paradoxical situation: the ever-increasing need for getting things done by others on the one hand, and the description of human nature that emphasizes selfish behavior on the other. This paradoxical situation, or the inconsistency in the foundation of the modern capitalist system, can explain most of the ethical problems and declining morality in the modern business and finance arena" [45].

3.7 Choices between management perspectives

The paradox is indeed embodied in the extreme positions taken regarding whose interests business managers act (or should act) in – the so-called agency theory. Two schools of thought have traditionally been pointed out in this regard [48]:

For the shareholder school, such as FRIEDMAN, the business aims to provide returns to its owners, and diverting from this objective to other purposes would render an expropriation of shareholder values and threaten the survival of the company. Thus, this should not be subject to a supposed social responsibility promoting charitable contributions or similar (voluntary reduction of pollution, expanding pension benefits for retirees, donations for scientific research purposes, etc.): "The corporation is an instrument of the stockholders who own it. If the corporation makes a contribution, it prevents the individual stockholder from himself deciding how he should dispose of his funds" [49].

For the generalist school, represented by FREEMAN, shareholders constitute a highly relevant group, but do not exhaust the range of stakeholders interested in the implementation of company activities and its success. Both have substantial relevance for various groups of people (workers, clients, suppliers, and the very community within which that unit operates), so company management should consider, as far as possible, the interests of these groups. The decision-making delays that might arise from considering the various interests involved and the need to find the just balance in their satisfaction are offset by the fact that the company begins to be understood as a relational link, encouraging management to consider the diversity of established relationships: "The idea of stakeholders, or stakeholder management, or a stakeholder approach to strategic management, suggests that managers must formulate and implement processes that satisfy all and only those groups who have a stake in the business. The central task in this process is to manage and integrate the relationships and interests of shareholders, employees, customers, suppliers, communities, and other groups in a way that ensures the long-term success of the firm. A stakeholder approach emphasizes active management of the business environment, relationships and the promotion of shared interests[7]" [50, 51].

In summary, we highlight that the core critique of agency theory centers on the inherent incompatibility between profit-maximization incentives and ethical behavior. While profit maximization may drive financial performance, we argue that it can undermine ethical behavior, leading to consequences for institutions and society.

[7] R. Edward Freeman and John Mcvea [50] mandatory, in this regard, is the work of R. Edward Freeman [51] considered one of the focal points of construction of this school of thought.

As underlined, all the examples of bank scandals abovementioned dealt with, in a common way, a culture that prioritized short-term profits, completely disregarding stakeholders interests, so mining the public confidence in the financial system.

The debate on these issues is far from over, but one thing seems certain in the current historical moment: companies (and especially financial institutions) do not exist isolated from the surrounding social environment; rather, they integrate into it and share with it the successes and failures of daily life. Perhaps the specific responses demanded by ongoing issues cannot yet be fully realized, but several options for approach remain on the horizon that might contribute to positive evolutions, such as: (i) the adoption of ethical codes within companies, as a classic indicator of promoting ethical behavior; (ii) the stimulation of generalized internal discussions about ethical issues; (iii) specific reflections on the concrete problems posed by the daily exercise of business activity; or, finally, (iv) the change of the business paradigm, proposing a re-examination of the conceptual foundations of the modern capitalist system, aimed at altering the necessary assumptions for greater consistency with the traditional agency relationship. The mere consideration of these issues constitutes, in some way, a first very positive step toward adopting best business practices as individualized entities of profitable economic intervention but also as integral elements of a structured social fabric built around its own values.

3.8 Profit vs. doing the right thing

In this line of thought, it has become almost commonplace to state that the relationship between financial institutions and their clients is robustly anchored in the appropriate basis of trust established between the parties. We argue, however, that trust does not depend on economic laws nor is established by decree... it is born and develops around the contributions made by the parties in pursuing common objectives. It seems evident, therefore, that an approach to the crises of the financial system, which does not exhaust itself in seeking technical solutions of an economic or legal nature, but seeks alternatives to re-evaluate the very way of exercising the activity, could significantly contribute to the strengthening and consolidation of public trust in financial institutions, bringing it back to traditional levels and enabling that exercise to reassume characteristics of technical rigor, careful professionalism, and demanding concern for protecting the legitimate interests of clients that have usually characterized it. It may also contribute to altering the value frameworks where easy profits and gain at any cost constitute ends in themselves, replacing them with lasting social values more aligned with respect for human dignity as a person: "The professional concerns himself with doing the right thing rather than making money, knowing that profit takes care of itself if the other things are attended to" [52].

In other words, trust in the financial system is built and maintained as long as it is anchored in solid compliance mechanisms that ensure alignment between the adopted practice and the required ethical posture: compliance, here construed in a broad sense of spontaneous disposition toward abiding by the letter of laws or any explicit and generally accepted rules; and ethics, in the sense of the willingness to make every possible effort also to conform to the spirit of those laws (or rules) as is generally intended, including compliance with the letter of laws whose adherence is not coercively enforced or verifiable [17].

4. Policy framework: Initiatives to strengthen banking ethics

4.1 Role of regulatory oversight in mitigating unethical behavior in financial institutions

Regulatory oversight plays a crucial role in mitigating unethical behavior by establishing a framework of rules, standards, and accountability. The promotion of ethical behavior by regulatory oversight may be achieved, namely, by:

i. Monitoring compliance

Regulatory oversight involves continuous monitoring of financial institutions to ensure compliance with established laws and regulations. Regular audits and assessments help identify and address potential unethical practices before they escalate into larger issues. For example, the monitoring of lending practices can prevent predatory lending behaviors.

ii. Enforcement and accountability

Regulatory agencies have the authority to impose penalties, fines, or sanctions on institutions that engage in unethical behavior. This enforcement mechanism serves as a deterrent, encouraging financial institutions to adhere to ethical standards. High-profile cases, such as the fines imposed on banks for manipulating interest rates (e.g., the LIBOR scandal), highlight the importance of accountability.

iii. Promoting transparency

Regulators often require financial institutions to disclose information about their operations, financial health, and risk exposure. This transparency allows stakeholders, including investors and customers, to make informed decisions and hold institutions accountable for their actions. Increased transparency can deter unethical behavior by making it harder to conceal misconduct.

iv. Encouraging ethical culture

Regulatory oversight can foster a culture of ethics within financial institutions by promoting the adoption of codes of conduct and ethical training programs. By encouraging organizations to prioritize ethical considerations alongside financial performance, regulators contribute to a more responsible banking environment.

v. Setting standards and guidelines

Regulatory bodies, such as the Basel Committee on Banking Supervision (BCBS) and the European Banking Authority (EBA), develop comprehensive guidelines that define acceptable practices within the financial sector. These standards address issues like risk management, capital adequacy, and corporate governance, helping to ensure that institutions operate within ethical boundaries.

In summary, regulatory oversight serves as a critical mechanism for promoting ethical behavior in financial institutions. By effectively implementing these measures

of strong risk management and governance, regulators can help mitigate unethical practices and restore public trust in the financial system. However, this must be supported by ethical standards. While restoring trust takes time, it is achievable, and banking supervisors have a role to play in this effort: "As 'trust comes by foot, but leaves on horseback', it may take a while before we see results, but I am confident results can be achieved. Banking supervisors should be aware of these issues and contribute to the process" [17].

4.2 The initiatives of BCBS and EBA

The strengthening of ethics within banking activity has received special attention from banking supervisors. Notably, the Basel Committee on Banking Supervision and the European Banking Authority have undertaken several initiatives. We emphasize that these initiatives highlight the responsibility of boards and senior management for defining conduct risk and promoting a robust corporate culture.

4.2.1 Basel Committee on Banking Supervision

Since 1999, the Basel Committee on Banking Supervision has been developing the so-called *Corporate Governance Principles for Banks*, with the most recent version dating back to July 2015 (1999, 2006, 2010) [53].

Regarding the topic at hand, the following illustrative references stand out:

Right in the *Introduction* (Point 14, p. 5), it refers to identifying cases of misconduct resulting, for example, from the improper selling of financial products to retail and business clients or from manipulating financial markets (such as the manipulation of Libor rates and exchange rates). Consequently, it emphasizes the responsibility of boards and senior management for defining the conduct risk of banking firms based on the context of their respective businesses[8] [54, 55]. The board must establish the 'tone at the top' and supervise the role of senior management in promoting and maintaining a robust corporate and risk culture, developing, in writing, an ethical code or code of conduct. Both codes aim to foster a culture of honesty and accountability to protect the interests of customers and shareholders.

Pertaining to *Principle 1. General responsibilities of management* (Point 29, p. 9), it points out that a corporate culture of reinforcing norms, appropriate for responsible and ethical behavior, is a fundamental component of good governance. Such norms are especially critical concerning a bank's risk awareness, risk-taking behavior, and risk management (i.e., the bank's 'risk culture').

Concerning *Principle 3. Administrative structure and practices* (Point 77, p. 18) and within other specialized board committees, it is recommended to have an *Ethics and Compliance Committee* (verifying compliance with the norms), to ensure that the bank has appropriate means to promote sound decision-making, duly consider reputation risks, and comply with laws, regulations, and internal standards.

4.2.2 European Banking Authority

On March 21, 2018, the European Banking Authority published *Guidelines on Internal Governance*, from which the following examples of references may be drawn [56]:

[8] In the same sense, see Group of Thirty [54]; European Systemic Risk Board [55].

- Management body's responsibilities should include setting, approving and overseeing the implementation of:...
  k. a corporate culture and values in line with Section 10, which fosters responsible and ethical behaviors, including a code of conduct or similar instrument; ... (Point 23, p. 9);

- Institutions may... establish other committees (e. g., ethics, conduct, and compliance committees) - (Point 41, p. 13);

- The management body should develop, adopt, adhere to and promote high ethical and professional standards, taking into account the specific needs and characteristics of the institution, and should ensure the implementation of such standards (through a code of conduct or similar instrument). It should also oversee adherence to these standards by staff. Where applicable, the management body may adopt and implement the institution's groupwide standards or common standards released by associations or other relevant organizations (Point 99, p. 25).

4.3 Defining a corporate culture guided by ethics

These guidelines emphasize the contributions of codes of conduct and the role of management in promoting an ethical organizational structure.

On the one hand, the contribution of so-called codes of conduct, as sets of rules voluntarily agreed upon by banks, defining standards for exercising activity in providing financial services to their respective clients [57, 58]. These codes aim for objectives relating to clients and to the banks themselves.

Regarding the former, they intend to delineate the framework of their positions in developing financial products and services. Regarding the latter, they aim to enhance public confidence in banks and the banking system as a whole by establishing ethical standards and principles of banking activity.

On the other hand, the key role played by management in developing an organizational structure based on ethical values, which should shape every decision-making process, guide managers and employees in adopting upright behaviors, and, in some way, consider the interests of all stakeholders, thereby preventing the costs of future litigations [59].

For this purpose, two elements are of special relevance: (i) the diversity in the composition of boards of directors, which should be welcomed as it improves the exchange of viewpoints and ideas among members, provided this is based on mutual trust and shared values; (ii) the role played by non-executive and independent directors, whose relative distance from management enables the board to maintain an objective and critical position in strategic decision-making.

4.4 Codes of conduct

In this context, it cannot be ignored that, given the behavioral nature ethics assumes, it is true that in many cases, moral and ethical relationships are closely related to legal norms. A clear example of this is evident by the compilation of conduct norms permeating banking legislations, for example, within EU Member States, especially regarding consumer rights protection (technical competency,

diligence, loyalty, discretion, neutrality, duty of information and assistance, fair competition, banking secrecy, etc.).

This results in legal breaches naturally generating conflicts of a moral and ethical nature. Thus, in the banking sector, ethics aims to determine behavior standards that prevent violations of financial legislation [60].

A lateral question concerns the oversight mechanisms regarding the behavioral aspect of banking activity. Still within the context of the EU, it is known that its supervisory architecture fundamentally rests on the pillars of prudential and behavioral oversight.

The European Central Bank (ECB) is assigned special powers regarding prudential supervision; however, there is no institution responsible for behavioral oversight, which remains solely under the jurisdiction of national authorities. The question arises as to how to overcome this lack of a single authority for behavioral supervision, with various hypotheses having been suggested: it could also be the task of the ECB, complementing its mission as the authority for prudential supervision; or the EBA, given that it has already been granted power for regulation and supervision; or a differentiated entity, to avert criticisms directed toward other proposed solutions.

Without delving into the discussion, it seems possible to subscribe to the greater reasonableness of the latter solution: "... one regulatory authority solely devoted to financial stability and other prudential oversight issues, and another regulator with responsibility for investor and consumer protection in light of scandals involving mis-selling of investments and financial products[9]" [61, 62].

5. Ethical banking: What future?

5.1 Early examples and subsequent development

Examples of ethical banking can be detected back in the sixteenth century when some Italian banks (Monte di Pieta), rooted in religious ethics and community support, financed local companies. The example and philosophy of operation were similarly followed by credit unions and cooperative banks during the nineteenth century, satisfying the financial service needs of entrepreneurs and the emerging middle class. However, it is at the end of the 1970s that the foundations of the first ethical banks are found, aimed at offering alternative models of ethically-founded finance and banking services [53].

5.2 What is an ethical bank: Fundamental principles

The function of an ethical bank is to "... work for the common good and ensure the right to receive credit through bank activity that involves raising funds and reallocating them in the form of credits for cultural, social, and environmental projects. Through their activity, ethical banks promote social inclusion, sustainable development, the social economy, and social entrepreneurship" [63].

Ethical banking is aware of how banking practices affect society and the environment and, although they seek profit like any other financial institution, they strive to achieve this objective without sacrificing principles or causing harm, operating

[9] Kern Alexander [61]; also Danieli Marina [62].

according to a set of ethical principles that govern how they interact with customers, the community, and the world at large [64].

The term embraces a broad range of ideas and concepts, including banks lending and providing financial assistance to environmentally friendly startups, to those serving struggling communities, or helping individuals seeking affordable housing.

The inclusive nature of the term affords banks great flexibility in terms of defining the precise nature of their operational modalities. Nonetheless, they generally adhere to certain primary characteristics concerning ethical guidelines:

- Client screening

The evaluation of clients in terms of financial soundness is accompanied by a screening process that allows the bank not to work with companies or individuals that do not maintain ethical practices.

- Community involvement

Interaction with the relevant community and the promotion of a healthy environment are essential for ethical banks, meaning their involvement can include projects as diverse as creating financing for affordable housing complexes, sponsoring community events, or establishing university scholarships for high school students.

- Consistency of ethics

Banks need to "walk the talk", maintaining alignment between their internal and external ethics, ensuring that everything the bank considers ethical externally must also be upheld internally. If, for instance, an ethical bank does not accept working with a company that does not hire disabled workers, it must begin by accommodating employees with various disabilities.

The ethical banking movement is supported by six fundamental principles, namely [65, 66]:

i. Triple bottom line approach

The heart of the business model resides in its (positive) social and environmental impact and sustainability.

ii. Real economy

Communities and service to the real economy form the foundation of ethical banking, allowing for new business models that satisfy the needs of both.

iii. Client centered

Creating long-term relationships with clients and a deep understanding of their economic activities and associated risks.

iv. Long-term resiliency

Adopting a long-term perspective on self-sustainability and resilience to external disruptions.

v. Transparency

A transparent and inclusive corporate governance, which means this inclusion entails an active relationship with a broader community of stakeholders of a bank, and not merely with its shareholders or its management.

vi. Culture

Incorporating all previous principles into the banks' culture.

This principled framework supports the exercise of socially and environmentally responsible banking activity, benefiting the real economy. In fact, it provides: (i) an alternative financing channel for individuals or companies that are financially excluded; (ii) allocates credit for social and profitable economic activities benefiting the community at large or the environment, even if presenting a return rate below the average financial rate of return; (iii) is transparent regarding credit allocation; (iv) favors reciprocity and cooperation compared to market-based organizations; (v) promotes lending practices founded on trust, in contrast to loan practices based on guarantees.

5.3 Why is ethical banking 'ethical'?

The 'ethical nature' of ethical banking derives from the fact that its principles are fundamentally intertwined with trust, stakeholder theory, and business ethics, creating a framework that emphasizes the importance of ethical conduct in financial institutions.

i. Trust

Trust is a cornerstone of banking relationships. Ethical banking principles prioritize transparency, fairness, and accountability, which are essential for building and maintaining trust among customers, investors, and the broader community. When banks adhere to ethical standards, they signal to stakeholders that they are committed to responsible practices, thereby fostering confidence and loyalty. Trust is particularly crucial in financial sectors, where customers rely on institutions to manage their resources responsibly.

ii. Stakeholder theory

Stakeholder theory posits that businesses should consider the interests of all stakeholders, not just shareholders. Ethical banking aligns closely with this theory by recognizing that banks have responsibilities to a diverse range of stakeholders, including customers, employees, communities, and the environment. By adopting ethical principles, banks can make decisions that balance profitability with social responsibility, ensuring that their operations benefit not only their owners but also society at large. This broader focus encourages banks to engage with stakeholders, understand their needs, and incorporate their feedback into strategic decisions.

iii. Business ethics

Business ethics involves the moral principles that guide the way a business behaves. Ethical banking practices emphasize integrity, fairness, and respect for all stakeholders. This aligns with the broader discourse on business ethics, which advocates for responsible corporate behavior. By embedding ethical considerations into their operations, banks can work toward preventing practices that lead to financial crises, exploitation, or discrimination. Ethical banking practices also encourage banks to engage in socially responsible investing, support local communities, and promote sustainable development, reinforcing the notion that ethical behavior is not just a legal requirement but a moral imperative.

In summary, ethical banking principles enhance trust by promoting transparency and accountability, align with stakeholder theory by recognizing the importance of all parties affected by business decisions, and embody the essence of business ethics through a commitment to moral conduct. Together, these elements contribute to the creation of a financial system that prioritizes ethical behavior, fostering a more sustainable and equitable economy. By integrating these concepts, banks can not only enhance their reputation but also contribute positively to society.

In other words, "ethical banking assumes holistic social responsibility, meaning it considers the social and environmental impact of all its actions. It commits to transparency in operations and clearly communicates its business practices and ethical values to customers. Moreover, it seeks to contribute to the well-being of society as a whole, not only through financial services but also through projects and programs that support social and community causes" [67].

5.4 Conventional banking vs. ethical banking: A comparative summary

We may compare conventional banking and ethical banking across various criteria, highlighting the differences in goals, investment criteria, and transparency (**Table 1**) [10][68, 69]:

5.5 Ethical banks: Advantages and challenges

Since the 1950s banking industry has faced pressure from civil society to become more environmentally and socially responsible, leading, for example, to (i) *the Collevecchio Declaration on Financial Institutions and Sustainability* (World Economic Forum, 2003), listing six fundamental commitments to: Sustainability, 'do no harm', responsibility, accountability, transparency and sustainable markets and governance; or (ii) the more extensive ten *Equator Principles* (2013) [70–72].

Banks have been criticized for neglecting certain segments of society and for their irresponsible lending practices, which have degraded the environment [73]. In response, alternative banking systems, such as ethical banking, have emerged, focusing on social and environmental responsibility [74, 75]. Ethical banks prioritize social and economic profitability over financial gains [76], earning them trust, social and economic profits [77]. An increase in demand for ethical banking was the response to the 2007 financial crisis, with customers seeking alternative options due to the

[10] Based on Francisco Climent [68]; also Jayasekera MAKDS, Pushpakumari MD. [69].

Category	Conventional banking	Ethical banking
Primary goal	• Seek only profit • Focus on shareholder value • Ensure high performance by managers	• Obtain benefits to ensure the bank's survival • Achieve positive social and environmental impact • Place the economy at the service of the people
Investment criteria and principle of involvement	Return on equity (ROE), return on assets (ROA), and risk diversification	• Negative criteria: Refusal to finance certain products (e.g., arms) and companies that violate human rights • Positive criteria: Desire to finance companies and projects that positively transform society • Application of principles of ethical banking: transparency, coherence, participation, and involvement
Criteria for granting loans	• Purely financial • Guarantees from applicants	An ethical committee evaluates the project from the ethical point of view and then determines whether it is financially viable
Target of funds	Financially profitable projects	Projects with values shared by partners and customers
Profit	Primary goal is to reward shareholders	Most ethical banks do not seek profits; profits are reinvested in social or environmental projects
Organizational model	One share equals one vote	In cooperative banks (the majority), one person equals one vote
Transparency	Regular ongoing training is not offered to funded projects	Regular bulletins on financed activities are provided
Coherence	Financing for projects that may not coincide with customers' values	Investment in activities that reflect customers' values
Participation	Only shareholders that have contributed sufficient capital participate	Most banks encourage and facilitate participation
Customers and their money	Customers cannot decide how their money is used	Partners or customers know and decide how their money is used

Table 1.
Comparison criteria between conventional banking and ethical banking.

irresponsibility and negligence of conventional banks [74, 78, 79]. Ethical banks have proven their stability during the crisis and are growing in popularity, with their asset bases increasing.

As noted by the *European Federation of Ethical and Alternative Banks and Financiers* (FEBEA), on the presentation of its 7th Report, when comparing 60 major European banks, directly supervised by the European Central Bank (ECB), with 26 Ethical Banks from GABV and FEBEA using the CAMEL model, analyzing capital, asset quality, management, profitability, and liquidity, "the result shows a picture where Ethical Banks are as solid as traditional banks but show a stronger tendency

to support the real economy. Specifically, nearly 70% of Ethical Banks' assets are allocated to credit for the real economy, compared to only 51.6% for traditional banks, which favor lower-risk financial assets such as government bonds or more speculative instruments" [80].

This same report shows that the total assets of European ethical banks continue to grow – € 79.2 billion (2022) [81].

The stability shown by Ethical banks, during and after the 2007 financial crisis proves, to the fullest, their ability to be an alternative answer to the conventional banking system [82].

Along with these advantages, the challenges faced by ethical banks, that threaten their future, should not be forgotten. Some main challenges may be underlined [83]:

i. Viability - Ethical banks are more prone to bankruptcy due to their smaller size and the difficulty of balancing financial performance with social and environmental goals.

ii. Competition - Traditional banks are now offering products similar to those of ethical banks, increasing competition for the same market segment.

iii. Legal framework - Ethical banks lack specific legislation and legal incentives, which hinders and limits their activity, as they are regulated by traditional banking system laws.

iv. Digital world - The need for adaptation and commitment to responsible practices by the ethical banking and finance sector, as a result of the use of technologies such as blockchain and smart contracts for transparent transactions, fintech innovations for financial inclusion, and an increasing focus on green finance and sustainable investments. Other important points include the ethical use of big data, the need for enhanced cybersecurity, and the integration of Environmental, Social, and Governance (ESG) factors in investment decisions. The ethical dilemmas related to technological advancements, the importance of gender diversity in financial leadership, and the need to balance profitability with sustainability. The future of this sector will face economic uncertainties and geopolitical tensions, requiring financial institutions to proactively confront these challenges in order to promote a more ethical and inclusive financial environment [84].

Concluding, ethical banks have emerged in response to societal pressure for responsibility and have demonstrated stability during financial crises. However, it must be recognized that they face challenges, including viability and competition from traditional banks, as well.

5.6 Ethical banking: A complement to or an alternative to traditional banking?

The understanding of ethical banking as an alternative to traditional banking has seen significant development in recent past: "Ethic banking is a real alternative to the current financial institutions, as a sector of banking that have been doing well in terms of business and social responsibility so far, and the banks that belongs to this group are sustainable and economically viable financial institutions" [85]; "Ethical banking represents a transformative force, posing a valuable alternative for the

conscientious investors and championing sustainability and social responsibility in the heart of finance" [66].

Some key points are to be considered regarding this conclusion:

i. Changing consumer preferences: As more people become aware of social and environmental issues, there is a growing demand for financial institutions that align with their values. This could lead to a significant shift away from traditional banks toward ethical banks.

ii. Trust and transparency: Ethical banks often emphasize transparency and community engagement, which can attract customers disillusioned with traditional banking practices. If ethical banks can demonstrate better practices, they may replace traditional banks in the eyes of consumers.

iii. Financial performance: Studies indicate that ethical banks can be just as profitable as traditional banks while adhering to sustainable practices. If this trend continues, it could lead to a broader transformation in the banking sector.

iv. Technological advancements: The rise of fintech and digital banking allows ethical banks to offer competitive services, potentially drawing customers away from traditional banks that may be slower to adapt.

Even so, others consider that "... the ethical banking has not yet been developed as an alternative to traditional financial system, but as a complementary system. However, the principles, values and theories about ethical banking suggest that it could be a possible and good alternative especially during hard times of crisis" [86].

The arguments supporting this conclusion may be aligned with:

i. Niche market: Ethical banks often serve a specific segment of the market that prioritizes sustainability and social responsibility. Traditional banks can collaborate with ethical banks to offer a wider range of financial products to socially conscious consumers.

ii. Innovative practices: Ethical banking introduces innovative practices that traditional banks can adopt, such as transparent fee structures and community-focused investments. This can enhance the reputation of traditional banks and attract customers who value ethics.

iii. Investment opportunities: Ethical banks focus on projects that benefit the community and environment, providing traditional banks with potential partnerships for funding and investment opportunities that align with growing consumer demand for sustainability.

iv. Regulatory pressure: As regulations become stricter regarding sustainability, traditional banks may adopt ethical practices to comply, thus complementing the rise of ethical banking.

We conclude that whether ethical banking serves as a complement to or a replacement for traditional banking may depend on various factors, including consumer

preferences, regulatory changes, and the willingness of traditional banks to adopt ethical practices. It is likely that both forms of banking will coexist, with ethical banking pushing traditional banks to evolve and adopt more responsible practices. Ultimately, the financial landscape may shift toward a model where ethical considerations are integrated into all banking practices, benefiting both consumers and the broader society as technological pressures.

6. Conclusions: How to develop banking and financial ethics?

The examination of business ethics in the banking sector reveals a pressing need for ethical conduct, governance, and accountability to restore and maintain public trust and prevent future crises. The analysis of high-profile failures, such as Lehman Brothers, Silicon Valley Bank, and Credit Suisse, demonstrates how unethical practices can lead to significant institutional breakdowns and a crisis of trust within the financial system.

The importance of trust in banking is emphasized as a foundational element that affects customer relationships and overall market stability. Ethical banking emerges as a potential solution, promoting principles that align financial practices with social responsibility and environmental sustainability.

The relationship between financial institutions and their clients is complex, necessitating a delicate balance between profit maximization and ethical considerations. The ongoing debate between shareholder and stakeholder perspectives reflects the evolving nature of corporate governance in the financial sector.

Furthermore, regulatory oversight is essential in mitigating unethical behavior within financial institutions, fostering a culture of accountability, and enhancing public trust.

To address these challenges, we propose three thematic priorities:

1. Rebuilding trust: Trust is the cornerstone of banking relationships and must be actively restored through transparency and accountability. Financial institutions should prioritize open communication with stakeholders, ensuring that customers are informed about how their funds are managed. Building a culture of trust requires not only compliance with regulations but also a commitment to ethical practices that align with societal values and principles.

2. Embedding ethics in governance: Ethical considerations should be integrated into the governance structures of financial institutions. This includes establishing clear codes of conduct, fostering ethical leadership, and ensuring that management prioritizes long-term sustainability over short-term profits. Boards must be accountable for promoting a corporate culture that values integrity and ethical behavior, which can help mitigate conflicts of interest and enhance the overall ethical climate of the organization.

3. Reforming regulatory expectations: Regulatory frameworks should evolve to emphasize ethical behavior alongside compliance. Regulators must promote standards that encourage transparency, risk management, and accountability within financial institutions. Policies should support the development of ethical banking practices and provide incentives for institutions that prioritize social responsibility and sustainability in their operations.

Ultimately, the future of banking may depend on a paradigm shift that prioritizes ethical behavior and stakeholder interests, integrating these values into the core operations of financial institutions. Ethical banking could serve not only as a complement but also as a viable alternative to traditional banking, driving a transformation toward a more responsible and trustworthy financial landscape. As consumer preferences shift toward sustainability and ethical practices, the banking industry must adapt to meet these demands, ensuring that ethical considerations are woven into the fabric of financial operations for the benefit of society as a whole.

In conclusion, the future of the banking sector hinges on the ability to rebuild trust, embed ethics in governance, and reform regulatory expectations. By prioritizing these themes, financial institutions can create a more resilient and responsible banking environment that not only meets the needs of their clients but also contributes positively to the greater community.

At the end of the day, improving ethics in banking is a question of choice between two different perspectives: one justifying the idea that "*A banker is a fellow who lends you his umbrella when the sun is shining, but wants it back the minute it begins to rain*[11]."; the other, considering that "...; *the first thing is character. ... Before money or anything else*[12]".

But of course, this is a dynamic and never-ending story...

Author note

This text is partially based, revised and updated, in António Pedro A. Ferreira, O Governo das Sociedades e a Supervisão Bancária. Interacções e Complementaridades, Lisboa: Quid Juris, 2009, especially pp. 168.

[11] This quote has been attributed to several authors (*v. g.*, Ralph Waldo EMERSON, Mark TWAIN, Robert FROST, Philip LA FOLLETTE, Ambrose BIERCE), but whose paternity has not yet been possible to authenticate – Quote Investigator, April 7, 2011 [https://quoteinvestigator.com/2011/04/07/banker-umbrella/ - 27.12.2024].

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Author details

António Pedro A. Ferreira
Universidade Autónoma de Lisboa – Luís de Camões, Lisbon, Portugal

*Address all correspondence to: apferreira@autonoma.pt

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Chapter 16

The State of Corporate Governance in Private Banking: Challenges, Implementation, and Pathways to Effective Governance

Kawa Wali and Bnar Kareem Darwish

Abstract

Corporate governance in private banking is essential for achieving regulatory compliance, mitigating risks, and ensuring financial stability. This chapter explores the implementation of governance frameworks in private banks, with particular emphasis on the challenges posed by conflicts of interest, concentrated ownership, and legal and regulatory gaps, using a descriptive and analytical methodology. Adherence to Basel II and Basel III standards is highlighted as a critical mechanism to enhance risk management and solvency through robust controls, stress testing, and capital adequacy requirements. The chapter identifies barriers to effective governance, including internal misalignments, varying regulatory enforcement across jurisdictions, and resource limitations. By incorporating examples from different regions, it underscores the diversity in governance challenges and solutions, offering insights into context-specific frameworks. Recommendations focus on improving transparency, accountability, and stakeholder alignment to strengthen governance structures. This analysis contributes to the understanding of corporate governance's role in creating a more resilient and adaptive private banking sector.

Keywords: corporate governance, private banks, Basel standards, risk management, regulatory compliance

1. Introduction

This chapter examines the understanding and implementation of corporate governance in private banks, focusing on its effectiveness in achieving stability and regulatory compliance. Using a descriptive and analytical methodology, the chapter delves into participants' perspectives on governance as a fundamental discipline, revealing significant challenges rooted in legal and environmental factors. The findings demonstrate that, despite participants' solid understanding of governance principles, their implementation faces both internal and external barriers. The chapter also discusses

how compliance with Basel standards enhances risk management and solvency through stringent oversight procedures. By analyzing these barriers, this chapter offers important insights and recommendations for improving governance frameworks, paving the way for a more resilient banking sector.

1.1 Principal research question

How do internal organizational dynamics and external institutional factors affect the effectiveness of corporate governance implementation in private banks?

1.2 Guiding thesis statement

This chapter examines how internal and external constraints affect the effectiveness of corporate governance implementation in private banks, with a particular focus on regional variations in legal frameworks, regulatory maturity, and market conditions.

For example, in the Middle East and North Africa (MENA) region, governance implementation is often hampered by weak legal enforcement mechanisms and limited regulatory independence, leading to inconsistent compliance. In contrast, European private banks operate within more mature legal systems and integrated regulatory structures, enabling enhanced adherence to governance protocols. Meanwhile, South Asian banks may face mixed challenges—such as political influence and market volatility—that hinder governance consolidation despite their formal alignment with global standards. These contextual variables, including the robustness of the legal system, regulatory capacity, and market maturity, play a critical role in shaping governance outcomes across all regions.

2. The role of corporate governance in private banking

Corporate governance has emerged as a cornerstone for sustainable operations in the private banking sector, where maintaining trust, regulatory compliance, and financial stability is paramount [1]. In this context, private banks are unique due to their often-exclusive client base, distinctive shareholder structures, and exposure to conflicts of interest [2]. These characteristics necessitate governance frameworks that are not only robust but also tailored to address the specific challenges of private banking. Muhamad Ali et al. [3] investigated the impact of changes in accounting standards on earnings management, providing applied research spanning from 2003 to 2014. Their study shed light on the dynamic relationship between accounting regulations and financial manipulation, underlining the importance of robust regulatory frameworks to control unethical practices within the banking sector [4]. Moreover, Wali's [5] research on the detection of earnings management through a decrease in corporate income tax highlighted the critical need for transparency and accountability in financial reporting.

Wali [6] explored the influence of Dutch firms' performance on discretionary accrual models, highlighting the complexities of financial management and reporting practices. The study emphasized the importance of regulatory oversight and compliance measures to foster transparency and accountability within the banking sector, stressing the significance of maintaining ethical standards in financial operations.

2.1 The importance of governance frameworks for risk management

Private banks play a pivotal role in managing the wealth of individuals and institutions, which inherently brings added scrutiny from regulatory authorities and stakeholders [5, 6]. The implementation of corporate governance within this domain is therefore critical for mitigating risks, preventing ethical breaches, and ensuring adherence to regulatory standards such as those outlined in the Basel Accords. Effective governance frameworks facilitate risk management by fostering transparency, accountability, and robust internal controls. These mechanisms are particularly vital in aligning the operations of private banks with regulatory requirements while maintaining the confidence of high-net-worth clients. Recent studies offer context and support to the premise that a thorough understanding of governance is required for good management, particularly in the areas of environmental policy, crisis management, community development, and healthcare readiness. Participants' understanding of governance principles and practices is expected to improve their performance in these areas, which will benefit both their companies and the larger community. Furthermore, the study underlines the significance of aligning governance with changing accounting standards, identifying and preventing earnings manipulation, and responding to technological changes, all while adhering to stringent legal compliance and ethical principles. These insights offer valuable recommendations to policymakers and sector stakeholders for strengthening governance mechanisms and improving the sector's long-term sustainability and stability.

2.2 Governance challenges in private banking

One of the primary issues in private banking governance is the potential for conflicts of interest. These may arise due to the dual roles played by some stakeholders, such as being both shareholders and clients, which can blur the lines between fiduciary duty and personal interest. Additionally, the concentrated ownership structures typical of many private banks can exert significant influence on governance decisions, sometimes to the detriment of broader stakeholder interests [6]. These unique governance challenges underscore the need for private banks to implement tailored solutions that uphold the principles of fairness, independence, and accountability.

2.3 Adherence to Basel standards

Adherence to international standards such as those established by Basel II and Basel III has provided private banks with a framework to strengthen their governance practices. The Basel standards emphasize risk management and solvency, two critical areas where private banks face considerable challenges. By mandating rigorous capital adequacy requirements, stress testing, and supervisory reviews, these standards push private banks to adopt robust governance measures that enhance stability and resilience. However, the practical application of these standards often encounters barriers such as legal ambiguities, lack of skilled personnel, and varying levels of regulatory enforcement across jurisdictions [4–6].

2.4 Internal and external governance challenges

Private banks also face governance challenges shaped by internal conflicts, regulatory gaps, and legal constraints [6]. Internal conflicts may stem from

misaligned incentives among stakeholders, while regulatory gaps can create inconsistencies in governance application. Legal constraints, including differing interpretations of international standards, further complicate governance practices. Addressing these challenges requires not only a thorough understanding of governance principles but also actionable insights that can inform the development of adaptive frameworks.

The financial sector, both public and private, is confronted with issues such as inadequate laws, rules, and transparency. Private banks struggle to contribute to economic growth, particularly those lacking strategic departments, excellent practices, and international standards. The International Monetary Fund (IMF) [6] emphasizes the significance of corporate governance in developing human capital and mitigating risks. To enhance corporate governance, banks must promote awareness among all stakeholders and strengthen the role of administration in risk reduction, crisis prevention, and beneficiary rights protection. Banks may improve their performance, control, and client focus by applying corporate governance, thereby contributing to financial prosperity.

2.5 Conceptual framework of banking governance

In the past two decades, both the corporate world and, more specifically, the banking sector have faced several significant challenges. The adoption and integration of governance principles into banking operations has become imperative due to the rapid growth of the industry, increased competition, liberalization of financial markets, and the prevalence of financial misconduct. Understanding the motivations behind the adoption of bank governance, as discussed in the initial focus area, along with its key components, discussed in Section II, is vital. Furthermore, examining the broader dimensions of bank governance, which are discussed in detail in Section III, provides a comprehensive perspective [4, 5].

2.6 Rationale for the implementation of banking governance

The necessity of bank governance arises from the profound changes in the financial sector. The banking environment has undergone significant transformations due to the growth of the industry and the expansion of operational scope, both geographically and functionally. According to the International Monetary Fund [5, 6], these developments have contributed significantly to the transformation of the sector. Moreover, the emergence of nonbanking financial institutions as strong competitors has intensified competition in the market, forcing traditional banks to adapt their strategies. This shift toward adopting governance practices has been driven by various factors, including:

2.7 Financial liberalization

Financial liberalization has become a hallmark of modern financial systems and a key driver of economic progress. Throughout the twentieth century, it has become increasingly associated with the global trend of economic integration and financial policy liberalization. Al-Sayediya and Mohammed [7] describe financial liberalization as a set of measures aimed at reducing excessive regulation in the financial sector, limiting government monopolies, and promoting competitive practices.

2.8 Technological advancements and digital transformation

The banking industry has undergone a profound transformation due to rapid technological advancements and the widespread adoption of digital innovations. These changes have led to increased competition, especially from nonbank financial institutions that leverage advanced technologies. As a result, banks have realized the need to modernize their operations and integrate digital strategies to maintain competitiveness [8, 9]. Several factors have driven this shift:

1. Changing customer expectations: Customers increasingly expect seamless and efficient digital banking experiences. To meet these demands, banks have invested in digital platforms such as mobile applications and online banking systems.

2. Developing new financial products: Advances in technology have enabled the creation of new services, including robo-advisors, peer-to-peer lending platforms, and online payment solutions. Nonbank institutions, often less constrained by traditional regulations, have seized these opportunities, prompting banks to innovate.

3. Operational efficiency: Technologies such as automation, artificial intelligence, and data analytics have streamlined banking operations and improved risk management, fraud detection, and customer engagement.

Recognizing these developments, banks have placed greater emphasis on governance frameworks to address technological risks, ensure data protection, and comply with regulatory standards. Embracing technological innovations while adhering to governance principles is now essential to navigate a competitive landscape and deliver value to customers [10].

2.9 Definition of bank governance

Bank governance refers to the ways in which a bank's board of directors and senior management oversee its operations. It involves several critical responsibilities, including:

i. Setting the strategic direction and priorities of the bank, including ensuring returns to shareholders.

ii. Setting the risk tolerance levels of the institution.

iii. Effectively overseeing the day-to-day operations of the bank.

iv. Balancing the interests of all stakeholders, including shareholders, employees, and customers.

v. Aligning the bank's activities with applicable legal and regulatory requirements while ensuring safety and health in operations [11, 12].

3. The research methodology

This study uses both descriptive and analytical methods to thoroughly explore corporate governance in private banks. The main objective is to build a well-rounded framework that reflects the different elements and dimensions of governance, helping to better understand its impact and outcomes. To achieve this, the researchers carefully selected a diverse group of private banks that vary in size and location. These banks played a central role in the research, offering practical insights into how governance is applied and followed in real-world settings.

The primary tool for gathering data was a thoughtfully designed questionnaire, which focused on two key areas directly tied to the study's goals [12]. It was created to encourage detailed responses from experts, bank officials, and other important stakeholders, allowing for a deeper look into governance practices in the banking industry.

The first section of the questionnaire focused on the foundational aspects of governance—how it is defined, what its goals are, and why it matters in the banking world. It included eight carefully designed questions aimed at understanding how respondents perceive and interpret the core principles of good governance.

The second section shifted to the practical side of governance. It examined the specific strategies, rules, and processes that private banks use to implement effective governance. This part was split into two subsections with a total of nine targeted questions that explored respondents' experiences and views on how governance is actually carried out.

To analyze the responses effectively, the study used a standard five-point Likert scale. This allowed the researchers to systematically assess attitudes and perceptions about corporate governance across the selected banks. The sampling process itself was thoughtfully structured to ensure a wide range of representation, incorporating both purposive and random sampling techniques. This approach helped ensure that the findings were both reliable and reflective of the broader private banking sector.

Regarding the sample, the study sought comprehensiveness and depth. A combination of purposive and random sampling techniques was used to construct a comprehensive picture. Key individuals with governance-related roles were carefully selected, while the random sampling ensured that the views of various roles and banks were heard. The study involved 150 participants, representing approximately 79% of the total private banking employees in the region. This level of participation enhances the credibility and representativeness of the findings, ensuring that the combined insights reflect the current state of corporate governance in private banks.

4. Results

This section includes a description and analysis of the research variables. We also present the study's results and discuss them. The majority of participants (51.7%) are between the ages of 20 and 30, followed by those aged 31–40 (26.7%), 41–50 (16.7%), and those above 50 (5%). Females make up a bigger proportion (65%) than males (35%). In terms of education, the majority of participants (58.3%) hold a master's degree, while 23.3% have a diploma, and 18.3% have a bachelor's degree. None of the participants has a PhD. The majority (33.3%) have less than 4 years of work experience, while a sizable portion (26.7%) have a history in finance and banking. **Table 1** presents the descriptive statistics for the demographic questions in order to provide a comprehensive knowledge of the study's participants. These statistics provide an

Details	No		%
Age	20–30	31	52
	31–40	16	27
	41–50	10	17
Gender	Female	39	65
	Male	20	35
Education level	Diploma	14	23
	Bachelor	11	18
	Master	35	58
	PhD	0	0.0
Experience in years	Less than 4	20	33
	4–8	16	27
	8–12	9	15
	12 and more	15	25
Academic major	Finance and banking	16	27
	Economics	3	5
	Administration	10	17
	Accounting	16	27
	Computer	10	17
	Others	5	8

Source: Wali et al. [12] Descriptive data for population-related questions typically refers to statistics and information that provide a comprehensive overview of various demographic characteristics of the group or population being studied. These data are essential to understanding the composition, distribution, and trends among the sample.

Table 1.
Descriptive statistics of various demographic characteristics.

important lens through which we can distinguish the different traits and histories of the individuals participating, enriching our contextual knowledge of the research findings. We hope that this analytical lens will provide a nuanced perspective that not only encompasses the numerical data but also creates a vivid portrait of the participants, showing the unique fabric of their experiences and perspectives. **Table 2** presents descriptive data on the goals, significance, and notion of governance. As shown in **Figures 1** and **2**, Q1 has the highest mean score (4.133) out of all the questions, followed by Q7 (4.117), Q5 (4.100), Q4 (4.050), Q6 (4.050), Q8 (4.050), Q2 (4.017), and Q3 (3.967). The overall average is 4.062, indicating that respondents overwhelmingly agree with all of the questions on governance, its goals, and its significance. As a result of accepting the first premise, it is now demonstrated that governance exists and is important.

The second half of the study, separated into two subsections with nine questions each, focused on the concepts, principles, and tools for implementing governance. The researchers utilized a five-point Likert scale to collect data. A frequency distribution was employed to examine the replies, which was consistent with the study's aims. The sample was purposefully chosen, but it also had random elements, and standard deviation was used in the analysis. **Table 3** summarizes the foundations,

Inquiries	Strongly disagree		Disagree		Neutral		Agree		Strongly agree		Mean	Standard dev.
	N	%	N	%	N	%	N	%	N	%		
Q1	1	1.7	0	0.0	10	16.7	28	46.7	21	35.0	4.133	0.812
Q2	0	0.0	0	0.0	11	18.3	37	61.7	12	20.0	4.017	0.624
Q3	0	0.0	0	0.0	13	21.7	36	60.0	11	18.3	3.967	0.637
Q4	0avb	0.0	1	1.7	10	16.7	34	56.7	15	25.0	4.050	0.699
Q5	0	0.	1	1.7	12	20.0	27	45.0	20	33.3	4.100	0.775
Q6	0	0.0	1	1.7	8	13.3	38	63.3	13	21.7	4.050	0.649
Q7	0	0.0	0	0.0	10	16.7	33	55.0	17	28.3	4.117	0.666
Q8	0	0.0	0	0.0	7	11.7	43	71.7	10	16.7	4.050	0.534
Overall											**4.062**	**0.421**

Source: Wali et al. [12]. The total average is 4.062, suggesting that respondents overwhelmingly concur with all of the inquiries on the idea of governance, its goals, and its significance. It is proven that governance exists and is important as a result of this acceptance of the first hypothesis.

Table 2.
Descriptions of the governance idea, its goals, and its significance.

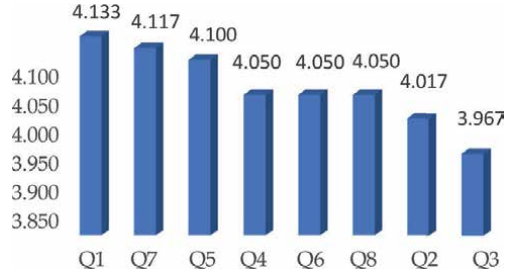


Figure 1.
The mean of each question on governance.

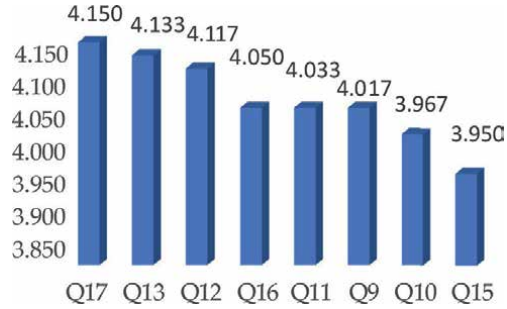


Figure 2.
The mean of each question on governance.

standards, and procedures involved in governance implementation. The study reveals some interesting insights regarding the responses received. Q17 had the highest mean score of 4.150 among the questions in this section, showing that participants have strong feelings about this specific issue. Q13 follows it with a mean of 4.133, Q12 and Q16 with a mean of 4.117, Q11 with a mean of 4.050, Q9 with a mean of 4.033, Q10 with a mean of 4.017, and Q15 with a mean of 3.967. Q14 has the lowest average score in this division, with a mean of 3.950. **Figure 2** shows such results.

The findings indicate that the surveyed experts and officials place a high value on Q17, viewing it as a critical component in the successful implementation of governance. Q13, Q12, and Q16 all obtained high mean ratings, indicating that they are highly valued features of government. Q14, on the other hand, had a considerably lower mean score, indicating that it may be seen as less significant in comparison to the other questions in the section.

4.1 Discussion

The study results provide clear evidence that participants possess a comprehensive understanding of governance and its various components, closely aligned with the theoretical frameworks outlined in the governance literature. Previous research confirms that effective governance depends not only on formal structures and policies but also on the understanding and commitment of stakeholders, e.g., [13, 14]. Participants' shared perception of the importance of governance supports this perspective and suggests that they are well-positioned to implement governance mechanisms that reflect best practices and the contextual realities within their

Inquiries	Strongly disagree		Disagree		Neutral		Agree		Strongly agree		Mean	St. deviation
	N	%	N	%	N	%	N	%	N	%		
Q9	0	0.0	0	0.0	11	18.3	36	60.0	13	21.7	4.033	0.637
Q10	0	0.0	0	0.0	16	26.7	27	45.0	17	28.3	4.017	0.748
Q11	2	3.3	0	0.0	9	15.0	31	51.7	18	30.0	4.050	0.872
Q12	0	0.0	0	0.0	11	18.3	31	51.7	18	30.0	4.117	0.691
Q13	0	0.0	0	0.0	10	16.7	32	53.3	18	30.0	4.133	0.676
Q14	1	1.7	1	1.7	12	20.0	32	53.3	14	23.3	3.950	0.811
Q15	2	3.3	1	1.7	5	8.3	41	68.3	11	18.3	3.967	0.802
Q16	0	0.0	1	1.7	6	10.0	38	63.3	15	25.0	4.117	0.640
Q17	2	3.3	1	1.7	5	8.3	30	50.0	22	36.7	4.150	0.899
Overall											**4.058**	**0.450**

Source: Wali et al. [12]. The total average is 4.058, suggesting that respondents overwhelmingly concur with all of the inquiries on the idea, showing that participants have strong feelings about this specific issue. And it is important as a result of this acceptance of the second hypothesis.

Table 3.
Statistical data for applying governance principles.

organizations. Descriptive statistics, such as means, reinforce this interpretation by providing quantitative insight into participants' perceptions of key elements such as transparency, accountability, and procedural fairness—principles widely emphasized in the literature [15, 16].

5. Conclusion and practical recommendation

5.1 Conclusion

1. Corporate governance is essential to maintaining stability and managing risk in the private banking sector, particularly in light of persistent issues such as conflicts of interest and regulatory asymmetry.

2. The Basel II and III frameworks play an important role in shaping governance by focusing on risk management and solvency, although their implementation remains inconsistent.

3. Internal imbalances and regulatory disparities hinder effective governance practices, particularly in jurisdictions with divergent legal interpretations.

4. Differences between jurisdictions highlight the need for flexible governance models that can adapt to local conditions while maintaining core standards.

5.2 Practical recommendations

1. Implement training programs for governance officers to improve capacity and awareness.

2. Promote the harmonization of enforcement standards across jurisdictions to reduce regulatory fragmentation.

3. Integrate digital tools for compliance tracking and real-time governance monitoring.

4. Promote stakeholder collaboration platforms to enhance transparency and collective decision-making.

5. Develop regionally adapted governance frameworks that align with international best practices, taking into account local legal and market realities.

Author details

Kawa Wali* and Bnar Kareem Darwish
Salahaddin University, Regional Kurdish Government, Erbil, Iraq

*Address all correspondence to: kawa.wali@su.edu.krd

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Chapter 17

Is It Possible to Implement New Regulations without Increasing Complexity and Cost? The Journey toward Suitable and Sustainable Wealth Management

Abigail Vasquez, Prof. Ari-Pekka Hameri, Dr. Pius Bienz, Virginie van Doorn, Dr. Anna Baranowska, Dr. Ilias Pnevmonidis and Dr. Stephan Zilker

Abstract

As banks transition toward sustainable and digital finance, they face increasing regulatory and cost pressures, alongside growing client demands for transparency, added value, and execution speed. This research investigates whether new regulations, such as Environmental, Social, and Governance (ESG) requirements, can be implemented without adding complexity or increasing costs. Using ESG suitability considerations in the Advisory Investment Process as a case study, this study developed a scalable methodology and toolbox grounded in lean management principles and advanced digital tools, validated with a sample of Swiss private banks. These findings underscore the potential for substantial process improvements, including possible cost reductions of up to 60% and a return on investment (ROI) of 84%, while ensuring regulatory compliance. Conducted within a Community of Practice framework, the research leveraged industry expertise and academic insights through an iterative design-science-based methodology. This chapter offers practitioners actionable solutions to optimize processes, supported by quantitative results from key advisory stages. For academics, it underscores the value of collaborative research, showcasing how a Community of Practice bridges theory and industry needs. By demonstrating the feasibility of combining efficiency with compliance, this study provides a roadmap to address regulatory challenges in wealth management and beyond.

Keywords: wealth management, ESG integration, lean principles, digital banking, process optimization, green finance, sustainable finance, financial services, regulatory compliance

1. Introduction

As the wealth management industry advances toward sustainable and digital finance, it faces mounting regulatory pressures, increasing operational costs, and growing client expectations for transparency, added value, and accelerated service delivery. A central challenge within this transformation is the integration of Environmental, Social, and Governance (ESG) principles[1], which has amplified stakeholder demands and necessitated substantial regulatory and operational adjustments [1–4]. In this context, financial institutions must balance compliance obligations with the imperative to innovate, raising a critical question: *Is it possible to implement new regulations without increasing complexity or cost?* [5, 6].

This chapter addresses that question through the lens of ESG suitability integration in the Advisory Investment Process. It introduces a practical methodology and toolbox grounded in lean management principles and advanced digital tools. By systematically eliminating inefficiencies and streamlining value delivery, this approach generates measurable benefits from the client's perspective [7, 8]. Findings from its application suggest the potential for cost reductions of up to 60% and a return on investment (ROI) exceeding 80%, while maintaining regulatory compliance.

The methodology was developed within the *Community of Practice – Compliance*, a collaborative platform uniting wealth management practitioners and academic researchers. It was validated through application in a sample of Swiss private banks. Key enablers of successful implementation included strategic leadership, strong top management support, a culture of continuous improvement, active employee engagement, and the effective use of enabling technologies.

The study is particularly timely, as ESG has evolved from a niche concern into a foundational component of investment decision-making [9, 10]. Incorporating ESG factors into financial analysis and portfolio construction enables alignment with long-term sustainability goals while targeting risk-adjusted returns [11, 12]. However, ESG integration presents significant challenges, including inconsistent and fragmented ESG data, jurisdictional divergence in regulatory frameworks, high implementation and reporting costs, and the need for substantial technological upgrades [13]. Additional barriers include limited internal ESG expertise, inadequate training for front-office personnel, and client skepticism, all of which hinder scalable and meaningful adoption.

To address these challenges, regulatory frameworks such as the Sustainable Finance Disclosure Regulation (SFDR), the EU Taxonomy Regulation, and the Corporate Sustainability Reporting Directive (CSRD) have introduced harmonized standards across the financial sector. While these initiatives promote transparency and mitigate climate-related risks, they also impose operational burdens. Chief among these are heightened reporting obligations requiring granular, auditable disclosures. Closely related are the substantial investments needed to upgrade IT systems, redesign data architectures, and ensure cybersecurity and data integrity. Institutions must also allocate resources to staff capacity-building and client communication enhancements. Taken together, these requirements significantly increase operational and compliance complexity, particularly for firms with legacy systems or limited digital maturity.

[1] The ESG framework encompasses three key dimensions: Environmental, focusing on ecological impact and governance; Social, addressing employee rights, diversity, and community engagement; and Governance, involving corporate transparency, shareholder rights, and ethical practices.

Financial institutions require strategic, system-level approaches that ensure regulatory alignment while enhancing efficiency and client value. In this context, lean management offers a compelling solution. Originally developed in manufacturing, lean principles focus on eliminating waste, reducing variability, and optimizing value streams [7, 14]. When adapted to financial services, Lean methodologies have proven effective in improving operational efficiency, regulatory compliance, and client experience [8, 15]. This research employs Value Stream Mapping (VSM) to systematically identify inefficiencies across the initial stages of the Advisory Investment Process, including client profiling, suitability assessments, and advisory workflows, thereby enabling targeted, data-driven process enhancements [14, 16, 17].

By reframing ESG integration through a Lean lens, financial institutions can transform compliance challenges into drivers of innovation and strategic value creation. This chapter provides a practical roadmap for achieving that transformation, combining Lean thinking with digital tools to meet evolving regulatory and client demands.

The remainder of this chapter is organized as follows: Section 2 presents the conceptual and literature foundations, including an overview of wealth management, ESG integration, and regulatory frameworks, as well as prior applications of Lean in financial services. Section 3 outlines the three-phase methodology developed in this study. Section 4 presents the case study findings and process improvements. Finally, Section 5 discusses key outcomes, limitations, and directions for future research.

2. Conceptual and literature foundations

2.1 Definition, scope, and trends of wealth management

Wealth management is a specialized discipline within banking focused on managing, preserving, and growing client wealth through integrated services such as financial planning, investment management, wealth financing, and a variety of services, including portfolio management, risk management, accounting, and wealth planning [5, 18]. Its client-centric approach aligns financial strategies with individual goals, fostering stability and long-term growth [6].

The wealth management industry is undergoing a significant transformation, driven by technological innovation, regulatory changes, and evolving client expectations. Advances in financial technology are improving scalability and cost-effectiveness while equipping relationship managers (RMs) with advanced digital tools, such as advisory suites, to provide personalized services and enhance client engagement [19]. At the same time, regulations such as the European Union's Sustainable Finance Disclosure Regulation (SFDR) and the Markets in Financial Instruments Directive II (MiFID II) have introduced stricter transparency requirements and mandated the integration of sustainability considerations into financial institutions' operations.

2.2 ESG integration in wealth management

The ESG framework constitutes a structured and measurable evolution of Corporate Social Responsibility (CSR), offering a strategic foundation for embedding sustainability into core business strategies and decision-making processes [20, 21].

Over recent decades, the integration of ESG principles has evolved from a niche consideration to a mainstream requirement, driven by growing stakeholder expectations and stricter regulatory frameworks. It entails the explicit incorporation of these

factors into financial analysis and investment strategies [11, 12]. Grounded in rigorous research, this approach systematically assesses the material impact of ESG factors on corporate performance and long-term portfolio returns, enabling the construction of diversified portfolios that not only adhere to minimum ESG standards but also advance sustainable development [9, 22].

2.2.1 Regulatory framework

Understanding regulatory frameworks is essential for navigating ESG integration in wealth management. As part of this research, an ESG regulatory depository platform was developed, providing streamlined access to ESG-related regulations. Organized by themes and types, the platform allows users to efficiently search and view regulations. If you are interested in this database and would like to get an overview or demo, please contact the first author.

At the EU level, the regulatory landscape is shaped by the European Commission (EC) through a series of initiatives designed to promote sustainable finance. These began with the Action Plan on Sustainable Finance in 2018, followed by the EU Green Deal in 2019 and the Strategy for Financing the Transition to a Sustainable Economy in 2021. Together, these initiatives aim to redirect capital flows toward sustainable investments, mitigate climate-related financial risks, and enhance market transparency. To achieve these objectives, the EC introduced legally binding regulations, either directly applicable or requiring transposition into national laws. Key regulations include the Sustainable Finance Disclosure Regulation (SFDR), the EU Taxonomy Regulation, and the Markets in Financial Instruments Directive (MiFID II), among others.

Key impacts on financial services

- *SFDR*: Financial Market Participants (FMPs) must disclose how they integrate sustainability risks into investment decisions, report on principal adverse impacts (PAIs), and update remuneration policies to include sustainability considerations.

- *EU taxonomy regulation*: FMPs must report the alignment of their products with the EU Taxonomy in periodic reports, varying by the product's sustainability ambition under the SFDR.

- *MiFID II*: MiFID rules related to ESG suitability require investment firms to integrate client sustainability preferences into suitability assessments.

2.3 Challenges and opportunities in ESG integration

While ESG integration offers significant potential, it also presents considerable challenges. Incorporating ESG factors into investment decisions increases complexity, as financial institutions must adapt existing processes by embedding ESG considerations into client profiling questionnaires, investment matching methodologies, compliance frameworks, and reporting systems. These adjustments require additional time, specialized resources, and advanced technological capabilities, thereby raising operational costs [9, 10]. Front-office personnel often struggle to communicate the value proposition of ESG-compliant investments to clients, particularly when faced with a limited supply of investment products that meet high ESG standards and

insufficient training opportunities [11, 13]. These difficulties are often exacerbated by the absence of clear, actionable top-down guidance, as many ESG-related regulations remain broad and non-specific, leaving financial institutions uncertain about how to implement them in practice [10].

The diversity and rapid evolution of regulatory requirements further compound these challenges, particularly for globally active financial institutions. Navigating high-level, non-prescriptive rules and applying specialized ESG terminology introduces communication barriers and operational strain [23, 24]. Market limitations—such as the small size and limited liquidity of green bond markets—also restrict the scalability of ESG investment strategies [25]. Additionally, inconsistent ESG data, often based on subjective third-party methodologies, fuels ongoing debates regarding data accuracy, reliability, and comparability. Initiatives such as the European Union's Green Taxonomy and the Sustainable Stock Exchanges Initiative aim to address these gaps; however, implementation remains uneven across jurisdictions [3, 13].

To address these challenges, a strategic solution is required—one that balances operational efficiency with regulatory compliance. The framework proposed in this chapter adopts a Lean-based approach to reduce complexity and streamline ESG integration across front-office processes. At the same time, it ensures effective risk management and cost control through the integration of decision-support tools, such as the compliance cost and risk calculator, developed as part of a parallel research stream. While a forthcoming article will present the calculator and its underlying risk evaluation methodology in detail, this chapter focuses on the Lean-driven solution that enables ESG integration to become a scalable, efficient, and practicable process.

2.4 Lean thinking in wealth management

Lean principles, originally developed within the Toyota Production System, focus on identifying and eliminating overburden (muri), inconsistency (mura), and waste (muda) from operational processes [8]. By emphasizing value from the client's perspective, Lean offers a robust framework for continuous improvement that combines operational efficiency with client-centered outcomes [26]. Womack and Jones [7] outlined five foundational principles of Lean: defining value from the client's perspective, mapping the value stream, ensuring smooth flow, aligning production with client demand (pull), and striving for perfection.

While lean principles have been highly effective in manufacturing, their application in service industries, including banking, requires careful adaptation to sector-specific dynamics. This is particularly true in high-end wealth management, as practiced by Swiss private banks, where customization and highly personalized services are central to the client relationship [15, 27]. By tailoring Lean methodologies to different models of wealth management, financial institutions can streamline processes, reduce complexity, and enhance both regulatory compliance and client satisfaction. The complexity of the banking industry, combined with its emphasis on client-centricity and the need for cost-efficient operations, makes it particularly well-suited for adopting lean management principles. By streamlining processes, reducing costs, and enhancing client experiences, Lean thinking provides a direct response to these challenges [28–30]. Furthermore, it elevates service quality, improves cost efficiency, and fosters employee engagement, enabling banks to deliver superior value while remaining agile in adapting to evolving client expectations [31].

Despite its benefits, the sector's reliance on high levels of customization often creates tension with the standardization emphasized in traditional Lean frameworks. However, advancements in technology are bridging this gap. Innovations such as data-driven insights, modularization, and automation have significantly reduced the cost and complexity of providing personalized services, allowing banks to offer bespoke portfolios to a broader client base [32]. Modern WealthTech platforms facilitate hyper-personalization[2] at scale, transforming inefficiencies into opportunities for optimization and client-focused innovation. By enabling banks to standardize the underlying structure while preserving individual client tailoring, modularization supports operational efficiency without compromising service quality. Womack and Jones [34] emphasize that Lean approaches can accommodate customization when value streams are carefully structured to eliminate inefficiencies without eroding client value. Private banks can leverage these technological advancements to reconcile the demand for tailored services with the principles of Lean efficiency [35, 36].

This research employs Value Stream Mapping (VSM) as the primary Lean tool to achieve these objectives. VSM provides a visual framework to identify inefficiencies, prioritize value-adding activities, and guide targeted process improvements [14, 16, 17, 37]. The following section presents the proposed VSM framework and illustrates its application within the Advisory Investment Process.

2.5 Critical success factors for lean implementation in wealth management

Lean implementation in wealth management requires a strategic focus on leadership, top management support, organizational culture, employee engagement, and technology to optimize efficiency and create value for the client. Leadership commitment is pivotal, fostering a culture of collaboration, transparency, and continuous improvement across all levels of the organization [38]. Moreover, advancements in technology, such as data-driven insights and automation, are crucial for bridging the gap between customization and standardization, empowering wealth managers to implement lean principles effectively while meeting client-specific needs. Addressing rigid bureaucratic structures that hinder adaptability and accurate performance measurement is critical, especially in traditional financial institutions [39, 40].

A client-centered approach, which prioritizes delivering value as defined by the client, is essential for minimizing waste while maintaining operational efficiency. This focus not only enhances service reliability but also addresses the inherent variability in wealth management processes, leading to improved client satisfaction. Engaging employees through tailored training programs and empowering them to contribute actively to process optimization further drives innovation and operational effectiveness [41]. Finally, leveraging advanced technological solutions plays a vital role in streamlining processes, reducing complexity, and aligning operations with lean principles, thereby achieving sustainable performance improvements in an increasingly dynamic and competitive landscape.

[2] Hyper-personalization at scale refers to the ability to deliver highly tailored services to individual clients through standardized, data-driven processes that operate efficiently across a broad client base [33].

3. Methodology: Lean implementation framework

3.1 Approach

This research presents a lean management-based methodology structured into three sequential phases. Each phase is designed to build a solid foundation for organizational maturity, ensuring stability and readiness before advancing to the next stage. **Figure 1** provides an overview of the three-phase methodology.

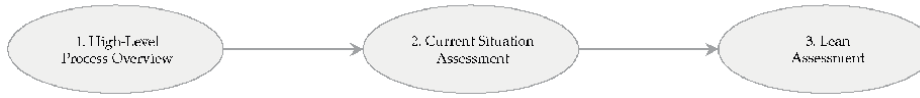


Figure 1.
Three-phase lean management-based methodology. Source: Own elaboration.

- Phase 1: High-level process overview
  - *Goal*: Obtain a broad understanding of the process, align business and compliance perspectives, and establish project organization.
  - *Approach*:
    a. Conduct discussions to gather high-level insights into the process.
    b. Align with stakeholders to understand key objectives, scope, and challenges.
    c. Collect supporting data, including documentation and preliminary observations.
  - *Deliverable*: A structured overview document including the process name, goal, scope, process owner, involved entities, key steps, IT tools, processing volumes and times, regulations, and identified problems.
- Phase 2: Current situation assessment
  - *Goal*: Analyze individual process steps qualitatively (who and how) and quantitatively (time and accuracy), and achieve stakeholder consensus on the current state.
  - *Approach*:
    a. Map the process, identifying key steps.
    b. Perform a qualitative analysis of key activities, responsible roles, inputs, outputs, systems/IT tools, documents/forms, and decision points.
    c. Conduct a quantitative analysis, focusing on processing time, waiting time, volume/frequency, and accuracy rate.
    d. Consolidate findings, assess risks, and validate with the process owner.
  - *Deliverable*: A Value Stream Map (VSM) of the current process, highlighting inefficiencies and opportunities for improvement.

- Phase 3: Lean assessment
  - *Goal*: Optimize the process by identifying and eliminating inefficiencies, reducing operational costs and compliance risks, and enhancing overall process performance.
  - *Approach*:
    a. Identify sources of waste and prioritize improvement opportunities.
    b. Conduct root cause analysis and propose targeted, feasible solutions.
    c. Validate proposed changes and assess their coherence, alignment, and impact on time, cost, and risk.
  - *Deliverable*: A Value Stream Map (VSM) of the future state, illustrating optimized process flows and enhanced efficiency. The output also includes a detailed list of required changes—spanning system configurations, personnel roles, IT support, training needs, and client communication protocols—alongside a cost-benefit analysis and a risk mitigation assessment.

Under the assumption that the results of this three-phase assessment are conclusive, necessary changes must be implemented; however, this falls beyond the scope of this research. From a continuous improvement perspective, actual cost reductions and risk exposures should be systematically compared with estimated values, with any significant discrepancies identified and analyzed. If substantial deviations arise, the assessment methodology should be reviewed and refined to enhance its accuracy and effectiveness.

4. Real-world case study: Enhancing the initial stages of the advisory investment process

This case study applies the proposed approach to the initial stages of the Advisory Investment Process, including client classification, Client Investment Profile, and Knowledge and Experience (K&E) assessment, and the Advisory Session, with a focus on improving efficiency while integrating ESG regulatory considerations.

4.1 Phase 1: High-level process overview

This subsection presents an overview of the Advisory Investment Process, detailing its goal, scope, organization, ownership, governance, key steps, supporting IT systems, processing volumes and durations, and relevant regulations.

4.1.1 Overview

- *Name of process*: Advisory investment process
- *Process goal*: Establish a structured framework to provide personalized client advice while ensuring regulatory compliance.

4.1.2 Organization

- *Process ownership and governance*: Managed by a process owner responsible for standards and compliance. Governance involves specialized committees ensuring suitability, compliance, and operational efficiency.

4.1.3 Process overview

The Advisory Investment Process consists of five main steps, as illustrated in **Figure 2**.

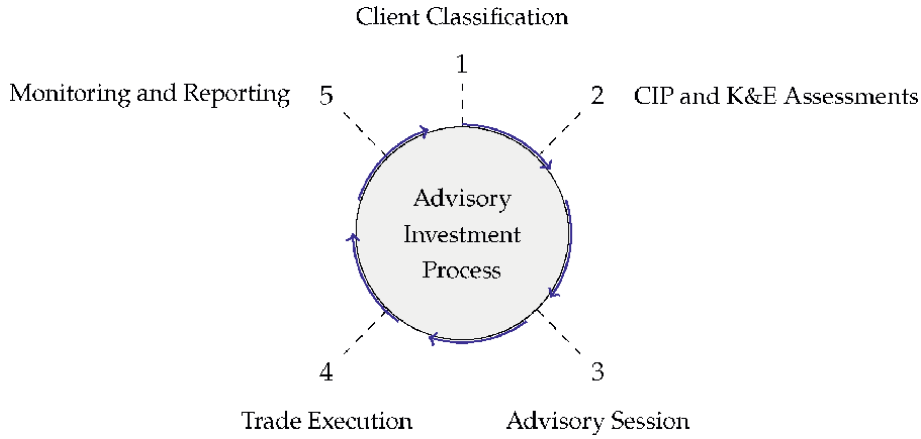


Figure 2.
Advisory investment process. Source: Own elaboration.

4.1.3.1 Client classification

Financial service providers classify clients into segments based on regulatory frameworks such as MiFID II[3], applicable within the EEA.

MiFID II establishes three client categories: Retail Clients, Professional Clients (Per Se and Elective), and Eligible Counterparties. This classification ensures that the level of protection and information provided aligns with the client's expertise, experience, and financial resources. Some banks may apply different criteria when classifying Per Se Professionals and Eligible Counterparties.

Clients are assigned Retail status by default unless they explicitly request an opt-up to Professional status or are reclassified by service personnel upon meeting defined conditions. As a best practice, reclassification should undergo a formal review process.

- Main output documents: Client classification form, if applicable.

[3] For Swiss private banks, MiFID II classification, if applied, generally pertains to EEA entities of Swiss banking groups or EEA-domiciled clients. Swiss client classification follows the Financial Services Act (FinSA), which is similar to MiFID II in terms of classification criteria.

4.1.3.2 Client investment profile (CIP) and knowledge and experience (K&E) assessments

The CIP aggregates all investment-related information, including the client's investment objective, risk profile (derived from financial risk capacity and tolerance), investment strategy, and ESG preferences.

The K&E assessment evaluates the client's investment knowledge across product categories and their trading experience. Clients claiming good knowledge must substantiate their expertise through professional background, education, or extensive trading activity.

- Main output documents: CIP form and K&E form.

4.1.3.3 Advisory session

The advisory session begins by classifying the transaction as investment advice or execution-only. This classification dictates the suitability and appropriateness checks, the mandatory documents to be provided to clients, etc.

- Main output documents: Clients are provided, where applicable, with mandatory documentation such as suitability reports, cost disclosures, and Key Information Documents (KIDs) before executing trades.

4.1.3.4 Trade execution

Once all suitability and appropriateness checks have been completed, the trade is executed. A record is created to document key discussions, decisions, and rationales related to risk and suitability.

- Main output documents: Post-trade information and trade confirmation.

4.1.3.5 Monitoring and reporting

Ongoing portfolio monitoring depends on regulatory requirements and contractual obligations.

- Main output documents: Periodic portfolio assessments and periodic cost reports.

4.1.4 IT systems and tools

- Client onboarding and profiling tools:
    - Client relationship management tool (CRM system): Handles different aspects of client management, such as account opening (KYC, investment profiles, legal documents), transaction monitoring, risk reviews, and client interactions.

- Client lifecycle management system (CLM system): Manages client data and interactions across all stages, including onboarding, Client Investment Profile (CIP), and task tracking.

- Advisory tool:

  - Supports the delivery of compliant, personalized advisory services by generating investment ideas, monitoring portfolios, and automating document creation. It ensures regulatory compliance while streamlining order execution for greater efficiency.

4.1.5 Regulations and internal policies relevant to the process

Main elements of the regulatory framework
Federal Act on Financial Services ("FinSA"); SR 950.1
Financial Services Ordinance ("FinSO")
Swiss Code of Obligations ("CO")
Directive 2014/65/EU on markets in financial instruments ("MiFID II")
EU Taxonomy. Regulation EU 2020/852 of the European Parliament and the Council
Sustainable Finance Disclosure Regulation (SFDR)
Main internal policies
List of internal policies relevant to the process. The exact list is confidential; see explanation below.

Source: Own elaboration.

Table 1.
Swiss/European regulations and internal policies relevant to the process.

The subject of these regulatory frameworks is integrated into the internal policies of financial institutions (**Table 1**). For instance, the sustainability-related requirements outlined in MiFID II are embedded in policies governing client and investment suitability, ensuring alignment with regulatory expectations.

4.2 Phases 2 and 3: Current and lean process assessments

This subsection presents a comparative analysis of the current (As-is) and lean (To-be) states of the process. The research focuses on the initial stages of the Advisory Investment Process, including Client Classification, Client Investment Profile and Knowledge and Experience assessment, and the Advisory Session. This scope decision was intentionally made by the research team.

To illustrate the developed approach, a detailed analysis of the Client Classification process is provided, along with a general analysis of the Client Investment Profile, K&E assessment, and the Advisory Session.

4.2.1 Client classification

As outlined in Subsubsection 4.1.3, client reclassification is permitted at the client's request, provided that the regulatory and internal criteria are fully met. This process, particularly relevant for transitions from Retail to Elective Professional status, was

selected as one of the case studies due to its high operational complexity, regulatory sensitivity, and frequent client demand in Swiss private banking. It involves multiple touchpoints across front-office and control functions, as well as manual documentation, which increases processing time and the risk of error or noncompliance.

Figure 3 and **Table 2** present a comparative analysis of the current ("As-is") and optimized ("To-be") workflows. These workflows were validated with a sample of Swiss private banks and illustrate the opportunities to streamline reclassification by eliminating redundant tasks, automating quality checks, and integrating front-office actions into digital client lifecycle management (CLM) systems. The Lean redesign not only reduces turnaround time but also enhances control and traceability and improves the client experience through increased transparency and faster processing.

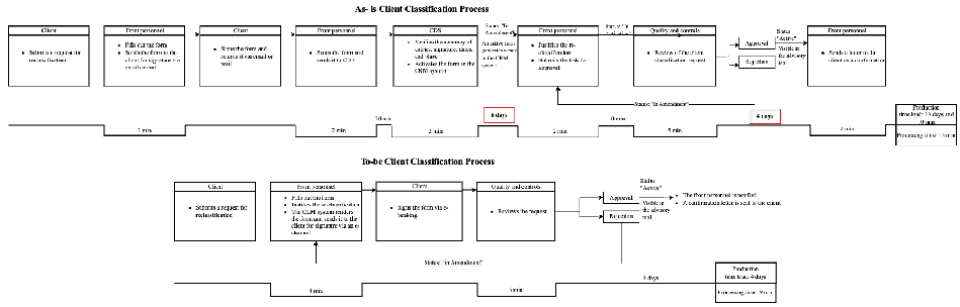


Figure 3.
Comparison of current and lean-state workflows for client classification, validated with a sample of Swiss private banks. Source: Own elaboration.

Process step	As-is process description	To-be process description
1. Client request for reclassification	The client submits a request for reclassification to become an Elective Professional.	The client continues to submit a request for reclassification to become an Elective Professional.
2. Form completion and distribution	Front-office personnel complete the form manually and send it to the client *via* email or mail.	Front-office personnel complete the form in the CLM system, add justification, and verify it using logic controls. The verified form is sent to the client's e-banking environment for e-signature.
3. Client signature	The client signs and returns the form *via* email or mail.	The client signs the form electronically *via* e-banking. Signed forms are forwarded automatically to the quality and controls department, notifying front-office personnel.
4. Form scanning and submission to CDS	Front-office personnel scan the signed form and send it to the Client Documentation Service (CDS) for activation.	N/A: This step is eliminated because the e-banking functionality allows the client to e-sign the form, which is then automatically routed to the quality and controls team.
5. Form accuracy validation and activation	CDS checks the form for accuracy, including signatures, date, and place, and activates it in the CRM system. A task is generated the next day.	N/A: This step is eliminated because date and place checks are automated in Step 2, and e-banking ensures signature validity.
6. Justification and submission for approval	Front-office personnel provide justification and submit the request to the quality and controls department.	Integrated into Step 2. Justification is added directly in the CLM system during form completion.

Process step	As-is process description	To-be process description
7. Quality review and decision	The quality and controls department reviews the request and either approves or rejects it. Approved requests update the client status in the advisory tool.	The quality and controls team reviews the request (form and justification). Approved requests update the client status in the advisory tool, and notifications are sent to front-office personnel.
8. Confirmation and completion	Front-office personnel send a confirmation letter to the client.	Upon approval, a confirmation letter is sent to the client automatically.
Total duration	10 days and 25 minutes	4 days and 9 minutes

Source: Own elaboration.
Note: Durations include both processing and waiting times.

Table 2.
Comparison of current and lean-state workflows for client classification, validated with a sample of Swiss private banks.

4.2.2 Required changes for enhancing the client classification process

As documented in **Table 2**, comparing the "As-is" and "To-be" workflows identifies gaps requiring closure. The related changes are categorized into system changes, personnel and IT support, skill development, and client communication, as summarized in **Table 3**. These proposed changes are then presented to the process owner, who decides about their implementation.

Category	Required changes
System changes	*CLM system*: • Render forms with field validation, secure distribution, and data integrity. • Allow front-office personnel to add justifications during form completion. • Restrict forms to the CLM system for centralized processing. *E-signature*: • Integrate e-signatures and automate forwarding. *Integration and security*: • Sync client classification status in the advisory tool in real time. • Strengthen sensitive data protection.
Personnel and IT support	• Define roles for front-office personnel and the quality team in the updated workflow. • Ensure adequate IT staffing for CLM system maintenance and support.
Skill development	*Training*: • Train front-office personnel and quality teams on new functionalities and e-signatures. • Improve digital literacy and regulatory compliance expertise.
Client communication	• Inform clients about e-signature processes with clear step-by-step guides.

Source: Own elaboration.

Table 3.
Required changes for enhancing the client classification process.

4.2.3 Cost analysis

Due to confidentiality agreements with our partner institutions, precise quantitative data cannot be disclosed. Nevertheless, the cost analysis was conducted using a structured estimation approach grounded in conservative assumptions.

The methodology accounted for average personnel costs, estimated monthly volumes, and measured reductions in process duration before and after optimization. To ensure accuracy, a correction factor was applied to account for overlapping tasks and multitasking in day-to-day operations, resulting in a more realistic calculation of time savings.

Implementation costs included a one-time investment in system upgrades, workflow automation, and associated support activities such as testing and stakeholder training. These cost elements were benchmarked against internal budgeting practices and validated qualitatively with operational stakeholders.

The following formulas were used to estimate time savings, annual labor cost savings, and return on investment (ROI):

- *Time savings calculation*
  - Time saved per classification:

$$\Delta T = T_{As-\text{is}} - T_{\text{To-}be} \tag{1}$$

where $T_{As-\text{is}}$ is the processing time before optimization, and $T_{\text{To}-be}$ is the expected processing time after optimization.

- Adjusted time savings: Accounting for overlapping tasks using the factor:

$$OF = \frac{\text{Working Time per Month}}{\text{Total Processing Time per Month}} \tag{2}$$

$$\Delta T_{adj} = \Delta T \times OF \tag{3}$$

where OF corrects for multitasking and non-dedicated task execution time.

- *Cost savings calculation*
  - Monthly time saved:

$$T_{\text{saved, month}} = \Delta T_{adj} \times N_m \tag{4}$$

where N_m is the number of cases or classifications processed monthly.

- Yearly labor cost savings:

$$C_{s,\text{year}} = T_{\text{saved, month}} \times W \times 12 \tag{5}$$

where W is the average hourly wage.

- *Net savings and ROI*
  - Net savings:

$$S_{net} = C_{s,\text{year}} - C_i \tag{6}$$

where C_i represents the one-time implementation cost.

- Return on investment:

$$ROI = \frac{S_{net}}{C_i} \times 100 \tag{7}$$

While numerical results are not shown, internal validation confirmed a potential cost reduction of up to 60%. These estimates reflect a conservative scenario designed to avoid overstating efficiency gains.

4.2.4 Risk assessment for proposed process enhancements

Especially in processes with strong regulatory constraints, improving efficiency requires careful consideration of its impact on risk levels. Developing an approach to identify, assess, and quantify these risks was a key objective of this research (detailed results to be presented in a forthcoming article). The impact of proposed changes on risk levels is a critical decision-making criterion.

The risk assessment evaluated residual risks by combining inherent risks with the effectiveness of the control environment. Key risks include client suitability, cross-border compliance, product and service risks, and technology gaps. Proposed improvements to client classification, client investment profile, knowledge and experience assessments, and the advisory session could enhance the control framework, thereby further reducing inherent risk.

4.2.5 General comparison of As-is and To-be process states

Table 4 presents a high-level overview of the initial stages of the Advisory Investment Process, comparing the As-is state with the proposed To-be state and outlining the key changes required for implementation.

Stage	As-is assessment	To-be assessment	Required changes
Client classification	• Manual form completion with multiple steps. • Signature and return *via* email/mail. • Total duration: 10 days, 25 minutes.	• Automated form completion with validation in the CLM system. • E-signature *via* e-banking with automated forwarding. • Total duration: 4 days, 9 minutes.	*System changes*: Implement dynamic forms, e-signatures, and automated workflows. *Skill development*: Train staff on the CLM system's new features and digital processes.
Client investment profile & K&E assessment	• Manual form completion and approvals. • Signature *via* email/mail. • Total duration: 5 days, 22 minutes.	• Form completion with logic validation in the CLM system. • E-signature *via* e-banking with automated workflows. • Total duration: 2 days, 2 minutes.	*System changes*: Integrate automated validations, e-signatures, and forwarding. *Skill development*: Enhance staff expertise in managing workflows and validations.

Stage	As-is assessment	To-be assessment	Required changes
Advisory session (Execution-only)	• Manual validation and order processing. • Total duration: 6 minutes.	• Fully automated validation and order processing. • Total duration: 1 minute.	*System changes*: Automate validation, data extraction, and order processing. *Skill development*: Train staff on system operations.

Source: Own elaboration.

Table 4.
Comparison of current and lean process states.

5. Conclusion and outlook

5.1 Outcomes in process optimization, cost efficiency, and risk mitigation

Is it possible to implement new regulations without increasing complexity and cost? This research demonstrates that regulatory compliance and operational efficiency are not mutually exclusive. By leveraging Lean methodologies, financial institutions can simultaneously enhance regulatory adherence and optimize operations. When applied effectively, Lean strategies can potentially deliver up to a 60% cost reduction and an ROI exceeding 80%, highlighting their ability to balance regulatory demands with operational innovation. By eliminating inefficiencies and prioritizing client value, financial institutions can navigate the complexities of regulatory frameworks while driving sustainable growth. Future research should further investigate the broader applicability of these findings, particularly their long-term impact on client satisfaction, operational resilience, and regulatory agility.

The findings of this study highlight the transformative potential of Lean methodologies, even within high-end wealth management, a sector characterized by highly personalized services for high-net-worth clients. For instance, streamlining the client classification process could reduce its duration from 10 days and 25 minutes to 4 days and 9 minutes, yielding a cost reduction of nearly 60%. Similarly, optimizing the CIP and K&E assessment process could shorten its duration from 5 days and 22 minutes to 2 days and 2 minutes, reflecting a 40% cost reduction. Furthermore, enhancements to the advisory session for execution-only transactions could reduce its duration from 6 minutes to 1 minute, potentially lowering costs by 83% and significantly improving operational efficiency. These results demonstrate the effectiveness of lean principles in optimizing processes and reducing costs. While compliance and client value were not directly measured, the observed efficiency gains may also contribute to improved regulatory adherence and enable faster service delivery for high-net-worth clients.

Although quantitative figures cannot be disclosed due to confidentiality constraints, the underlying estimation model is transparently documented and based on conservative assumptions. The cost and efficiency projections were derived from structured calculations, including time savings, adjusted overlap factors, and implementation cost benchmarks. These calculations were validated through internal stakeholder engagement with participating private banks, ensuring that the reported outcomes are both methodologically sound and practically feasible. As such, the study's findings reflect not only theoretical consistency but also real-world applicability within operational environments.

The proposed enhancements focus on system improvements, personnel and IT support, skill development, and client communication to optimize accuracy,

efficiency, and compliance. Recommendations include integrating digital tools such as electronic signatures, automated validations, document distribution, notifications, and streamlined workflows as central elements for improving operational processes. Clearly defined roles within operational and IT teams ensure accountability, while sufficient IT resources sustain these systems effectively. Equipping employees with expertise in digital tools, regulatory compliance, and workflow management through targeted skill development would facilitate seamless adoption. Transparent client communication, accompanied by clear guidance on updated procedures, is vital to minimize disruptions and ensure alignment. Top management support, active employee engagement, and stakeholder collaboration and validation are identified as critical factors for aligning these proposed changes with industry standards.

This study also demonstrates the potential of Lean methodologies to address sector-specific challenges, such as the need for high levels of customization and the complexity of regulatory demands. By leveraging tools like Value Stream Mapping (VSM) and adopting modularized workflows, financial institutions can achieve hyper-personalization at scale, transforming inefficiencies into opportunities for optimization and client-focused innovation. Additionally, integrating ESG considerations into Lean practices highlights the adaptability of these methodologies in aligning operational processes with sustainability goals.

Ultimately, this research offers a roadmap for achieving sustainable process optimization in financial services, showcasing how Lean methodologies can transform compliance challenges into opportunities for efficiency, innovation, and long-term growth. At the same time, certain limitations should be acknowledged.

The methodology was validated with a sample of Swiss private banks, and its broader applicability may be influenced by differences in regulatory frameworks, organizational cultures, and levels of technological maturity in other regions. Smaller institutions or those operating in less digitally advanced environments may also face implementation challenges. Nevertheless, the modular structure of the methodology allows for adaptation to diverse institutional contexts, offering flexibility for refinement and contextual application across different regulatory landscapes.

5.2 Learnings from ESG integration while maintaining lean processes

The integration of ESG requirements into the Advisory Investment Process revealed both challenges and opportunities, highlighting insights into maintaining lean principles in complex regulatory environments. ESG considerations added complexity to client profiling, suitability assessments, and advisory workflows, necessitating updates to CIP assessments, IT systems, and staff training to meet binding regulations.

Key challenges included prolonged processing times, inconsistencies in ESG data, communication barriers due to specialized terminology, and the "cluster effect," where employee disinterest in sustainability affected client perceptions. Limited training for front-office personnel further hindered effective engagement with clients.

Despite these challenges, the integration of ESG regulatory requirements confirms the assumption made in this research that implementing regulatory changes can create opportunities to improve efficiency and deliver client benefits. Reframing ESG as a value-driven initiative helps employees and clients recognize its financial and ethical advantages. Advanced IT systems, incorporating automated suitability checks and ESG data integration, have the potential to enhance operational efficiency while ensuring regulatory compliance.

5.3 Recommendations for future research

This research opens several avenues for future exploration to advance the integration of regulatory constraints in financial services, with a particular focus on ESG.

Future studies could apply the design-science-based approach to other banking processes, such as risk assessment, compliance monitoring, and operational management, as well as explore its application in other sectors of the financial services industry. Examining its use across diverse institutions and regulatory contexts could highlight regional variations and provide insights into the successful adoption of lean methodologies and ESG integration in different jurisdictions.

Long-term studies tracking compliance, client satisfaction, and financial performance would evaluate the sustainability of these enhancements. Measuring the risk level is equally critical for a complete evaluation, as it provides a comprehensive view of the effectiveness of process enhancements. Further details on the risk management approach and the development of a risk calculator tool will be presented in a forthcoming article.

From an automation perspective, implementing additional digital tools, particularly workflow systems that support end-to-end processes, could be highly beneficial. Emerging technologies, such as artificial intelligence, machine learning, and blockchain, offer significant opportunities to address inefficiencies, enhance ESG data accuracy, and automate workflows. Qualitative research involving employees, clients, and regulators could help uncover practical challenges and foster better alignment. Furthermore, developing metrics beyond traditional cost savings, such as client market gains and long-term outcomes, would enable a more comprehensive evaluation of improvements.

Finally, and more fundamentally, promoting ESG integration in sectors such as insurance, lending, and asset management could deepen the understanding of sustainability practices across financial services. By pursuing these directions, future studies can build on this research, fostering greater efficiency, sustainability, and compliance in the industry.

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Author details

Abigail Vasquez[1], Prof. Ari-Pekka Hameri[1], Dr. Pius Bienz[1*], Virginie van Doorn[2], Dr. Anna Baranowska[3], Dr. Ilias Pnevmonidis[4] and Dr. Stephan Zilker[5]

1 Business and Economics Faculty (HEC), University of Lausanne, Switzerland

2 Conser ESG Verifier SA, Geneva, Switzerland

3 Bank Julius Baer, Zurich, Switzerland

4 Banque Pictet and Cie SA, Geneva, Switzerland

5 Banque UBP, Geneva, Switzerland

*Address all correspondence to: pius.bienz@unil.ch

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Section 7

Sustainability, Climate Risk and Green Finance

Chapter 18

Climate-Related Financial Risk Disclosure: A Critical Review of Mapping and Mitigating Strategies of BIS and ECB Documents

A K M Kamrul Hasan

Abstract

Climate-related financial risk is a much more debatable issue in contemporary banking regulation literature. Bank for International Settlements (BIS) has issued detailed consultative instructions for the disclosure of climate-related risk for financial institutions and other member countries of BIS that are attempting to map and formulate mitigating strategies for climate-related financial risk. Besides, the European Central Bank has started to publish climate-related financial risk disclosures. This paper critically reviewed the BIS consultative document and climate-related financial risk disclosure issued by the European Central Bank (Eurozone). We shed an analytical light on how those prudential documents help to combat climate-related financial risk. In addition, we offer a primary framework to enhance the coverage of the disclosure of the climate-related financial risk of the bank. This paper contributes to the ongoing debate on mapping and mitigating strategies for climate-related risk. We offer a few policy recommendations to the regulator to tackle this issue more prudently.

Keywords: climate risk, financial risk, BIS, Eurozone, central Bank

1. Introduction

BIS has issued consultative instructions for the financial institutions in November 2023 to address climate-related risk disclosures [1]. Climate change or extreme weather (such as extreme heatwaves, drought, wildfires, and flooding) has been considered a top risk faced by the world's economies in 2024, and its severity will continue in the next decade [2]. "Human activities and greenhouse gas (GHG) emissions, in particular, are causing an increase in the Earth's average surface temperature, which in turn leads to increased climate variability and more frequent and intense extreme climate events" [3]. Climate change poses threats to financial markets and institutions, and there are two main channels through which climate change can affect financial stability [4]. First is

physical risk, which includes the economic costs and financial losses due to the increasing frequency and severity of climate-related weather events and the effects of long-term changes in climate patterns. Second, transition risk is associated with the uncertain financial impacts that could result from a rapid low-carbon transition, including policy changes, reputational impacts, technological breakthroughs or limitations, and shifts in market preferences and social norms [4]. Physical and transition risks can be translated into five types of financial risks: credit risk, market risk, liquidity risk, operational risk, and insurance risk [5]. Those financial risks obviously affect organizational performance and, ultimately, investors' decisions. To provide necessary information to all related stakeholders, such as investors, lenders, and insurance underwriters, about the appropriate assessment and pricing of climate risks, the Financial Stability Board (FSB) and Group of 20 (G 20) formed a task force in 2015 namely "Task Force on Climate-related Financial Disclosures" (TCFD). In fact, TCFD is the first global initiative to address climate change-related disclosures in a consistent and systematic way. TCFD, in its final report on climate-related financial disclosures, recommended four pillars of climate-related financial risk disclosure reporting format: (i) governance, (ii) strategy, (iii) risk management, and (iv) metrics and targets [6]. Later on, the TCFD reporting format was accepted by most countries, and "the 2021 status report shows that climate-related financial reporting is building momentum, with 2,600 organizations having adopted the TCFD framework, including 1,069 financial institutions responsible for $194 trillion in assets" [3]. By this time, the Bank for International Settlements (BIS) and the European Central Bank (ECB) have published detailed climate-related consultative documents and disclosures in 2023 and 2024, respectively. Both documents are comprehensive in nature and describe the methodologies of computation of climate-related risk, especially applicable to banks and financial institutions. We should note that other regulatory bodies' initiatives, like the Network for Greening the Financial System (NGFS), have released their second edition of "Guide on climate-related disclosure for central banks" in 2024 [7], which includes TCFD's four basic disclosure recommendations. It indicates that the NGFS document is an advanced and edited version of TCFD. The document advocates for how to respond to the four disclosures from the central bank's perspective. In a word, this is a comprehensive discussion on what to disclose and how to ensure the quality of disclosure. The missing issue is how to quantify the four disclosures that are not elaborated in detail in the NGFS document, whereas the BIS and ECB documents (which we referred to earlier) discuss the quantification of the disclosure elements in every stage and linked with the Basel framework pillar 3 disclosure both in qualitative and quantitative format. Hence, in this study, we focus on BIS and ECB documents, as those are more aligned with the implementation of climate-related financial risk disclosures in a broader landscape.

We should note that the objectives of pillar 3 in the Basel framework are to provide market participants with the key information necessary to understand a bank's risk exposures and the adequacy of its regulatory capital. In this sense, the BIS document ensures comparability. It maintains a prudential risk-based approach, which helps promote comparability of banks' risk profiles and enables market participants to access key information relating to a bank's financial risk exposures in relation to climate [8]. Hence, BIS and ECB documents could act as a catalyst for understanding TCFD and NGFS guidelines on climate risk-related disclosures of central banks.

In addition, since the issue is in the developing stage, little research has been done on the BIS and ECB documents mentioned above. The aim of the study is to fill this research gap and provide a brief and critical analysis of these two public documents.

In this paper, we shed an analytical light on these two documents and propose a primary framework to comply with the disclosures. The remainder of the paper is

organized as follows. The next section provides a deeper analysis of the core features of the BIS document. Section 3 presents the analytical review of core features of the ECB's published report on "Climate-related financial risk disclosure of the ECB's non-monetary policy portfolios." Section 4 presents a comparative discussion of both documents in the context of value addition. Section 5 provides a policy recommendation for regulators and concludes with remarks.

2. Core features of consultative documents: "Disclosure of climate-related financial risks" issued by BIS

It is argued that the quality of climate-related information is still evolving, and climate-related reporting has just started to be disclosed. The Basel Committee issued two documents to facilitate climate-related risk disclosure: "Climate-related

Qualitative disclosure	
Theme	**Details**
1. Governance	A governance framework has to be established to monitor and manage climate-related risk and opportunities. The main yardstick is that each bank has such an organogram in the organization.
2. Strategy	Banks and financial institutions develop strategies for mitigating climate-related risks and disclosing comprehensive information. In addition, there is a clear pathway to disclose quantitative metrics and transition plans.
3. Risk Management	Banks have to disclose their risk management organization, processes and procedures. Also, the disclosure of how to impair the potential risk through capital resources and liquidity positions is needed.
4. Concentration Risk	Track the change in risk exposure and concentration in economic, industry sectors and geographic regions due to climate-related risks (physical transition risk drivers).
Quantitative disclosure	
Theme	**Details**
1. Transaction risk	Transaction risk exposure and Sector-wise financed emission information.
2. Physical risk by geographical area	"Physical risks are defined as economic costs and financial losses resulting from the increasing severity and frequency of (i) extreme climate change-related weather events, (ii) longer-term gradual shifts of the climate, and (iii) indirect effects of climate change. Banks should disclose their exposures by geographical region or locations, subject to climate change physical risk".
3. Bank-specific metrics for quantitative climate disclosures	"Introduction of bank-specific risk metrics that would enable market participants to better assess the potential impact of climate-related financial risks on the safety and soundness of banks".
4. Disclosure requirements subject to jurisdictional discretion	The following three additional quantitative metrics are recommended to be disclosed subject to jurisdictional discretion: "(i) real estate exposures in the mortgage portfolio by energy efficiency level, (ii) emission intensity per physical output, and (iii) facilitated emissions related to capital markets and financial advisory activities."

Source: [1].

Table 1.
Types of disclosures.

risk drivers and their transmission channels" and "Climate-related financial risks – measurement methodologies" in 2021. Later, in 2022, BIS issued another document, "Principles for the effective management and supervision of climate-related financial risks." All three of these documents are relevant to climate-related risks and methodologies. Finally, in 2023, BIS issued a consultative document, "Disclosure of climate-related financial risks." In this section, we will focus on this consultative document. There are two types of disclosures: qualitative and quantitative. Both sections have specific yardsticks. The core feature of this document is as follows. **Table 1** shows the details of each section.

In addition, the document recommends that the local regulator assess the resilience of the bank's business models over different time horizons. The BIS committee proposed implementing the disclosure date from 1 January 2026. The document refers to a total of 54 consultative questions at the end of the document for further development of climate-related financial risk. We will discuss those in the later part of the paper.

3. Core features of "climate-related financial risk disclosure of the ECB's non-monetary policy portfolios"

The ECB published its first climate-related financial risk disclosure of non-monetary policy portfolios (NMPPS) in 2023 and, in June 2024, published its second edition. The disclosure follows the TCFD's full recommendations. The disclosure covers four themes: governance, strategy, risk management, and metrics and targets. Below, we quote and unquote the related text from the ECB's report.

Regarding governance, the report states that "the ECB continues to address climate change-related considerations within its existing governance structures and investment strategies. The Executive Board is supported in its oversight of climate-related risks and opportunities for the own funds portfolio by the ECB's internal Investment Committee (ICO), and for the staff pension fund by the Investment Committee in its Pension Fund composition (ICO/PF), which includes two staff representatives. Investment decisions in pension funds also fall under the scrutiny of the staff-elected ECB Pension Oversight Committee (OCO). Investment strategies incorporating climate change considerations are implemented by the ECB's portfolio management experts in the Directorate General Market Operations and Directorate Risk Management for the own funds portfolio and by external investment managers for the pension fund. The Executive Board regularly approves the investment strategies and interim and long-term sustainability targets for both portfolios based on the proposals of the ICO and ICO/PF" [9]. It is clear from this statement that the ECB has formed a high-profile committee to ensure governance and transparency in climate-related financial risk.

In the context of strategy, "the ECB's strategy is to align its NMPPs with the EU's long-term decarbonization objective in support of the Paris Agreement and the European Climate Law. To this end, the ECB presents interim emission reduction targets for corporate investments in its staff pension fund for the first time. The ECB has also bolstered its 2023 commitment to lower the emissions of its own fund's portfolio by adding an explicit climate objective for its investments, which is of equal priority to its pre-existing financial objectives" [9]. Besides, the ECB has invested in several green bonds issued by its member countries and other countries in the world. This was implemented in two ways: the purchase of green bonds

Sl no.	Key issues	BIS document	ECB document
1	Coverage	All areas of climate risk should be addressed in pillar 3.	Disclosed climate-related financial information is about the ECB's euro-denominated non-monetary policy portfolios.
2	Scope	All internationally active banks are required to follow.	Cover only the Eurozone.
3	Aspects	A policy framework for addressing climate risk under the Basel framework will be mandatory.	Implementation and disclosure of climate risk from the Eurozone context, with details about the achievements and future targets.
4	Timeline	The initial implementation date is 1 January 2026.	For the first time, the ECB disclosed climate-related financial information in 2023. It is published on an annual basis.

Table 2.
Main differences between BIS and ECB documents.

issued by other central banks and investment in the BIS green bond investment fund for central banks.

Regarding risk management, the ECB identifies, assesses, and monitors climate-related risks through a systematic approach that TCFD recommends. These are: (i) risk identification and assessment, (ii) review of the risk strategy and policies, (iii) implementation of risk-mitigating actions, and (iv) risk monitoring and reporting, all of which are supported by effective methodologies, processes, and systems [9]. "Carbon intensity metrics are used as a proxy for transition risks with a potential negative impact on the balance sheet, as policies adopted to align with the Paris Agreement can affect the financial position and performance of issuers and investment limits are monitored within the established risk management framework for the NMPPs" [9]. Therefore, the ECB comply with risk management of climate-related risks in line with the Paris Agreement and internal risk management policies.

Finally, the ECB publishes its metrics and targets comprehensively. The key metrics used by the ECB are the (i) weighted average carbon intensity (WACI), (ii) carbon intensity, (iii) total carbon emissions, and (iv) the carbon footprint. Each ECB's portfolio fund follows Paris-aligned benchmarks and a pre-defined self-decarbonization path [9]. ECB, in its disclosed report [9], has shown details of the fund's decarbonization achievement between 2022 and 2023.

Based on the above discussion in Sections 2 and 3, we could summarize the key features of the two documents in **Table 2.**

4. Comparative discussion on BIS and ECB documents

The Task Force on Climate-related Financial Disclosures (TCFD) and other regulatory frameworks seek to enhance the transparency and disclosure of climate-related risks within banks and other financial institutions. BIS document [1] is literally a text document, whereas ECB disclosure [9] is an example of an applied document. The BIS document is an advanced version of the TCFD recommendations, and the ECB report merely follows the TCFD recommendations. Both regulators, BIS and ECB, attempt to establish a formal reporting format on climate-related financial risks, which could be evidence for establishing a link between financial stability and climate risk. Both reports support contemporary scholars' findings. For instance, Fan and Gao

[10] conducted an empirical study on European regional and international financial institutions from January 2000 to December 2020 to examine how financial stability, climate change, and green finance are interrelated. They found a strong link between financial stability and climate change.

BIS guidelines help to understand the measure of climate-related risks and the techniques to mitigate such risks. To illustrate, five templates have been developed by the BIS to explain the reporting format of transition and physical risks. Template 1 addresses transition risk by sector, template 2 deals with exposures subject to physical risk, template 3 explores transition risk by real estate exposure, template 4 addresses transition risk, that is, emission intensity per physical output and by sector, and template 5 report transition risk, that is, facilitated emissions related to capital markets and financial advisory activities by sector (see [1], pp. 20–32).

Indeed, the BIS document addresses the climate risk mapping approaches and provides regulatory insights to mitigate the risks. In addition, in the consultative document, BIS document [1] refers to several consultative questions and asks for feedback from stakeholders. We will not continue our discussion on the question to keep our discussion on track. Regarding the document [1], the European Banking Federation (EBF) commented this way: "The pattern of the consultative question is summarized in **Table 3**. Indeed, the BIS guidelines provide a comprehensive light to the deeper analysis of climate-related risk and are helpful for banks to address future risks. The main benefit of the Pillar 3 framework is establishing the transparency and comparability of the information to be provided to market participants while maintaining the right balance between its usefulness for market participants and the effort required from institutions, without undermining their business model" [8].

ECB's report quantifies all themes and translates the TCFD recommendations in a meaningful way. For instance, the ECB disclosed all key climate-related risk metrics and explained how the index is built up. The ECB disclosure would be considered a

Sl no.	Questions No.	Theme of the questions
1	1 to 10	General
2	11 to 16	Qualitative disclosure
3	17 to 23	Quantitative disclosure: General
4	24 to 29	Quantitative disclosure: Transition risk: exposures and financed emissions by sector
5	30 to 33	Quantitative disclosure: Physical risk: exposures subject to climate change physical risks
6	34 to 36	Quantitative disclosure: Bank-specific metrics for quantitative climate disclosures
7	37 to 41	Quantitative disclosure: Forecasts
8	42 to 46	Quantitative disclosure: Concentration risk
9	47 to 48	Templates
10	49 to 51	Quantitative disclosure requirements subject to jurisdictional discretion
11	52 to 53	Effective date
12	54	Liquidity risk

Table 3.
Categorization of consultative questions referred to in the BIS document [1].

benchmark for other central banks or large banks reporting from the concept to practice. As we mentioned earlier, the prime metrics used in the ECB report to quantify the climate risk are the weighted average carbon intensity (WACI), carbon intensity, total carbon emissions, and the carbon footprint. ECB calculated the Weighted average carbon intensity (WACI) as the greenhouse gas emissions of a debtor/issuer divided by the debtor's/issuer's total revenue and weighted by the value of the creditor's/holder's investment as a share of its total investment portfolio (source: https://www.ecb.europa.eu). The computation process of other indicators is available in the report (see [9], p. 31). Those key indicators helped to set the interim decarbonization targets for the ECB.

ECB adopted a decarbonization target for its staff pension fund and own funds' portfolios. Staff pension fund which €2 billion in 2023 was invested in equities (67% of the fund), sovereign bonds (26% of the fund) and corporate bonds (6% of the funds) and others (1% of the fund) whereas the ECB's own fund portfolio's green bond investments provide €4.5 billion of funding for the low-carbon transition, of which over 90% is allocated to issuers located in the EU [9]. The report also reveals that the ECB targets to reduce the emissions associated with its staff pension fund and its own funds portfolio in line with the goals of the Paris Agreement and the European Climate Law [9]. For instance, ECB expects the carbon footprint of its staff pension fund to further decline by at least 40% by 2030 and by at least 70% by 2040, compared with 2023 and in its own fund's portfolio, the ECB aims to further step up its funding of the low-carbon transition by increasing the share of green bonds. By the end of 2024, the ECB aims to increase the green bond share to at least 25% [9]. This public disclosure shows that the ECB heavily invests in the low-carbon transition and climate solutions-related financial market instruments to decarbonize the real economy. It could be a real example of a policy experiment for other central banks or large banks to diversify their investment portfolio in the context of climate risk.

However, there are two issues that need to be addressed in the BIS document. First, once financial institutions are allowed to map their climate risk, there is an incentive for banks to undermine the climate risk. To avoid this, a sector-wise national database for decarbonization is required, and developing countries are far away from establishing such an information system. Until the preparation of such a database, the best temporary solution should be addressed in the document. Second, the mitigation techniques are not specific in the documents. The role of the central bank in this process should be specified and disclosed in the disclosures. The next section discusses how to resolve these two issues.

5. Policy recommendations and concluding remarks

Several developing countries in the Global South, like Bangladesh, Pakistan, and Nigeria, adopted the climate-related financial disclosure rules. However, it required a few years to implement the rules fully in the Global South countries. For instance, while reviewing the climate-related disclosure guidelines issued by the Bangladesh Bank (Central Bank of Bangladesh), it is observed that the country's central bank is set to fully implement the reporting system (i.e., full disclosure) in 2027 and introduced a limited supervisory reporting system in 2025 and 2026 [11]. Bangladesh followed the International Financial Reporting Standards (IFRS) (IFRS S2), which sets out disclosure requirements for climate-related financial risks and opportunities that are incorporated with the recommendations of the TCFD. However, the country's

central bank did not publish any mitigation measures for climate risks in the guidelines. As discussed in the previous section, the BIS and ECB, developed countries' regulators, issued the guidelines; however, they did not address any risk mitigation techniques in the documents. Perhaps regulators wish to keep the issue as the individual bank's responsibility and on a case-to-case basis.

In banking regulation, especially in the context of developing countries, we have observed that regulators are often trapped in the "regulatory capture" and "regulatory failure" syndrome while implementing new rules and regulations in the market [12]. While adopting climate-related financial risk disclosures, regulators may be trapped in these two syndromes. In addition, the regulator should provide specific policy measures for hedging the climate-related risks in individual bank cases. These two issues could be resolved by establishing separate third-party assurance institutions that will assess climate-related risks in lieu of individual banks. During the implementation of the Basel framework, external credit assessment institutions (ECAIs) played an important role in mapping the risk weights of exposures, which individual banks later used. Although the introduction of ECAIs has been criticized for their rating quality, it is still accepted by BIS and local regulatory bodies around the world [13].

From the above discussion, we have two policy recommendations for BIS and other regulatory bodies to map and mitigate climate-related financial risks. First, while mapping climate-related risks and publishing disclosures, a separate entity (we could rename it as "climate risk rating agency") could assess them instead of financial institutions. It could be made a liaison between the bank and the client (exposure). Regulators will approve and regulate the entity's licensing process. It could reduce the individual bank's opportunistic behavior to window dress the exposure to reduce its climate risk challenges. To avoid additional transaction costs, the entity should be a public entity. This entity is akin to external credit assessment institutions (ECAIs) under the Basel framework; however, the basic difference between the proposed 'climate risk rating agency' and the ECAIs is that the former should be state-owned and engage and specialize in the climate risk mapping process. **Figure 1** shows the preliminary framework for mapping climate risks through a separate entity ("climate risk rating agency").

Second, the central bank could establish a complete sector-wise database of climate risk conditions of the country and provide access to the database to all banks and financial institutions to reduce information asymmetry. It will help financial institutions to map and mitigate their climate-related financial risks. Once there is no

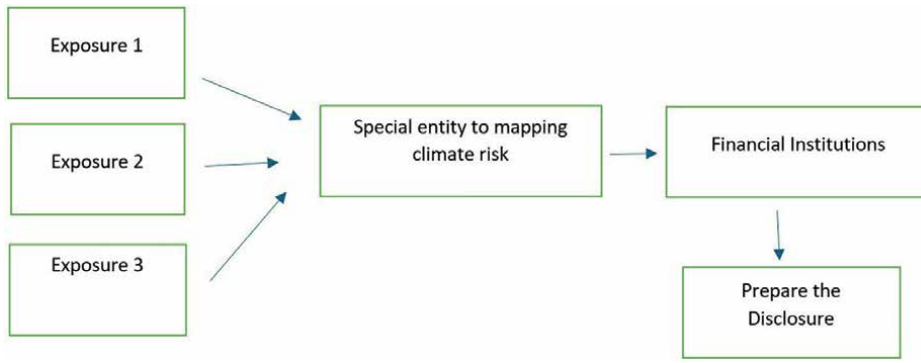


Figure 1.
Preliminary framework for mapping and mitigating climate risk.

information asymmetry, the disclosure becomes more transparent and reliable to the investors and other stakeholders.

Alternatively, in the short run, the EU, the EBA, or the ESRB might coordinate such a data repository for the developing countries. Local regulators or multi-donor agencies can invest in a standardized climate data platform.

The study has a few limitations. For instance, we have no empirical information to check the thesis that climate-related disclosures have deficiencies. As a result, our policy recommendation is based solely on theoretical concepts. In addition, we focus only on climate risk-related documents. However, the study does not consider discussing the ESG disclosures and IFRS S 1 and S 2 (which are related to sustainability and climate-related financial risks and opportunities, respectively) to keep focus on track.

To conclude, the work shed an analytical light on two key documents on climate-related financial risk disclosure issued by the Bank for International Settlements and the European Central Bank. We mentioned that disclosure is dynamic and evolving in nature. Advanced economies have just started to publish the disclosures (most Eurozone countries will start publishing them in 2023). Global South countries also took the initiative to publish the climate-related risk disclosures. Since the regulation is also evolving, we expect this research will be supportive of future research in the regulation of Climate-related financial risk disclosure. In addition, future research might empirically test how banks adopt the new BIS or ECB disclosure requirements once it is mandatory to comply, or in the future, the longitudinal data set could show whether these disclosures actually reduce climate-related financial risk.

Author details

A K M Kamrul Hasan
School of Business and Economics (SOBE), Westminster International University in Tashkent, Uzbekistan

*Address all correspondence to: hasan.hasanakmkamrul@gmail.com

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Chapter 19

Green Finance in the Global South: A Case Study of Bangladesh

A K M Kamrul Hasan

Abstract

The Global South suffers the most from global warming, deteriorating air quality, and so on. But it fails to put the green agenda on the table in a timely fashion. For instance, some South Asian economies attempted to address it in the early 2000s; however, due to governance and institutional failures, the greening agendas slumped. According to the Air Quality Life Index 2023, Bangladesh has the most polluted air in the world. It found that the air in Bangladesh had an average PM 2.5 level of 74 micrograms per cubic meter. Unplanned construction and transport pollution contribute more to making the situation worse. In this chapter, we investigate Bangladesh as a case study, which failed to capture the momentum of green finance. The country started to implement a green finance agenda in 2010, establishing a special fund funded by donor agencies, and the central bank provided policy guidelines for green finance in 2011. However, it seems that the poor capacity of banks and financial institutions to manage green projects, as well as the institutional failure of the central bank to monitor and lead the agendas, could be mentioned as prime reasons for the country's slow growth of green finance. Our institutional analysis shows that the central bank requires more independence to make decisions on the green finance agenda. We note that the central bank's independence is important for implementing green finance agendas in emerging economies; Bangladesh could be cited as an example.

Keywords: green finance, green banking, green projects, banking regulation, commercial bank Bangladesh

1. Introduction

According to United Nations (UN) Trade and Development (UNCTAD), Global South countries comprise Asia (except Israel, Japan, and South Korea), Latin America and Caribbean and Oceania (excluding Australia and New Zealand), mainly developing countries and the least developing countries [1] and environmental sustainability is a key challenge in the entire region [2]. Global South, especially the Asia region, is highly vulnerable to the consequences of climate change and related natural disasters [3]. Researchers put emphasis on green finance topics, including green bonds [4], the governance of Sustainable Finance [5], and greening monetary policy [6] to examine the sustainability of green finance projects. Bangladesh, a

low-lying country located on the Ganges–Brahmaputra Delta, "has some of the highest risk levels in the world to climate-related hazards such as cyclones and floods (flash, riverine, and coastal flooding) and more than 90 million Bangladeshis (56% of the population) are estimated to live in "high climate exposure areas" affected by "multiple hazards" [7].

Bangladesh ranks seventh on the list of countries most vulnerable to climate devastation, according to the Global Climate Risk Index [8]. The country is confronting climate change in several ways. For instance, Huq et al. [8] report that, "over the satellite era (1970–2015), sea level in the coastal zone of Bangladesh has risen by 3.8–5.8 mm per year, which is faster than the global average of 2.1 mm per year. There has been a 27% increase in salt-affected coastal areas since the 1970s, with consequences for crops and livelihoods." The International Monetary Fund (IMF) in its report states that a rise in sea levels and coastal erosion could lead to a loss of 17% of land surface in Bangladesh and 30 percent of food production by 2050 in the country [9]. Increasing high temperatures in Bangladesh are another concern due to climate change, and the country also experiences high temperatures in Asia, reaching above 35°C on 70 days of the year [8]. In fact, in the last 49 years (from 1971 to 2020), "the country's average temperature increased by 0.16°C per decade and projected to increase 0.41°C (−0.19°C, 0.76°C) from the historical reference period to 26.03°C (25.26°C, 26.65°C) for the period 2020–2039, and 0.89°C (0.45°C, 1.70°C) to 26.59°C (25.78°C, 27.56°C) for the period 2040–2059" [9]. We should note that the heatwave seriously affects food systems, livelihoods, and human health. In addition, the country is scheduled to graduate on 24 November 2026 from the United Nations LDCs category [10]. "The potential prosperity of Bangladesh, however, will depend on how strategically and holistically the key risks from climate change can be dealt with to reduce the impacts on resources, water and food security, infrastructure, livelihoods, health, and biodiversity" [8]. Based on the above statistics, we could consider Bangladesh a suitable case study for green finance struggles.

It is argued that decarbonization and financing in green projects by financial institutions in developing countries are crucial to the success of combating climate change. Bangladesh is the first country among the least developed countries (LDCs) to develop a national strategy with a clear vision to deal with climate-induced challenges [11]. The country has initiated the green finance projects in the early 2000s through several channels. The central bank of the country, Bangladesh Bank (BB), has introduced a revolving refinancing scheme of BDT 2.0 billion, which was established in 2009 with a view to broadening finance for green products or initiatives at a lower cost of funds, which increased to BDT 4.0 billion subsequently. Initially, six green products or initiatives were identified to extend the refinance facility under this scheme. Later on, considering market demand and expert opinions from the technical advisory committee, time-to-time experts, and stakeholder consultations, BB enhanced the eligible green products/initiatives for refinance under the scheme from 55 in FY20 to 68 products in FY22. Participatory banks/financial institutions (FI) are allowed to charge a maximum interest rate of 5–6% on financing green products/initiatives under the scheme [12]. Besides, in January 2016, a long-term refinancing scheme named the 'green transformation fund' (GTF) of 200 million USD was launched to ensure sustainable growth in export-oriented textile and leather sectors, conducive to the transformation of the green economy in the country. Despite this initiative, the refinancing scheme is not appealing to the financial institutions. The disbursement status of the refinancing scheme is shown in **Figure 1**.

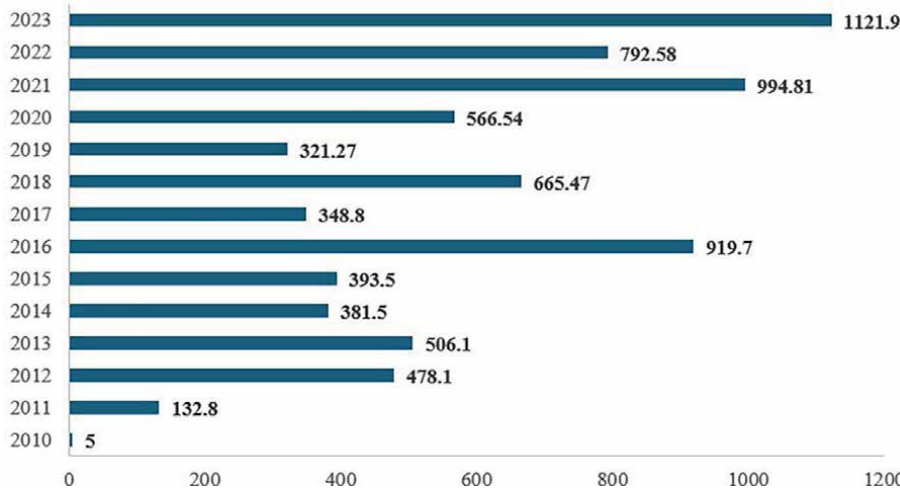


Figure 1.
Refinancing scheme of Bangladesh Bank (in Million Taka).

Recent statistics show that green finance consists of BDT 67.970 billion. The total amount of disbursement as green finance during July–September 2024 was BDT 65.85 billion by banks and BDT 2.12 billion by NBFIs, which is 5.64 and 78.64% lower than that of quarter 2, of banks and NBFIs, respectively [13]. Although previous statistics show that there is positive growth, the proportion of green finance in the total banking portfolio is still below the surpass level. For instance, in Q3 of 2024 (July–September 2024), only 30 Banks and 07 Finance Companies surpassed the target of green finance (5%) compared to the total term loan disbursement, which indicates that 50% of banks and 80% of finance companies could not be able to complete the target of green finance [13].

Contemporary scholars have increasingly focused on several factors that accelerate green finance and have viewed that in the absence of these factors, green finance would not flourish in emerging economies and would be considered an obstacle to green finance. These factors include good governance [14–16], quality of the institution [17–19], and regulations [15, 20, 21]. We discuss in detail all those factors in the following section. In the case of Bangladesh, governance, institutional, and regulatory capacity largely come to the forefront when the financial institutions' performance and menace are discussed. Due to gross irregularities in the country's banking sector, experts consider the 'regulatory failure' as the prime reason for the malaise in the sector and sectoral growth [22]. In the context of the combined third and fourth review of the IMF's Extended Credit Facility (ECF), Extended Fund Facility (EFF), and Resilience and Sustainability Facility (RSF), the IMF provided a few recommendations. These includes, "improving institutional capacity and ensuring more efficient use of resources will support progress toward climate objectives; improving governance and increasing transparency will play a vital role in creating a more favorable investment environment; institutional reforms to enhance Bangladesh Bank's (BB's) independence and governance will be critical for maintaining long-term macroeconomic and financial stability and for the successful implementation of financial sector reforms" [23]. As the government has been enforcing green finance agendas through the central bank, financial institutions are implementing the central bank's policies and guidelines; we primarily concentrate on governance, institutional, and regulatory capacity to analyze

the development of green finance in the context of Bangladesh. From the above discussion, the study raises the following research question,

> *Research question: Why is the growth of green finance in Bangladesh slow despite the country starting its journey toward green finance about fifteen years ago?*

We examine policy documents, official data from BB, and relevant literature to explore the research question. In other words, we adopt a desk-based approach to glean insights from the regulatory and institutional contexts. There is little research exploring the development of green finance in Bangladesh from an institutional approach. Hence, the chapter aims to fill this research gap through institutional lenses. This chapter investigates why financial institutions were reluctant to invest in green projects in the past decades and the role of institutions in the development of green finance in the country. The remainder of the chapter is organized as follows. Section 2 presents related literature on green finance and the contemporary debate on green finance. Sections 3, 4, and 5 address the issues related to governance, institutional capacity, and the regulatory role, respectively, in the context of green finance. Section 6 provides a brief discussion of the state of green finance in Bangladesh. Section 7 presents policy implications and a conclusion.

2. Theories on green finance and contemporary debate

Green finance includes the financing of tasks in various eco-friendly activities, such as renewable electricity, efficiency in strength, green industry establishment, green brick manufacturing, clean energy, pollution management, water management, climate change mitigation and adoption strategies, biodiversity safety and so on [24]. "Green Financing is a part of ethical financing and subsequently of Sustainable Finance. It is a means of promoting environment and resource conservation by

Sl no.	Category of drivers	Key indicators of the driver	Reference
1	Governance drivers	Government effectiveness	[30]
		Rule of law	[30]
		Control of corruption	[30]
		Voice and accountability	[30]
2	Institutional drivers	Incentive policies	[29]
		Political directives	[29]
		Banking regulations	[29]
		Capacity building	[29]
		Proactivity of the institution	[29]
3	Regulatory drivers	Government participation and support for green finance	[27]
		Regulatory incentives for green finance	[27]
		Mandatory legislation, standards, and climate-relative financial disclosures	[27]

Table 1.
Drivers of green finance.

reducing consumption of resources (e.g., electricity, water, moving away from paper-based transactions) through its operations" [25].

Ozili [26] articulated six theories on Sustainable Finance based on the nature of Sustainable Finance: the priority theory, the resource theory, the peer emulation theory, the life span theory, the positive signaling theory, and the system disruption theory. Based on an extensive contemporary literature survey, Debrah et al. [27, 28] identified four major categories of generic drivers: regulatory, financial, organizational, and environmental and social drivers that influence green finance in the developing countries. Besides, Sossou and Moyegue [29] and Liu and Zhang [30] describe the relationships of institutional factors and governance quality with the adoption of green finance, respectively, from the developing countries context. Considering [27, 29–31] approaches to green finance drivers in the context of emerging countries, we identified three key drivers and their indicators of green finance in the case of Bangladesh. These are governance drivers, institutional drivers, and regulatory drivers. The IMF also stresses the need to improve those issues in the case of Bangladesh [23]. **Table 1** describes each driver with relevant indicators and their references.

3. Governance and green finance

A well-documented contemporary literature has examined various factors affecting Global South green finance, such as governance, institutional capacity, central bank role, etc. Scholars have stated that governance is a major concern for the implementation of green finance in the Global South. For instance, [16] investigated the link between green finance and governance effectiveness in BRICS nations, and they found that in the long run, government effectiveness and CO_2 emissions have negative effects. They suggest strengthening the governance structure and supporting green finance mechanisms. In the context of China [30], scholars explore how government policies support China in accelerating renewable energy projects. In the case of India, the investigation reveals that state bureaucracies can impede the green financing of renewable projects [32]. Beasies [33] examined the case of Brazil and explored the role of governmental policies, such as financial incentives, in achieving sustainable development goals. Their approach particularly focused on how the country's renewable energy is supportive of achieving SDGs. Through qualitative research, [5] explores Indonesia's governance issues and green finance. The extensive interview with various stakeholders has identified that existing regulations have failed to identify key incentive/disincentive mechanisms for promoting Sustainable Finance in Indonesia [5]. Therefore, from the governance context, scholars identified two factors that have recently expedited green finance: governmental support in terms of incentives and proper disclosure to ensure the effectiveness of green finance.

4. Institutional quality and green finance

According to Polanyi [34, 35], a renowned economic sociologist, economic growth and social institutions are interrelated, and self-regulating market demands quality of institutions that are clearly separated from any political and economic interference. In that sense, institutional quality depends on how the market behaves. Institutional quality included legal structure, corruption, expropriation risk, degree of corruption, and bureaucracy quality [36]. In addition, the quality of political institutions, such

as law and order and democratic quality, is also considered a yardstick for measuring institutional quality. Contemporary scholars conducted research to find a link between institutional quality and green financing. For instance, [37] conducted a comprehensive analysis of the impact of institutional quality on sustainable development in 65 countries for a long period (1984–2019). They found a negative relationship between institutional qualities (such as government stability, control over corruption, law and order, democratic accountability, and bureaucracy quality) and CO_2 emissions. Sun et al. [38] conducted a panel data analysis of 46 countries from 2013 to 2022 to investigate the role of institutional quality in green finance. Their study reveals that strong institutional quality positively affects investing in green finance, and when institutions' quality is strong, the efficiency of green finance is significantly improved [38]. Rodríguez-Martínez et al. [39], while investigating a large dataset of 149 countries (from low-income to high-income), show that lower corruption positively impacts the environmental performance index. Hence, to execute green finance agendas, the quality of institutions matters.

5. Regulatory role and green finance

In the previous section, we described why institutions are important. To extend this argument, a rationale query is how institutions seem effective in achieving specific economic or political objectives. Eminent economic historian North [40] advocates that the organization should have enough power to enforce the law. North distinguishes institutions from organizations. Institutions are the rules of the game, while organizations are players in economic, political and social processes [41]. Khan [42] explains the role of institutions and the economic growth from rent and rent-seeking theories and advocates the 'political settlement' concept. Further empirical investigation on the role of regulators in Bangladesh researchers found evidence that corruption is a constraint to the enforcement of rules by the regulator in several sectors of Bangladesh. Islam et al. [43] conducted research on the reason for absenteeism by doctors in public healthcare facilities in rural Bangladesh, which is considered a critical problem by the government, and found that due to doctors' socio-political network, the Ministry of Health cannot take action against the absentees. In fact, the effectiveness of the implementation of any policy or contract depends on the power and capabilities not only of the actors directly involved as enforcers and rule-followers but also of other actors in the networks in which those actors are embedded [44]. To illustrate, Khan et al. [44] explore the effectiveness of governmental subsidies for Bangladeshi private power sector investment and found that only politically connected investors are likely to be bidding and negotiating the collusive pricing system, which creates an unhealthy market environment. Collusive contracting with private power plants in Bangladesh has resulted in high power prices that cost the taxpayer around U$1 billion in subsidies [44]. Amin et al. [45] also suggest phasing out subsidized tariffs and enabling a competitive market environment in the 'Captive Power Plants' of the country. However, the Bangladesh Energy and Regulatory Commission (BERC), the prime regulatory body for the energy sector in Bangladesh, is still not able to reform the pricing contract with private power plant companies. This evidence tells us about the inefficiency of the regulatory bodies in Bangladesh.

In the context of green finance, the role of the regulator on green finance varies from region to region, and it largely depends on an institutional framework, which determines regulators' objectives, functions, and power in the decision-making and

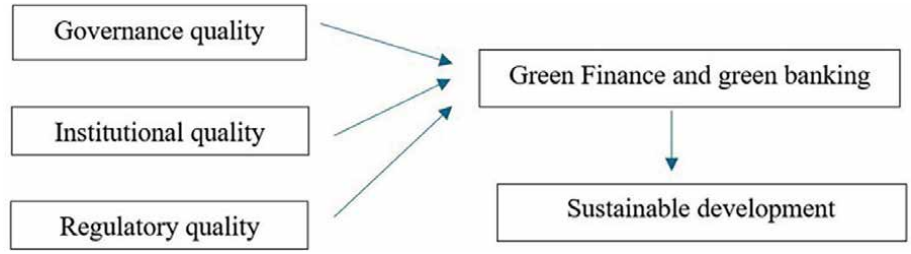


Figure 2.
Key driving factors of green finance.

execution of regulatory functions [46]. ADB conducted a survey among 18 central banks of Asia and the Pacific regarding green and Sustainable Finance in 2020. "The survey suggests that central banks can pursue the following areas to encourage green finance initiatives: (i) Incorporating environmental and climate change considerations in monetary policy and financial stability mandates, as well as in their own operations and practices; (ii) Undertaking studies on the impact of environmental and climate change risks on the domestic economy and players including the financial system; (iii) Promoting close collaboration and cooperation among central banks, regulators and other government/multilateral agencies to ensure that the physical and transition risks arising from environmental and climate change are well managed" [47]. Besides, Xia et al. [48] while analyzing the relationship between local governmental regulations and support for green finance in 30 provinces in China from 2009 to 2019, have found a nonlinear moderating effect on green finance development in China. Based on the above discussion, the key driving factors of green finance in Bangladesh is shown in **Figure 2**.

6. Discussion of the state of green finance in Bangladesh

6.1 Evolution of green finance policies in Bangladesh

BB has issued several instructions related to green finance since 2011 (See **Table 2**). BB first issued its Green Banking guidelines in 2011, and on November 6, 2024, it issued the latest instruction on its target in green finance. In its first guideline, BB instructed banks and financial institutions to initiate a 'Green Banking policy' and implement it in three phases, starting in 2011 and ending in 2013 [49]. Besides, two governance-related instructions were provided to the banks and financial institutions. These two are: (i) formulate a Green Banking policy and strategy approved by the Board of Directors and (ii) establish a separate Green Banking Unit or Cell that is responsible for designing, evaluating, and administering related Green Banking issues of the bank. The three phases are.

Phase 1: Banks are to develop Green Banking policies and show general commitment to the environment through in-house performance. Phase I was implemented on December 31, 2011.

Phase 2: Phase II should be implemented by December 31, 2012, and it includes specific sector-wise environment policies and disclosures and reporting of Green Banking activities.

Phase 3: Banks are expected to address the whole ecosystem through environmentally friendly initiatives and introduce innovative products. Standard environmental

Year	Reform development	BB instruction #
2011	Environmental Risk Management (ERM) Guidelines	BRPD Circular No. 01/2011
	Green Banking Policy Guidelines	BRPD Circular No. 02/2011
2013	Policy Guidelines for Green Banking	GBCSRD Circular No. 04/ 2013
2014	Minimum target of direct green investment was set at 5% of the total funded loan disbursement/finance for all Banks and FIs	GBCSRD Circular No. 04/ 2014
2015	Banks and FIs were instructed to form a "Climate Risk Find" having allocation at least 10% of their Corporate Social Responsibility (CSR) budget	GBCSRD Circular No. 04/ 2015
2016	Banks and FIs are instructed to set up "Solid Waste Management System", "Rainwater Harvesting", and "Solar Power Panel" in their buildings	SFD Circular No. 01/2016
2016	All banks and FIs must ensure the establishment of "Effluent Treatment Plant (ETP)" during financing/investing to all clients	SFD Circular No. 03/2016
2016	Banks and FIs to establish "Sustainable Finance Unit" and "Sustainable Finance Committee"	SFD Circular No. 02/2016
2017	Environmental and Social Risk Management (ESRM) for Banks and FIs along with a "Risk Rating Model" guideline issued	SFD Circular No. 02/2017
2017	A Comprehensive list of products/initiatives of Green Finance/ Investment for Banks and FIs issued	SFD Circular No. 04/2017
2018	A new uniform reporting format of Quarterly Review Report on Green Banking Activities issues	SFD Circular No. 01/2018
	Banks and FIs to monitor Green Banking policy and other regulations to ensure the quality and uniformity	
2019	Investment by Banks and FIs in any impact fund that is registered under BSEC (Alternative Investment) Rules, 2015, and formed for environmentally friendly sectors/purposes (resource, energy, renewables energy, waste management and treatment, women and child protection) will be considered as green investment	SFD Circular No. 01/2019
2020	Minimum target of Green Investment is set at 5% of the total funded term loan disbursement/finance for all banks and FIs	SFD Circular No. 04/2020
2020	Sustainable Finance Policy for Banks and FIs is issued, and new reporting format of Quarterly Report on Sustainable Finance is introduced	SFD Circular No. 05/2020
2020	Sustainable Rating Methodology for banks and FIs is issued	SFD Circular No. 06/2020
2021	Yearly "Target and Achievement" of Green Investment and Sustainable Finance is issued	SFD Circular No. 01/2021
2021	Target Fixation of Green Investment and Sustainable Finance	SFD Circular No. 03/2021 & 05/2021
2022	Guidelines on Environment and Social Risk Management (ESRM) for Banks and Financial Institutions in Bangladesh	SFD Circular No. 03/2022
2022	Green Bond financing for Bank and Financial Institutions	SFD Circular No. 05/2022
2023	Sustainable Finance Policy	SFD Circular No. 03/2023
2023	Sustainability Rating of Bank and Financial Institutions	SFD Circular No. 04/2023
2023	Guideline on Sustainability and Climate-related Financial Disclosure	SFD Circular No. 06/2023
2024	Sustainability Rating of Bank and Financial Institutions	SFD Circular No. 01/2024
2024	Minimum target of Green Investment is set at 5% of the total funded term loan disbursement/finance for all banks and FIs	SFD Circular No. 02/2024

Table 2.
Green finance-related instructions issued by Bangladesh bank (BB).

Phase	Timeline	Intended outcomes	Actual outcomes
Phase I	December 31, 2011	Banks would develop Green Banking policies	Partially achieved, Not all FIs were able to comply
Phase II	December 31, 2012	Disclosures and reporting of Green Banking activities	Partially achieved, Not all FIs were able to comply
Phase III	December 31, 2013	Introduce innovative green products	Partially achieved, Not all FIs were able to comply

Table 3.
Intended outcomes and actual outcomes of the three phases.

reporting with external verification should be part of the phase [49]. Phase III was implemented on December 31, 2013. However, there are gaps between the intended outcomes and the actual outcomes of the three phases, which are shown in **Table 3**.

6.2 Key achievements and shortfalls

BB issued a 'Sustainable Finance Policy' in 2020, and it was further revised in 2023. Indeed, Sustainable Finance Policy 2023 is a more comprehensive and extended version than the previous two policy guidelines. The policy guidelines have five chapters: Sustainable Finance, Sustainable Finance Taxonomy, Green Taxonomy, Target, Rating and Rewards, and Exclusion List and Inclusion Criteria of Products/Projects/Initiatives for Sustainable Finance [50]. To keep our discussion on track, we would not discuss all chapters rather focus on governance issues related to green finance mentioned in the latest guideline.

The policy identifies several benchmarks to identify green products that would ultimately be the green finance of the banks. These are (i) consultation and review of all national rules, regulations, guidelines, and perspective plans, (ii) climate fiscal framework (iii) environmental conservation rules (iv) green transformation fund (v) technology development fund. To monitor and screen the green finance projects, the mentioned policy instructed the banks and other financial institutions to follow the 'Environmental and Social Risk Management (ESRM) guideline 2022' and introduce an off-site supervision reporting mechanism. In addition, the policy proposed criteria for the fixation of green finance targets and offered incentives to the top-performing banks and FIs based on sustainability rating scores. However, it is observed that there are several shortcomings in the documents, such as governance and institutional quality issues, regulatory limitations to enforce green finance policies, which are largely responsible for the slow growth of green finance in the country. We describe those issues in the following two sub-sections.

6.3 Observed governance and institutional capacity issues

In a deep analysis of the Sustainable Finance Policy (SFP) issued by BB, it is observed that there are three major loopholes from the governance point of view. First, the SFP was introduced in 2020, and ESRM was introduced in late 2022, which makes it clear that the risk management system was introduced 2 years after the initiation of the SFP. Therefore, how to resolve the environmental and risk management issues in implementing green finance was unclear to the business managers from 2020 to 2022. However, once ESRM is issued, there is still a gray area for risk managers since there is no clear-cut risk weightage approved by the authority to consider

high-risk and low-risk profile credit. Hence, ESRM gives some hints about risk management but does not assign specific risk weights (as per the Basel framework) to green and non-green loans. As a result, managers make the decision on a 'green finance target' rather than a prudent and risk-based approach.

Second, the policy did not make it clear how the banks and FIs will monitor the green financing in the bank's balance sheet, since the green financing disclosure was not included in the disclosure. We noticed that BB issued a notification regarding Sustainability and Climate-related Financial Disclosure at the end of 2023 [50]. This disclosure is still limited to submission to BB, and it is not mandatory to make it publicly available. Finally, the policy did not specify the role of management and the Board of Directors in the case of non-compliance. It is presumed that the Board of Directors could easily shift their responsibility to the managers in terms of non-compliance with the policy, and managers select the green finance projects just to avoid responsibility.

The institutional capacity of the country has not noticeably improved over the last decades. For instance, as per the institutional quality index published by the World Bank, Bangladesh's institutional quality index is at the bottom level (see **Table 4**). **Table 4** shows how the institutional quality dropped from 2009 to 2022 when the country promoted green finance. Specifically, the 'regulatory Quality' and 'Voice and Accountability' sharply declined from 2009 to 2022, and other indicators were slightly improved over that period. However, most developing countries in the Global South face the same problems in their institutional quality index. In the case of Bangladesh, we observed that the green finance policy was revised multiple times, and the central bank reformed the policies frequently (see **Table 2**). It provides a strong signal that the regulator has failed to formulate a consistent regulation for green finance. Consequently, it revised the policy almost every year. Another reason for frequently changing the policy is that there are regular changes in the definition of green finance at the policy level; consequently, the central bank revised it. Whatever the case, it creates noise for the banks and financial institutions to finance green projects since the regulator changes its notification frequently. On the other hand, it is also incompatible for the regulator to work with its regulated institutions in different approaches each year. Perhaps such a low level of institutional quality is the prime reason that the banks are still not accustomed to green finance and are far behind the global greening trend.

6.4 Regulatory compliance challenges and others

Regulatory quality mainly indicates the ability of the government to formulate and implement sound policies and regulations [51]. As discussed in the previous Section 5, the enforcement of regulations in Bangladesh is weak in almost all sectors. There may be two reasons behind this: first, the technical incapacity of the regulator to create efficient regulations, and/or the fact that there are fewer resources to implement new regulations. Second, an external political and social network that is powerful enough to break the rules and the regulator is probably under 'regulatory capture'. We shall note here that green finance and Green Banking policies are formulated and monitored by the country's central bank. The central bank, although an autonomous body, is under the Ministry of Finance (MOF), and MOF has a mandate for the governance and administration of State-owned Commercial Banks (SOCBs) [52]. Such a mandate creates an imbalance in the enforcement of green finance rules and regulations between SOCBs and Private Commercial Banks (PCBS). Because the central bank

Year	Control of Corruption: Percentile Rank	Government Effectiveness: Percentile Rank	Political Stability and Absence of Violence/ Terrorism: Percentile Rank	Regulatory Quality: Percentile Rank	Rule of Law: Percentile Rank	Voice and Accountability: Percentile Rank
1996	17.7	27.3	26.6	17.9	20.1	50
1998	28.9	36.6	33.5	15.2	19	47.3
2000	6.9	31.7	24.9	16.3	20.9	44.8
2002	1.6	27.6	19	14.6	17.4	37.3
2003	0.5	23.2	16.6	16.8	14.4	31.8
2004	1	18.4	10.2	12.4	14.9	27.9
2005	2.9	18.6	4.4	15.2	17.7	30.3
2006	2.9	22.4	8.7	17.2	20.6	32.2
2007	13.6	26.7	9.2	18.4	23.4	31.3
2008	15	25.7	9.6	18.9	25.5	33.2
2009	*14.8*	*23.4*	*9*	*22*	*26.1*	*38.4*
2010	14.8	25.8	10	20.6	26.1	37
2011	13.7	25.1	9	22.7	28.2	36.2
2012	20.9	23.7	9	18.5	18.8	34.7
2013	21.3	23.7	7.6	20.4	20.7	34.7
2014	18.8	21.6	16.7	16.8	24	32
2015	21.9	23.8	10	17.1	25.2	30
2016	18.6	26.2	11	21.9	27.6	30.5
2017	18.6	22.4	10.5	20	27.6	30
2018	17.1	22.4	14.2	17.6	27.6	27.2
2019	16.2	24.8	15.6	15.2	27.1	26.6
2020	17.1	21	15.6	15.2	31.4	26.6
2021	18.1	28.1	14.2	20.5	28.6	28
2022	*15.6*	*24.1*	*13.2*	*17.9*	*29.2*	*28*

Source: World Bank. https://databank.worldbank.org/embed/InstitutionalQuality/id/1ae62b79?zm=n.

Table 4.
Institutional quality index of Bangladesh (1996–2022).

cannot discipline the SOCBs for non-compliance with green finance policies or failure to achieve the annual target of green finance. To illustrate this, it is observed from the latest green finance statistics that SOCBs disbursed a total of 2.30 billion BDT in green finance, which is 4.69% of the total term loan disbursement. In contrast, Private Commercial Banks (PCBs) disbursed an amount of BDT 52.58 billion in July–September 2024, which is 20.78% of the total term loan disbursement [13]. Besides, the performance of sector-wise green finance investment of SOCBs is dire in comparison to PCBs. To illustrate, in July–September 2024, there was no investment by the SOCBs in alternative energy, liquid waste management, green establishments, and blue economy financing, whereas the PCBs have a significant portfolio in those sectors [13]. BB did not mention in the report that any sanctions/penalties were

imposed on the state-owned bank for missing the targets. It seems that the central bank mostly relies on PCBs to implement its green finance agendas and does not fully control SOCBs. Therefore, such a dual system of supervision, or Bangladeshi mode of supervision, hinders green finance development in Bangladesh.

Before moving toward the final section of this study, it is worth referring to the challenges that the donor agencies or external partners faced in the development of green finance in the case of Bangladesh. We mentioned earlier that the green financing agents in Bangladesh include the government of Bangladesh, several donor agencies, etc. For instance, the Bangladesh Climate Change Resilience Fund (BCCRF), a multi-donor trust fund, was established in 2010 with the mandate of developing the country's resilience to climate change vulnerabilities [11]. The BCCRF had received around $130 million from a number of donors, including the European Union, Australia, Switzerland, Denmark, Sweden, the USA, and the UK, since it was set up [53]. The fund was closed in 2017. Indeed, this fund acts as an enabler of green finance in Bangladesh. Apart from this fund, Bangladesh received grants from Green Equity Finance (GEF), Global Environment Facility (GEF), and Climate Investment Funds set by the World Bank, and the Green Climate Fund set by the United Nations Framework Convention on Climate Change (UNFCCC). However, there are two major challenges for Bangladesh in accessing green finance from international funds. First, a lack of confidence of funding agencies in fiduciary and institutional governance in place, including a lack of transparency. For example, a US$ 12.2 million World Bank Biodiversity Conservation Fund in the Sundarbans project and another Aquatic Biodiversity Conservation Fund were canceled because of inept handling [11]. Second, there are local political realities and the absence of good governance in the banking system. To illustrate, the Bangladesh Climate Change Trust (BCCT), which operates under the environment ministry, created a Fixed Deposit Receipt (FDR) account of US$ 44.66 million in 2015, then known as Farmers Bank (now Padma Bank PLC), for a period of 1 year. Later, in 2017, the bank collapsed due to the corruption of the Board of Directors and gross loan mismanagement and was later restructured. However, BCCT has so far received just US$ 6.16 million after around 10 years [54]. The Farmers Bank case is an example of how a very poorly rated bank got a huge government deposit with a political connection (the bank's Board of Directors were highly politically exposed people). Therefore, while accessing the international fund for climate change, donor agencies consider those realities (poor governance and weak institutional quality) that exist in the country, which consequently hinder the development of green finance in the country.

7. Policy implications and concluding remarks

This study focuses on the three drivers, governance quality, institutional quality, and regulatory quality, that are crucial for advancing green finance agendas in the Global South, especially in Bangladesh. This explorative study has at least three implications for policymakers.

First, policymakers should provide a consistent definition for green finance and stable policy guidelines over multi-year horizons. To do so, policymakers should pay more attention to improving institutional quality by formulating consistent and coherent policies aligned with international best practices. To enhance the quality of the regulations, the government should establish a 'National Green Finance Regulatory Commission' within the umbrella of the Ministry of Laws or the Ministry

of Finance. This commission will be responsible for formulating new regulations and modifying existing rules on green finance targeting over multi-year horizons. Currently, only the central bank is responsible for doing so. Since more ministries like the Ministry of Laws, the Ministry of Environment, and the Ministry of Industries are closely related to advancing green finance agendas, it will be effective if a separate commission looks after the related laws and proposes new laws. This will improve the governance quality.

Second, restructure the existing green refinancing scheme so that it's more appealing to private banks. We observed in the case of institutional quality that proper 'incentive' and 'disclosure of green finance' are the two major issues that have not been properly addressed in the green finance policies issues in the past years in Bangladesh. As a result, green finance definitions and activities seem merely to target achieving activities instead of business-sense activities. In 2023, the central bank issued a new green finance policy addressing these two issues. Still, there is room in the policy guidelines. For instance, in the case of incentives, the central bank could enlarge the refinancing fund, which encourages the banks and financial institutions to become green project-friendly.

Third, strengthen central bank autonomy to enforce Green Banking rules equally on all banks, aiming to improve the regulatory quality. We have discussed earlier that the enforcement of laws is a major problem in the Global South, including Bangladesh. Scholars [42, 44, 55] illustrated how developing countries are trapped by a strong 'socio-political network' that hinders the enforcement of laws in these countries. Therefore, to improve the quality of the regulation, the regulators' capacity should be improved. To improve the capacity of the central bank, two reforms could be implemented, such as (i) the central bank should have a mandate in the governance and discipline of the SOCBs instead of the MOF, and (ii) train the central bank and other related ministries' staff about green finance and supervision of green finance activities.

One of the backdrops of this study is that we consider only three drivers of green finance development; several socio-factors, like cultural factors and political factors, are not considered in this research. Besides, within the study, we adopted institutional approaches as a prime methodological approach; however, in-depth interviews with several stakeholders could provide a comprehensive outlook.

In a nutshell, we find that while Bangladesh has introduced numerous green projects, the real constraints lie in the absence of good governance, weak institutions, and regulatory incapacity. Consequently, although the country started its journey toward green finance more than a decade ago, green finance has not been attracted by both supply-side (financiers) and demand-side (entrepreneurs) actors. Bangladesh's case could be evidence of why the Global South is far from the implementation of green finance. The tragedy is that the Global South is more of a victim of climate change, whereas the region has less preparedness to promote green finance. Future research could focus on primary data, such as interviews with bankers, regulators, and entrepreneurs, to understand the actual environmental impact of financed green projects and the impact of regulations on their intentions in the green finance projects in the case of the Global South.

Author details

A K M Kamrul Hasan
School of Business and Economics (SOBE), Westminster International University in Tashkent, Uzbekistan

*Address all correspondence to: hasan.hasanakmkamrul@gmail.com

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