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Legal Protection of Artificial Intelligence Applications in Banking

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Abstract: The rapid development of Artificial Intelligence (AI) in Indonesia's banking sector has transformed traditional financial services into digital-based systems that emphasize speed, efficiency, and accessibility. However, this transformation presents significant legal and ethical challenges related to data security, algorithmic accountability, and consumer protection. This study analyzes the legal framework governing AI implementation in Indonesian banking, focusing on the Financial Sector Development and Strengthening Law, the Personal Data Protection Law, the Electronic Information and Transactions Law, and the regulatory role of Bank Indonesia and the Financial Services Authority. The research employs a normative legal approach supported by limited empirical insights, combining statutory, case, comparative, and historical analyses. The findings reveal regulatory fragmentation and a legal vacuum concerning liability for AI-related losses, particularly in cases of algorithmic error and data breaches. In contrast, comparative studies of Japan and the European Union show the necessity of establishing AI governance based on transparency, accountability, and proportional liability. Therefore, Indonesia urgently requires a specific legal framework that integrates ethical, human-centered, and risk-based principles to ensure data security, protect consumer rights, and promote trustworthy AI implementation in the financial sector.

Keywords: Accountability; Artificial Intelligence; Banking Law; Data Security; Legal Protection;

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INTRODUCTION

Banking institutions constitute a vital component of Indonesia's modern economic system because they actively collect public funds and channel them back into the economy through various financial instruments to stimulate development and economic growth.[1] The concept of banking originates from the Italian term *banco*, meaning "table,"[2] which historically referred to the setting where early financial transactions and administrative activities were conducted.[3] Within Indonesia's legal framework, a bank functions as a business entity that gathers funds from the public in the form of deposits and redistributes them through credit and other financial mechanisms to enhance public welfare.[4] Banks perform three primary functions that

[1] Rahmatina Awaliah Kasri and others, 'Digital Payment and Banking Stability in Emerging Economy with Dual Banking System', *Heliyon*, 8.11 (2022), e11198 https://doi.org/10.1016/j.heliyon.2022.e11198

[2] Constantinos Challoumis and Nikolaos Eriotis, 'Evolution of Banking Systems: A Comprehensive Historical Analysis', *Journal of Contemporary Research in Business, Economics and Finance*, 7.1 (2025), 1–21 https://doi.org/10.55214/jcrbef.v7i1.4245

[3] Donato Di Carlo, Andrea Ciarini and Anna Villa, 'Between Export-Led Growth and Administrative Keynesianism: Italy's Two-Tiered Growth Regime', *New Political Economy*, 29.5 (2024), 733–54 https://doi.org/10.1080/13563467.2024.2336515

[4] Neni Sri Imaniyati and others, 'The Function of Sharia Banks in Optimizing Waqf as the Integration of the Commercial Economy and Social Economy to Improve Public Welfare', in *6th Social and*

define their essential role in sustaining economic stability.[5] They receive and manage public deposits to maintain liquidity, provide credit to support productive sectors, and administer financial resources to ensure efficient capital allocation.[6] As agents of development, banks facilitate national economic growth through credit expansion and investment activities. As agents of trust, they uphold the security, reliability, and transparency of customer assets, thereby maintaining confidence in the financial system.[7]

The emergence of digital transformation driven by the Fourth Industrial Revolution has reshaped the operational structure of Indonesia's banking industry.[8] The integration of digital technologies and the widespread use of the internet have altered consumer behaviour and banking services, emphasizing efficiency, accessibility, and real-time interaction.[9] Although national regulations have sought to guide the implementation of digital financial services, disparities in infrastructure and digital literacy continue to hinder full financial inclusion.[10] The acceleration of digital adoption during the Covid-19 pandemic increased online transactions and digital payments but also revealed persistent structural inequalities in access and technological capacity.[11] Consequently, the advancement of digital banking must be accompanied by the development of supportive infrastructure, the enhancement of digital literacy, and the implementation of adaptive regulatory frameworks. These measures are essential to ensure that Indonesia's banking sector operates inclusively, transparently, and sustainably, thereby reinforcing its role as a cornerstone of national economic growth and stability.[12]

The development of Artificial Intelligence represents a pivotal milestone in the digital transformation of the financial sector. The term intelligential, derived from Latin, denotes "understanding" and reflects the ability of machines to process data, recognize patterns, analyze information, and make autonomous decisions that

Humaniora Research Symposium (6th SoRes): Ethical Governance (KnE Social Sciences, 2024), pp. 337–349 https://doi.org/10.18502/kss.v9i24.16848

[5] Peterson K. Ozili and Paul Terhemba Iorember, 'Financial Stability and Sustainable Development', *International Journal of Finance & Economics*, 29.3 (2024), 2620–46 https://doi.org/10.1002/ijfe.2803

[6] Gang Yang and others, 'Social Security Contribution Burden and Firms' Financial Resource Mismatch', *Finance Research Letters*, 85 (2025), 108191 https://doi.org/10.1016/j.frl.2025.108191

[7] Ayodeji Ajuwon and others, 'Blockchain Technology and Its Role in Transforming Financial Services: The Future of Smart Contracts in Lending', *International Journal of Multidisciplinary Research and Growth Evaluation*, 2.2 (2021), 319–29 https://doi.org/10.54660/.IJMRGE.2021.2.2.319-329

[8] Riris Shanti and others, 'Role of Digital Transformation on Digital Business Model Banks', *Sustainability*, 15.23 (2023), 16293 https://doi.org/10.3390/su152316293

[9] Yiyang Sun and Qian Zhang, 'Navigating the Digital Transformation of Commercial Banks: Embracing Innovation in Customer Emotion Analysis', *Journal of the Knowledge Economy*, 16.1 (2024), 3440–61 https://doi.org/10.1007/s13132-024-01938-5

[10] Lee-Ying Tay, Hen-Toong Tai and Gek-Siang Tan, 'Digital Financial Inclusion: A Gateway to Sustainable Development', *Heliyon*, 8.6 (2022), e09766 https://doi.org/10.1016/j.heliyon.2022.e09766

[11] Jayaprada Putrevu and Charilaos Mertzanis, 'The Adoption of Digital Payments in Emerging Economies: Challenges and Policy Responses', *Digital Policy, Regulation and Governance*, 26.5 (2024), 476–500 https://doi.org/10.1108/DPRG-06-2023-0077

[12] Ahmad Dhiaulhaq and others, 'Joined-up Governance and Sustainable Finance for Inclusive Ridge-to-Reef Conservation in Southwest Papua, Indonesia', *Environmental Development*, 57 (2026), 101360 https://doi.org/10.1016/j.envdev.2025.101360

simulate human intelligence.[13] Artificial Intelligence operates through two essential components: a knowledge base that stores facts, theories, and experiential data, and an inference engine that enables logical reasoning and automated decision-making.[14] In Indonesia, the banking industry has adopted AI through customer service chatbots such as Sabrina of Bank Rakyat Indonesia, Vira of Bank Central Asia, and Cinta of Bank Negara Indonesia. These applications enhance operational efficiency by facilitating customer interaction, resolving complaints, and streamlining transactions. Although the implementation of AI in banking has improved service quality and efficiency, significant challenges remain concerning data security, system integrity, and legal protection.[15]

The Financial Services Authority recorded digital banking transactions in Indonesia exceeding 64 quadrillion rupiahs in 2023, reflecting a 13.5 percent increase from the previous year. This growth parallels the rise in internet penetration, which reached 78 percent of the national population. However, the expansion of digital banking has also intensified the risks of cybercrime. The National Cyber and Encryption Agency reported more than 361 million cyberattacks throughout 2023, with the banking sector as a primary target.[16] The Financial Transaction Reports and Analysis Center received over 1.6 million suspicious transaction reports, many of which involved data manipulation and digital fraud using AI technology.[17] Approximately seventy percent of data breaches in the financial services sector resulted from digital security weaknesses, including vulnerabilities in AI system configurations and unauthorized data processing, which may contravene the Personal Data Protection Law.[18]

From a legal standpoint, Indonesia faces a normative vacuum in defining liability for damages arising from algorithmic errors in AI-driven banking operations.[19] The absence of explicit legal provisions creates uncertainty that contradicts the constitutional principle of legal certainty. Moreover, algorithmic bias in credit assessment processes can produce discriminatory outcomes, undermining prudential

[13] Rohit Nishant, Dirk Schneckenberg and MN Ravishankar, 'The Formal Rationality of Artificial Intelligence-Based Algorithms and the Problem of Bias', *Journal of Information Technology*, 39.1 (2024), 19–40 https://doi.org/10.1177/02683962231176842

[14] Amin Beheshti, 'Empowering Generative AI with Knowledge Base 4.0: Towards Linking Analytical, Cognitive, and Generative Intelligence', in *2023 IEEE International Conference on Web Services (ICWS)* (IEEE, 2023), pp. 763–71 https://doi.org/10.1109/ICWS60048.2023.00103

[15] Umut Turksen, Vladlena Benson and Bogdan Adamyk, 'Legal Implications of Automated Suspicious Transaction Monitoring: Enhancing Integrity of AI', *Journal of Banking Regulation*, 25.4 (2024), 359–77 https://doi.org/10.1057/s41261-024-00233-2

[16] Shreyas Kumar, Anika Garg and Maitreya Niranjan, 'Enhancing Government Efficiency Through Cybersecurity Hardening', *Conference on Digital Government Research*, 1 (2025) https://doi.org/10.59490/dgo.2025.1047

[17] Ezekiel Onyekachukwu Udeh and others, 'The Role of Big Data in Detecting and Preventing Financial Fraud in Digital Transactions', *World Journal of Advanced Research and Reviews*, 22.2 (2024), 1746–60 https://doi.org/10.30574/wjarr.2024.22.2.1575

[18] Adedotun Oladinni and Olanrewaju Olukoya Odumuwagun, 'Enhancing Cybersecurity in FinTech: Safeguarding Financial Data Against Evolving Threats and Vulnerabilities', *International Journal of Computer Applications Technology and Research*, 14.1 (2025), 62–78 https://doi.org/10.7753/IJCATR1401.1005

[19] Yudi Prihartanto and others, 'From Legal Formalism to Algorithmic Justice: Rethinking Consumer Protection in the Digital Economy', *Supremasi Hukum: Jurnal Kajian Ilmu Hukum*, 14.1 (2025), 65–88 https://doi.org/10.14421/gqmmwr98

principles and potentially harming marginalized groups. To address these challenges, Indonesia must establish a comprehensive regulatory framework and a robust supervisory mechanism that safeguard consumers, ensure data protection, and maintain financial system stability. Legal safeguards for AI applications are essential to guarantee that this technology operates in a secure, ethical, and accountable manner, consistent with the objectives of inclusive and sustainable economic development.[20]

This research holds significant urgency due to several foundational considerations that highlight the necessity for legal reform in regulating Artificial Intelligence within the banking sector.[21] The first consideration concerns the absence and fragmentation of existing legal frameworks, which necessitate a comprehensive study to establish a coherent regulatory foundation.[22] Indonesia has not yet developed specific legislation that comprehensively governs the utilization and legal protection of Artificial Intelligence in financial institutions.[23] Current legal instruments, including general laws and sectoral regulations, remain insufficient to address the complexity of data processing, automated decision-making, and potential violations arising from algorithmic operations.[24] The second consideration involves the increasing risk of cybersecurity threats and the protection of customer data. Artificial Intelligence systems, which depend on extensive data collection and processing, expose the banking sector to potential data breaches, manipulation, and unauthorized access. These threats endanger individual privacy, create financial losses, erode public trust, and disrupt national financial stability.[25]

The third consideration relates to the absence of clear legal provisions defining liability for losses caused by Artificial Intelligence systems. When algorithmic processes produce erroneous predictions or operational failures that result in customer harm, the law has yet to specify whether liability should rest with developers, financial institutions, or other parties involved in the system's operation.[26] This regulatory

[20] Kennedy Darvishi, Lee Liu and Sumner Lim, 'Navigating the Nexus: Legal and Economic Implications of Emerging Tech-Nologies', *Law and Economics*, 16.3 (2022), 172–86 https://doi.org/10.35335/laweco.v16i3.59

[21] Nurhadhinah Nadiah Ridzuan and others, 'AI in the Financial Sector: The Line between Innovation, Regulation and Ethical Responsibility', *Information*, 15.8 (2024), 432 https://doi.org/10.3390/info15080432

[22] Rim El Khoury, Muneer M. Alshater and Mayank Joshipura, 'RegTech Advancements-a Comprehensive Review of Its Evolution, Challenges, and Implications for Financial Regulation and Compliance', *Journal of Financial Reporting and Accounting*, 23.4 (2025), 1450–85 https://doi.org/10.1108/JFRA-05-2024-0286

[23] Fanny Tanuwijaya and others, 'The Urgency of Regulating the Use of Artificial Intelligence in Detecting Suspicious Financial Transactions', in *Proceedings of the 3rd International Conference on Law, Governance, and Social Justice (ICoLGaS 2023)* (Atlantis Press, 2023), pp. 1066–79 https://doi.org/10.2991/978-2-38476-164-7_99

[24] Therese Enarsson, Lena Enqvist and Markus Naarttijärvi, 'Approaching the Human in the Loop – Legal Perspectives on Hybrid Human/Algorithmic Decision-Making in Three Contexts', *Information & Communications Technology Law*, 31.1 (2022), 123–53 https://doi.org/10.1080/13600834.2021.1958860

[25] Kenneth Chukwujekwu Nwafor and others, 'Mitigating Cybersecurity Risks in Financial Institutions: The Role of AI and Data Analytics', *International Journal of Science and Research Archive*, 13.1 (2024), 2895–2910 https://doi.org/10.30574/ijsra.2024.13.1.2014

[26] Mohammad Bashayreh, Fadi N. Sibai and Amer Tabbara, 'Artificial Intelligence and Legal Liability: Towards an International Approach of Proportional Liability Based on Risk Sharing', *Information &*

vacuum generates legal uncertainty and contradicts the constitutional principle of legal certainty. The fourth consideration emphasizes the need to strengthen legal policies based on prudential principles and consumer protection. [27] Without adequate supervisory mechanisms, the use of Artificial Intelligence in banking may lead to algorithmic discrimination, inaccurate credit assessments, and unauthorized use of customer data.[28] Such practices threaten the protection of consumers and undermine fairness in the delivery of financial services. The fifth consideration underscores the importance of harmonizing Indonesia's legal framework with international regulatory developments. Although Indonesia's legal system has distinctive characteristics, adopting comparative insights from jurisdictions that have implemented Artificial Intelligence regulations can provide valuable guidance. A harmonized regulatory framework should uphold the values of justice, transparency, accountability, and data sovereignty, ensuring that Artificial Intelligence contributes to a secure, ethical, and inclusive financial ecosystem that supports sustainable economic development.[29]

Research on legal protection for the implementation of Artificial Intelligence (AI) in Indonesia's banking sector has attracted increasing attention from both academics and legal practitioners in recent years. Guswandi (2025), through his article Legal Accountability in AI-Driven Banking Crimes: Regulatory Gaps and the Roles of Developers, Owners, and Users in Indonesia, highlights the regulatory gaps in determining legal accountability for criminal acts involving AI in the banking sector. He emphasizes that the absence of clear legal norms defining the responsibilities of developers, owners, and users of AI technology creates legal uncertainty, which may harm customers and undermine public trust in the banking system. [30] Furthermore, Agustianto et al. (2025), in their study Analysis of Financial Risks in Banking through Artificial Intelligence (AI): Legal Politics and the Potential for Legal Development, analyze financial risks arising from AI utilization, including algorithmic bias, data security issues, and system vulnerabilities. Their research stresses the importance of a responsive legal policy to develop regulations that can anticipate these risks while ensuring ethical, secure, and accountable AI practices within Indonesia's banking institutions.[31]

Communications Technology Law, 30.2 (2021), 169–92 https://doi.org/10.1080/13600834.2020.1856025

[27] Mochamad Ali Fajar, Diyan Isnaeni and Moh. Muhibbin, 'Strengthening Legal Certainty in the Implementation of Metrological Supervision and Guidance', *JURNAL USM LAW REVIEW*, 8.3 (2025), 1184–1206 https://doi.org/10.26623/julr.v8i3.12308

[28] Hicham Sadok, Fadi Sakka and Mohammed El Hadi El Maknouzi, 'Artificial Intelligence and Bank Credit Analysis: A Review', *Cogent Economics & Finance*, 10.1 (2022) https://doi.org/10.1080/23322039.2021.2023262

[29] Ayush Patil and others, 'Securing Financial Systems through Data Sovereignty: A Systematic Review of Approaches and Regulations', *International Journal of Information Security*, 24.4 (2025), 159 https://doi.org/10.1007/s10207-025-01074-4

[30] Cynthia Putri Guswandi, 'Legal Accountability in AI-Driven Banking Crimes: Regulatory Gaps and the Roles of Developers, Owners, and Users in Indonesia', *Nomos : Jurnal Penelitian Ilmu Hukum*, 5.4 (2025), 902–915 https://doi.org/https://doi.org/10.56393/nomos.v5i4.3224

[31] Agustianto Agustianto and others, 'Analisis Risiko Finansial Perbankan Melalui Artificial Intelligence (AI): Politik Hukum Dan Potensi Pengembangan Hukum', *Jurnal Magister Hukum Udayana (Udayana Master Law Journal)*, 14.1 (2025), 17 https://doi.org/10.24843/JMHU.2025.v14.i01.p02

Similarly, Pratama, Hapsari, and Wulandari (2024), in Bridging Regulation and Reality: Comparative Study of Artificial Intelligence Regulation in the Financial Sectors, identify a significant gap between existing legal frameworks and the actual implementation of AI in financial systems. Their findings reveal that consumer protection and supervisory mechanisms for AI applications remain inadequate, generating potential legal risks and hindering the establishment of an inclusive and safe digital financial ecosystem.[32] In another study, Listyono, Rapini, and Farida (2024), through Analysis of Artificial Intelligence Implementation to Enhance Customer Financial Security in the Banking Sector, conduct a quantitative survey among bank customers in Ponorogo Regency. The results indicate that although AI-based banking services improve efficiency and convenience, most customers remain concerned about data security and the lack of legal certainty in resolving disputes arising from AI system errors or failures.[33] Moreover, Sitinjak et al. (2023), in their study Legal Protection for Customer Data Security in Internet Banking Systems: Evaluating Legal Frameworks for Customer Data Protection, assess the effectiveness of Indonesia's legal framework for safeguarding customer data in digital banking. Their research concludes that, despite the enactment of several relevant laws, including Law No. 27 of 2022 on Personal Data Protection, practical implementation still faces challenges such as weak supervision, limited enforcement mechanisms, and insufficient remedies for affected parties.[34]

Based on these previous studies, the urgency of this research lies in the need to strengthen Indonesia's legal framework to address challenges related to data security, legal certainty, consumer protection, and accountability for risks associated with AI utilization.[35] These prior findings provide both theoretical and empirical foundations for developing a more responsive legal policy toward the dynamics of AI-based financial technologies in Indonesia. This research aims to analyze the legal framework governing the implementation of AI in Indonesian banking by examining the provisions of the Financial Sector Development and Strengthening Law, the Personal Data Protection Law, and the relevant regulations issued by the Financial Services Authority and Bank Indonesia. The study focuses on identifying legal gaps, protecting personal data, assessing algorithmic errors, and evaluating accountability for both banking institutions and AI technology providers. It also examines the effectiveness of supervisory mechanisms and dispute resolution processes related to AI use in banking. The expected outcome is the formulation of an adaptive model of legal protection

[32] Andistya Pratama, Dwi Ratna Indri Hapsari and Listiyani Wulandari, 'Bridging Regulation and Reality: Comparative Study of Artificial Intelligence Regulation in the Financial Sectors', *Legality : Jurnal Ilmiah Hukum*, 33.2 (2025), 307–33 https://doi.org/10.22219/ljih.v33i2.38908

[33] Rizki Listyono, Titi Rapini and Umi Farida, 'Analisis Penerapan Kecerdasan Buatan (Artificial Intelligence) Untuk Meningkatkan Keamanan Finansial Nasabah Pada Sektor Perbankan', *Lokawati : Jurnal Penelitian Manajemen Dan Inovasi Riset*, 3.1 (2024), 79–91 https://doi.org/10.61132/lokawati.v3i1.1433

[34] Ayu Margareth R. Sitinjak, Martono Anggusti and Roida Nababan, 'Legal Protection For Customer Data Security In Internet Banking Systems', *International Journal of Law, Crime and Justice*, 2.3 (2025), 128–34 https://doi.org/10.62951/ijlcj.v2i3.757

[35] Rina Arum Prastyanti and Ridhima Sharma, 'Establishing Consumer Trust Through Data Protection Law as a Competitive Advantage in Indonesia and India', *Journal of Human Rights, Culture and Legal System*, 4.2 (2024), 354–90 https://doi.org/10.53955/jhcls.v4i2.200

that ensures legal certainty, customer protection, data security, and promotes a fair, safe, and sustainable digital banking ecosystem in Indonesia.

METHOD

This study employs a normative legal research method with a limited empirical approach to comprehensively analyze legal protection for the implementation of artificial intelligence (AI) in Indonesia's banking sector.[36] Through statutory, case, historical, and comparative approaches, the study examines positive legal regulations governing the financial and information technology sectors and compares them with international practices to strengthen the national legal framework.[37] Using a descriptive-analytical specification, the research systematically explains concepts, practices, and legal issues arising from the use of AI and critically evaluates the findings through legal theories and principles to formulate responsive legal solutions. Data are collected from primary, secondary, and tertiary legal materials through library research, document review, and archival study, aiming to assess the adequacy of legal protection for AI implementation in the banking sector and identify areas that require further regulatory development in Indonesia.[38]

RESULT AND DISCUSSION

Digital Transformation and Fintech Development Policy in Banking Industry

In recent decades, banking institutions have actively transformed their operational and service models through continuous technological innovation to strengthen interactions with customers.[39] The introduction of automated teller machines in the 1960s marked the beginning of banking digitalization, which expanded further with the implementation of electronic payment systems in the 1970s.[40] The early 2000s witnessed the integration of online banking services that enabled customers to access financial transactions continuously throughout the day. The emergence of mobile-based banking applications in the 2010s further advanced financial accessibility, allowing customers to conduct transactions in real time without geographical limitations. Since 2020, the banking sector has entered a comprehensive digital era characterized by a notable reduction in in-person transactions and a substantial increase in digital-based activities. This evolution reflects the acceleration of information technology, improvements in data processing efficiency, global

[36] Abdul Kadir Jaelani, Anila Rabbani and Muhammad Jihadul Hayat, 'Land Reform Policy in Determining Abandoned Land for Halal Tourism Destination Management Based on Fiqh Siyasah', *El-Mashlahah*, 14.1 (2024), 211–38 https://doi.org/10.23971/el-mashlahah.v14i1.8051

[37] Ni Komang Sutrisni and others, 'The Compliance of Governance on Family Data Protection Regulation', *Journal of Human Rights, Culture and Legal System*, 4.3 (2024), 706–41 https://doi.org/https://doi.org/10.53955/jhcls.v4i3.293

[38] Anila Robbani, Raffy Arnanda Faturrohman and Ahmad Hananul Amin, 'Optimization of Income Tax Revenue in Land and Building Rights Transfer Transactions', *Journal of Justice Dialectical*, 2.1 (2024), 28–42 https://doi.org/10.70720/jjd.v2i2.38

[39] David Olanrewaju Olutimehin and others, 'Developing a Framework for Digital Transformation in Retail Banking Operations', *International Journal of Multidisciplinary Research and Growth Evaluation*, 2.1 (2021), 608–22 https://doi.org/10.54660/.IJMRGE.2021.2.1.608-622

[40] William Gaviyau and Jethro Godi, 'Banking Sector Transformation: Disruptions, Challenges and Opportunities', *FinTech*, 4.3 (2025), 48 https://doi.org/10.3390/fintech4030048

interconnectivity, and the progressive development of artificial intelligence within financial operations.[41]

Artificial intelligence enhances automation in banking activities and, under effective risk management, strengthens the precision and speed of decision-making processes.[42] The application of this technology contributes significantly to the creation of economic value by optimizing analytical capacity and service quality. In providing financial services, banks recognize that human interaction remains a fundamental component of social and economic relations.[43] Therefore, banking institutions consistently implement service standards that emphasize quality assurance, operational efficiency, transparency of fees, product innovation, and effective complaint resolution mechanisms.[44] The implementation of banking services adheres to core principles of prudence, transparency, education, courtesy, efficiency, and customer data protection. These principles guide banks in ensuring ethical, accountable, and secure service delivery.[45] Meanwhile, international practices highlight the importance of accessibility and inclusion as essential elements in modern banking systems, aiming to extend equal access for all customers, including those with special needs. Through adaptive and interactive digital platforms supported by artificial intelligence, banks strive to ensure that technological progress aligns with fairness, inclusivity, and the overall integrity of the financial system.[46]

Artificial intelligence and machine learning have evolved from simple automation tools into strategic instruments that redefine financial services.[47] Asset management companies employ artificial intelligence to analyze investment portfolios, assess financial risks, and optimize decision-making processes.[48] The implementation of this technology covers four main functional areas: customer acquisition, regulatory compliance, client interaction, and investment support.[49] Through these applications,

[41] Dhanasak Bhumichai and others, 'The Convergence of Artificial Intelligence and Blockchain: The State of Play and the Road Ahead', *Information*, 15.5 (2024), 268 https://doi.org/10.3390/info15050268

[42] Arvind Ashta and Heinz Herrmann, 'Artificial Intelligence and Fintech: An Overview of Opportunities and Risks for Banking, Investments, and Microfinance', *Strategic Change*, 30.3 (2021), 211–22 https://doi.org/10.1002/jsc.2404

[43] Thomas Marois, 'A Dynamic Theory of Public Banks (and Why It Matters)', *Review of Political Economy*, 34.2 (2022), 356–71 https://doi.org/10.1080/09538259.2021.1898110

[44] Matteo Cotugno and Valeria Stefanelli, 'Management Customer Complaints and Performance: Banks, Be Careful!', *Journal of Management and Governance*, 27.1 (2023), 371–412 https://doi.org/10.1007/s10997-021-09616-3

[45] Ahmet Aysan and others, 'AI Development in Financial Markets: A Balanced Scorecard Analysis of Its Impact on Sustainable Development Goals (February 2024)', *Kybernetes*, 2024 https://doi.org/10.1108/K-05-2024-1181

[46] Soudeh Pazouki and others, 'Artificial Intelligence and Digital Technologies in Finance: A Comprehensive Review', *Journal of Economics, Finance and Accounting Studies*, 7.2 (2025), 54–69 https://doi.org/10.32996/jefas.2025.7.2.5

[47] Carlo Milana and Arvind Ashta, 'Artificial Intelligence Techniques in Finance and Financial Markets: A Survey of the Literature', *Strategic Change*, 30.3 (2021), 189–209 https://doi.org/10.1002/jsc.2403

[48] Joseph Byrum, 'AI in Financial Portfolio Management: Practical Considerations and Use Cases', in *Innovative Technology at the Interface of Finance and Operations*, Springer, 2022, pp. 249–70 https://doi.org/10.1007/978-3-030-75729-8_9

[49] Jinying Li, Ananda Maiti and Jiangang Fei, 'Features and Scope of Regulatory Technologies: Challenges and Opportunities with Industrial Internet of Things', *Future Internet*, 15.8 (2023), 256 https://doi.org/10.3390/fi15080256

financial institutions gain deeper insight into customer behavior and preferences, enabling the development of personalized financial services through collaborative interaction between financial advisors and clients. In the capital market, artificial intelligence technologies such as machine learning and natural language processing facilitate automated trade monitoring and enhance the accuracy of anomaly detection systems in financial transactions.[50]

The integration of artificial intelligence in banking relies on multiple subdisciplines, including machine learning, deep learning, neural networks, cognitive computing, natural language processing, and computer vision.[51] Machine learning enables computer systems to identify data patterns and improve performance through experience. Deep learning enhances analytical capacity by using neural networks that mimic the human brain's structure.[52] Neural networks allow systems to process repetitive data to discover relationships and meanings within unstructured datasets. Cognitive computing replicates human interactions with machines to complete complex analytical tasks such as speech and text interpretation. Natural language processing allows computers to understand and process human language naturally, while computer vision empowers systems to recognize and interpret visual information intelligently.[53]

The advancement of these technologies has fundamentally reshaped the global banking industry.[54] The integration of financial institutions and digital technologies has produced new business models that enhance efficiency, transparency, and accessibility. In Indonesia, the rapid transformation of the banking system results from increasing collaboration between banks and financial technology companies.[55] Financial technology innovations divide traditional banking functions into specialized services such as digital payments, peer-to-peer lending, financial product comparison, and microfinancing.[56] The main advantages of fintech lie in its lower operational costs, superior value propositions, and the ease with which customers can switch services

[50] Adel M. Qatawneh, 'The Role of Artificial Intelligence in Auditing and Fraud Detection in Accounting Information Systems: Moderating Role of Natural Language Processing', *International Journal of Organizational Analysis*, 33.6 (2025), 1391–1409 https://doi.org/10.1108/IJOA-03-2024-4389

[51] Martina Feierabend and others, 'Applications of Machine Learning and Deep Learning in Musculoskeletal Medicine: A Narrative Review', *European Journal of Medical Research*, 30.1 (2025), 386 https://doi.org/10.1186/s40001-025-02511-9

[52] Zahra Amiri and others, 'Adventures in Data Analysis: A Systematic Review of Deep Learning Techniques for Pattern Recognition in Cyber-Physical-Social Systems', *Multimedia Tools and Applications*, 83.8 (2023), 22909–73 https://doi.org/10.1007/s11042-023-16382-x

[53] Balakrishnan Chinnaiyan and others, 'AI Applications – Computer Vision and Natural Language Processing', in *Model Optimization Methods for Efficient and Edge AI* (Wiley, 2025), pp. 25–41 https://doi.org/10.1002/9781394219230.ch2

[54] Daniel Broby, 'Financial Technology and the Future of Banking', *Financial Innovation*, 7.1 (2021), 47 https://doi.org/10.1186/s40854-021-00264-y

[55] Abdurrahman Abdurrahman, Aurik Gustomo and Eko Agus Prasetio, 'Enhancing Banking Performance through Dynamic Digital Transformation Capabilities and Governance, Risk Management, and Compliance: Insights from the Indonesian Context', *THE ELECTRONIC JOURNAL OF INFORMATION SYSTEMS IN DEVELOPING COUNTRIES*, 90.2 (2024) https://doi.org/10.1002/isd2.12299

[56] Nicola Del Sarto and Peterson K. Ozili, 'FinTech and Financial Inclusion in Emerging Markets: A Bibliometric Analysis and Future Research Agenda', *International Journal of Emerging Markets*, 20.13 (2025), 270–90 https://doi.org/10.1108/IJOEM-08-2024-1428

according to their needs.[57] The ongoing technological revolution has accelerated structural changes in the banking sector, creating a fundamentally different landscape compared to a decade ago.[58] This transformation occurs not only because banking institutions have rapidly adopted emerging technologies but also because technology companies have become increasingly involved in providing financial services. The resulting combination of collaboration and competition between these two sectors has given rise to new business ecosystems that redefine how banks operate, compete, and interact with society.[59]

Technology companies actively drive innovation within the banking sector and simultaneously transform the overall structure of financial services through the development of financial technology.[60] Fintech segments traditional financial service value chains into specialized categories such as digital payment systems, electronic wallets, cross-border payments, and other digital financial services.[61] This development expands further through innovations including aggregators, robo-advisors, big data analytics, peer-to-peer lending, micro-investment platforms, and personal finance tools, which enhance the global digital financial ecosystem.[62] Banking institutions adopt fintech solutions to respond to market demands and operational efficiency requirements. They integrate these technologies as essential components of modern banking systems to improve customer experience. Fintech services fall into five main categories: digital payment systems, peer-to-peer lending, market comparison platforms, microfinancing, and crowdfunding. Digital payment systems facilitate everyday transactions such as bill payments and retail purchases, while peer-to-peer lending connects borrowers and lenders directly.[63] Market comparison platforms provide consumers with comparative financial product information,

[57] Evelyn Ng and Shan L. Pan, 'Competitive Strategies for Ensuring Fintech Platform Performance: Evidence from Multiple Case Studies', *Information Systems Journal*, 34.3 (2024), 616–41 https://doi.org/10.1111/isj.12406

[58] Hanane Allioui and Youssef Mourdi, 'Exploring the Full Potentials of IoT for Better Financial Growth and Stability: A Comprehensive Survey', *Sensors*, 23.19 (2023), 8015 https://doi.org/10.3390/s23198015

[59] Yana S. Matkovskaya, Elena Vechkinzova and Valeriy Biryukov, 'Banking Ecosystems: Identification Latent Innovation Opportunities Increasing Their Long-Term Competitiveness Based on a Model the Technological Increment', *Journal of Open Innovation: Technology, Market, and Complexity*, 8.3 (2022), 143 https://doi.org/10.3390/joitmc8030143

[60] Imeda A. Tsindeliani and others, 'Digital Transformation of the Banking System in the Context of Sustainable Development', *Journal of Money Laundering Control*, 25.1 (2022), 165–80 https://doi.org/10.1108/JMLC-02-2021-0011

[61] Tara Renduchintala and others, 'A Survey of Blockchain Applications in the FinTech Sector', *Journal of Open Innovation: Technology, Market, and Complexity*, 8.4 (2022), 185 https://doi.org/10.3390/joitmc8040185

[62] Krishna Chandra Balodi, Aditya Raizada and Sagnika Datta, 'Trading War: Evolving Landscape of Discount Brokerage in India', *Journal of Information Technology Teaching Cases*, 2024 https://doi.org/10.1177/20438869241240492

[63] Sumit Agarwal and Jian Zhang, 'FinTech, Lending and Payment Innovation: A Review', *Asia-Pacific Journal of Financial Studies*, 49.3 (2020), 353–67 https://doi.org/10.1111/ajfs.12294

microfinancing expands access to funding for underserved communities, and crowdfunding enables collective fundraising through digital platforms.[64]

The four leading categories, digital payment, peer-to-peer lending, market comparison, and microfinancing, significantly reshape banking service structures.[65] Services that previously operated under centralized conventional banks now function as specialized offerings from independent digital companies.[66] This transformation increases competition and challenges traditional one-stop banking models. Fintech achieves these changes through superior value propositions, including lower operational costs, enhanced efficiency, transparency, and easier service switching for consumers.[67] Fintech companies improve service quality by offering user-focused, efficient, and rapid solutions supported by advanced technologies such as artificial intelligence, big data analytics, cloud computing, and blockchain.[68] These technologies strengthen analytical capacity, security, and automation, reduce customer loyalty to traditional banks, and lower barriers to switching as digital literacy rises. Virtual assistants, automated service transfers, and omnichannel distribution systems reinforce these effects.[69]

In Indonesia, banking institutions and fintech companies actively integrate digital technologies, resulting in the unbundling of banking services, reduced operational costs, and increased consumer mobility.[70] The Financial Services Authority reports that peer-to-peer lending, digital payment, and digital finance innovations dominate the fintech ecosystem.[71] Rapid growth in digital financial transactions demonstrates a significant shift in consumer behavior and preference toward digital services.[72] Traditional banks undergo comprehensive digital transformations to remain competitive, transitioning from legacy systems to fully digital banking frameworks in response to technological advancement, consumer expectations, and the demand for

[64] Bamidele Micheal Omowole and others, 'Integrating Fintech and Innovation in Microfinance: Transforming Credit Accessibility for Small Businesses', *International Journal of Frontline Research and Reviews*, 3.1 (2024), 090–100 https://doi.org/10.56355/ijfrr.2024.3.1.0032

[65] Nicola Del Sarto, 'Exploring Peer-to-Peer Lending: Key Influences of Firm Uncertainty, Loan Features and Venture Quality', *International Journal of Bank Marketing*, 43.3 (2025), 591–614 https://doi.org/10.1108/IJBM-04-2024-0239

[66] Mariana Santos, '"If You Believe in a Platform World…" – Corporate Banking and Digital Transformation in Investor Relations Discourse', *Geoforum*, 151 (2024), 103695 https://doi.org/10.1016/j.geoforum.2023.103695

[67] Ng and Pan.

[68] Pankaj Trivedi and others, 'Finance and Technology-Integrated Digital Economy', in *Navigating the Circular Age of a Sustainable Digital Revolution*, 2024, pp. 91–120 https://doi.org/10.4018/979-8-3693-2827-9.ch004

[69] Chikezie Paul- Mikki Ewim and others, 'Future of Work in Banking: Adapting Workforce Skills to Digital Transformation Challenges', *International Journal of Multidisciplinary Research and Growth Evaluation*, 2.1 (2021), 663–76 https://doi.org/10.54660/.IJMRGE.2021.2.1.663-676

[70] Robert Jeyakumar Nathan, Budi Setiawan and Mac Nhu Quynh, 'Fintech and Financial Health in Vietnam during the COVID-19 Pandemic: In-Depth Descriptive Analysis', *Journal of Risk and Financial Management*, 15.3 (2022), 125 https://doi.org/10.3390/jrfm15030125

[71] Mansurali Anifa and others, 'Fintech Innovations in the Financial Service Industry', *Journal of Risk and Financial Management*, 15.7 (2022), 287 https://doi.org/10.3390/jrfm15070287

[72] Giovanna Patzy Uribe-Linares, Cristian Armando Ríos-Lama and Jorge Alberto Vargas-Merino, 'Is There an Impact of Digital Transformation on Consumer Behaviour? An Empirical Study in the Financial Sector', *Economies*, 11.5 (2023), 132 https://doi.org/10.3390/economies11050132

faster, safer, and more efficient financial services. This process highlights the critical role of digital integration and financial innovation in establishing an inclusive, efficient, and competitive modern banking ecosystem.[73]

The banking sector accelerated digital transformation in response to global financial challenges, technological advancements, and evolving consumer expectations.[74] During the 2007–2008 Global Financial Crisis, banks shifted their focus to stabilizing balance sheets and complying with stricter regulations, which temporarily delayed the adoption of digital innovations. Meanwhile, other industries such as retail, travel, communications, and media had already leveraged digital technologies to transform operations, creating a gap in service expectations among younger, technology-oriented consumers. After the crisis, global banking experienced structural shifts, including a transition of dominance from European and American banks to Asian institutions, driven by economic growth in Asia and digital disruption that promoted innovation, operational efficiency, and competitive practices.[75]

Fintech emerged as a critical driver of financial inclusion by reducing the unbanked population and expanding access to formal financial services, particularly in Asia, where digital payment solutions and non-bank financial platforms increased adoption even in rural areas.[76] Chinese banks, for instance, expanded assets significantly while implementing digital ecosystems that integrated technology, infrastructure, and data management to maintain global competitiveness.[77] Research highlights that digital transformation requires redefining institutional value propositions and restructuring organizations to align with Industry 4.0 innovations, including artificial intelligence, machine learning, cloud computing, and the Internet of Things. Four primary factors drive banking digital transformation: changing consumer expectations demanding speed, security, and cost efficiency; leveraging big data to develop information-driven business models; building collaborative digital ecosystems between banks, fintech, and technology companies to optimize service delivery; and adopting operational models that emphasize efficiency and financial inclusion.[78]

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[73] Valeria Stefanelli and Francesco Manta, 'Digital Financial Services and Open Banking Innovation: Are Banks Becoming "Invisible"?', *Global Business Review*, 2023 https://doi.org/10.1177/09721509231151491

[74] Ali Naimi-Sadigh, Tayebeh Asgari and Mohammad Rabiei, 'Digital Transformation in the Value Chain Disruption of Banking Services', *Journal of the Knowledge Economy*, 13.2 (2022), 1212–42 https://doi.org/10.1007/s13132-021-00759-0

[75] JinHyo Joseph Yun and others, 'Theme Issue: Open Innovation and "Catch-up": Globalist or Localist?', *European Planning Studies*, 31.5 (2023), 845–61 https://doi.org/10.1080/09654313.2022.2146942

[76] Sunil Kumar and Samarjit Saha, 'Transforming the Rural Banking System into a Digital Village Bank Model: A Global Analysis of Opportunities, Challenges and Governance', *EDPACS*, 2025, 1–33 https://doi.org/10.1080/07366981.2025.2524942

[77] Tao Xu and others, 'From Data to Data Asset: Conceptual Evolution and Strategic Imperatives in the Digital Economy Era', *Asia Pacific Journal of Innovation and Entrepreneurship*, 18.1 (2024), 2–20 https://doi.org/10.1108/APJIE-10-2023-0195

[78] Abdurrahman Abdurrahman, Aurik Gustomo and Eko Agus Prasetio, 'Exploring Barriers, Drivers, and Routines of Dynamic Capabilities in Indonesian Digital Banking Transformation: A Qualitative Study Based on the <scp>TOE</Scp> Framework', *THE ELECTRONIC JOURNAL OF INFORMATION SYSTEMS IN DEVELOPING COUNTRIES*, 90.6 (2024) https://doi.org/10.1002/isd2.12329

Regulatory authorities, such as the Financial Services Authority, support this transformation by providing legal frameworks for digital banking services, including account management, payments, lending, investments, and financial oversight while addressing risks related to cybersecurity and system integrity. International experiences demonstrate that contextualized principles, such as decentralized governance or human-AI collaboration, enhance service accessibility and operational efficiency. National strategies emphasize accountable, secure, and inclusive AI governance, integrating data protection principles to ensure ethical compliance and reinforce consumer trust. Central bank frameworks define financial technology as both an innovative tool and a systemic instrument with direct impacts on monetary stability, financial system resilience, and payment efficiency, illustrating the dual role of digital innovation in enhancing service provision and maintaining institutional integrity.[79]

Indonesia currently lacks a dedicated legal framework that specifically regulates artificial intelligence in the banking sector, and existing regulations such as the Electronic Information and Transactions Law and the Personal Data Protection Law provide only partial guidance, leaving significant gaps in addressing liability, accountability, and data security issues.[80] These regulatory gaps create legal uncertainty regarding responsibility for AI-related harms, particularly in cases involving autonomous decision-making that affects consumers, financial stability, or operational integrity.[81] Indonesian banks, fintech companies, and technology providers continue to implement AI systems for credit scoring, fraud detection, customer service, and investment management, yet the absence of clear statutory provisions leaves questions of legal liability unresolved, especially when system errors or algorithmic bias cause financial or reputational losses. Comparative analysis with Japan shows that liability currently falls on human actors or corporate entities, as AI does not hold legal personhood, while European Union regulations, including the Artificial Intelligence Act and the AI Liability Directive, classify AI systems by risk levels and establish obligations for transparency, accountability, and human-centered design. Drawing from these international frameworks, Indonesia has begun developing a national AI strategy to provide ethical guidelines, infrastructure support, and regulatory clarity, aiming to ensure that AI deployment aligns with human oversight, consumer protection, and national interests. Implementing these measures will strengthen legal certainty, enhance accountability, and enable the responsible use of AI technologies in the Indonesian banking sector.[82]

[79] Romain Svartzman and others, 'Central Banks, Financial Stability and Policy Coordination in the Age of Climate Uncertainty: A Three-Layered Analytical and Operational Framework', *Climate Policy*, 21.4 (2021), 563–80 https://doi.org/10.1080/14693062.2020.1862743

[80] Muhammad Bashri Bas and others, 'Artificial Intelligence and Financial Regulation in Indonesia's Islamic Banking', *Paradoks : Jurnal Ilmu Ekonomi*, 8.3 (2025), 1174–87 https://doi.org/10.57178/paradoks.v8i3.1519

[81] Aleksandra Nastoska and others, 'Evaluating Trustworthiness in AI: Risks, Metrics, and Applications Across Industries', *Electronics*, 14.13 (2025), 2717 https://doi.org/10.3390/electronics14132717

[82] Aulia Anugrah Intani and Fauza Annisa, 'Legal Analysis of Artificial Intelligence Technology Development in Healthcare Industry in Indonesia', *South-East Asian Journal of Advanced Law and Governance (SEAJ ALGOV)*, 1.1 (2024), 1–19 https://doi.org/10.22146/seajalgov.v1i1.10155

Legal Challenges in Protecting AI Applications in Banking

Artificial intelligence has fundamentally transformed the structure and operation of many industries, and the banking sector has become one of the fastest to adopt this technology.[83] Banks actively utilize artificial intelligence to ensure data accuracy, strengthen transaction security, and enable real-time decision-making. The application of this technology does not only improve operational efficiency but also serves as a proactive measure to prevent complex financial crimes.[84] The widespread use of artificial intelligence in banking demonstrates the urgency of establishing strong governance systems that combine technical, legal, and ethical dimensions. Such governance must ensure that every algorithm and system functions transparently, responsibly, and in accordance with principles of accountability. Banking institutions, regulators, and technology developers share the responsibility to implement artificial intelligence in a manner that upholds ethical standards, protects personal data, and prevents misuse for criminal purposes.[85] The strengthening of governance frameworks will enable the banking sector to maintain innovation while ensuring security and public trust. Through structured and accountable management, artificial intelligence can become a reliable instrument in supporting financial integrity and preventing criminal activities within the banking system.[86]

The Financial Services Authority has established Regulation Number 11 of 2022 on the Implementation of Information Technology by Commercial Banks and Regulation Number 17 of 2023 on Commercial Bank Governance to strengthen the legal foundation for artificial intelligence in the banking sector.[87] However, these regulations and the Personal Data Protection Law Number 27 of 2022 remain general and do not clearly define liability when artificial intelligence operates autonomously.[88] This condition creates uncertainty because the existing legal system still depends on human intent as the basis for criminal responsibility, making it difficult to determine accountability when harm results from algorithmic actions.[89] The principle of legal protection requires the state to guarantee the safety and rights of its citizens through clear and enforceable legal mechanisms. Preventive protection

[83] V. Mahalakshmi and others, 'The Role of Implementing Artificial Intelligence and Machine Learning Technologies in the Financial Services Industry for Creating Competitive Intelligence', *Materials Today: Proceedings*, 56 (2022), 2252–55 https://doi.org/10.1016/j.matpr.2021.11.577

[84] Veer B.P. Singh and others, 'The Future of Financial Crime Prevention and Cybersecurity with Distributed Systems and Computing Approaches', in *Meta Heuristic Algorithms for Advanced Distributed Systems* (Wiley, 2024), pp. 321–40 https://doi.org/10.1002/9781394188093.ch19

[85] Ahmed Oudah Mohammed Al-Dulaimi and Mohammed Abd-Al Wahab Mohammed, 'Legal Responsibility for Errors Caused by Artificial Intelligence (AI) in the Public Sector', *International Journal of Law and Management*, 2025 https://doi.org/10.1108/IJLMA-08-2024-0295

[86] Luis A. Garcia-Segura, 'The Role of Artificial Intelligence in Preventing Corporate Crime', *Journal of Economic Criminology*, 5 (2024), 100091 https://doi.org/10.1016/j.jeconc.2024.100091

[87] Al Sentot Sudarwanto and Dona Budi Budi Kharisma, 'Comparative Study of Personal Data Protection Regulations in Indonesia, Hong Kong and Malaysia', *Journal of Financial Crime*, 29.4 (2022), 1443–57 https://doi.org/10.1108/JFC-09-2021-0193

[88] Xiongbiao Ye and others, 'Privacy and Personal Data Risk Governance for Generative Artificial Intelligence: A Chinese Perspective', *Telecommunications Policy*, 48.10 (2024), 102851 https://doi.org/10.1016/j.telpol.2024.102851

[89] Jung-Chieh Lee and Xueqing Chen, 'Exploring Users' Adoption Intentions in the Evolution of Artificial Intelligence Mobile Banking Applications: The Intelligent and Anthropomorphic Perspectives', *International Journal of Bank Marketing*, 40.4 (2022), 631–58 https://doi.org/10.1108/IJBM-08-2021-0394

must ensure that the development and use of artificial intelligence in banking do not create opportunities for crimes such as money laundering and digital fraud. At the same time, repressive protection must provide corrective measures when violations occur. Developers and banking institutions must take responsibility by ensuring that artificial intelligence systems function transparently, can be audited, and meet ethical and regulatory standards. Banks must also strengthen risk management, conduct regular audits, and ensure that employees understand the technical and legal implications of artificial intelligence. Through consistent supervision, accountability, and collaboration with regulatory authorities, the banking sector can ensure that artificial intelligence operates responsibly, supports financial integrity, and enhances public trust in the national banking system.[90]

The banking industry has extensively integrated artificial intelligence into its core operations through various applications such as fraud detection systems, credit scoring mechanisms, chatbot-based customer services, robo-advisory platforms, and biometric authentication technologies. [91] These technologies demonstrate that artificial intelligence has become an inseparable component of modern banking activities, functioning not only as an operational instrument but also as a legal entity subject to regulatory control. Although the implementation of artificial intelligence improves efficiency and accuracy, it simultaneously raises complex legal questions concerning accountability for system errors, compliance with data protection standards, and the distribution of responsibility among developers, owners, and users. [92] The confidentiality and privacy of customer data represent a central obligation in banking operations, particularly in the digital era marked by the growing use of artificial intelligence. The law requires every banking institution to safeguard customer data, including information processed by artificial intelligence systems such as credit scoring, fraud detection, and chatbot services. However, existing legal norms were formulated based on human conduct, creating uncertainty when data breaches occur through autonomous algorithmic processes rather than intentional human actions.[93]

The reliance on intent as the foundation for liability highlights the inadequacy of current legal frameworks in addressing artificial intelligence operations. Therefore, the banking sector must adopt a risk-based approach that establishes strict accountability for developers and owners of artificial intelligence systems, ensuring compliance and responsibility regardless of the level of algorithmic autonomy. Each activity involving data processing by artificial intelligence must comply with legal and ethical principles

[90] Rahul Meena, Akshay Kumar Mishra and Rajdeep Kumar Raut, 'Strategic Insights: Mapping the Terrain of Artificial Intelligence (AI) in Banking through Mixed Method Approach', *VINE Journal of Information and Knowledge Management Systems*, 55.5 (2025), 1192–1222 https://doi.org/10.1108/VJIKMS-01-2024-0028

[91] Jiunn-Woei Lian and Cai-Wei Li, 'Using a Two-Stage Method to Understand the Critical Factors Influencing Customers' Intention to Switch from Traditional to Artificial Intelligence Based Banking Services: A Perspective Based on the Push–Pull–Mooring Model', *Computers in Human Behavior*, 168 (2025), 108645 https://doi.org/10.1016/j.chb.2025.108645

[92] Naga Simhadri Apparao Polireddi, 'An Effective Role of Artificial Intelligence and Machine Learning in Banking Sector', *Measurement: Sensors*, 33 (2024), 101135 https://doi.org/10.1016/j.measen.2024.101135

[93] Ridho Bramulya Ikhsan and others, 'An Empirical Study on the Use of Artificial Intelligence in the Banking Sector of Indonesia by Extending the TAM Model and the Moderating Effect of Perceived Trust', *Digital Business*, 5.1 (2025), 100103 https://doi.org/10.1016/j.digbus.2024.100103

to protect customer privacy and prevent unauthorized data disclosure. Developers and banking institutions must embed accountability mechanisms within system design, conduct continuous supervision, and implement transparent operational procedures. By adapting confidentiality obligations to technological realities, the banking industry can ensure that artificial intelligence operates responsibly, maintains public trust, and upholds the integrity of Indonesia's financial system.[94]

Users of artificial intelligence, including bank employees and customers, hold an important role in ensuring that this technology operates safely, ethically, and in accordance with legal principles. Their responsibility must exist within a structured chain of accountability in which education and awareness support, but do not replace, the primary legal duties of developers and owners. Employees must possess the competence to operate artificial intelligence systems effectively and to identify potential legal violations arising from algorithmic misuse.[95] Customers must understand both the technological functions and the legal implications of interacting with artificial intelligence systems, including their rights and mechanisms for seeking redress in the event of harm. Educational initiatives should extend beyond technical training to include awareness of compliance obligations and legal accountability, allowing users to act as active participants in maintaining responsible and lawful artificial intelligence practices. The effective prevention of banking-related crimes requires close and continuous collaboration between developers, owners, and users under clear and enforceable regulatory frameworks.[96] Developers must ensure the reliability and security of artificial intelligence design, owners must demonstrate due diligence in operational oversight, and users must interact with artificial intelligence systems responsibly and within legal boundaries. This integrated model of accountability aligns preventive and corrective legal protections, ensuring that each actor contributes to a balanced and secure technological ecosystem. With transparent governance, robust risk management, and comprehensive user education, artificial intelligence can evolve into a reliable legal and technological instrument that supports the integrity, stability, and security of the banking system while reducing the risk of technology-driven financial crimes.[97]

Singapore has implemented a comprehensive regulatory framework for artificial intelligence in the financial sector through the Monetary Authority's FEAT principles, which emphasize fairness, ethics, accountability, and transparency. These principles require financial institutions to ensure that every algorithm functions transparently and that accountability remains with the institution, regardless of human involvement. In contrast, China has adopted a centralized and stringent approach through the

[94] Feras Mi Alnaser and others, 'Does Artificial Intelligence (AI) Boost Digital Banking User Satisfaction? Integration of Expectation Confirmation Model and Antecedents of Artificial Intelligence Enabled Digital Banking', *Heliyon*, 9.8 (2023), e18930 https://doi.org/10.1016/j.heliyon.2023.e18930

[95] Ana Rita D. Rodrigues and others, 'Artificial Intelligence, Digital Transformation and Cybersecurity in the Banking Sector: A Multi-Stakeholder Cognition-Driven Framework', *Research in International Business and Finance*, 60 (2022), 101616 https://doi.org/10.1016/j.ribaf.2022.101616

[96] Seyedmohammad Mousavian and Shah J Miah, 'Review of Artificial Intelligence-Based Applications for Money Laundering Detection', *Intelligent Systems with Applications*, 27 (2025), 200572 https://doi.org/10.1016/j.iswa.2025.200572

[97] Ting Fan and Xuejun Zhao, 'Artificial Intelligence Applications, Financial Integration, and Regional Criminal Risk', *Finance Research Letters*, 85 (2025), 108190 https://doi.org/10.1016/j.frl.2025.108190

Cyberspace Administration of China, requiring prior approval of artificial intelligence systems before deployment to maintain financial stability and prevent systemic risks. China's model represents a preventive, state-controlled mechanism that focuses on mitigating risks before they occur rather than imposing sanctions afterward. The comparison between these countries shows that Indonesia's current regulatory framework remains limited, as existing policies emphasize procedural compliance without providing clear doctrinal guidance on algorithmic accountability, artificial intelligence autonomy, or the distribution of legal responsibility.[98]

To address this gap, Indonesia must reform its policies by adopting a strict liability model or a reverse burden of proof mechanism for artificial intelligence developers and owners. Such a framework would ensure that accountability does not depend solely on human intent but also covers autonomous algorithmic actions. Policy reform should not remain reactive but must evolve adaptively to anticipate technological advances and emerging risks. Collaboration among government institutions, academic experts, and industry practitioners is essential to formulate legal doctrines that ensure both innovation and protection. Indonesia's regulatory framework must combine preventive measures, such as risk assessment and pre-implementation evaluation, with repressive measures, including sanctions for misuse, to align with international best practices while maintaining local relevance. By integrating legal compliance, ethical standards, and technological oversight, Indonesia can strengthen its capacity to prevent artificial intelligence misuse and ensure that technological development proceeds in harmony with justice and public interest.[99]

Regular supervision ensures that the use of Artificial Intelligence operates within safe and lawful boundaries. Institutions implement periodic audits to detect potential irregularities or misuse at an early stage, allowing authorities to take immediate corrective action. Law enforcement agencies impose firm sanctions on individuals or organizations that misuse AI to maintain accountability and deter violations. The application of penalties, including fines, license revocation, or other proportional legal measures, strengthens the integrity of AI governance. Indonesia must adjust its legal framework by applying strict liability principles or a reverse burden of proof to AI developers and owners to ensure responsibility rests with those who design and control AI systems rather than requiring proof of human intent.[100]

Government institutions, industries, and academic sectors cooperate to ensure that AI systems comply with legal and ethical standards. This collaboration allows regulations to adapt to technological developments and to be implemented effectively across different sectors. Public education about AI, including its potential benefits and risks, raises digital literacy and fosters public awareness of responsible

[98] Paul C.Y. Liu and others, 'Will Artificial Intelligence Undermine the Effects of Guanxi on Relationship Performance? Evidence from China's Banking Industry', *Industrial Marketing Management*, 116 (2024), 12–25 https://doi.org/10.1016/j.indmarman.2023.11.007

[99] Xin Li, Zhihai Yu and Xiaoran Sarah Zhang, 'Can the Application of Artificial Intelligence in Criminal Investigation Reduce Regional Criminal Offences? The Moderating Effect of Digital Financial Development', *Finance Research Letters*, 82 (2025), 107563 https://doi.org/10.1016/j.frl.2025.107563

[100] Xintong Wu, 'Securing the Economic Management and Service Infrastructure of Banks via the Use of Artificial Intelligence (MO-ILSTM)', *Systems and Soft Computing*, 7 (2025), 200227 https://doi.org/10.1016/j.sasc.2025.200227

technology use. A well-informed society can monitor and evaluate the application of AI to prevent potential abuse.[101] Technology developers maintain transparency in algorithmic processes to allow the public to understand how AI operates and to identify unfair or harmful outcomes. Protection of personal data remains essential to prevent data leakage and misuse. Developers uphold fairness and accountability in every stage of AI development to ensure that the technology benefits society equitably. Whistleblowing mechanisms support this integrity by providing safe and confidential channels for reporting misconduct. Researchers continually examine AI safety to anticipate possible risks and develop preventive solutions before negative impacts arise. Risk assessments evaluate both operational and legal responsibilities to ensure that liability remains clear when AI causes harm. International cooperation plays a critical role in aligning Indonesia's regulatory framework with global standards to maintain consistency and fairness in the use of AI. Law enforcement authorities strengthen their capacity through training and technological enhancement to handle AI-related cases effectively. Continuous dialogue on accountability and legal recognition of AI ensures that Indonesia's legal system remains dynamic, coherent, and responsive to technological advancement.[102]

CONCLUSION

Based on the discussion presented above, it can be concluded that, *first*, the development and implementation of Artificial Intelligence in Indonesia have actively transformed the legal enforcement system and digital governance, particularly within the banking and financial sectors, by enhancing efficiency, accuracy, and transparency in legal processes and public service delivery. Government institutions and private organizations increasingly apply AI to automate complex tasks, optimize decision-making, and facilitate real-time monitoring, thereby improving operational effectiveness. Despite these benefits, the widespread use of AI introduces significant challenges related to regulatory gaps, ethical considerations, and cybersecurity risks. *Second*, the existing legal framework, including the Electronic Information and Transactions Law, the Personal Data Protection Law, and the Law on the Development and Strengthening of the Financial Sector, does not explicitly address legal responsibility for the outcomes generated by AI systems. This lack of clear regulation creates uncertainty in determining civil and criminal liability for damages resulting from algorithmic errors, data breaches, or violations of privacy. Comparative studies of international practices in the European Union and Japan highlight the necessity of integrating principles of accountability, transparency, and prudence into AI governance to ensure that technological advancement aligns with human rights protection. In response to these challenges, Indonesia must actively develop specific AI regulations that define responsibilities, establish mechanisms for oversight, and incorporate ethical and cybersecurity standards. The regulations should also delineate proportional liability for developers, service providers, and users while safeguarding individual rights. Implementing such a regulatory framework would

[101] Yingying Tian and others, 'From Algorithms to Access: Role of Artificial Intelligence in Revolutionizing Financial Inclusion', *Technology in Society*, 84 (2026), 103098 https://doi.org/10.1016/j.techsoc.2025.103098

[102] Hui Mao, 'The Optimization Strategy and Application Practice of Business Management Supply Chain Based on Artificial Intelligence Technology', *Procedia Computer Science*, 261 (2025), 707–15 https://doi.org/10.1016/j.procs.2025.04.324

support the modernization of the legal system, mitigate potential harms, and ensure public trust in digital governance. By embedding justice, accountability, and risk management into national AI policy, Indonesia can create a sustainable legal environment that balances innovation with societal protection and positions the country to leverage AI strategically in advancing both financial and public sector services.

References

Abdurrahman, Abdurrahman, Aurik Gustomo and Eko Agus Prasetio, 'Enhancing Banking Performance through Dynamic Digital Transformation Capabilities and Governance, Risk Management, and Compliance: Insights from the Indonesian Context', *THE ELECTRONIC JOURNAL OF INFORMATION SYSTEMS IN DEVELOPING COUNTRIES*, 90 (2024) https://doi.org/10.1002/isd2.12299

———, 'Exploring Barriers, Drivers, and Routines of Dynamic Capabilities in Indonesian Digital Banking Transformation: A Qualitative Study Based on the <scp>TOE</Scp> Framework', *THE ELECTRONIC JOURNAL OF INFORMATION SYSTEMS IN DEVELOPING COUNTRIES*, 90 (2024) https://doi.org/10.1002/isd2.12329

Agarwal, Sumit and Jian Zhang, 'FinTech, Lending and Payment Innovation: A Review', *Asia-Pacific Journal of Financial Studies*, 49 (2020), 353–67 https://doi.org/10.1111/ajfs.12294

Agustianto, Agustianto, Henry Soelistyo Budi, Lu Sudirman, Nurlaily Nurlaily and Windi Afdal, 'Analisis Risiko Finansial Perbankan Melalui Artificial Intelligence (AI): Politik Hukum Dan Potensi Pengembangan Hukum', *Jurnal Magister Hukum Udayana (Udayana Master Law Journal)*, 14 (2025), 17 https://doi.org/10.24843/JMHU.2025.v14.i01.p02

Ajuwon, Ayodeji, Ademola Adewuyi, Chigozie Regina Nwangele and Abiola Oyeronke Akintobi, 'Blockchain Technology and Its Role in Transforming Financial Services: The Future of Smart Contracts in Lending', *International Journal of Multidisciplinary Research and Growth Evaluation*, 2 (2021), 319–29 https://doi.org/10.54660/.IJMRGE.2021.2.2.319-329

Al-Dulaimi, Ahmed Oudah Mohammed and Mohammed Abd-Al Wahab Mohammed, 'Legal Responsibility for Errors Caused by Artificial Intelligence (AI) in the Public Sector', *International Journal of Law and Management*, 2025 https://doi.org/10.1108/IJLMA-08-2024-0295

Allioui, Hanane and Youssef Mourdi, 'Exploring the Full Potentials of IoT for Better Financial Growth and Stability: A Comprehensive Survey', *Sensors*, 23 (2023), 8015 https://doi.org/10.3390/s23198015

Amiri, Zahra, Arash Heidari, Nima Jafari Navimipour, Mehmet Unal and Ali Mousavi, 'Adventures in Data Analysis: A Systematic Review of Deep Learning Techniques for Pattern Recognition in Cyber-Physical-Social Systems', *Multimedia Tools and Applications*, 83 (2023), 22909–73 https://doi.org/10.1007/s11042-023-16382-x

Anifa, Mansurali, Swamynathan Ramakrishnan, Shanmugan Joghee, Sajal Kabiraj and Malini Mittal Bishnoi, 'Fintech Innovations in the Financial Service Industry', *Journal of Risk and Financial Management*, 15 (2022), 287 https://doi.org/10.3390/jrfm15070287

Ashta, Arvind and Heinz Herrmann, 'Artificial Intelligence and Fintech: An Overview of Opportunities and Risks for Banking, Investments, and Microfinance', *Strategic Change*, 30

(2021), 211–22 https://doi.org/10.1002/jsc.2404

Aulia Anugrah Intani and Fauza Annisa, 'Legal Analysis of Artificial Intelligence Technology Development in Healthcare Industry in Indonesia', *South-East Asian Journal of Advanced Law and Governance (SEAJ ALGOV)*, 1 (2024), 1–19 https://doi.org/10.22146/seajalgov.v1i1.10155

Aysan, Ahmet, Hasan Dincer, Ibrahim Musa Unal and Serhat Yüksel, 'AI Development in Financial Markets: A Balanced Scorecard Analysis of Its Impact on Sustainable Development Goals (February 2024)', *Kybernetes*, 2024 https://doi.org/10.1108/K-05-2024-1181

Ayu Margareth R. Sitinjak, Martono Anggusti and Roida Nababan, 'Legal Protection For Customer Data Security In Internet Banking Systems', *International Journal of Law, Crime and Justice*, 2 (2025), 128–34 https://doi.org/10.62951/ijlcj.v2i3.757

Balodi, Krishna Chandra, Aditya Raizada and Sagnika Datta, 'Trading War: Evolving Landscape of Discount Brokerage in India', *Journal of Information Technology Teaching Cases*, 2024 https://doi.org/10.1177/20438869241240492

Bamidele Micheal Omowole, Oghenekome Urefe, Chukwunweike Mokogwu and Somto Emmanuel Ewim, 'Integrating Fintech and Innovation in Microfinance: Transforming Credit Accessibility for Small Businesses', *International Journal of Frontline Research and Reviews*, 3 (2024), 090–100 https://doi.org/10.56355/ijfrr.2024.3.1.0032

Bashayreh, Mohammad, Fadi N Sibai and Amer Tabbara, 'Artificial Intelligence and Legal Liability: Towards an International Approach of Proportional Liability Based on Risk Sharing', *Information & Communications Technology Law*, 30 (2021), 169–92 https://doi.org/10.1080/13600834.2020.1856025

Beheshti, Amin, 'Empowering Generative AI with Knowledge Base 4.0: Towards Linking Analytical, Cognitive, and Generative Intelligence', in *2023 IEEE International Conference on Web Services (ICWS)* (IEEE, 2023), pp. 763–71 https://doi.org/10.1109/ICWS60048.2023.00103

Bhumichai, Dhanasak, Christos Smiliotopoulos, Ryan Benton, Georgios Kambourakis and Dimitrios Damopoulos, 'The Convergence of Artificial Intelligence and Blockchain: The State of Play and the Road Ahead', *Information*, 15 (2024), 268 https://doi.org/10.3390/info15050268

Broby, Daniel, 'Financial Technology and the Future of Banking', *Financial Innovation*, 7 (2021), 47 https://doi.org/10.1186/s40854-021-00264-y

Byrum, Joseph, 'AI in Financial Portfolio Management: Practical Considerations and Use Cases', in *Innovative Technology at the Interface of Finance and Operations*, Springer, 2022, pp. 249–70 https://doi.org/10.1007/978-3-030-75729-8_9

Di Carlo, Donato, Andrea Ciarini and Anna Villa, 'Between Export-Led Growth and Administrative Keynesianism: Italy's Two-Tiered Growth Regime', *New Political Economy*, 29 (2024), 733–54 https://doi.org/10.1080/13563467.2024.2336515

Challoumis, Constantinos and Nikolaos Eriotis, 'Evolution of Banking Systems: A Comprehensive Historical Analysis', *Journal of Contemporary Research in Business, Economics and Finance*, 7 (2025), 1–21 https://doi.org/10.55214/jcrbef.v7i1.4245

Chinnaiyan, Balakrishnan, Sundaravadivazhagan Balasubaramanian, Mahalakshmi Jeyabalu and Gayathry S Warrier, 'AI Applications – Computer Vision and Natural Language Processing', in *Model Optimization Methods for Efficient and Edge AI* (Wiley, 2025), pp. 25–41 https://doi.org/10.1002/9781394219230.ch2

Cotugno, Matteo and Valeria Stefanelli, 'Management Customer Complaints and Performance: Banks, Be Careful!', *Journal of Management and Governance*, 27 (2023), 371–412 https://doi.org/10.1007/s10997-021-09616-3

Darvishi, Kennedy, Lee Liu and Sumner Lim, 'Navigating the Nexus: Legal and Economic Implications of Emerging Tech-Nologies', *Law and Economics*, 16 (2022), 172–86 https://doi.org/10.35335/laweco.v16i3.59

Dhiaulhaq, Ahmad, Maxensius Tri Sambodo, Syarif Hidayat, Nicholas Stacher, Dewi Sari, Tomi Haryadi, and others, 'Joined-up Governance and Sustainable Finance for Inclusive Ridge-to-Reef Conservation in Southwest Papua, Indonesia', *Environmental Development*, 57 (2026), 101360 https://doi.org/10.1016/j.envdev.2025.101360

Enarsson, Therese, Lena Enqvist and Markus Naarttijärvi, 'Approaching the Human in the Loop – Legal Perspectives on Hybrid Human/Algorithmic Decision-Making in Three Contexts', *Information & Communications Technology Law*, 31 (2022), 123–53 https://doi.org/10.1080/13600834.2021.1958860

Ezekiel Onyekachukwu Udeh, Prisca Amajuoyi, Kudirat Bukola Adeusi and Anwulika Ogechukwu Scott, 'The Role of Big Data in Detecting and Preventing Financial Fraud in Digital Transactions', *World Journal of Advanced Research and Reviews*, 22 (2024), 1746–60 https://doi.org/10.30574/wjarr.2024.22.2.1575

Fan, Ting and Xuejun Zhao, 'Artificial Intelligence Applications, Financial Integration, and Regional Criminal Risk', *Finance Research Letters*, 85 (2025), 108190 https://doi.org/10.1016/j.frl.2025.108190

Feierabend, Martina, Julius Michael Wolfgart, Maximilian Praster, Marina Danalache, Filippo Migliorini and Ulf Krister Hofmann, 'Applications of Machine Learning and Deep Learning in Musculoskeletal Medicine: A Narrative Review', *European Journal of Medical Research*, 30 (2025), 386 https://doi.org/10.1186/s40001-025-02511-9

Garcia-Segura, Luis A, 'The Role of Artificial Intelligence in Preventing Corporate Crime', *Journal of Economic Criminology*, 5 (2024), 100091 https://doi.org/10.1016/j.jeconc.2024.100091

Gaviyau, William and Jethro Godi, 'Banking Sector Transformation: Disruptions, Challenges and Opportunities', *FinTech*, 4 (2025), 48 https://doi.org/10.3390/fintech4030048

Guswandi, Cynthia Putri, 'Legal Accountability in AI-Driven Banking Crimes: Regulatory Gaps and the Roles of Developers, Owners, and Users in Indonesia', *Nomos : Jurnal Penelitian Ilmu Hukum*, 5 (2025), 902–915 https://doi.org/https://doi.org/10.56393/nomos.v5i4.3224

Ikhsan, Ridho Bramulya, Yudi Fernando, Hartiwi Prabowo, Yuniarty, Anderes Gui and Engkos Achmad Kuncoro, 'An Empirical Study on the Use of Artificial Intelligence in the Banking Sector of Indonesia by Extending the TAM Model and the Moderating Effect of Perceived Trust', *Digital Business*, 5 (2025), 100103 https://doi.org/10.1016/j.digbus.2024.100103

Imaniyati, Neni Sri, Arif Firmansyah, Indra Fajar Alamsyah and Anita Kamilah, 'The Function

of Sharia Banks in Optimizing Waqf as the Integration of the Commercial Economy and Social Economy to Improve Public Welfare', in *6th Social and Humaniora Research Symposium (6th SoRes): Ethical Governance* (KnE Social Sciences, 2024), pp. 337–349 https://doi.org/10.18502/kss.v9i24.16848

Jaelani, Abdul Kadir, Anila Rabbani and Muhammad Jihadul Hayat, 'Land Reform Policy in Determining Abandoned Land for Halal Tourism Destination Management Based on Fiqh Siyasah', *El-Mashlahah*, 14 (2024), 211–38 https://doi.org/10.23971/el-mashlahah.v14i1.8051

Kasri, Rahmatina Awaliah, Banjaran Surya Indrastomo, Nur Dhani Hendranastiti and Muhammad Budi Prasetyo, 'Digital Payment and Banking Stability in Emerging Economy with Dual Banking System', *Heliyon*, 8 (2022), e11198 https://doi.org/10.1016/j.heliyon.2022.e11198

Kenneth Chukwujekwu Nwafor, Ayodeji Oyindamola Ikudabo, Chinedu C. Onyeje and Daniel O. T. Ihenacho, 'Mitigating Cybersecurity Risks in Financial Institutions: The Role of AI and Data Analytics', *International Journal of Science and Research Archive*, 13 (2024), 2895–2910 https://doi.org/10.30574/ijsra.2024.13.1.2014

El Khoury, Rim, Muneer M Alshater and Mayank Joshipura, 'RegTech Advancements-a Comprehensive Review of Its Evolution, Challenges, and Implications for Financial Regulation and Compliance', *Journal of Financial Reporting and Accounting*, 23 (2025), 1450–85 https://doi.org/10.1108/JFRA-05-2024-0286

Kumar, Shreyas, Anika Garg and Maitreya Niranjan, 'Enhancing Government Efficiency Through Cybersecurity Hardening', *Conference on Digital Government Research*, 1 (2025) https://doi.org/10.59490/dgo.2025.1047

Kumar, Sunil and Samarjit Saha, 'Transforming the Rural Banking System into a Digital Village Bank Model: A Global Analysis of Opportunities, Challenges and Governance', *EDPACS*, 2025, 1–33 https://doi.org/10.1080/07366981.2025.2524942

Lee, Jung-Chieh and Xueqing Chen, 'Exploring Users' Adoption Intentions in the Evolution of Artificial Intelligence Mobile Banking Applications: The Intelligent and Anthropomorphic Perspectives', *International Journal of Bank Marketing*, 40 (2022), 631–58 https://doi.org/10.1108/IJBM-08-2021-0394

Li, Jinying, Ananda Maiti and Jiangang Fei, 'Features and Scope of Regulatory Technologies: Challenges and Opportunities with Industrial Internet of Things', *Future Internet*, 15 (2023), 256 https://doi.org/10.3390/fi15080256

Li, Xin, Zhihai Yu and Xiaoran Sarah Zhang, 'Can the Application of Artificial Intelligence in Criminal Investigation Reduce Regional Criminal Offences? The Moderating Effect of Digital Financial Development', *Finance Research Letters*, 82 (2025), 107563 https://doi.org/10.1016/j.frl.2025.107563

Lian, Jiunn-Woei and Cai-Wei Li, 'Using a Two-Stage Method to Understand the Critical Factors Influencing Customers' Intention to Switch from Traditional to Artificial Intelligence Based Banking Services: A Perspective Based on the Push–Pull–Mooring Model', *Computers in Human Behavior*, 168 (2025), 108645 https://doi.org/10.1016/j.chb.2025.108645

Listyono, Rizki, Titi Rapini and Umi Farida, 'Analisis Penerapan Kecerdasan Buatan (Artificial Intelligence) Untuk Meningkatkan Keamanan Finansial Nasabah Pada Sektor Perbankan', *Lokawati : Jurnal Penelitian Manajemen Dan Inovasi Riset*, 3 (2024), 79–91

https://doi.org/10.61132/lokawati.v3i1.1433

Liu, Paul CY, Weisha Wang, Zi Wang and Ying Yang, 'Will Artificial Intelligence Undermine the Effects of Guanxi on Relationship Performance? Evidence from China's Banking Industry', *Industrial Marketing Management*, 116 (2024), 12–25 https://doi.org/10.1016/j.indmarman.2023.11.007

Mahalakshmi, V, Nirzar Kulkarni, KV Pradeep Kumar, K Suresh Kumar, D Nidhi Sree and S Durga, 'The Role of Implementing Artificial Intelligence and Machine Learning Technologies in the Financial Services Industry for Creating Competitive Intelligence', *Materials Today: Proceedings*, 56 (2022), 2252–55 https://doi.org/10.1016/j.matpr.2021.11.577

Mao, Hui, 'The Optimization Strategy and Application Practice of Business Management Supply Chain Based on Artificial Intelligence Technology', *Procedia Computer Science*, 261 (2025), 707–15 https://doi.org/10.1016/j.procs.2025.04.324

Marois, Thomas, 'A Dynamic Theory of Public Banks (and Why It Matters)', *Review of Political Economy*, 34 (2022), 356–71 https://doi.org/10.1080/09538259.2021.1898110

Matkovskaya, Yana S, Elena Vechkinzova and Valeriy Biryukov, 'Banking Ecosystems: Identification Latent Innovation Opportunities Increasing Their Long-Term Competitiveness Based on a Model the Technological Increment', *Journal of Open Innovation: Technology, Market, and Complexity*, 8 (2022), 143 https://doi.org/10.3390/joitmc8030143

Meena, Rahul, Akshay Kumar Mishra and Rajdeep Kumar Raut, 'Strategic Insights: Mapping the Terrain of Artificial Intelligence (AI) in Banking through Mixed Method Approach', *VINE Journal of Information and Knowledge Management Systems*, 55 (2025), 1192–1222 https://doi.org/10.1108/VJIKMS-01-2024-0028

Mi Alnaser, Feras, Samar Rahi, Mahmoud Alghizzawi and Abdul Hafaz Ngah, 'Does Artificial Intelligence (AI) Boost Digital Banking User Satisfaction? Integration of Expectation Confirmation Model and Antecedents of Artificial Intelligence Enabled Digital Banking', *Heliyon*, 9 (2023), e18930 https://doi.org/10.1016/j.heliyon.2023.e18930

Mikki Ewim, Chikezie Paul-, Hope Ehieghe Omokhoa, Ibidapo Abiodun Ogundeji and Augustine Ifeanyi Ibeh, 'Future of Work in Banking: Adapting Workforce Skills to Digital Transformation Challenges', *International Journal of Multidisciplinary Research and Growth Evaluation*, 2 (2021), 663–76 https://doi.org/10.54660/.IJMRGE.2021.2.1.663-676

Milana, Carlo and Arvind Ashta, 'Artificial Intelligence Techniques in Finance and Financial Markets: A Survey of the Literature', *Strategic Change*, 30 (2021), 189–209 https://doi.org/10.1002/jsc.2403

Mochamad Ali Fajar, Diyan Isnaeni and Moh. Muhibbin, 'Strengthening Legal Certainty in the Implementation of Metrological Supervision and Guidance', *JURNAL USM LAW REVIEW*, 8 (2025), 1184–1206 https://doi.org/10.26623/julr.v8i3.12308

Mousavian, Seyedmohammad and Shah J Miah, 'Review of Artificial Intelligence-Based Applications for Money Laundering Detection', *Intelligent Systems with Applications*, 27 (2025), 200572 https://doi.org/10.1016/j.iswa.2025.200572

Muhammad Bashri Bas, Rika Febby Rhamadhani, Rasmi Nur Anggraeni, I Putu Edi Darmawan

and Phatra Anggana Djuri, 'Artificial Intelligence and Financial Regulation in Indonesia's Islamic Banking', *Paradoks : Jurnal Ilmu Ekonomi*, 8 (2025), 1174–87 https://doi.org/10.57178/paradoks.v8i3.1519

Naimi-Sadigh, Ali, Tayebeh Asgari and Mohammad Rabiei, 'Digital Transformation in the Value Chain Disruption of Banking Services', *Journal of the Knowledge Economy*, 13 (2022), 1212–42 https://doi.org/10.1007/s13132-021-00759-0

Nastoska, Aleksandra, Bojana Jancheska, Maryan Rizinski and Dimitar Trajanov, 'Evaluating Trustworthiness in AI: Risks, Metrics, and Applications Across Industries', *Electronics*, 14 (2025), 2717 https://doi.org/10.3390/electronics14132717

Nathan, Robert Jeyakumar, Budi Setiawan and Mac Nhu Quynh, 'Fintech and Financial Health in Vietnam during the COVID-19 Pandemic: In-Depth Descriptive Analysis', *Journal of Risk and Financial Management*, 15 (2022), 125 https://doi.org/10.3390/jrfm15030125

Ng, Evelyn and Shan L Pan, 'Competitive Strategies for Ensuring Fintech Platform Performance: Evidence from Multiple Case Studies', *Information Systems Journal*, 34 (2024), 616–41 https://doi.org/10.1111/isj.12406

Nishant, Rohit, Dirk Schneckenberg and MN Ravishankar, 'The Formal Rationality of Artificial Intelligence-Based Algorithms and the Problem of Bias', *Journal of Information Technology*, 39 (2024), 19–40 https://doi.org/10.1177/02683962231176842

Oladinni, Adedotun and Olanrewaju Olukoya Odumuwagun, 'Enhancing Cybersecurity in FinTech: Safeguarding Financial Data Against Evolving Threats and Vulnerabilities', *International Journal of Computer Applications Technology and Research*, 14 (2025), 62–78 https://doi.org/10.7753/IJCATR1401.1005

Olutimehin, David Olanrewaju, Titilola Olufunke Falaiye, Chikezie Paul- Mikki Ewim and Augustine Ifeanyi Ibeh, 'Developing a Framework for Digital Transformation in Retail Banking Operations', *International Journal of Multidisciplinary Research and Growth Evaluation*, 2 (2021), 608–22 https://doi.org/10.54660/.IJMRGE.2021.2.1.608-622

Ozili, Peterson K and Paul Terhemba Iorember, 'Financial Stability and Sustainable Development', *International Journal of Finance & Economics*, 29 (2024), 2620–46 https://doi.org/10.1002/ijfe.2803

Patil, Ayush, Biswajeeban Mishra, Sabarathinam Chockalingam, Sanjay Misra and Petter Kvalvik, 'Securing Financial Systems through Data Sovereignty: A Systematic Review of Approaches and Regulations', *International Journal of Information Security*, 24 (2025), 159 https://doi.org/10.1007/s10207-025-01074-4

Pazouki, Soudeh, Mohamad (Behdad) Jamshidi, Mirarmia Jalali and Arya Tafreshi, 'Artificial Intelligence and Digital Technologies in Finance: A Comprehensive Review', *Journal of Economics, Finance and Accounting Studies*, 7 (2025), 54–69 https://doi.org/10.32996/jefas.2025.7.2.5

Polireddi, Naga Simhadri Apparao, 'An Effective Role of Artificial Intelligence and Machine Learning in Banking Sector', *Measurement: Sensors*, 33 (2024), 101135 https://doi.org/10.1016/j.measen.2024.101135

Prastyanti, Rina Arum and Ridhima Sharma, 'Establishing Consumer Trust Through Data Protection Law as a Competitive Advantage in Indonesia and India', *Journal of Human Rights, Culture and Legal System*, 4 (2024), 354–90

https://doi.org/10.53955/jhcls.v4i2.200

Pratama, Andistya, Dwi Ratna Indri Hapsari and Listiyani Wulandari, 'Bridging Regulation and Reality: Comparative Study of Artificial Intelligence Regulation in the Financial Sectors', *Legality : Jurnal Ilmiah Hukum*, 33 (2025), 307–33 https://doi.org/10.22219/ljih.v33i2.38908

Prihartanto, Yudi, Firdaus Arifin, Ihsanul Maarif and Abdul Hamid Kwarteng, 'From Legal Formalism to Algorithmic Justice: Rethinking Consumer Protection in the Digital Economy', *Supremasi Hukum: Jurnal Kajian Ilmu Hukum*, 14 (2025), 65–88 https://doi.org/10.14421/gqmmwr98

Putrevu, Jayaprada and Charilaos Mertzanis, 'The Adoption of Digital Payments in Emerging Economies: Challenges and Policy Responses', *Digital Policy, Regulation and Governance*, 26 (2024), 476–500 https://doi.org/10.1108/DPRG-06-2023-0077

Qatawneh, Adel M, 'The Role of Artificial Intelligence in Auditing and Fraud Detection in Accounting Information Systems: Moderating Role of Natural Language Processing', *International Journal of Organizational Analysis*, 33 (2025), 1391–1409 https://doi.org/10.1108/IJOA-03-2024-4389

Renduchintala, Tara, Haneen Alfauri, Zebo Yang, Roberto Di Pietro and Raj Jain, 'A Survey of Blockchain Applications in the FinTech Sector', *Journal of Open Innovation: Technology, Market, and Complexity*, 8 (2022), 185 https://doi.org/10.3390/joitmc8040185

Ridzuan, Nurhadhinah Nadiah, Masairol Masri, Muhammad Anshari, Norma Latif Fitriyani and Muhammad Syafrudin, 'AI in the Financial Sector: The Line between Innovation, Regulation and Ethical Responsibility', *Information*, 15 (2024), 432 https://doi.org/10.3390/info15080432

Robbani, Anila, Raffy Arnanda Faturrohman and Ahmad Hananul Amin, 'Optimization of Income Tax Revenue in Land and Building Rights Transfer Transactions', *Journal of Justice Dialectical*, 2 (2024), 28–42 https://doi.org/10.70720/jjd.v2i2.38

Rodrigues, Ana Rita D, Fernando AF Ferreira, Fernando JCSN Teixeira and Constantin Zopounidis, 'Artificial Intelligence, Digital Transformation and Cybersecurity in the Banking Sector: A Multi-Stakeholder Cognition-Driven Framework', *Research in International Business and Finance*, 60 (2022), 101616 https://doi.org/10.1016/j.ribaf.2022.101616

Sadok, Hicham, Fadi Sakka and Mohammed El Hadi El Maknouzi, 'Artificial Intelligence and Bank Credit Analysis: A Review', *Cogent Economics & Finance*, 10 (2022) https://doi.org/10.1080/23322039.2021.2023262

Santos, Mariana, '"If You Believe in a Platform World…" – Corporate Banking and Digital Transformation in Investor Relations Discourse', *Geoforum*, 151 (2024), 103695 https://doi.org/10.1016/j.geoforum.2023.103695

Del Sarto, Nicola, 'Exploring Peer-to-Peer Lending: Key Influences of Firm Uncertainty, Loan Features and Venture Quality', *International Journal of Bank Marketing*, 43 (2025), 591–614 https://doi.org/10.1108/IJBM-04-2024-0239

Del Sarto, Nicola and Peterson K Ozili, 'FinTech and Financial Inclusion in Emerging Markets: A Bibliometric Analysis and Future Research Agenda', *International Journal of Emerging Markets*, 20 (2025), 270–90 https://doi.org/10.1108/IJOEM-08-2024-1428

Shanti, Riris, Hermanto Siregar, Nimmi Zulbainarni and Tony, 'Role of Digital Transformation on Digital Business Model Banks', *Sustainability*, 15 (2023), 16293 https://doi.org/10.3390/su152316293

Singh, Veer BP, Pratibha Singh, Shouvik K Guha, Asif I Shah, Abdullah Samdani, MZM Nomani, and others, 'The Future of Financial Crime Prevention and Cybersecurity with Distributed Systems and Computing Approaches', in *Meta Heuristic Algorithms for Advanced Distributed Systems* (Wiley, 2024), pp. 321–40 https://doi.org/10.1002/9781394188093.ch19

Stefanelli, Valeria and Francesco Manta, 'Digital Financial Services and Open Banking Innovation: Are Banks Becoming "Invisible"?', *Global Business Review*, 2023 https://doi.org/10.1177/09721509231151491

Sudarwanto, Al Sentot and Dona Budi Budi Kharisma, 'Comparative Study of Personal Data Protection Regulations in Indonesia, Hong Kong and Malaysia', *Journal of Financial Crime*, 29 (2022), 1443–57 https://doi.org/10.1108/JFC-09-2021-0193

Sun, Yiyang and Qian Zhang, 'Navigating the Digital Transformation of Commercial Banks: Embracing Innovation in Customer Emotion Analysis', *Journal of the Knowledge Economy*, 16 (2024), 3440–61 https://doi.org/10.1007/s13132-024-01938-5

Sutrisni, Ni Komang, Putu Angga Pratama Sukma, Rahimah Embong and Khanlar Haydarov, 'The Compliance of Governance on Family Data Protection Regulation', *Journal of Human Rights, Culture and Legal System*, 4 (2024), 706–41 https://doi.org/https://doi.org/10.53955/jhcls.v4i3.293

Svartzman, Romain, Patrick Bolton, Morgan Despres, Luiz Awazu Pereira Da Silva and Frédéric Samama, 'Central Banks, Financial Stability and Policy Coordination in the Age of Climate Uncertainty: A Three-Layered Analytical and Operational Framework', *Climate Policy*, 21 (2021), 563–80 https://doi.org/10.1080/14693062.2020.1862743

Tanuwijaya, Fanny, Fatimah Zulfa Salsabilla, M Arief Amrullah and Dina Tsalist Wildana, 'The Urgency of Regulating the Use of Artificial Intelligence in Detecting Suspicious Financial Transactions', in *Proceedings of the 3rd International Conference on Law, Governance, and Social Justice (ICoLGaS 2023)* (Atlantis Press, 2023), pp. 1066–79 https://doi.org/10.2991/978-2-38476-164-7_99

Tay, Lee-Ying, Hen-Toong Tai and Gek-Siang Tan, 'Digital Financial Inclusion: A Gateway to Sustainable Development', *Heliyon*, 8 (2022), e09766 https://doi.org/10.1016/j.heliyon.2022.e09766

Tian, Yingying, Delong Zhu, Raima Nazar, Sajid Ali and Aboubakar Mirza, 'From Algorithms to Access: Role of Artificial Intelligence in Revolutionizing Financial Inclusion', *Technology in Society*, 84 (2026), 103098 https://doi.org/10.1016/j.techsoc.2025.103098

Trivedi, Pankaj, A Ravisankar, Gajula Praveen Kumar, V Krishnamoorthy, Suchita Shukla and Sampath Boopathi, 'Finance and Technology-Integrated Digital Economy', in *Navigating the Circular Age of a Sustainable Digital Revolution*, 2024, pp. 91–120 https://doi.org/10.4018/979-8-3693-2827-9.ch004

Tsindeliani, Imeda A, Maxim M Proshunin, Tatyana D Sadovskaya, Zhanna G Popkova, Mariam A Davydova and Oksana A Babayan, 'Digital Transformation of the Banking System in the Context of Sustainable Development', *Journal of Money Laundering Control*, 25 (2022), 165–80 https://doi.org/10.1108/JMLC-02-2021-0011

Turksen, Umut, Vladlena Benson and Bogdan Adamyk, 'Legal Implications of Automated Suspicious Transaction Monitoring: Enhancing Integrity of AI', *Journal of Banking Regulation*, 25 (2024), 359–77 https://doi.org/10.1057/s41261-024-00233-2

Uribe-Linares, Giovanna Patzy, Cristian Armando Ríos-Lama and Jorge Alberto Vargas-Merino, 'Is There an Impact of Digital Transformation on Consumer Behaviour? An Empirical Study in the Financial Sector', *Economies*, 11 (2023), 132 https://doi.org/10.3390/economies11050132

Wu, Xintong, 'Securing the Economic Management and Service Infrastructure of Banks via the Use of Artificial Intelligence (MO-ILSTM)', *Systems and Soft Computing*, 7 (2025), 200227 https://doi.org/10.1016/j.sasc.2025.200227

Xu, Tao, Hanning Shi, Yongjiang Shi and Jianxin You, 'From Data to Data Asset: Conceptual Evolution and Strategic Imperatives in the Digital Economy Era', *Asia Pacific Journal of Innovation and Entrepreneurship*, 18 (2024), 2–20 https://doi.org/10.1108/APJIE-10-2023-0195

Yang, Gang, Hanxi Yan, Zhuxin Zhang and Wanhuan Cai, 'Social Security Contribution Burden and Firms' Financial Resource Mismatch', *Finance Research Letters*, 85 (2025), 108191 https://doi.org/10.1016/j.frl.2025.108191

Ye, Xiongbiao, Yuhong Yan, Jia Li and Bo Jiang, 'Privacy and Personal Data Risk Governance for Generative Artificial Intelligence: A Chinese Perspective', *Telecommunications Policy*, 48 (2024), 102851 https://doi.org/10.1016/j.telpol.2024.102851

Yun, JinHyo Joseph, Philip Cooke, Kwangho Jung and Bo Yang, 'Theme Issue: Open Innovation and "Catch-up": Globalist or Localist?', *European Planning Studies*, 31 (2023), 845–61 https://doi.org/10.1080/09654313.2022.2146942