Exploring the Potential of Artificial Neural Network in Sharīʿah Decision-making for Digital Banking: A Literature Review

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Abstract

This study examines the application of Artificial Neural Networks (ANNs) in Islamic finance with a specific focus on their potential to enhance Sharīʿah decision-making within the digital banking landscape. It explores the intersection between Islamic jurisprudence (*fiqh*) and ANNs, elucidating the complex nature of Artificial Intelligence (AI) for stakeholders in the Islamic finance and digital banking sectors. The methodology employed in this study involves a comprehensive review of the literature on the potential of ANNs. This literature review systematically examines how ANNs can be integrated into Sharīʿah-compliant digital banking to enhance the decision-making processes, highlighting both opportunities and challenges. The findings highlight the paucity of literature on the potential of AI to streamline operations and enhance the efficacy of Sharīʿah-compliant decision-making in the digital age. The research also addresses the ethical considerations and governance challenges associated with implementing AI in Islamic finance, emphasising the need for robust frameworks to ensure ongoing alignment with Sharīʿah guidelines. The findings suggest a practical model, structure, and workable framework for ANNs to enhance efficiency, accuracy, and transparency in Sharīʿah decision-making in digital financial practices while also identifying areas for further investigation.

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Introduction

The integration of technological solutions to enhance and automate financial services is growing swiftly, driven by progress in fields such as Artificial Intelligence (AI), Machine Learning (ML), deep learning, and big data analytics. Digital banking is a subsector of fintech that refers to the use of technology to deliver banking services to customers through digital channels such as mobile apps and online banking platforms.[1] The application of Artificial Neural Networks (ANNs) in Islamic finance and compliant banking has recently gained significant attention.[2] ANNs are computer programmes that simulate problem-solving capabilities of the human brain. These networks consist of processing elements, also known as artificial neurones, that are connected by links. Through the use of algorithms for training and recall, Machine Learning systems based on artificial neural networks have the capability to extract information from datasets and generate predictions., classifications, and clustering of new information. ANNs are designed to replicate how human brains learn, thereby enabling them to recognise patterns and process data using machine learning.[3]

Figure 1 Basic Structure of ANNs Model
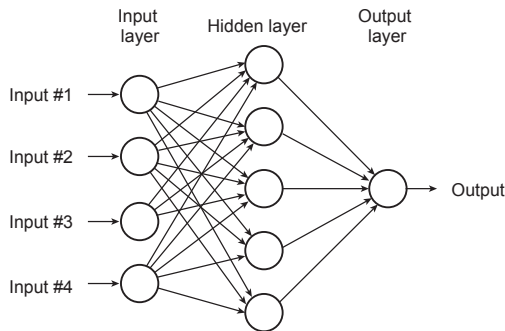
Source: Author's illustration

1. Arvind Ashta and Heinz Herrmann, "Artificial Intelligence and Fintech: An Overview of Opportunities and Risks for Banking, Investments, and Microfinance," *Strategic Change* 30, no. 3 (1 May 1, 2021): 211–222.

2. Amit Mittal, "A Selective Landscape of Artificial Intelligence in Finance and Banking," *SSRN Electronic Journal* (2020); Saida Mammadova, "Artificial Intelligence Use in Finance and Banking System," in *PAHTEI-Proceedings of Azerbaijan High Technical Educational Institutions* (Azerbaijan: Azerbaijan High Technical Educational Institutions, 2022); and Adel Sarea et al., "Artificial Intelligence (AI) Applications in Islamic Finance and Banking Sector," in *Artificial Intelligence and Islamic Finance: Practical Applications for Financial Risk Management* (New York: Routledge, 2021), 108–121.

3. Puspalata Mahapatra and Sarita Kumari Singh, "Artificial Intelligence and Machine Learning: Discovering New Ways of Doing Banking Business," in *Artificial Intelligence and Machine Learning in Business Management: Concepts, Challenges, and Case Studies* (Oxon: CRC Press, 2022), 53–80.

Owing to their capacity for learning and adapting to complex data patterns, Artificial Neural Networks (ANNs) are extensively utilised in domains such as image recognition, natural language processing, and speech recognition.. ANNs have become an integral part of modern technology, providing efficient solutions for tasks such as predictive modelling, recommendation systems, and data analysis.

Figure 2 Artificial neural network architecture.
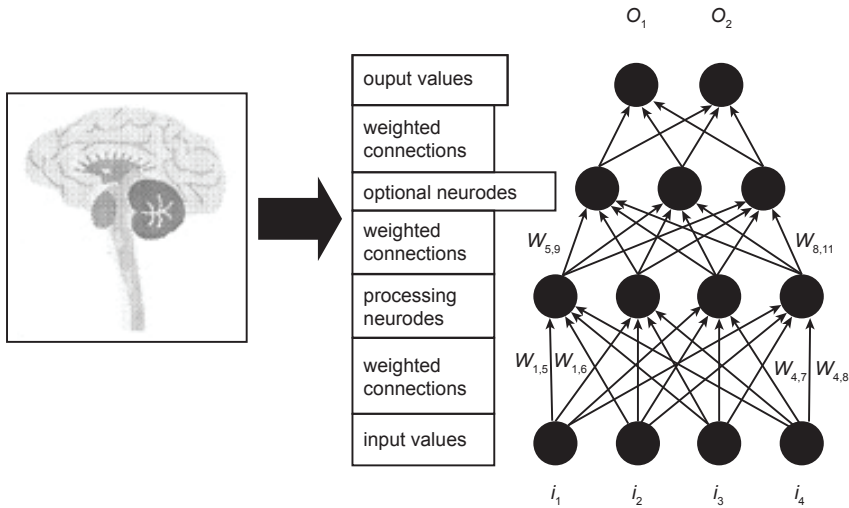
Source: Walczak and Cerpa, "Artificial Neural Networks."[4]

The application of ANNs to Islamic finance and Sharīʿah decision-making holds promise for improving financial analysis, decision making, risk management, and product development in the Islamic finance industry. By leveraging the capabilities of ANNs, practitioners and researchers can contribute to the growth and development of this rapidly expanding sector, while ensuring adherence to Sharīʿah principles and ethical standards. ANNs can help achieve this by enabling the creation of new financial products and services that are both innovative and compliant with Islamic finance regulations, thereby expanding the industry's reach and appeal to a wider global audience. It is imperative to note that the application of Artificial Neural Networks (ANNs) to Islamic financial services and Sharīʿah-compliant banking remains a relatively underexplored area of research. Current Sharīʿah decision-making processes in digital banking rely heavily on manual interpretation and application of Islamic law, leading

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4. Steven Walczak and Narciso Cerpa, "Artificial Neural Networks," *Encyclopedia of Physical Science and Technology* (Massachusetts: Academic Press, 2001).

to inefficiencies and inconsistencies. Current manual processes for Sharīʿah decision making are not only time-consuming but also prone to inconsistencies, underscoring an unmet need for more streamlined, accurate, and automated solutions.

Following a brief introduction to the principles of ANNs, this review focuses specifically on their emerging role in Islamic finance, outlining key areas of application and recent scholarly attention. However, the literature does not directly discuss the application of ANNs in the context of the ShariahSharīʿah law or Islamic finance. Interestingly, while ANNs are not explicitly linked to Sharīʿah in the papers provided, there is a potential intersection in the broader context of Islamic finance. This lacuna presents an opportunity for researchers to investigate the potential customisation of Artificial Neural Networks ANNs for interpreting and implementing Islamic financial principles within digital banking systems. Such research could focus on developing AI models that can efficiently process complex Sharīʿah guidelines while ensuring consistency and accuracy in decision-making. Sharīʿah compliance is a critical aspect of Islamic banking and finance, and Sharīʿah auditors ensure that all operations adhere to Islamic principles.[5] The literature review reveals a critical gap in the understanding of how ANNs can be designed to inherently respect and incorporate the Sharīʿah principles, which are necessary for their adoption in Islamic finance. The lack of research on ANNs' application in Sharīʿah-compliant digital banking hampers innovation within the sector and limits Islamic financial institutions' ability to leverage technological advancements to compete effectively in the global market. Moreover, investigating the ethical implications and potential limitations of using AI in Islamic finance could provide valuable insights for policymakers and financial institutions seeking to modernise their operations. This review seeks to answer the following questions: How can ANNs contribute to Sharīʿah-compliant decision-making in digital banking? What are the model and structure of ANNs for Sharīʿah decision-making frameworks? And what are the challenges and limitations of integrating ANNs in this context?

Research Methodology

This study employs a comprehensive review of extant literature to examine the convergence of artificial neural networks (ANNs) and Sharīʿah-based decision-making in the domain of digital banking. The objective of this systematic analysis is to synthesise current knowledge, identify gaps requiring further investigation, and provide direction for prospective research endeavours. We utilised academic databases, such as Google Scholar, JSTOR, Scopus, and Web

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5.   U. Noreen, A. Shafique, Z. Ahmed, and M. Ashfaq, "Banking 4.0: Artificial Intelligence (AI) in Banking Industry & Consumer's Perspective," *Sustainability* 15, no. 4: (2023).

of Science. Employ-specific keywords and combinations included "Artificial Neural Networks AND Sharīʿah decision-making," "Machine Learning AND *Fiqh*," "Neural Networks AND Islamic Finance," and "Deep Learning AND Sharīʿah decision-making." The results were filtered according to publication date (recent years), relevance, and citation count. References cited within the relevant articles were explored to uncover further research. The availability of high-impact articles specifically focusing on ANNs in decision-making in Sharīʿah and *Fiqh* jurisprudence may be limited. A greater number of articles discussing AI or machine learning in general within an Islamic context may be found, which could subsequently lead to more specific research on ANNs. As the field evolves, it is anticipated that more research on this topic will be published in the future.

Articles were included if they focused on the application of ANNs in Sharīʿah decision-making or related areas in digital banking, provided empirical evidence or theoretical frameworks relevant to the research topic, or were published in reputable, peer-reviewed journals. Articles were excluded if they were not directly related to the research topic, were published in languages other than English or conference papers, book chapters, or other non-journal publications. Relevant data were extracted from the articles, including author(s), publication year, research objectives and methodology, key findings and conclusions, limitations, and suggestions for future research. The extracted data were then analysed using a thematic analysis approach which involved identifying recurring themes and patterns in the literature and synthesising information to provide a comprehensive overview of the research landscape.[6] The review of literature faced certain unavoidable constraints. Primarily, it was confined to English-language publications indexed in the chosen databases, potentially omitting pertinent studies published in other languages or less readily available sources. Second, the quality and rigour of the included studies may vary, which could affect the overall conclusions of the review. Despite these limitations, this review provides a valuable overview of the current state of research on the application of ANNs in Sharīʿah decision making in digital banking. The findings highlight the potential of ANNs to enhance efficiency, accuracy, and transparency in Sharīʿah-compliant financial practices while also identifying areas for further investigation.

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6. M. Kabir Hassan et al., "An Insight into the Fintech and Islamic Finance Literature: A Bibliometric and Visual Analysis," in *FinTech in Islamic Financial Institutions: Scope, Challenges, and Implications in Islamic Finance* (Cham: Palgrave Macmillan, 2022), 131–156.

Application of Artificial Intelligence in Finance and Banking Industry

AI, ML, deep learning, and big data have been used to develop new digital banking products and services, improve existing ones, and automate these processes.[7] For example, AI and ML have been used to develop chatbots that can answer customer questions, fraud-detection systems that can identify fraudulent transactions, and risk-assessment models that can help lenders assess the risk of lending money to borrowers. Deep learning was used to develop trading algorithms that can automatically buy and sell assets, and big data was used to analyse customer behaviour and identify trends. Indeed, the use of AI, ML, deep learning, and big data in digital banking has the potential to revolutionise the industry. These financial innovations possess the capability to enhance the efficacy, accessibility, and security of monetary services. Moreover, they have the potential to augment the economic prosperity of both individuals and commercial entities.[8] Concrete exemplifications of the implementation of artificial intelligence, machine learning, deep learning, and big data technologies within the domain of digital banking services include the following.

1. Chatbots, which are computer programmes that simulate user conversation that are used in digital banking to answer customer questions, provide support, and complete transactions.[9]
2. AI and ML have been used to develop fraudulent detection systems for identifying fraudulent transactions, where such systems possess the capability to analyse vast datasets, identifying patterns that may potentially indicate fraudulent behaviour.[10]

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7. He Xia et al., "The Application of Artificial Intelligence in Emotion Recognition," in *Proceedings of 2020 International Conference on Intelligent Computing and Human-Computer Interaction (ICHCII)*, Sanya, China, 2020.

8. Heike Felzmann et al., "Towards Transparency by Design for Artificial Intelligence," *Science and Engineering Ethics* 26, no. 6 (2020).

9. D. Boiko, "Using of Natural Language Processing in Chatbot," in *Proceedings of the 4th International Conference Computational Linguistics and Intelligent Systems* 2 (2020); and Shahnawaz Khan and Mustafa Raza Rabbani, "Artificial Intelligence and NLP-Based Chatbot for Islamic Banking and Finance," *International Journal of Information Retrieval Research* 11, no. 3 (2021).

10. Merryta Djakaria and Tuga Mauritsius, "Artificial Intelligence Model as an Early Warning System for Fraudulent Transactions in Mobile Banking," *ICIC Express Letters, Part B: Applications* 14, no. 7 (2023); M Hrishita, KSSS Tulasi, and K Tejasri, "Review of Online Fraud Detection by Machine Learning Using Artificial Neural Network," *Advances And Applications in Mathematical Sciences* 20, no. 11 (2021); and Bohdan Mytnyk et al., "Application of Artificial Intelligence for Fraudulent Banking Operations Recognition," *Big Data and Cognitive Computing* 7, no. 2 (2023).

3. Risk assessment: AI and ML have been used to develop risk assessment models to help lenders assess the risk of lending money to borrowers. These models can analyse a borrower's financial history, credit score, and other factors to determine the likelihood of default.[11]
4. Personalised lending: AI and ML were used to develop personalised lending products. These products are tailored to the specific needs of each borrower, which can help improve the chances of repayment.[12]
5. Robo-advisors: Robo-advisors are automated investment advisors which use AI and ML to manage investment portfolios. These advisors can help investors save time and money and provide more personalised advice than traditional investment advisors.[13]
6. Customer service: AI and ML were used to develop chatbots and other automated customer service solutions. These solutions can help improve customer satisfaction and reduce costs.[14]

ANNs have various applications in finance, marketing, logistics, and information technology.[15] The application of ANNs in the financial services industry has shown tremendous potential in solving various financial problems.[16] One of the key areas where ANNs have been applied is the analysis and

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11. Bertrand K. Hassani, "Societal Bias Reinforcement through Machine Learning: A Credit Scoring Perspective," *AI and Ethics* 1, no. 3 (2021): 239–47; and Chih Fong Tsai and Jhen Wei Wu, "Using Neural Network Ensembles for Bankruptcy Prediction and Credit Scoring," *Expert Systems with Applications* 34, no. 4 (2008).

12. Shorouq Fathi Eletter, Saad Ghaleb Yaseen, and Ghaleb Awad Elrefae, "Neuro-Based Artificial Intelligence Model for Loan Decisions," *American Journal of Economics and Business Administration* 2, no. 1 (2010): 27–34; and Ira I. Makrygianni and Angelos P. Markopoulos, "Loan Evaluation Applying Artificial Neural Networks," in *ACM International Conference Proceedings Series* 25 (2016).

13. Seungho Baek et al., "Robo-Advisors: Machine Learning in Trend-Following ETF Investments," *Sustainability, MDPI* 12, no. 16 (2020); Auwal Adam Sa'ad et al., "Robo-Advisory for Islamic Financial Institutions: Shari'ah and Regulatory Issues," *European Journal of Islamic Finance* (2020): 1–8; and Daniel Belanche, Luis V. Casaló, and Carlos Flavián, "Artificial Intelligence in FinTech: Understanding Robo-Advisors Adoption among Customers," *Industrial Management and Data Systems* 119, no. 7 (2019): 1411–30.

14. Mark Cullen, Kh Eghtesadi, and Dai Vu, "An Artificial Neural Network Customer Forecasting Model," in *World Congress on Neural Networks*, vol. 2 (2021); Hatem El-Gohary et al., "An Exploratory Study on the Effect of Artificial Intelligence-Enabled Technology on Customer Experiences in the Banking Sector," *Journal of Technological Advancements* 1, no. 1 (2021); and A. Vieira and A. Sehgal, "How Banks Can Better Serve Their Customers through Artificial Techniques," in *Digital Marketplaces Unleashed* (Berlin: Springer, 2017), 311–326.

15. Ali Azadeh, Leili Javanmardi, and Morteza Saberi, "The Impact of Decision-Making Units Features on Efficiency by Integration of Data Envelopment Analysis, Artificial Neural Network, Fuzzy C-Means and Analysis of Variance," *International Journal of Operational Research* 7, no. 3 (2010).

16. Chandrima Bhattacharya and Manish Sinha, "Role of Artificial Intelligence in Banking for Leveraging Customer Experience," *Australasian Accounting, Business and Finance Journal* 16, no. 5 (2022).

prediction of market trends and structures in Islamic finance. This includes an analysis of sukuk, syndications, funds, project financing, and Islamic liquidity management.[17] ANNs have been used to develop risk assessment and management models in Islamic finance to ensure compliance, risk indexing, liquidity risk, early warning systems, and cloud security issues in financial transactions.[18] ANNs have also been used to evaluate the performance and synergies between Islamic funds and socially responsible investments (SRIs) in light of Sustainable Development Goals (SDGs).[19] The integration of ANNs offers a promising solution for automating and standardising these processes; however, research on how to effectively align AI technologies with the Sharīʿah principles remains scant. Current research suggests that Artificial Neural Networks (ANNs) demonstrate potential for enhancing the efficacy, accuracy, and regulatory compliance of financial operations within the Islamic banking sector.[20] With their ability to process complex and nuanced datasets, ANNs are uniquely positioned to identify Sharīʿah-compliant financial instruments, assess credit risk in accordance with Islamic law, and detect noncompliant transactions. In addition to their application in financial analysis and decision-making, ANNs have been used in the development of Sharīʿah-compliant financial products and services.[21] For instance, ANNs have been employed in the design and implementation of Islamic peer-to-peer (P2P) lending practices

17. Tika Arundina, Mira Kartiwi, and Mohd. Azmi Omar, "Artificial Intelligence for Islamic Sukuk Rating Predictions," in *Artificial Intelligence in Financial Markets* (London: Palgrave Macmillan, 2016); Muhammad Luqman Nurhakim, Zainul Kisman, and Faizah Syihab, "The Validity of Multinomial Logistic Regression and Artificial Neural Network in Predicting Sukuk Rating: Evidence from Indonesian Stock Exchange," *Review of Pacific Basin Financial Markets and Policies* 23, no. 4 (2020); and Madjid Tavana et al., "An Artificial Neural Network and Bayesian Network Model for Liquidity Risk Assessment in Banking," *Neurocomputing* 275 (2018): 2525–2554.

18. Aishwarya Kumar, Ankita Srivastava, and Puneet Kumar Gupta, "Banking 4.0: The Era of Artificial Intelligence-Based Fintech," *Strategic Change* 31, no. 6 (2022); Nurfarahin Mohd Haridan et al., "Financial Innovation in Islamic Banks: Evidence on the Interaction between Shariah Board and FinTech," *Journal of Islamic Accounting and Business Research* 14, no. 6 (2023): 911–30; J. Trigkas Sotirios and K. Liapis, "Assessing Artificial Neural Networks (ANNS) Adequacy Against Econometric Models for Decision Making Approaches in Banking Industry," in *Business Performance and Financial Institutions in Europe: Contributions to Economics* (Cham: Springer, 2020).

19. Fahmi Ali Hudaefi, "How Does Islamic Fintech Promote the SDGs? Qualitative Evidence from Indonesia," *Qualitative Research in Financial Markets* 12, no. 4 (25, 2020): 353–66.

20. Othman bin Abdullah et al., "Artificial Intelligence (AI) Application in Islamic Finance: A Review of Business Use Cases," in *E-Proceeding SAIS 2022 Seminar Antarabangsa Islam dan Sains*, Nilai: USIM, 2022; Mustafa Raza Rabbani, "Fintech Innovations, Scope, Challenges, and Implications in Islamic Finance: A Systematic Analysis," *International Journal of Computing and Digital Systems* 13, no. 1 (2022): 579–608; and Mustafa Raza Rabbani et al., "Introduction to Islamic Fintech: A Challenge or an Opportunity?," in *FinTech in Islamic Financial Institutions: Scope, Challenges, and Implications in Islamic Finance* (Cham: Palgrave Macmillan, 2022), 1–27.

21. Widhy Setyowati and Intan Sri Rahayu, "Sector Analysis of Islamic Capital Markets and Artificial Intelligence Functioning as Sharia Advisors," *International Transactions on Artificial Intelligence (ITALIC)* 1, no. 2 (2023).

to ensure compliance with Sharīʿah principles.[22] This demonstrates the potential of ANNs to support the alignment of Islamic finance with the ethical and sustainability principles. Building on the broad applications of ANNs, there is a unique, yet underexplored opportunity to tailor these technologies to Islamic finance by automating decision-making processes in accordance with Islamic jurisprudence. The literature lacks comprehensive frameworks and practical guidelines for harnessing ANNs in Sharīʿah-compliant digital banking. Further research is needed to explore the full potential of ANNs in this domain and to address any challenges or limitations that may arise. The absence of detailed research on integrating ANNs into Sharīʿah-compliant digital banking hampers the sector's ability to innovate and limits its competitiveness in the broader financial industry. Addressing this knowledge disparity is vital for the continued advancement and triumph of Islamic finance in the future.

ANNs for Sharīʿah Decision-Making

Sharīʿah compliance refers to the adherence to Islamic principles and ethical standards in the development and operation of digital banking systems. Sharīʿah decision-making in digital banking is of utmost importance to financial institutions operating in Islamic jurisdictions. Such organisations must ensure that their online banking platforms and services adhere to Sharīʿah principles, which prohibit practices such as interest-based lending, unethical investments, and other non-compliant activities.[23] Sharīʿah compliance digital banking is a rapidly growing field, as an increasing number of Muslims are looking for ways to bank online while still adhering to the principles of Islamic law. This has led to the development of several innovative products and services specifically designed to meet the needs of Sharīʿah-compliant customers.[24] The implementation of AI in Islamic financial services, particularly to ensure Sharīʿah compliance in products and services, is regarded as an optimism. This has prompted the

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22. Golnoosh Babaei and Shahrooz Bamdad, "A Neural-Network-Based Decision-Making Model in the Peer-to-Peer Lending Market," *Intelligent Systems in Accounting, Finance and Management* 27, no. 3 (2020): 142–50.

23. Mohamad Zaid Mohd Zin et al., "Products of Islamic Finance: A Shariah Compliance Advancement," *Australian Journal of Basic and Applied Sciences* 5, no. 12 (2011): 479–84; Hasan Mukhibad et al., "Open Innovation in Shariah Compliance in Islamic Banks–Does Shariah Supervisory Board Attributes Matter?," *Journal of Open Innovation: Technology, Market, and Complexity* 9, no. 1 (2023); and Noor Aimi Mohamad Puad, Nurdianawati Irwani Abdullah, and Zurina Shafii, "The Shariah Audit Framework from Practitioners' Perspective: A Mirage or Fact?," *The Journal of Muamalat and Islamic Finance Research* 30 (2020): 1–16.

24. Md Kausar Alam et al., "The Influences of Shariah Governance Mechanisms on Islamic Banks Performance and Shariah Compliance Quality," *Asian Journal of Accounting Research* 7, no. 1 (2022): 2–16; and Farrukh Habib, "Islamic Finance and Sustainability: The Need to Reframe Notions of Shariah Compliance, Purpose, and Value," in *Islamic Finance, FinTech, and the Road to Sustainability. Palgrave CIBFR Studies in Islamic Finance* (Cham: Palgrave Macmillan, 2023).

development of AI-driven digital tools, termed Sharīʿah robo-advisors, to provide advisory services within Islamic finance. Sa'ad and others (2020) observe that robo-advisory technology has been integrated into the Islamic financial services sector to enhance its offerings and strengthen Sharīʿah oversight in Islamic banking and financial operations.[25] However, Abdullah and others posed a question regarding Sharīʿah scholars' willingness to embrace the concept of Sharīʿah or *fiqh* rulings in Islamic banks?'. This study addresses this question by examining the attitudes of Sharīʿah Committee (SC) members in Malaysian Islamic banks towards the adoption of AI technologies in the *fiqh* ruling process for Islamic banking products and services.[26] As anticipated, artificial intelligence-driven technology demonstrates significant potential in facilitating and enhancing processes and is generally received with considerable interest.

The utilisation of artificial neural networks for Sharīʿah-compliant decision-making in digital banking could transform how financial institutions maintain adherence to Islamic principles and ethical guidelines. Research conducted within the financial services sector has demonstrated that artificial neural networks constitute a valuable tool for addressing financial challenges.[27] A case study of Bank Syariah Indonesia (BSI) was conducted, involving interviews with three IT department specialists and one customer relations employee. The research indicates that the implementation of AI in Islamic banking institutions is feasible, provided that it adheres to Sharīʿah principles. The primary AI technologies utilised by the BSI awere chatbots and AI-powered mobile banking applications. A SWOT analysis revealed several potential benefits: AI technologies have the potential to enhance operational efficiency, augment decision-making processes, increase productivity, improve customer satisfaction, and enable the development of customised financial products. However, these advantages are accompanied by several challenges. The study identified implementation costs, cybersecurity concerns, Sharīʿah compliance issues, and ethical considerations as significant obstacles in the adoption of AI tools.[28]

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25. Sa'ad et al., "Robo-Advisory for Islamic Financial Institutions: Shariah and Regulatory Issues."

26. Othman bin Abdullah et al., "AI Applications for Fiqh Rulings in Islamic Banks–Shariah Committee Acceptance," *ISRA International Journal of Islamic Finance* 16, no. 1 (2024): 111–126.

27. V. V. Khilenko, R. Strzelecki, and I. Kotuliak. "Solving the Problem of Dynamic Adaptability of Artificial Intelligence Systems that Control Dynamic Technical Objects." *Cybernetics and Systems Analysis* 54, no. 6 (2018); Bernard Marr, "The 10 Best Examples of How Companies Use Artificial Intelligence in Practice," *Forbes*, https://www.forbes.com/sites/bernardmarr/2019/12/09/the-10-best-examples-of-how-companies-use-artificial-intelligence-in-practice/, accessed on 25th May 2024; and Bernard Marr and Matt Ward, *Artificial Intelligence in Practice: How 50 Successful Companies Used Artificial Intelligence to Solve Problems* (New Jersey: Wiley, 2019).

28. Issa Hamadou et al., "Unleashing the Power of Artificial Intelligence in Islamic Banking: A Case Study of Bank Syariah Indonesia (BSI)," *Modern Finance* 2, no. 1 (2024): 131–44.

Figure 3 Connected papers integrating Sharīʿah decision-making with fintech.
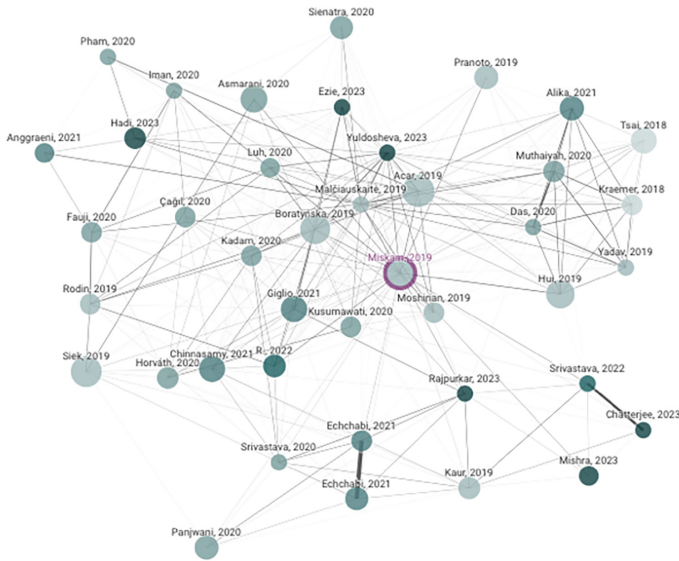
Source: Author's own illustration

The image depicts a network of interconnected documents pertaining to the application of Sharīʿah-based decision making and financial technology, with a particular focus on the utilisation of artificial intelligence. It was generated using an AI-powered search platform called connectedpapers.com, employing terms such as "smart Sharīʿah-based decision-making" and "Islamic fintech'." A noteworthy observation is made regarding the correlation between the proliferation of fintech applications and increasing volume of publications on related topics. Concerns may arise regarding prohibitions, the essence of *Maqāṣid al-Sharīʿah*, adherence to Sharīʿah auditing and evaluation, and the potential for artificial intelligence to identify and categorise these such matters. The figure highlights the growing intersection between Islamic finance principles and modern financial technology, showcasing the evolving landscape of Sharīʿah-compliant financial solutions. This underscores the potential for AI to play a significant role in interpreting and applying Sharīʿah guidelines within the context of fintech innovations. The interconnectedness of the papers also suggests a collaborative approach among scholars and industry experts to address the challenges and opportunities presented by the integration of Islamic finance and cutting-edge technology.[29]

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29. Ahmet Faruk Aysan and Ibrahim Musa Unal, "Challenges in Islamic Fintech and Digitalization: An Extensive Literature Review," *World Scientific Annual Review of Islamic Finance* 1 (2023): 41–52.

The fusion of cutting-edge financial technology swiftly reshapes the realm of Sharīʿah-compliant financial products, generating a complex interplay between upholding time-honoured principles and embracing innovative fintech solutions. This transformation is unfolding within the framework of Islamic finance, which has its roots in age-old religious doctrines. The rapid advancement of modern financial technology is creating dynamic tension between preserving traditional values and adopting novel fintech approaches in the sphere of Sharīʿah-compliant financial services. This evolution is taking place against the backdrop of Islamic finance principles, which have been firmly anchored in long-established religious teaching for centuries. However, the advent of innovative technological solutions has prompted a re-evaluation of how these time-honoured principles can be applied in the digital age. This intersection of traditional Islamic finance and cutting-edge technology creates a dynamic environment in which financial institutions strive to maintain the core tenets of Islamic banking while simultaneously embracing the efficiencies and opportunities presented by fintech.[30] The challenge lies in achieving a delicate equilibrium between maintaining the fundamental principles of Islamic finance, including the prohibition of interest (*riba*) and the emphasis on risk-sharing, whilst leveraging technological innovations to enhance service provision, improve transparency, and expand the accessibility of financial products.[31]

The integration of fintech into Islamic finance manifests itself in various ways. For example, blockchain technology is being investigated to ensure the traceability and compliance of financial transactions with Sharīʿah principles. Smart contracts are being developed to automate and streamline Islamic financial products such as sukuk issuance and management. Mobile banking applications make Islamic financial services more accessible to a broader audience, particularly in regions with large Muslim populations, but limited banking infrastructure. Moreover, the use of AI and big data analytics enables Islamic financial institutions to better assess risk, tailor products to customer needs, and ensure compliance with both regulatory and religious requirements. These technological advancements not only improve operational efficiency, but also open up new possibilities for product innovation within the constraints of Islamic finance principles.[32] The rapid pace of this transformation reshapes

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30. Zhuming Chen et al., "The Transition from Traditional Banking to Mobile Internet Finance: An Organizational Innovation Perspective: A Comparative Study of Citibank and ICBC," *Financial Innovation* 3 (2017).

31. Monzer Kahf, "*Maqasid al-Shari'ah* in the Prohibition of *Riba* and their Implication for Modern Islamic Finance," presented at the IIUM International Conference on Maqasid al-Shari'ah, Gombak, 8–10 August 2006; Hamid Harasani, "Analysing the Islamic Prohibition on *Ribā*: A Prohibition on Substance or Form," *Arab Law Quarterly* 27, no. 3 (2013): 289–296.

32. Junwei Wang et al., "Managerial Decision Support System Using an Integrated Model of AI and Big Data Analytics," *Annals of Operations Research* (2022); Swarajya Lakshmi V. Papineni et al., "Big Data Analytics Applying the Fusion Approach of Multicriteria Decision Making with Deep Learning Algorithms," *International Journal of Engineering Trends and Technology* 69,

the entire ecosystem of Islamic financial services. Traditional Islamic banks are investing heavily in digital transformation to remain competitive, whereas new fintech startups are emerging with Sharīʿah-compliant solutions. This evolution is also attracting the attention of conventional financial institutions and tech companies, whicho see potential in the growing market for ethical and religiously compliant financial products. As the abovementioned integration progresses, it fosters greater financial inclusion, particularly in predominantly Muslim countries where a significant portion of the population may have been underserved by traditional banking systems. The convergence of Islamic finance and fintech not only modernises age-old practices but also expands the reach and appeal of Islamic financial products to a global audience, including non-Muslim consumers attracted to its ethical principles.[33]

The convergence of Islamic finance and financial technology represents a significant paradigm shift in the financial services industry. This exemplifies how traditional religious and ethical principles can adapt to and benefit from technological innovation, potentially leading to a more inclusive, efficient, and ethically driven financial system.[34] In short, there are several benefits to using Sharīʿah compliance in digital banking. These include: (1) convenience: Sharīʿah-compliant digital banking facilitates remote financial transactions for customers globally, operating continuously throughout the week; (2) security: Sharīʿah-compliant digital banking is just as secure as conventional digital banking, and in some cases, even more so. This is because Sharīʿah-compliant banks must follow strict security protocols to protect their customer data; (3) transparency: Sharīʿah-compliant digital banking is transparent as customers can easily see how their money is used. This is because Sharīʿah-compliant banks are required to disclose all their financial dealings; and (4) adherence to Islamic Law: Sharīʿah-compliant digital banking allows customers to bank in a manner consistent with their religious beliefs. This is attributable to the requirement for Sharīʿah-compliant banks to offer products and services that adhere to Islamic law.

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no. 1 (2021); and Yassine Himeur et al., "AI-Big Data Analytics for Building Automation and Management Systems: A Survey, Actual Challenges and Future Perspectives," *Artificial Intelligence Review* 56, no. 6 (2023): 4929–5021.

33. Anju Patwardhan, "Financial Inclusion in the Digital Age," in *Handbook of Blockchain, Digital Finance, and Inclusion*, Volume, vol. 1, (Massachusetts: Academic Press, 2018), 57–89; and "Leveraging Islamic Fintech to Improve Financial Inclusion," *World Bank Group* (18th November 2020), accessed on 27th July 2024, https://www.worldbank.org/en/country/malaysia/publication/leveraging-islamic-fintech-to-improve-financial-inclusion.

34. Keng Siau and Weiyu Wang, "Artificial Intelligence (AI) Ethics: Ethics of AI and Ethical AI," *Journal of Database Management* (2020); and Marina Budic, "AI and Us: Ethical Concerns, Public Knowledge and Public Attitudes on Artificial Intelligence," in *Proceedings of the 2022 AAAI/ACM Conference on AI, Ethics, and Society (AIES '22)*, New York: Association for Computing Machinery, 2022.

Innovative applications are expected as these technologies continue to evolve. Nevertheless, the use of AI, ML, deep learning, and big data in digital banking does raise ethical and regulatory concerns.[35] These concerns include: (1) data privacy: AI, ML, deep learning, and big data require large amounts of data for training and operations. Such data can be sensitive; therefore, it is important to protect them from unauthorised access; (2) biasness: AI, ML, deep learning, and big data models may be biased, resulting in unfair or inaccurate results. Therefore, it is important to mitigate such biasness in these models; (3) explicability: AI, ML, deep learning, and big-data models are difficult to explain. This made it difficult to validate the model results; (4) accountability: to whom can responsibility be attributed for the decisions made by artificial intelligence-powered systems?; and (5) regulation: how should AI-powered systems be regulated? These important issues must be addressed, as the use of AI, ML, deep learning, and big data in digital banking continues to increase. The following studies provide insights into the potential benefits and challenges of ANNs. Firstly, in the article "Application of Artificial Neural Networks in Islamic Finance: A Review of Business Use Cases," USIM Research Repository System analyseds the use of ANNs in Islamic finance, including Sharī'ah Compliance Digital Banking. This study identified several potential benefits of using ANNs inthis space Islamic Finance, such as improved accuracy of risk assessment and product development. Nevertheless, this investigation also identified several challenges, including the requirement for substantial quantities of data and technical expertise to develop and utilise ANNs.[36] In another article, Zain and others (2019) discuss the potential of AI in Islamic finance, including the Sharī'ah compliance with digital banking. This study identified several potential benefits of using AI, including improved efficiency and risk management. Nevertheless, the investigation also identified several challenges, including the necessity for ethical guidelines, regulatory clarity, and the potential for misuse.[37] Meanwhile, Abdullah and others conducted a study and they reported that the participants exhibited a predominantly favourable response to the integration of AI technologies in the *fiqh* ruling process within Islamic banking institutions. The participants recognised the potential of AI-

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35. Sajid Ali et al., "Explainable Artificial Intelligence (XAI): What We Know and What is Left to Attain Trustworthy Artificial Intelligence," *Information Fusion* 99 (2023); and Heike Felzmann et al., "Transparency you can trust: Transparency requirements for artificial intelligence between legal norms and contextual concerns," *Big Data & Society* 6 (2019).
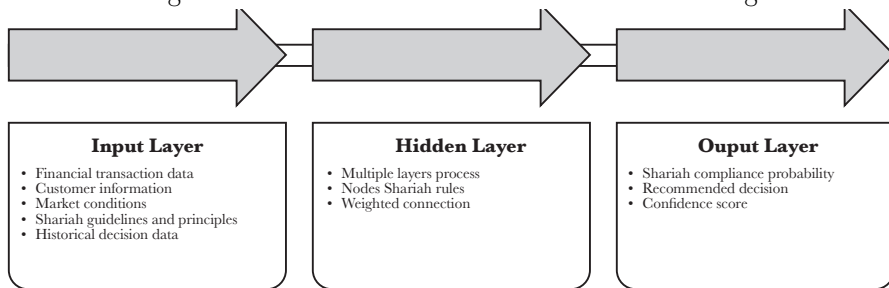
36. Kaoutar Abbahaddou and Mohammed Salah Chiadmi, "Study of the Use of Artificial Neural Networks in Islamic Finance," presented at the 2nd World Conference on Management and Economics, Brussels, 29–31 October 2021; Sulaiman Abdullah Saif al-Nasser Mohammed, "Artificial Intelligence, Financial System, and Islamic Finance: Addressing Issues Prior to Technology Adoption," in *Artificial Intelligence and Islamic Finance: Practical Applications for Financial Risk Management* (New York: Routledge, 2022), 122–137; and Rabbani, "Fintech Innovations, Scope, Challenges, and Implications in Islamic Finance."

37. Ibid.

powered smart assistants to augment the efficiency and efficacy of the *fiqh* ruling process. Nonetheless, they articulated concerns and expectations that necessitated addressing. These studies provide insights into the potential benefits and challenges of utilising Artificial Neural Networks (ANNs) in Sharīʿah decision-making. Further research is required to fully understand the potential applications of ANNs. The ethical and social values of Islamic finance have been noted to align with environmental, social, and governance (ESG) issues, which could be an area where ANNs might contribute, for instance, to in analysing and predicting Sharīʿah-compliant investments.[38] However, to date,Tthere is no direct connection between ANNs and Sharīʿah decision-making in digital banking.

The following presents the proposed model, structure, and framework of Artificial Neural Networks (ANNs) for Sharīʿah decision-making in digital banking.: A proposed model, structure, and framework for utilising Artificial Neural Networks (ANNs) in Sharīʿah decision-making for digital banking may encompass the following components:

Figure 4 ANNs Model for Sharīʿah Decision Making

| **Input Layer**	**Hidden Layer**	**Ouput Layer**
• Financial transaction data • Customer information • Market conditions • Shariah guidelines and principles • Historical decision data	• Multiple layers process • Nodes Shariah rules • Weighted connection	• Shariah compliance probability • Recommended decision • Confidence score

Source: Author's illustration

The architecture of the Artificial Neural Network (ANN) employed for Sharīʿah-compliant decision-making incorporates a sophisticated deep neural network, featuring numerous hidden layers, diverse activation functions, and strategically placed dropout layers. The model was trained using supervised learning with labelled historical data, backpropagation for weight adjustments, and cross-validation for generalisability. The framework encompasses data collection and integration from banking systems, iterative model development, a user-friendly decision support system, an explainability module employing techniques such as SHAP (SHapley Additive exPlanations), compliance and auditing mechanisms, and a feedback loop for continuous learning based on expert input. To elucidate this, please refer to the following diagram in Figure 5.

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38. Habib, "Islamic Finance and Sustainability."

Figure 5 ANNs Structure and Framework for Shariah Decision Making
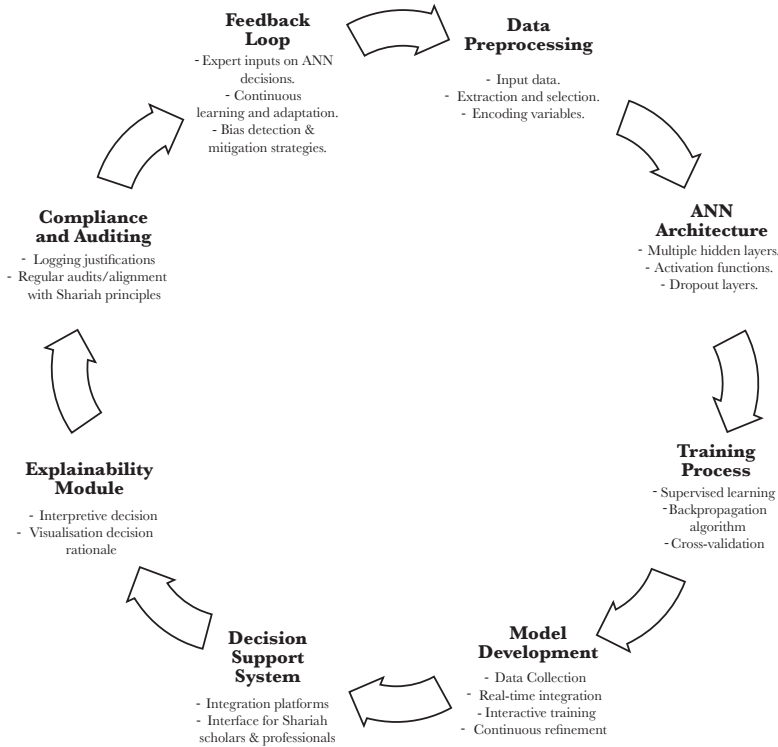
Source: Author's own illustration

A prevalent methodology for the development of the ANN prototypes involves the utilisation of Python in conjunction with specialised libraries. This approach typically employs essential tools such as TensorFlow, a comprehensive platform for constructing and implementing ANNs; PyTorch, renowned for its flexibility and user-friendly nature in research and prototype development; and Keras, a high-level interface that facilitates ANN construction, often utilising TensorFlow or alternative backends. The proposed model, structure, and framework aim to leverage the power of ANNs while ensuring transparency, accountability, and adherence to Sharīʿah principles in digital banking decision-making processes.

Challenges of Using ANNs in Digital Banking

While there are several benefits of using Sharīʿah compliance digital banking, there are also some challenges that need to be addressed. These include: (1) lack of products and services: the range of products and services offered by Sharīʿah-compliant banks remains relatively limited, because Sharīʿah-compliant

banks must ensure that all their products and services comply with Islamic law; and (2) regulatory challenges: the regulatory landscape for Sharīʿah-compliant digital banking is evolving, which can create challenges for Sharīʿah-compliant banks as they must comply with a variety of regulations.[39] Some challenges of using ANNs in Sharīʿah decision-making that need to be addressed are as follows: (1) the need for large amounts of data: ANNs require large amounts of data for effective training and operation, which can be a challenge for Sharīʿah-compliant digital banking institutions as they may not have access to the same amount of data as their conventional counterparts; (2) technical expertise in developing and using ANNs: ANNs are complex algorithms that require technical expertise for effective development and use, which can be a challenge for Sharīʿah-compliant digital banking institutions as they may not have the same level of technical expertise as their conventional counterparts; (3) regulatory uncertainty: the regulatory landscape of Sharīʿah-compliant digital banking is evolving, creating uncertainty for Sharīʿah-compliant digital banking institutions when they consider ANNs; and (4) the potential for misuse: ANNs can be misused to create products and services that do not comply with the Sharīʿah law and, hence, Sharīʿah compliant digital banking institutions and regulators must address this challenge. Despite these challenges, there is growing belief that ANNs have the potential to play a significant role in Sharīʿah compliance in digital banking. As research on ANNs continues, we expect to find more innovative and effective ways to use ANNs in this space.

Ethical and Governance Considerations.

Islamic financial institutions must develop robust governance frameworks and ethical guidelines specifically tailored to the use of ANNs in Sharīʿah-compliant digital banking. These frameworks should include mechanisms for continuous monitoring, auditing, and accountability, to ensure that AI-driven products and services remain aligned with Islamic principles. Collaboration among Sharīʿah scholars, AI experts, and regulatory bodies is essential for addressing the unique challenges posed by ANNs and fostering responsible innovation in the field of Islamic finance. Sharīʿah scholars and regulatory bodies must collaborate to develop comprehensive guidelines that address issues such as data privacy, algorithmic transparency, and the potential for unintended biases in AI-driven financial decisions. Additionally, Islamic financial institutions should prioritise the development of explainable AI models to ensure that their decision-making

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39. Surianom Miskam, Farah Mohd Shahwahid, and Nawal Sholehuddin, "Catching the Fintech Wave in Islamic Finance: Regulatory Approach for Malaysia," presented at the 4th Muzakarah Fiqh & International Fiqh Conference (MFIFC 2018), Kuala Lumpur, 17th October 2018; and Abdolhossein Zameni and Nafis Alam, "Regulatory Issues in Cryptocurrency Usage," in *Fintech, Digital Currency, and the Future of Islamic Finance* (Cham, Switzerland: Palgrave Macmillan, 2021), 127–146.

processes remain transparent and compliant with Sharīʿah principles.[40] To address these concerns, Islamic financial institutions should establish dedicated ethics committees to monitor the development and implementation of AI systems. These committees should include representatives from various stakeholders including Sharīʿah scholars, AI experts, legal professionals, and consumer advocates. Regular training programmes and workshops can be organised to educate staff members about the ethical implications of AI in Islamic finance and promote a culture of responsible innovation within the industry. Islamic financial institutions should invest in R&D to create AI models that are specifically designed to incorporate Sharīʿah principles. This approach would help ensure that AI-driven financial products and services are inherently aligned with Islamic values, rather than simply attempting to retrofit existing AI systems to comply with the Sharīʿah requirements. Educational initiatives should be implemented to enhance the understanding of AI technologies among Sharīʿah scholars and Islamic finance professionals, thereby fostering a more informed and collaborative approach to AI governance in the industry. Collaboration between AI experts and Sharīʿah scholars can lead to the development of innovative AI models that seamlessly integrate Islamic principles into the financial decision-making processes. These interdisciplinary efforts could result in sophisticated and nuanced AI systems that could better navigate the complexities of Islamic finance. Regular dialogues between technology specialists and religious authorities can help identify potential ethical concerns early in the development process, allowing for proactive solutions and adjustments.

The Future and Potential of Sharīʿah Compliance Digital Banking

The future of Sharīʿah compliance with digital banking is bright. There is a growing body of literature on the application of ANNs in Sharīʿah Compliance Digital Banking. Some of the key areas of research include the following: (1) the use of ANNs for risk assessment in regard to Sharīʿah non-compliance in financial transactions; (2) its use to develop new Sharīʿah-compliant financial products and services. This can be done by analysing customer needs, identifying market trends, and designing products that meet both the needs of customers and the requirements of Sharīʿah law; and (3) its use to provide customer service in line with Sharīʿah's Law. This can be achieved by automating tasks such as answering customer questions and providing guidance on Sharīʿah-compliant financial products and services. In addition to these key areas, ANNs have been used for various other tasks in Sharīʿah compliance digital banking such as fraud detection, detecting including fraudulent transactions, monitoring

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40.   Stefan Larsson and Fredrik Heintz, "Transparency in Artificial Intelligence," *Internet Policy Review* 9, no. 2 (2020).

compliance, and Sharīʿah risk aspects. As an increasing number of Muslims become aware of the benefits of Sharīʿah-compliant banking, and as the range of products and services offered by Sharīʿah- compliant banks expands, we can expect to see even more growth in this field. There are several potential benefits to using ANNs in compliance with digital banking in Sharīʿah. These include (1) improved accuracy in risk assessment: ANNs can be used to analyse large amounts of data and identify patterns that are difficult to manually identify. This can help improve the accuracy of risk assessment and prevent Sharīʿah noncompliance;[41] (2) increased transparency and accountability: ANNs can be used to track and monitor transactions, which can help ensure that they comply with the Sharīʿah law. This can help increase trust and confidence in Sharīʿah's compliance of digital banking;[42] and (3) development of new and innovative Sharīʿah-compliant financial products and services: ANNs can be used to identify new market opportunities and develop products that meet the needs of Sharīʿah-compliant customers. This can help expand the reach of Sharīʿah-compliant financing and make it more accessible to a wider range of people.[43]

Conclusion

Indeed, ANNs could significantly impact the Sharīʿah's digital banking compliance. By leveraging ANNs, Islamic financial institutions can enhance their ability to identify and mitigate Sharīʿah-related risks in real-time. Furthermore, these advanced AI systems can assist in automating complex Sharīʿah compliance processes, thereby improving efficiency and reducing the likelihood of human error. Through the integration of ANNs into Sharīʿah-compliant digital banking, these institutions could not only maintain adherence to Islamic principles, but also position themselves as pioneers in technological innovation within the financial sector. ANNs can also be leveraged to enhance customer service in

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41. Hayder M. Kareem Al Duhaidahawi et al., "An Efficient Model for Financial Risks Assessment Based on Artificial Neural Networks," *Journal of Southwest Jiaotong University* 55 (2020); and Carlo Milana and Arvind Ashta, "Artificial Intelligence Techniques in Finance and Financial Markets: A Survey of the Literature," *Strategic Change* 30, no. 3 (2021): 189–209.

42. Kacper Sokol, "Fairness, Accountability and Transparency in Artificial Intelligence: A Case Study of Logical Predictive Models," in *Proceedings of the 2019 AAAI/ACM Conference on AI, Ethics, and Society (AIES '19)*, New York: Association for Computing Machinery, 2019, 541–542.

43. Syed Asad A. Bokhari and Seunghwan Myeong, "Use of Artificial Intelligence in Smart Cities for Smart Decision-Making: A Social Innovation Perspective," *Sustainability MDPI* 14, no. 2 (2022); Sarea et al., "Artificial Intelligence (AI) Applications in Islamic Finance and Banking Sector"; and Mustafa Raza Rabbani et al., "Ethical Concerns in Artificial Intelligence (AI): The Role of RegTech and Islamic Finance," in *Artificial Intelligence for Sustainable Finance and Sustainable Technology. ICGER 2021. Lecture Notes in Networks and Systems 423* (Cham: Springer, 2022).

Sharīʿah-compliant digital banking by providing personalised recommendations and automated responses to customer queries. Moreover, these neural networks can be utilised to analyse market trends and customer behaviour patterns, enabling Islamic financial institutions to develop targeted and Sharīʿah-compliant products and services. The continuous advancement of ANN technology in this field promises to strengthen the integrity and competitiveness of Islamic banking in the global financial landscape. However, several challenges must be addressed before ANNs can be adopted widely. These challenges include the availability, quality, and technical expertise of data. To address these challenges, Islamic financial institutions can invest in comprehensive data collection and management systems to ensure the availability of high-quality Sharīʿah compliant data for ANN training. Additionally, collaborations between Islamic banks and technology firms can help bridge the gap in technical expertise and foster innovation and knowledge transfer in AI-powered Islamic banking. With everything in place, Islamic banking can leapfrog confidently into the future with ANNs.

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