



Article

The Impact of Artificial Intelligence Disclosure on Financial Performance

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Abstract: This study determines to what extent Jordanian banks refer to and use artificial intelligence (AI) technologies in their operation process and examines the impact of AI-related terms disclosure on financial performance. Content analysis is used to analyze the spread of AI and related information in the annual report textual data. Based on content analysis and regression analysis of data from 115 annual reports for 15 Jordanian banks listed in the Amman Stock Exchange for the period 2014 to 2021, the study reveals a consistent increase in the mention of AI-related terms disclosure since 2014. However, the level of AI-related disclosure remains weak for some banks, suggesting that Jordanian banks are still in the early stages of adopting and implementing AI technologies. The results indicate that AI-related keywords disclosure has an influence on banks' financial performance. AI has a positive effect on accounting performance in terms of ROA and ROE and a negative impact on total expenses, which supports the dominant view that AI improves revenue and reduces cost and is also consistent with past literature findings. This study contributes to the growing body of AI literature, specifically the literature on AI voluntary disclosure, in several aspects. First, it provides an objective measure of the uses of AI by formulating an AI disclosure index that captures the status of AI adoption in practice. Second, it provides insights into the relationship between AI disclosure and financial performance. Third, it supports policymakers', international authorities', and supervisory organizations' efforts to address AI disclosure issues and highlights the need for disclosure guidance requirements. Finally, it provides a contribution to banking sector practitioners who are transforming their operations using AI mechanisms and supports the need for more AI disclosure and informed decision making in a manner that aligns with the objectives of financial institutions.

Keywords: artificial intelligence; voluntary disclosure; content analysis; financial performance; banking sector; Jordanian banks



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1. Introduction

Over the last decades, the study of artificial intelligence (AI) has involved the development of intelligent machines that can perform tasks requiring human intelligence. AI uses computer systems and algorithms to learn, reason, and make decisions based on data inputs. AI technologies mimic human cognitive abilities and can analyze data, automate tasks, and assist in various domains (Kok et al. 2002). AI refers to the scientific field and technology that involves the development of intelligent machines capable of imitating human behavior and intelligence (Ottosson and Westling 2020).

The significant advancements and practical applications of AI started to gain momentum in the 21st century with the advent of more powerful computing systems and the availability of large amounts of data (Ratia et al. 2018; Haenlein and Kaplan 2019). The specific implementation of AI will vary based on the industry, goals, and available resources. For example, to harness the potential of AI and gain a competitive edge in their respective industries, companies have developed in-house AI capabilities, partnered with AI solution providers, or utilized cloud-based AI platforms (Burström et al. 2021). The

banking sector is experiencing improved efficiency, accuracy, and personalized customer experiences as a result of AI implementation (Anastasi et al. 2021). AI offers numerous possibilities for banks to improve operations and drive innovation: data analysis, adaptive learning platforms, personalized marketing, automating repetitive tasks, chatbots, enabling natural language processing and voice recognition, and implementing risk-based predictive maintenance and fraud detection, among others.

AI is the process of human intelligence implemented by machines. AI promotes the sustainable and effective use of resources (Nikitas et al. 2020). Data-driven companies can enhance decisions and enable more precise predictions (Anastasi et al. 2021). Specifically, it is a more advanced digital transformation strategy that generates knowledge from existing large datasets (Lichtenthaler 2020). Thus, the implementation of AI processes will improve bank employees' productivity (Plastino and Purdy 2018). Previous studies indicate that banks have already recognized cost reduction and revenue generation through enhancing the quality of the operations process, for example, in terms of lending, security services, compliance improvements, fraud detection, and new types of services (Burgess 2017; Kaya 2019; Ryll et al. 2020). Moreover, these customized solutions and services provide customers with personalized investment strategies, wealth management techniques, and robo-advisors (Wheeler 2020). Currently, AI plays a vital role in autonomous decision-making processes, monitors assets and processes in real time, and enables value creation (Alcácer and Cruz-Machado 2019), and the benefits will increase going forward (Cockburn et al. 2018). In the rapidly evolving landscape of the banking sector, the integration of AI holds significant potential for enhancing decision-making processes and improving financial performance.

While AI can improve financial reporting, it can also lead to biases, lack of transparency, data privacy concerns, and compliance challenges. Organizations may face job displacement, training gaps, high implementation costs, interoperability challenges, and ethical concerns (Nguyen 2022). To mitigate these negative effects, organizations should prioritize responsible AI practices, invest in data quality and governance, and address potential biases in AI models. Staying informed about regulations and ethical considerations is also crucial (Nguyen and Dang 2023).

There are multiple motivations for conducting this study, including addressing stakeholders' concerns regarding the accountability and transparency of AI systems. Transparent disclosure can attract investors who value technologically informed decision making and potentially influence a company's valuation and shareholder composition. Aside from attracting investors, transparent AI disclosure can align with evolving regulatory frameworks. As regulatory bodies scrutinize the ethical and responsible integration of AI, companies that disclose their AI practices can demonstrate adherence to these guidelines, contributing to compliance and a robust corporate reputation (Meiryani et al. 2022).

These findings suggest that AI applications are favorable for the banking sector and beneficial for both shareholders and stakeholders, as well as for increased efficiency in the financial sector, which leads to economic benefits. However, quantifying the link between the use of AI and bank performance is warranted to explore the extent to which AI affects businesses, consumers, and the whole economy.

Despite the opportunities and benefits of the application of AI, AI disclosure is still voluntary. The decision of whether to disclose, to what extent, and the type of information is almost entirely left to the discretion of companies. To date, there is no commonly accepted practice for the level of AI disclosure. AI applications are relatively new. There are no known dedicated international reporting standards agreed upon in this area. The existing AI disclosure practices do not adequately capture the unique impacts of AI. The lack of a shared vision and reporting standards for AI leads to different disclosure practices depending on companies' perceptions (Sætra 2021).

While several studies have been conducted on the benefit of AI in the banking sector, there remains a research gap concerning the impact of AI disclosure on financial performance. Filling this gap is essential to shedding light on the potential benefits of AI

disclosure. To bridge this research gap, this study provides insights into the current level of AI-related term disclosure practices among Jordanian banks. We create an AI disclosure index by analyzing the spread of AI in the data of annual reports and investigating the impact of mentioning AI-related keywords on financial performance to explore the potential influence of disclosing AI-related terms on the financial performance of these banks.

Clear and ethical communication about AI initiatives can also enhance a company's image as a responsible innovator, fostering trust among consumers and partners (Hasan et al. 2023). On the other hand, a lack of transparency or negative perceptions could lead to skepticism and a tarnished reputation, potentially affecting financial performance. In addition, this study is motivated to provide valuable insights that contribute to the discourse on AI's role in shaping contemporary business success, offering a comprehensive perspective that encompasses ethical, regulatory, financial, and reputational considerations. Depending on the timing of the study, there could be a lack of empirical evidence regarding the direct relationship between AI disclosure and financial outcomes. Consequently, this paper aims to answer the following research question:

- Does artificial intelligence disclosure impact financial performance?

Based on a content analysis of 115 annual reports for 15 Jordanian-listed banks from the period 2014 to 2021, the results show an increase in AI-related keywords disclosure in the annual reports of Jordanian-listed banks from 2014 to 2021. The results also indicate that AI-related keywords disclosure has an influence on banks' financial performance. AI-related term disclosure has a positive effect on accounting performance in term of ROA and ROE and has a negative impact on the bank's total expenses, which supports the dominant view that AI improves revenue and reduces cost and is consistent with past literature findings.

This study contributes to the growing body of AI literature. First, it determines the spread of AI-related term disclosure in Jordanian banks by forming an initial AI-related term disclosure index. Second, it provides insights into the relationship between AI disclosure and financial performance. The findings of this study contribute to policymakers', international authorities', and supervisory organizations' efforts to address AI disclosure issues and highlight the need for disclosure guidance requirements. Moreover, the study provides a contribution to banking sector practitioners who are transforming their operations using AI mechanisms and supports the need for more AI disclosure and informed decision making in a manner that aligns with the objectives of financial institutions.

The remainder of this paper is organized as follows. The Section 2 reviews the relevant literature. The Section 3 illustrates the research methodology. The Section 4 presents and discusses the study findings. The Section 5 concludes the study.

2. Literature Review

2.1. AI Implications in the Banking Industry

The latest tech innovations that have revolutionized digital business are AI, machine learning, big data analytics, cloud computing, and social media. These innovations are used in the daily life of modern society. Technology changes physical, tangible items; contributes to operations enhancement; and promotes competence and ability for future business solutions (Tekic and Koroteev 2019). AI's abilities simplify its applications. Firstly, AI can forecast what is going on via the processing of audio, text, and computational linguistics in the surrounding environment. Secondly, AI relies on language and meaning through natural language processing (NLP) and assists humans in complying with machines through related AI algorithms. Finally, AI software systems can act alone without human contribution (Purdy and Daugherty 2016; Rao and Verweij 2017; Tákacs et al. 2018; Ottosson and Westling 2020). Moreover, unlike conventional machines, AI can even enhance itself all the time due to its self-learning ability based on past operation experiences (Öztemel and Gursev 2020). The new digital solutions are always changing the competitive strategies used in business and contributing to new approaches to value creation (Shang and Zhang 2022).

There is increasing feasibility of the utilization of chatbots by the banking industry. For example, a chatbot utilizes natural language technology to solve the user's problems (Suhel et al. 2020). The use of chatbots in the financial sector has changed the problem solving and answering of consumers' queries (Hwang and Kim 2021). Chatbots comprehend written and spoken text and can respond to vague questions and communicate with other portals or online data stores. Chatbot technologies handle massive numbers of calls from customers and enhance customers' satisfaction and confidence in banking services and their perceived usefulness (Sanny et al. 2020; Eren 2021; Nguyen et al. 2021). Moreover, chatbots handle more accounts than human advisors at lower operational costs and maximize profits (Patil and Kulkarni 2019). Furthermore, the 24/7 availability of online assessment chatbots has made operations more flexible, leading to a decrease in the use of physical bank branches (Wheeler 2020). Generally, banks utilize software such as UiPath, Automation Anywhere, Blue Prism, end-user devices, robots, software, and artificial intelligence agents to aid the process of repetitive banking operations (Vijai et al. 2020).

The introduction of AI enhances and simplifies the process of decision making while continuing to obey regulations. AI can reduce the number of false contracts, enhance the prediction of operational resources (Han et al. 2020), and accomplish obedience to regulatory requirements (Couchoro et al. 2021; Garcia-Bedoya et al. 2020; Kute et al. 2021). Numerous modern AI techniques have been utilized by banks to reduce fraudulent processes, such as data mining, fuzzy logic, machine learning, sequence alignment, and genetic programming (Raj and Portia 2011). Banks have improved their process speed, accuracy, and efficiency through the use of autonomous data management (Soni 2019). Predictive analytics can stop fraud incidents before they happen through several technologies such as Secure Socket Layer (SSL) for online transactions, encryption data storage, multi-level authorization, device fingerprinting, malware detection, token passwords, signing transactions, and endpoint protection (Kikan et al. 2019). Banks have utilized deep learning and artificial neural networks in personalized retail banking to assess their performance in direct marketing and determine which customers are likely to accept marketing proposals (Kim et al. 2015; Zakaryazad and Duman 2016). AI enhances the speed of the process, decreases cost-related issues, reduces operational risks, and improves know-your-customer processes through the use of chatbots and robot-advisors' services (Kaya 2019).

2.2. The Impact of AI on Financial Performance

The business community has witnessed an increased interest in the use of AI techniques, with financial services, manufacturing, information services, and banks as the most beneficial sectors (Bughin et al. 2017; Green et al. 2009). According to executives' surveys across various industries, investment in AI and focus on collaboration between employees and machine learning technology could increase banks' revenue by 34% (Shook and Knickrehm 2018).

Furthermore, according to the AI McKinsey Global Surveys series since 2004 and the current state of AI in 2023, AI adoption is increasing globally; the survey's results show an increase in companies embedding AI in at least one business function or one business unit.

Firm performance has received great attention from researchers in the accounting and finance area (Agarwal 2020). In general, researchers examine what might impact the financial performance of a firm in both positive and negative ways. For example, Almustafa et al. (2023) found that national governance quality plays an important role in mitigating the negative impact of the COVID-19 crisis on firm performance. Moreover, Nguyen (2022) found that new technologies, such as FinTech, might have a negative impact on financial performance. This finding was supported by Nguyen and Dang (2023), who found that FinTech development might negatively impact stock price and crash risk.

The Financial Stability Board (FSB) has analyzed the potential financial stability implications of the growing use of AI in financial services. FSB (2017) describes supply and demand factors that drive AI adoption in the financial sector; supply factors such as technological advances and the availability of data and infrastructure; and demand factors such

as profitability needs, competition with other firms, and the demands of financial regulation. According to the FSB, there are four sets of AI use cases: “(i) customer-focused (or ‘front-office’) uses, including credit scoring, insurance, and client-facing chatbots; (ii) operations-focused (or ‘back-office’) uses, including capital optimization, risk management model, market impact analysis, trading and portfolio management in financial markets; and (iv) uses of AI and machine learning by financial institutions for regulatory compliance (‘RegTech’) or by public authorities for supervision (‘SupTech’)” (FSB 2017).

Furthermore, the Organisation for Economic Co-operation and Development (OECD) has highlighted the potential impact of AI in specific financial market activities. According to the OECD (2021), the deployment of AI drives competitive advantages through two main avenues: first, by improving the firms’ efficiency through cost reduction and productivity enhancement, therefore driving higher profitability (e.g., enhanced decision-making processes, automated execution, gains from improvements in risk management and regulatory compliance, back-office and other process optimization); and second, by enhancing the quality of financial services and products offered to consumers (e.g., new product offerings and high service customization). The use of AI generates new benefits, possibly leading to a substantial increase in labor productivity, operational workflow efficiency, and new revenue streams (PwC 2020). It will also strengthen risk management, improve customer experience, and enhance performance (Gokhale et al. 2019).

AI brings benefits to financial institutions in the form of stability, greater profitability, efficiencies in the provision of financial services, and systemic risk surveillance and regulation. From the firm’s perspective, AI taking over repetitive bank tasks and autonomous AI solutions reduce the demand for less skilled labor and improve the efficiency of remaining staff (Kaya 2019). Thus, the implementation of speed-enhancing processes will improve bank employees’ productivity (Plastino and Purdy 2018). Previous studies have indicated that banks have already recognized cost reduction and revenue generation through enhancing the quality of operations, for example, in terms of lending, security services, compliance improvements, fraud detection, and new types of services (Burgess 2017; Kaya 2019; Ryll et al. 2020). Moreover, these customized solutions and services provide customers with personalized investment strategies, wealth management techniques, and robo-advisors (Wheeler 2020).

These findings suggest that AI applications are favorable for the banking sector and beneficial for both shareholders and stakeholders, as well as for increased efficiency in the financial sector, which leads to economic benefits. The possible impact of AI in most practices has just started bringing benefits to financial institutions through various channels, improving efficiency and enhancing revenue sources by offering new services and products. Nevertheless, quantifying the link between the use of AI and bank performance is hard, not least due to issues around AI identification. In this context, a question arises about the extent to which AI affects businesses, consumers, and the whole economy.

2.3. AI Voluntary Disclosures and Financial Performance

The rapid advancements in AI have significantly impacted various sectors, and the banking industry is no exception. As banks increasingly integrate AI technologies into their operations, there is a crucial need to address the disclosure practices surrounding AI implementation (Sætra 2021). Financial services, among some other industries, with large volumes of customers and operations, depend on data processing in terms of text and speech; these services have most often adopted AI and disclose more information on natural language capabilities (AI McKinsey Global Surveys series).

Despite the opportunities and benefits of the application of AI, AI disclosure is still voluntary. The decision of whether to disclose, to what extent, and the type of information is almost entirely left to the discretion of companies. To date, there is no commonly accepted practice for the level of AI disclosure. AI applications are relatively new. There are no known dedicated international reporting standards agreed upon in this area. The existing AI disclosure practices do not adequately capture the unique impacts of AI. The lack

of a shared vision and reporting standards for AI leads to different disclosure practices depending on companies' perceptions (Sætra 2021).

In the age of AI, opacity is one of the greatest perils facing humans today. S. Lu (2021) argues that the current disclosure framework under corporate securities law has a limited impact on reducing opacity in AI systems. He calls for an effective disclosure framework for AI products and services in order to address AI opacity. It is crucial to ensure that AI algorithms are harmless by requiring more transparency to mitigate algorithmic opacity. Accordingly, such an advanced disclosure framework can help enhance transparency to reduce the risks posed to stakeholders, stabilize capital markets, and promote sustainability in the long run.

Recently, authorities' regulators and supervisors have been considering requirements around AI disclosure. For instance, the OECD addressed AI disclosure issues to promote innovative and trustworthy use of AI. Based on the OECD AI Principles, 'there should be transparency and responsible disclosure around AI systems to ensure that people understand AI-based outcomes and can challenge them' (OECD 2019). Thus, financial consumers need to be informed about the use of AI techniques in the delivery of a product, as well as potential interaction with an AI system instead of a human being, to make conscious choices among competing products. Moreover, the OECD (2021) further highlights the need for disclosure requirements that help financial service providers to better assess whether prospective clients have a solid understanding of how the use of AI affects the delivery of the product. Similarly, the International Organization of Securities Commissions (IOSCO) also calls for including more clear information about the AI system's capabilities and limitations in such disclosures. IOSCO (2020) proposes guidance on "Appropriate transparency and disclosures to investors, regulators, and other relevant stakeholders". Disclosure requirements, therefore, need to consider any information around the use of AI techniques that may impact investors, regulators, and other relevant stakeholders, such as information on algorithmic trading models, data collection, and cross-border cooperation.

AI regulations are under development worldwide. There is a wave of new AI regulation that will soon have significant implications for AI systems. For example, the US "AI Disclosure Act of 2023: A Step Towards Algorithmic Transparency" represents an important step towards AI algorithmic transparency for those interacting with AI systems to be more informed about what they are interacting with, allowing them to make decisions accordingly. The scope of the AI Disclosure Act applies to any entity engaged in commerce, including banks (Section 5, the Federal Trade Commission). The EU AI Act (European Parliament 2023) also imposes transparency requirements for AI systems used in the EU. It is a significant piece of legislation that could have a major impact on the development and use of AI in the European Union. The EU AI Act specifies corresponding requirements for transparency, documentation, auditing, and obligations. AI systems should be developed to allow appropriate transparency and provision of information to users (Article 13). Such acts are still in the early stages of development, only having recently passed, but it is clear that they have the potential to shape the future of AI in the US and Europe. Becoming prepared early by establishing the appropriate disclosure procedures is the best way to ensure compliance with transparency requirements.

2.4. Development of Hypotheses

The prior literature discusses voluntary disclosure based on various theoretical perspectives. For example, agency theory focuses on the communication of specialized information by managers to enhance firm value and reduce costs of capital (Jensen and Meckling 1976). Voluntary disclosure allows managers to communicate effectively and enhance the firm's value since it encompasses various aspects, such as investment opportunities and financing policies. Agency theory scholars have called for expanding the categories of voluntary disclosure as a tool to observe the managers' actions and improve firm performance (Barako et al. 2006; Fang and Jin 2012; Cockburn et al. 2018; Haninun et al. 2018; Hassanein et al. 2019; Albitar et al. 2020). Similarly, the theory of capital needs points out that volun-

tary disclosure helps companies to increase additional funds at lower cost. Since companies need capital to continue their operations, disclosing more information voluntarily provides investors with additional information that enables them to make more valuable economic predictions about the firm (Bertomeu et al. 2011; Bini 2018; Cheynel 2013; Shehata 2014). From the perspective of signaling theory, companies would disclose more information than is mandatory in order to attract investors' attention, reduce information asymmetry between the company and its stakeholders, and signal their capabilities (Bertomeu et al. 2011; An et al. 2011). Managers voluntarily disclose good news to signal positive outcomes and may also disclose bad news to demonstrate efforts to address future losses. Managers of profitable firms prefer to voluntarily disclose significant information to signal profitability, boost investor confidence, and improve financial performance (Campbell et al. 2003; Albitar et al. 2020; Hassanein et al. 2019; Alkaraan et al. 2022). Legitimacy theory also offers a reasonable explanation for voluntary disclosure. Transparency, through voluntary disclosure, is one of the different strategies that companies adopt to legitimate their practices and activities to prove compliance with stakeholders' expectations (Magness 2006; Lightstone and Driscoll 2008; Bonsón et al. 2021). Organizations can gain social approval for their actions by engaging in higher levels of transparency (Bonsón and Bednárová 2013).

Regarding voluntary AI disclosure, companies want to inform stakeholders about increased operational efficiency to signal value creation, sustainability, and better competition in the market related to their AI products and processes. Thus, being more transparent about new AI technologies would attract potential investors and increase the trustworthiness of other stakeholders. Information about applied AI tools is communicated to different stakeholders to gain their trust and acceptance and obtain legitimation (Osburg 2017; Thorun 2018; Bonsón et al. 2021, 2023). Similar to other voluntary disclosure challenges, the applications of AI models raises important disclosure issues in the banking industry due to the nature of the business and its operational environment. The growing development and utilization of AI can influence voluntary disclosure in the banking industry (Saenz et al. 2020). The competitive landscape in the banking industry impacts the decisions to disclose information about firms' use of AI. Firms may elect to disclose more voluntary information if they believe that will gain a competitive advantage. For example, banks like to show their expertise in the field (Yu et al. 2017; Krakowski et al. 2022). Therefore, banks that operate in highly competitive markets may choose to disclose more information about their AI systems to be competitive with their competitors. According to the AI McKinsey Global Surveys series, companies are most likely to adopt AI in functions that provide core value in their industry, and financial services are more likely than other industries to have adopted AI in service operations, marketing, sales, and risk functions.

AI is found to have a positive impact on a firm's nonfinancial indicators, such as the accounting information system efficiency and the success of the workflow within a firm (Hashem and Alqatamin 2021). Wamba-Taguimdje et al. (2020) stated that AI benefits organizations, and more specifically, their ability to improve performance at both the organizational (financial, marketing, and administrative) and process levels. Fethi and Pasiouras (2010) provided a comprehensive review of 179 academic papers that examined the impact of AI on different financial indicators of banks. They concluded that one of the financial indicators that is affected positively by AI is the banks' financial performance. Therefore, the following first hypothesis is suggested:

H1. *AI-related terms disclosure will be positively related to the banks' financial performance.*

In the same vein, banks that prefer clarity, moral behavior, transparency, and social responsibility are more likely to disclose information about their AI systems if they believe that disclosure enhances confidence and credibility among customers, regulators, and society at large (Elkelish and Hassan 2014). Disclosing information about AI practices, their algorithm models, data sources, and decision-making operations enhances justice and trust among customers, regulators, and stakeholders. Moreover, it keeps banks as far as possible from any reputational dangers that may emerge from AI utilization decisions. For

example, companies that have confidence in their use of AI are more likely to disclose more related information. Disclosing information about AI use creates a reputation of innovation and excellence that engages more clients who value advanced AI systems. AI transparency enhances banks' reputation, customer loyalty, and profitability (Felzmann et al. 2020). In addition, the banking industry is highly sensitive to stricter regulations in contrast to other industries. The banks may disclose more information about their AI systems to show their compliance with moral standards and gain a competitive edge in markets that value responsibility (Krakowski et al. 2022). Overall, the tendency of AI voluntary disclosure is to highlight favorable information to obtain positive effects in terms of economic impact and to appeal to investors, as this disclosure can help investors gain a clearer picture in terms of the company's investments in AI technologies (Bonsón et al. 2021).

Based on various theoretical perspectives, expectations, and the supporting literature, it is assumed that companies that apply AI in their processes and recognize a financial benefit already, in terms of increased revenue and decreased costs, are motivated to disclose positive information about the development, application, and use of AI. It is also anticipated that companies that voluntarily disclose AI information more often are more likely to have implemented AI as part of their business strategy and recognized financial benefits. Hence, we expect the frequency of disclosure of AI-related terms in banks' annual reports to impact financial performance in terms of increased revenue and decreased costs compared to other banks.

The advancement of new technological solutions such as AI has shown its merit through the impact on organizations' different financial indicators, and the total cost is one financial indicator that is expected to be reduced by the adoption of AI techniques (Nguyen and Dang 2023). Fethi and Pasiouras (2010) indicated that the bank's total cost would be minimized by using AI techniques. This evidence is supported by Doumpos et al. (2023), who reviewed AI techniques in the banking literature and concluded that AI techniques are expected to enhance financial indicators within the banking industry. Therefore, the following second hypothesis is suggested:

H2. *AI-related terms disclosure will be negatively related to the banks' total expenses.*

3. Research Design

3.1. AI Disclosure

Following the purpose of this study, we use the content analysis method for measuring levels of AI disclosure and produce a preliminary list of AI keywords. Previous studies have applied similar processes (e.g., Hassanein et al. 2019; Elmarzouky et al. 2021; Karim et al. 2021; Alkaraan et al. 2022). In particular, the selection of AI-disclosure-related items is carried out in three stages.

Firstly, we create an AI disclosure index through a comprehensive review of AI components that have been mostly mentioned in the finance sector by related professional organizations such as the FSB (2017), OECD (2019), and IOSCO (2020). For example, the AI Index Report 2019 highlight the terms most often mentioned in the finance sector, including "AI", "Big Data", "Cloud", and "Machine Learning" (Perrault et al. 2019), based on the previously related literature that utilizes various self-constructed disclosure proxies' measures (Finkenwirth 2021; Zetzsche et al. 2020; Hussainey et al. 2022). In the context of AI, Omar et al. (2017) applied content analysis to the annual reports of Malaysian publicly listed companies, searching for the words "Artificial Intelligence", "Machine Learning", and "Big Data". Cam et al. (2019) conducted a content analysis and classified the AI applications in USA banks; "Robotic Process Automation", "virtual agents", "natural language text understanding", "machine learning", and "computer vision" are mentioned frequently. Bonsón et al. (2023) conducted content analysis of European listed companies, and they identified search keywords items including "artificial intelligence", "machine learning", "automat", and "algorithm".

According to McWaters (2018), focusing on AI alone is not sufficient to understand the myriad ways in which it could be used within financial institutions. Advances in any

technology will increase the capabilities of all other technologies that interact with it. Thus, AI must be understood within the context of all other technologies. We combined a set of the most often mentioned AI-related terms in the finance sector to identify the preliminary AI disclosure index. Appendix A Table A1 Column A presents the keywords for AI-related disclosure terms.

Second, the frequency of AI-related terms for each bank's annual report is measured through the computerized content analysis software "Maxqda". The keywords and the context of those keywords are also analysed, including the sentence or sentences before and after the search term, to provide insight into the AI business strategy.

Third, the AI-related terms disclosure keywords are classified into three categories. The first group combines the keywords related to digital awareness, transformation, and capabilities. The second group is related to AI applications, products, services, and processes. The last group is related to AI challenges and threats in terms of information and cyber security (Appendix A Table A1 Column B presents the classes keywords for AI-related disclosure terms for each category). Thereafter, the resulting data for the content analysis are incorporated into multiple regressions.

3.2. Regression Model and Variable Definitions

The following regression model is used to measure the impact of mentioning AI-related keywords in the annual reports on financial performance.

$$\begin{aligned} \text{Performance } t = & \beta_0 + \beta_1 \text{AIFREC}_{t-1} + \beta_2 \text{BSIZE}_{t-1} + \beta_3 \text{DEBT}_{t-1} + \beta_4 \text{BDSIZ}_{t-1} \\ & + \beta_5 \text{INDPB}_{t-1} + \beta_6 \text{FORSH}_{t-1} + \beta_7 \text{LASHR}_{t-1} + \beta_8 \text{BRNCH}_{t-1} \\ & + \beta_9 \text{BKAGE}_{t-1} + \beta_{10} \text{YEAR} + e \end{aligned} \quad (1)$$

where performance is the bank's financial performance, assessed by several alternative estimations. We consider accounting measures of performance, including return on equity (ROE), return on assets (ROA), and net interest income (NII), in our basic analysis. We also consider market performance measures, such as price earnings ratio (P/E). ROA and ROE are widely used in the literature as the more effectively a company's management produces revenue from its assets and from shareholders' capital, the higher they are; thus, the higher the ROA and ROE, the higher the firm performance (Almustafa et al. 2023; Hasan et al. 2023). Alternatively, we also consider total expenses (TEXP), assuming that AI implementation reduces cost, which leads to higher financial performance. NII reflects the main banking operation's income from lending and borrowing, which is assumed to be affected directly by increased revenue and decreased cost of these main services. These ratios provide a picture of the firm's financial development; past studies have used them for evaluating financial performance (Hagel et al. 2013; Heikal et al. 2014; Fatihudin 2018).

AIFREC ('AI frequency') is the AI-related terms disclosure frequency measured as the number of mentioned AI-related terms in each annual report (Alkaraan et al. 2022; Finkenwirth 2021). The AI practices and AI disclosure choices at each bank are sensitive to many internal and external factors. The banks' specific characteristics create incentives for bank managers for AI implementation and AI disclosure practices according to these features. The literature provides abundant research on the association between banks' characteristics and bank performance. In our empirical models, we include three groups of control variables that reflect banks' governance features, ownership structure, and cost of capital attributes, and economic-specific characteristics, many of which are commonly known from the previous literature to be important factors affecting the banks' performance measures.

The first group of control variables reflects the internal corporate governance features at the bank level. We control for board size and board independence (Jensen 1993; Yermack 1996). Independent directors are deemed more effective monitors due to greater reputational costs (Fama and Jensen 1983; Coles et al. 2008). The board of directors is considered a core internal corporate governance variable in the literature (see S. Agarwal (2020) for a review; Dang and Nguyen 2021; Nguyen 2022). Hence, board size (BODSIZE) is the number of board directors, and independent board (INDD) is the proportion of

independent directors from the board. By including this control, we cater for the case that a bank's performance and AI disclosure are products of the board on which they serve.

In the second group, we include controls for bank ownership structure and costs of capital attribute variables that may affect performance. Theoretically, agency costs of capital arise from the conflict between shareholders and debt holders of a public company. The debtholders may also place limits on the use of their capital if they believe that management will take actions that favor shareholders instead of debtholders. Thus, we control the bank ownership structure, including the large shareholders' ratio (LSHAR), which is measured as the percentage of accumulated large shareholders who own 5% or more of the bank's stock. Foreign ownership ratio (FORSH) is used to control for investors' interest (Al-Gamrh et al. 2020; Mallinguh et al. 2020; Nguyen 2022). We also control for the debtholders' structure. The literature has found that debt ratio affects financial performance (Almustafa et al. 2023; Gander 2012; Shiyyab et al. 2014). The debt ratio (DEBT) is measured as the ratio of long-term debt to total debt. Large shareholders are predicted to be associated with AI disclosure and performance.

Third, we control for economic characteristics at the bank level, consistent with what has been documented in the bank performance literature. First, it has been documented that bank size and operation complexity have an impact on management activities and, primarily, bank performance (Almustafa et al. 2023; Nguyen 2022). Therefore, we control bank size as the natural logarithm of total assets (BSIZE). In addition, we control for the number of branches and bank age. Despite the widespread use of online banking services, the banks' physical presence is still important due to the opportunities for face-to-face contact with the customer (Almustafa et al. 2023). The literature provides evidence that branch networks still enable the bank to gain a competitive advantage by creating extensive-term personalized links with their clients, leading to increased profits and reduced loan losses (Berger and Black 2011; Hirtle 2007; Harimaya and Kondo 2012; Kondo 2018; Monferrer Tirado et al. 2019). Therefore, we control for the number of branches with BRNCH as a continuous variable reflecting the number of branches for each bank every year, and we also include a control for bank age (BKAGE) as the total number of years a corporation has been in operation (Almustafa et al. 2023; Nguyen 2022; Coad et al. 2018).

Finally, we also account for the impact of the COVID-19 crisis on bank performance; we use a dummy variable as the independent variable, which is 1 for the COVID-19 period or 0 otherwise. We define the COVID-19 crisis period as 2020 (Shen et al. 2020; Almustafa et al. 2023; Hasan et al. 2023). Finally, we also control for years' effects. We created an indicator variable representing the year-dummies (YEAR_DUM) to control for year-specific effects. All variable definitions are presented in Table 1.

Table 1. The variables' names and definitions.

	Variables Definitions
AIFREC	The number of mentioned AI-related terms in each annual report
ROA	Return on assets
ROE	Return on equity
NII	Net interest income
P/E	Price-to-earnings ratio
TEXP	The natural logarithm of total expenses
BKSIZ	The natural logarithm of assets
DEBT	The long-term debt to total debt
BDSIZ	The number of board directors
INDPB	The proportion of independent directors on the board
FORSH	The ratio of foreign shares to total shares
LASHR	The percentage of large shareholders who own more than 5% of total shares
BRNCH	The number of branches for each bank every year
BKAGE	The total number of years from the date of establishment of the bank
COVID-19	A dummy variable, equal to 1 for the COVID-19 period (the year 2020) or 0 otherwise

3.3. Sample and Data

Financial analysts use both financial and non-financial information to gain a reliable picture of companies' performance, and the annual report is one of the main sources for the decision-making process of investors in the financial market (Araújo Júnior et al. 2014; Zhou et al. 2017). Therefore, this research is based on the analysis of 130 annual reports for all 15 Jordanian-listed banks from the period 2014–2022. Most of the annual reports are available as a PDF version for all Jordanian banks on their websites. The relevant words are searched, being those previously mentioned in the context analysis. The newly created keyword dataset based on the annual reports provides insights into the development of AI-related mentions.

4. Finding and Discussion

4.1. Descriptive Statistics

Table 2 panel A provides an overview of the AI-related terms disclosure for each bank. The total AI-related keywords disclosure is 2658, while the range is wide between banks. The highest AI-related keywords disclosure 18% of the dataset belongs to the Jordan Ahli Bank, 12% to Safwa Islamic Bank, and 11% to Bank El Etihad. These banks mention AI-related terms with highly frequency, while Societe General, International Islamic Arab Bank, and Invest Bank are banks that mention AI-related terms with low frequency. The remaining banks' samples range from 4% to 9% of the dataset. Table 2 panel B presents the frequency of AI-related keywords mentioned in an annual report by year. The AI-related keywords disclosure varied across years and increased dramatically from 2014 to 2022 (733 related words in 2022, 73 in 2014). However, approximately 60% of AI-related keywords were disclosed in the last three years of 2019–2022. This reflects the recent revolution of AI in the banking industry, especially during COVID-19 time. The increase in AI-related disclosure in annual reports suggests that banks have made more investments and rely more on AI implementation.

Table 2. Summary statistics of AI disclosure by bank and by year.

Panel A. AI Disclosure Frequency by Bank			Panel B. AI Disclosure Frequency by Year		
Bank Name	AI Freq	Per%	Year	AI Freq	Per%
Jordan Ahli Bank	471	18%	2014	73	3%
Safwa Islamic Bank	311	12%	2015	75	3%
Bank El Etihad	283	11%	2016	122	5%
Bank of Jordan	228	9%	2017	220	8%
The housing Bank for Trade Arab Bank	215	8%	2018	289	11%
Jordan Commercial Bank	211	8%	2019	297	11%
Cairo Amman Bank	172	6%	2020	441	17%
Jordan Kuwait Bank	165	6%	2021	515	19%
Jordan Islamic Bank	137	5%	2022	733	23%
Arab Banking Corporation	118	4%			
Arab Jordan Investment Bank	113	4%			
Societe General Bank	103	4%			
International Islamic Arab Bank	54	2%			
Invest Bank	48	2%			
	29	1%			
Total	2658	100%		2658	100%

The AI-related disclosure keywords are classified into three categories. The first group combines the keywords related to digital awareness, transformation, and capabilities. The second group is related to AI applications, products, services, and processes. The last group relates to AI challenges and threats in terms of information and cyber security. Table 3 presents the AI-related disclosure terms classified into three categories.

Table 3. The AI-related disclosure terms are classified into three categories.

AI-Related Terms/Words	Frequency	Percentage
AI digital awareness, transformation, and capabilities	640	24.09%
AI application, product, service, and process	886	33.33%
Information and cyber security	1132	42.58%
Total—AI-related terms/words	1925	100%

The first group combining the keywords related to digital awareness, transformation, and capabilities represents 24% of the total, which highlights the banks' keenness and commitment to harnessing the potential of artificial intelligence in their operations and services. The most frequently recurring keywords are digital transformation (143), fintech (130), and financial technology (85). The annual reports of banks have mentioned artificial intelligence 13 times, reflecting a significant interest and focus on this transformative technology. This indicates a potential awareness within banks' management regarding the pivotal role these terms play in attracting attention to the banks' pioneering role and achieving a competitive advantage.

The second group related to AI applications, products, services, and processes represents 33% of the total. This reflects the level of dedication towards essential services in achieving digital transformation and utilizing artificial intelligence technologies. This signifies the unwavering commitment to harnessing the power of cutting-edge technologies and embracing a future where innovation and digital advancements drive progress. The keywords "robotic automation", "digital banking", "mobile banking", "online banking", and "digital services" are of the most importance in the banking industry. This signifies the transformation and advancements that are shaping the future of banking. Robotic automation streamlines operations, while digital banking, mobile banking, and online banking offer convenient access to services. Digital services encompass innovative solutions that enhance the overall banking experience. Together, these keywords represent the vital role technology plays in revolutionizing the industry.

The last group is related to AI challenges and threats in terms of information and cyber security. The extent of interest in this area is evident in the remarkable percentage (44%) highlighting collective challenges and threats. The most frequently mentioned keywords in this group are information security, cyber security, electronic security risks, IT security, electronic banking services, and electronic security policies. This finding demonstrates a strong emphasis on ensuring robust security measures in the digital landscape. These keywords highlight the importance of protecting sensitive data, combating cyber threats, and maintaining secure electronic banking services. They signify a commitment to safeguarding digital systems and providing secure experiences for individuals and organizations. This is consistent with previous results and industry surveys. For example, the global joint survey conducted by the World Economic Forum and the Cambridge Centre for Alternative Finance indicates that a majority of financial services companies (56%) have implemented AI technology in terms of risk management domains.

Table 4 provides descriptive statistics for the total sample. The mean of the AI-related terms frequency variable is 20.98, with a minimum of 2 and a maximum of 121. This reflects that some banks need more disclosure information with regard to AI-related terms. The bank characteristics also vary according to each bank; for example, BKSIZ varies between 22 and 8441 million, BRNCH ranges between 12 and 211 branches, and the bank age ranges between 5 and 88 years of operation. These differences are expected to explain bank performance as well as AI disclosure.

Table 4. Descriptive statistics.

Variable	Obs No.	Mean	Median	Sta Dev	Min	Max
AIFREC	127.00	20.98	14.00	20.63	2.00	121.00
ROE	127.00	7.84	7.92	4.36	−1.42	16.50
ROA	127.00	0.94	0.99	0.52	−0.43	2.05
P/E	127.00	12.87	10.93	9.33	0.00	62.10
NII (in millions)	127.00	174.48	111.89	249.17	9.11	913.23
TEXP (in millions)	127.00	109.71	63.20	165.02	11.78	860.18
BKSIZ (in millions)	127.00	2586	2200	1950	22.00	8441
DEBT	127.00	87.58	87.64	2.92	81.71	93.04
FORSH	127.00	0.07	0.05	0.09	0.00	0.52
LARSHR	127.00	0.67	0.66	0.21	0.30	0.97
BDSIZ	127.00	11.46	12.00	1.88	5.00	13.00
INDPB	127.00	0.41	0.42	0.11	0.18	0.64
BRNCH	127.00	64.78	48.00	49.61	12.00	211.00
BKAGE	127.00	40.69	39.00	18.81	5.00	88.00

AIFREC is the frequency of mentioned AI-related terms in each annual report. ROA is return on assets. ROE is return on equity. NII is the natural logarithm of net interest income. P/E is the price-to-earnings ratio. TEXP is the natural logarithm of total expenses. BDSIZ is the number of board directors. INDPB is the proportion of independent directors from the board. LASHR is the accumulated percentage of large shareholders who own 5% or more of the bank's stock. FORSH is the ratio of foreign shares to total shares. DEBT is the ratio of long-term debt to total assets. BKSIZ is the natural logarithm of assets. BRNCH is a number of branches for each bank every year. BKAGE is the number of years a corporation has been in operation.

4.2. Correlations

Table 5 provides the results of the correlations among variables, with some coefficients warranting particular attention. Overall, the correlations are relatively small, and the low inter-correlations among all independent variables indicate that multicollinearity does not appear to be a problem in the regression model. However, it provides valuable information regarding the associations between AI disclosure and firm variables. For example, we observe several associations between AI disclosure and bank characteristics that identify which bank features are more conducive to AI disclosure practices. AI disclosure practices are positively associated with corporate governance features in terms of BDSIZ and INDPB (at 1% and 10%, respectively). Similarly, as expected, AI disclosure is positively associated with BKAGE %, BKSIZ 5%, and BRNCH 10%. FORSH is positively associated with AI disclosure, whereas LASHR is negatively correlated with AI disclosure, which indicates that shareholders are either conservative with regard to AI implementation or they have symmetric information, which implies weak disclosure in the annual reports. LASHR is positively associated with BKSIZ, BDSIZ, and INDPB, while it is negatively related to FORSH. DEBTH is negatively correlated with FORSH, BRNCH, and BKAGE. BDSIZ is associated with INDPB and BRNCH. As expected, the economic characteristics are correlated to each other; BKSIZ is linked to BRNCH and BKAGE, all at a 1% significance level, and to the BDSIZ at a 5% level of significance.

Table 5. Correlations.

	AIFRCD	BKSIZ	DEBTH	LASHR	FORSH	BDSIZ	INDPB	BRNCH
AIFRCD	1.000							
BKSIZ	0.220 **	1.000						
DEBTH	0.107	−0.032	1.000					
LASHR	−0.327 ***	0.178 **	0.048	1.000				
FORSH	0.247 ***	0.266 ***	−0.205 **	−0.188 **	1.000			
BDSIZ	0.234 ***	0.173 *	−0.283	0.306 ***	−0.089	1.000		
INDPB	0.149 *	−0.041	0.175	0.199 **	0.073	0.170 *	1.000	
BRNCH	0.153 *	0.915 ***	−0.155 *	0.132	0.197 **	0.218 **	−0.192 **	1.000
BKAGE	0.275 ***	0.684 ***	−0.294 ***	−0.087	0.151 *	0.322 ***	−0.038	0.763 ***

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

4.3. Regression Model

Multiple regression analysis using ordinary least squares (OLS) has been used. Table 6 reports the results of OLS regressions of AI-related term disclosure on a set of performance indicator variables. Models 1, 2, 3, and 4 present the results for ROA, ROE, NII, and P/E ratio, respectively. Model 5 presents the result for total expenses. The models have a predictive capacity for the dependent variables, in terms of R², which ranges between 0.27 and 0.64, and F-values are significant at the 1% level.

Table 6. The OLS regressions of AI disclosure on financial performance.

	(1)	(2)	(3)	(4)	(5)
	ROA	ROE	P/E	NII	TEXP
AIFREC	0.00427 ** (2.86)	0.0314 ** (2.54)	0.0567 (1.25)	0.0172 * (1.97)	−0.00355 ** (2.31)
LASHR	−1.338 *** (−5.49)	−11.48 *** (−5.75)	3.059 (0.54)	−2.376 *** (−4.44)	−0.0298 (−0.16)
DEBTH	−0.0382 ** (−2.56)	−0.284 ** (−2.32)	−0.204 (−0.59)	−0.0850 ** (−2.59)	−0.0353 *** (−3.03)
FORSH	1.312 *** (3.03)	11.44 *** (3.22)	−18.55 (−1.86)	−0.118 (−0.12)	1.028 *** (3.05)
BDSIZ	0.0226 (0.89)	0.0619 (0.30)	0.266 (0.45)	0.352 *** (6.30)	−0.00208 (−0.10)
INDPB	−1.401 *** (−3.81)	−12.80 *** (−4.25)	7.738 (0.91)	−0.184 (−0.23)	0.0754 (0.26)
BKSIZ	−0.0168 (−0.15)	−0.855 (−0.95)	−0.194 * (−1.58)	−0.498 ** (−2.05)	0.314 *** (3.66)
BRNCH	0.00591 ** (2.57)	0.0763 *** (4.05)	0.0458 (0.86)	0.0493 *** (9.76)	0.00913 *** (5.10)
BKAGE	−0.0158 *** (−3.78)	−0.180 *** (−5.26)	0.0319 (0.33)	−0.0865 *** (−9.44)	0.00697 *** (2.45)
Year Dummy	Yes	Yes	Yes	Yes	Yes
Bank Dummy	Yes	Yes	Yes	Yes	Yes
_cons	6.123 ** (2.55)	15.97 *** (3.81)	22.56 * (1.91)	19.59 *** (3.72)	13.21 *** (7.08)
N	127	127	127	127	127
R ²	0.466	0.495	0.278	0.632	0.641
adj. R ²	0.425	0.456	0.212	0.579	0.594

t-statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. AIFREC is the frequency of mentioned AI-related terms in each annual report. ROA is return on assets. ROE is return on equity. NII is the natural logarithm of net interest income. P/E is the price-to-earnings ratio. TEXP is the natural logarithm of total expenses. BDSIZ is the number of board directors. INDPB is the proportion of independent directors from the board. LASHR is the accumulated percentage of large shareholders who own 5% or more of the bank's stock. FORSH is the ratio of foreign shares to total shares. DEBT is the ratio of long-term debt to total assets. BKSIZ is the natural logarithm of assets. BRNCH is the number of branches for each bank every year. BKAGE is the number of years a corporation has been in operation.

Models 1 and 2 show that performance indicator variables such as ROA and ROE provide an explanation for AI-related term disclosure. In particular, the impact of AI-related term disclosure is positive and statistically significant, with ROA and ROE at a 5% level of significance. This indicates that additional AI-related term disclosure is valued and related to better performance. Moreover, AI-related term disclosure provides an additional signal for specialist technology knowledge and expertise in modern operational settings that allow for additional performance. These results signify that AI frequency has an influence on the bank's profitability and shareholders' equity. In the same vein, the impact of the frequency of AI-related term disclosure on total expenses (TEXP) is negative and statistically significant at a 5% level of significance, which supports the dominant view that AI reduces cost and is consistent with past findings. For example, banks are already

strengthening customer relationships and lowering costs by using artificial intelligence (McKinsey & Company 2021).

The bank-specific features also provide additional insight into banking performance and can explain the variation between banks' performances. For example, FORSH is positively and statistically significantly correlated with bank performance in terms of ROA and ROE at a 1% level of significance. This result is consistent with previous studies that found foreign ownership positively affects firms' financial performance (Al-Gamrh et al. 2020; Mallinguh et al. 2020) and financial stability in emerging markets (Nguyen 2022). BRNCH is positively associated with bank performance in terms of ROA, ROE, and NII. BDSIZ is positively and statistically significantly correlated with NII at a 1% level of significance, while it did not have any significant influences on other measures of performance.

LASHR is negatively and statistically significantly correlated with bank performance in terms of ROA, ROE, and NII at a 1% level of significance. This finding is consistent with previous studies that found large and concentrated shareholdings have a negative impact on performance (Al-Malkawi et al. 2014; Abdallah and Ismail 2017). DEBTH is negatively and statistically significantly correlated with bank performance in terms of ROA, ROE, and NII at a 1% level of significance. This is consistent with Almustafa et al. (2023)'s finding that DEBTH is negatively and statistically significantly correlated with ROE and ROA.

Unexpectedly, BKAGE is negatively and statistically significantly correlated with the bank performance measures ROA, ROE, and NII. Loderer et al. (2017) argue that firm age increases organizational rigidity, monitoring, and corporate control, thus leading to declining growth opportunities; they found evidence that companies invested less as they grew older. Similarly, INDPB is negatively and statistically significantly correlated with the bank performance measures ROA and ROE. BKSIZ is also negatively and statistically significantly correlated with bank performance measures in terms of PE and NII. This indicates that the too-big-to-fail problem may exist. The results are consistent with previous studies that found large firms reduce financial stability and diversification in emerging markets (Nguyen 2022) and are associated with more risk due to the "too big to fail" problem (Zardkoohi et al. 2018; Almustafa et al. 2023; Nguyen 2022). Model 5 in Table 6 shows that TEXP is positively and statistically significantly correlated, all at a 1% level, with each of FORSH, BKSIZ, BRNCH, and BKAGE. However, TEXP is negatively and statistically significantly correlated with DEBTH, at a 1% significance level.

Finally, we investigate the impact of the COVID-19 crisis on firm performance. Firstly, we use a dummy variable, which is 1 for the COVID-19 period or 0 otherwise. We further split the sample into two parts: before and during COVID-19. Overall, we do not observe any impact on the relationship between AI disclosure and bank performance. Hasan et al. (2023)'s results indicate that COVID-19 does not necessarily significantly impact business performance outcomes. They argue that modern technology, such as artificial intelligence, significantly mitigates the negative impacts. Similarly, Almustafa et al. (2023) argue that the national governance system has significantly reduced the impact of the COVID-19 crisis on firms' operations, and government support reduces the effects of economic shock, especially in banking sectors. Meanwhile, some variables' coefficients have been changed as expected due to the COVID-19 crisis impact, as seen in Table A5 in Appendix C.

Although some evidence is provided that AI adoption has a positive effect on accounting performance, other performance indicator variables lack significance. These results are consistent with Nguyen (2022)'s finding that FinTech development negatively affects financial stability in an emerging market. A possible interpretation is that annual reports do not provide enough insights into AI implementation. It might be that banks implementing AI have not mentioned AI-related terms in their annual reports due to a lack of AI disclosure requirements. Therefore, banks that mentioned fewer AI-related terms have not adopted AI yet or adopted AI in limited business units. Moreover, the disclosure of AI-related terms is not enough to achieve financial impact, as the benefit of adopting AI cannot be expected automatically based solely on the AI disclosure mentions.

The weak relation may be due to the contextual settings in well-established developed customer relations countries, such that AI disclosure may not fully affect performance. If the banking operation's performance is highly developed, stable, and automated, AI disclosure may not require changes in some banking practices. These AI disclosure benefits could have had little impact on the bank's performance.

In line with these findings, the result shows that Jordanian-listed banks increased AI-related keywords disclosure in their annual reports. Banks developing AI applications often mention use cases and point out the benefits of AI for improving their operation. This indicates the importance of integrating AI technologies into business models, leading to lower cost and higher performance, which is consistent with previous AI results and industry surveys. Companies have already recognized the contribution of AI adoption for better overall performance, increased revenue, and decreased cost (AI McKinsey Global Surveys series; the global joint survey conducted by the World Economic Forum and the Cambridge Centre for Alternative Finance). Overall, the results align with the tendency of various theoretical perspectives of AI voluntary disclosure that companies are motivated to highlight favorable information to obtain positive economic impact and to appeal to investors.

5. Conclusions

This study examined whether AI-related references in annual reports could be used as an explanatory variable for financial performance. We analyzed 115 annual reports for 15 Jordanian-listed banks from the period 2014–2021. The analysis of annual reports shows an increase in the frequency of AI-related terms disclosures since 2014. This development indicates that Jordanian banks have become more aware of AI adoption, implications, and benefits. At the same time, there is a weak level of AI-related disclosure in some Jordanian banks, which indicates that they are still at an early AI implementation stage, at least on the level of AI disclosure. As the trend of AI adoption is still developing, more efforts are needed for improvement in the context of voluntary AI disclosures.

Based on the results, the presence of AI-related keywords in a bank's disclosures positively impacts its profitability and efficiency, as indicated by improved ROA and ROE. It also leads to a decrease in total expenses, suggesting that AI is streamlining operational processes and reducing costs. These findings demonstrate AI's potential to drive revenue growth and enhance efficiency in the banking sector.

Based on AI-related mentions in the annual reports of Jordanian banks, this study shows a positive impact of AI-related term disclosure on accounting performance, and financial benefits have been realized. To the best of the researchers' knowledge, this study is the first in Jordan that links AI-related terms disclosure in annual reports to financial performance. This study contributes to the existing literature by providing new evidence of AI voluntary disclosures, specifically offering insights into how Jordanian banks disclose information related to AI in their annual reports.

This study provides bank executives, annual report users, regulators, and policymakers with a view of AI disclosure's impact on financial performance and the competitive advantage of AI disclosure in financial services. The study's findings are relevant to annual report providers in that disclosures related to AI are increasing in the banking industry and are of interest to users. In particular, AI disclosure might be useful to investors and financial analysts because it helps them to gain a clearer picture in terms of the company's investments in AI technologies and the sustainability of their investments. The study also provides regulators with recent evidence on voluntary disclosures in general and disclosures on AI that can help regulators assess current trends in AI voluntary disclosures, understand the challenges and opportunities of AI, and predict future directions in the adoption and management of AI. Regarding implications for policymakers, we highlight the importance of establishing a unified AI disclosure framework, making annual reports more transparent and easier to understand for investors and other stakeholders. As a result,

we support the new AI regulation development worldwide that enhances the quality and clarity of the AI information presented in annual reports.

According to our results, we provide a topic for future research. The AI adoption decisions and AI-related terms disclosures may be driven by company culture, corporate governance, top management leadership, and ownership structure. Future research may consider more firms' characteristics and control for other factors that drive the success of AI implications, adoption, and disclosures. In addition, the benefit of AI implementation could be reviewed on the business unit level or process level rather than the level of the banks' overall performance. Future research could consider the business unit performance separately.

The results of this study have substantial practical implications for banks and their financial performance. This study shows that banks can improve their financial performance by voluntarily disclosing their AI initiatives. This increases stakeholder trust and attracts AI-informed investors. It also helps mitigate risks associated with AI and gives banks a competitive advantage through differentiation. Being transparent about AI practices also helps with regulatory compliance and can lead to cost reductions and technological innovation. These findings can guide banks in optimizing their AI-related practices to drive positive financial outcomes.

To understand AI adoption decisions within an organization, it is important to consider company culture, corporate governance, leadership, ownership structure, risk appetite, and change management. These factors shape the organization's approach to AI and impact how decisions are formulated and executed. By analyzing these dimensions, organizations can make informed decisions that align with their unique characteristics and aspirations.

Analyzing the impacts of AI implementation at the business unit or process level can reveal targeted performance improvements, enhanced decision making, efficiency gains, cost savings, customization, risk assessment, change management insights, competitive advantage, strategic alignment, and new performance metrics. This approach provides a detailed perspective on the transformational effects of AI within an organization and maximizes its potential benefits.

We identify some limitations of our research in terms of data availability; some of the annual reports are not published on the banks' websites or are not available in the English language. In addition, some annual reports are not available as PDF files but rather as scanned images, which prevents analyzing these through computerized software. Future research may also consider other banks' published information or publications of third parties rather than annual reports (e.g., bank websites, brochures, and social media advertisement tools). This paper is limited to the available data. Therefore, caution should be taken before generalizing the study's findings.

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Appendix A

Table A1. Keywords search items and list of AI-related disclosure terms.

Column A	Column B
AI-related terms disclosure/keywords search item	
Digital transformation, fintech, financial technology, modern technology, AI digital strategy, latest technology, advanced technology, AI computing technology, digital infrastructure, digital library, electronic channel, electronic system, Internet of things, 5g technology, advanced technical experiences, digital platform, digital technology, 5g networks, blockchain, smart connection, digital awareness, digital capabilities, digital culture, digital economy, digital futuristic, digital transition, augmented reality technology, technical platform, web technology, machine learning, deep learning, augmented intelligence, natural language processing (NLP)	Digital awareness, transformation, and capabilities
Robotics, robo-advisors, automation, digital banking, mobile banking, online banking, digital services, mobile apps, electronic payment, Internet banking service, mobile branches, mobile payment, robots, mobile ATMs, digital payment, digital identity, smartphones, smart bank websites, digital product, electronic service, intelligently analyses, digital wallet, electronic wallet, mobile device service	AI application, product, service, and process
Information security, cyber security, electronic security, it risks security, electronic security policies, card security, cyber risk, electronic security, cybercrime, bank electronic security, customized electronic security methods, cyber breach, cyber resiliency, defense technology, cyber intelligence, electronic attack, global security, information security breaches, security vulnerabilities	AI information challenges and cyber security threats

Appendix B

Table A2. AI-related terms disclosure frequency related to digital awareness, transformation, and capabilities.

AI Digital Awareness, Transformation, and Capabilities	Frequency
Digital transformation	143
Fintech	130
Financial technology	85
Modern technology	13
AI	13
Digital strategy	10
Latest technology	10
Advanced technology	8
AI technology computing	4
Digital infrastructure	3
Digital library	3
Electronic channel	3
Electronic system	3

Table A2. *Cont.*

AI Digital Awareness, Transformation, and Capabilities	Frequency
Internet of things (IoT)	3
Machine learning	3
Each of these words: 5g technology, advanced technical experiences, digital platform, digital technology, 5g networks, blockchain, and smart connection	2
Digital capabilities, digital culture, digital economy, digital futuristic, digital transition, augmented reality technology, technical platform, and web technology	1
Sub-category total	457
Total words	1925
Percentage	0.24

Table A3. AI-related terms disclosure frequency related to AI applications, products, services, and processes.

AI Application, Product, Service, and Process	Frequency
Robotic automation	140
Digital banking	85
Mobile banking	80
Online banking	75
Digital services	64
Mobile app	48
Electronic payment	34
Internet banking service	20
Mobile branch	16
Mobile payment	16
Robotic/robot	16
Mobile ATM	13
Digital payment	11
Digital identity	6
Smartphone	6
Smart bank website	4
Digital products, electronic services, intelligent analyses	2
Digital wallet, electronic wallet, mobile device service	1
Sub-category total	644
Total—AI-related terms/words	1925
Percentage	0.33

Table A4. AI-related terms disclosure related to AI information challenges and cyber security threats.

AI Information Challenges and Cyber Security Threats	Frequency
Information security	523
Cyber security	138
Electronic security risks	37
IT security	33
Electronic banking services	31
Electronic security policies	24
Card security	9
Cyber risk	6
Electronic security	5
Cybercrime, bank electronic security, customized electronic security methods, cyber breach, cyber resiliency, and defense technology	2
Cyber intelligence, electronic attacks, information security breaches, and security vulnerabilities	1
Sub-total—AI-related terms/words	824
Total—AI-related terms/words	1925
Percentage	43%

Appendix C

Table A5. The OLS regressions of AI disclosure on financial performance before and during COVID-19.

	Before COVID-19					During COVID-19				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	ROA	ROE	PE	NII	TEXP	ROA	ROE	PE	NII	TEXP
AIFREC	0.00369 ** (2.25)	0.0266 ** (1.05)	-0.0237 (-0.23)	0.0246 (0.26)	-0.00351 * (-2.05)	0.00734 ** (-2.04)	0.0570 *** (-1.93)	0.143 ** (2.30)	0.0229 (0.80)	-0.00565 * (-2.12)
LASHR	-1.695 *** (-3.39)	-13.67 *** (-3.19)	23.85 (1.37)	-4.252 *** (-4.33)	-0.195 (-0.57)	-1.140 *** (-3.80)	-10.66 *** (-4.33)	-4.701 (-0.91)	-1.968 *** (-2.89)	-0.00448 (-0.02)
DEBTH	-0.0397 (-1.50)	0.127 (0.56)	-0.393 (-0.43)	0.0202 (0.39)	-0.0621 *** (-3.44)	-0.0446 ** (-2.41)	0.352 ** (2.32)	0.132 (0.41)	0.0998 ** (2.37)	-0.0220 (-1.45)
FORSH	1.331 ** (2.30)	9.133 * (1.84)	-20.27 (-1.00)	0.217 (0.19)	0.696 * (1.76)	1.452 ** (2.34)	14.92 *** (2.93)	-13.25 (-1.23)	0.0715 (0.05)	0.973 * (1.91)
BDSIZ	0.0417 (0.61)	0.145 (0.25)	-1.989 (-0.83)	0.537 *** (3.99)	0.0338 (0.72)	0.0141 (0.49)	0.0912 (1.39)	0.695 (1.39)	0.327 *** (4.98)	-0.00483 (-0.20)
INDPB	-0.736 (-1.19)	-6.069 (-1.14)	31.93 (1.48)	1.241 (1.02)	-0.169 (-0.40)	-1.380 *** (-2.71)	-15.17 *** (-3.63)	-11.18 (-1.27)	-1.740 (-1.50)	-0.0312 (-0.07)
BKSIZ	-0.296 (-1.42)	-2.087 (-1.17)	-5.057 (-0.69)	-1.201 *** (-2.92)	0.802 *** (5.62)	0.0766 (0.58)	-0.246 (-0.22)	1.311 (0.57)	-0.309 (-1.02)	0.154 (1.41)
BRNCH	0.0123 *** (2.98)	0.104 *** (2.94)	0.0812 (0.56)	0.0750 *** (9.25)	0.00269 (0.95)	0.00354 (1.25)	0.0624 *** (2.68)	0.0193 (0.39)	0.0403 *** (6.25)	0.0112 *** (4.81)
BKAGE	-0.0270 *** (-3.22)	-0.234 *** (-3.25)	0.255 (0.87)	-0.140 *** (-8.48)	0.00335 (0.58)	-0.0123 ** (-2.40)	-0.171 *** (-4.07)	-0.0276 (-0.31)	-0.0705 *** (-6.05)	0.00929 ** (2.21)
_cons	11.76 ** (2.36)	52.21 (1.22)	139.1 (0.80)	39.35 *** (4.02)	5.314 (1.56)	4.716 (1.62)	-1.974 (-0.08)	-29.81 (-0.59)	14.73 ** (2.22)	15.35 *** (6.43)
N	45	45	45	45	45	82	82	82	82	82
R ²	0.490	0.518	0.207	0.851	0.951	0.452	0.489	0.215	0.678	0.891
adj. R ²	0.358	0.394	0.104	0.812	0.939	0.384	0.425	0.117	0.637	0.878

* p < 0.10, ** p < 0.05, *** p < 0.01.

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