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Corporate narrative reporting on Industry 4.0 technologies: Does the COVID-19 Pandemic and Governance structure Matter?

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Abstract

Purpose: This research examines the impact of the COVID-19 pandemic and governance structure on corporate narrative reporting (CNR) concerning Industry 4.0 (I4.0) technologies in Jordanian commercial banks. The study aims to explore how these factors influence the extent and nature of disclosures in annual reports

Methodology: The study utilizes a comprehensive manual content analysis method to investigate the annual reports from all 15 Jordanian commercial banks from 2010 to 2022. This approach allows for the detailed examination of I4.0 disclosures, employing a specially developed index to measure various disclosure dimensions. An Ordinary Least Squares (OLS) model is used to assess the determinants of CNR on I4.0, considering factors such as the pandemic's impact and various governance attributes.

Findings: Our findings indicate that both the COVID-19 pandemic and specific governance factors (e.g., board size, and audit committee size) significantly enhance the disclosure of I4.0 technologies. The study reveals that during the pandemic, banks significantly increased their level of detailed disclosures about I4.0 strategies, challenges, and benefits, reflecting a strategic response to the pandemic's disruption.

Originality: This study introduces a novel I4.0 Reporting Index for banks, measuring disclosures across strategy implementation, business model transformation, challenges, and benefits. It adds to the existing literature by offering insights into narrative reporting practices concerning I4.0 technologies within the banking sector and illuminates the impact of the COVID-19 pandemic on these practices.

Keywords: Industry 4.0, Corporate Narrative Reporting (CNR), Content Analysis, COVID-19, Business model transformation, Digital transformation.

Paper type: Research paper

1- Introduction

Industry 4.0, (I4.0) or the Fourth Industrial Revolution, signifies a transformative era that integrates advanced technologies such as the Internet of Things (IoT), artificial intelligence (AI), and cyber-physical systems into core business operations. This integration has revolutionized industries by enhancing operational efficiency, creating new business models, and offering unprecedented customer experiences (Alkaraan, 2021; Horani et al., 2023b). As these technologies reshape business landscapes, corporate narrative reporting must evolve to effectively communicate these changes to stakeholders, illustrating the transformation and its implications on company performance and strategy.

Effective IT governance, particularly through dedicated entities such as the Committee on Information Technology and Digitization, is crucial in overseeing the deployment and integration of I4.0 technologies. This governance ensures that technological advancements are in alignment with business objectives and comply with regulatory standards, striking a balance between innovation and risk management. Such frameworks support transparency and accountability in corporate reporting, which are vital for stakeholders to understand the strategic direction, risks, and opportunities presented by I4.0 initiatives.

The COVID-19 pandemic has significantly accelerated the digital transformation agenda, as businesses had to swiftly adapt to new operational challenges and market conditions. For the banking sector in Jordan, this meant a rapid deployment of digital solutions to continue serving customers under lockdown conditions. The surge in digital banking, as reported by JoPACC, highlighted the resilience and scalability of digital platforms but also brought forth new risks, particularly in cybersecurity (AlSalhi et al., 2020; Alkhwaldi et al., 2022; Hatamlah et al., 2023). This intense digital dependency during the pandemic further illustrates the need for robust narrative reporting to disclose how organizations manage these new risks and capitalize on digital opportunities.

Disclosure in corporate narrative reporting serves not only as a compliance measure but also as a strategic tool to communicate with investors, regulators, and the public. Effective disclosure provides insights into how an organization harnesses I4.0 technologies for strategic advantage, manages associated risks, and ensures sustainability and resilience in operations. Particularly in the wake of the COVID-19 pandemic, disclosure helps demonstrate how organizations have navigated unprecedented challenges and seized new opportunities offered by digital transformation.

While previous research has explored the relationship between corporate governance and various forms of disclosures (Shehadeh et al., 2024; Mazumder and Hossain, 2023; Allini et

al., 2016; Wang and Hussainey, 2013; Li et al., 2020; Ben Fatma and Chouaibi, 2021; Chen et al., 2021; Karim et al., 2021; Alkaraan et al., 2022), there remains a notable gap in understanding how these governance frameworks influence the narrative reporting of technological advancements under I4.0, particularly in the banking sector during periods of crisis such as the COVID-19 pandemic.

This study aims to address this gap by focusing on how corporate governance influences the narrative reporting of I4.0 advancements within Jordanian banks during the ongoing global health crisis. Specifically, it examines the impact of governance mechanisms such as gender diversity, board size, and board nationality on the disclosure and reporting of I4.0 technologies across three distinct periods: pre-pandemic, during the pandemic, and the unfolding post-pandemic effects. This approach allows us to analyze changes in disclosure practices and governance dynamics under varying economic conditions, providing insights into how banks adapt to and recover from major disruptions.

During this era, banks experienced significant industrial power and underwent a profound digital transformation, fundamentally affecting their strategies and capability to address new challenges. This digital shift was not only a response to the pandemic but also part of a broader strategic direction toward enhancing innovation and efficiency in banking services. The research questions posed are:

> RQ1: How do governance mechanisms influence the narrative reporting of I4.0 advancements within Jordanian banks across different periods marked by the pre-, during, and post-COVID-19 pandemic?
>
> RQ2: What impact has the COVID-19 pandemic had on the governance and reporting practices related to I4.0 technologies, and how have these practices evolved over time?

Methodologically, this study employs a content analysis approach combined with descriptive statistics, correlation, and regression analyses to evaluate the determinants of I4.0 disclosure from 2010 to 2022 within Jordanian commercial banks. Year-fixed effects are incorporated into our regression model to control for annual variations and capture the distinct impacts of the pre-pandemic, pandemic, and potential post-pandemic periods on governance practices.

This approach not only deepens our understanding of how governance structures respond to major disruptions but also offers practical insights into the resilience and adaptability of these frameworks. The findings are anticipated to provide nuanced views on the dynamic interaction between corporate governance and technological disclosures, contributing valuable perspectives for policymakers and practitioners aiming to design robust governance systems in similarly challenging environments.

The remainder of this paper is organized as follows. Section 2 reviews relevant literature on I4.0. Section 3 outlines the research methodology. Section 4 presents the findings. Section 5 concludes the paper.

2. Theoretical framework, literature review, and hypotheses development

2.1 Theoretical Framework and Literature Review

The advent of I4.0 has introduced transformative changes across multiple sectors, particularly in banking, where it has revolutionized management strategies and technological implementations. Hofmann and Rüsch (2017) and Sarbu (2021) emphasize that I4.0 fosters a comprehensive approach to improving banking operations through technological advancements, resulting in enhanced efficiency, productivity, and service quality. A critical element of I4.0 in the banking sector is the development of cyber-physical systems that integrate technologies such as algorithms, big data, IoT, automation, cloud computing, and cybersecurity, significantly enhancing operational capabilities (Leyh et al., 2017).

Beyond merely adopting new technologies, I4.0 represents a strategic investment comparable to major organizational decisions like mergers, acquisitions, and new product or technology launches (Alkaraan and Northcott, 2006; Adel and Alkaraan, 2019). The successful implementation of I4.0 can lead to cost savings, profit growth, better customer experiences, and optimized processes. However, the adoption rate varies among organizations, influenced by differing levels of understanding and attitudes towards I4.0 (Frank et al., 2019; Sony and Naik, 2020; Hamada, 2019).

The COVID-19 pandemic has further impacted the adoption and user acceptance of FinTech, which is integral to banks' I4.0 transformation and disclosure practices. Al-Khawaldi et al. (2022) demonstrate that the pandemic has significantly affected FinTech usage and acceptance in Jordan, with key factors including performance expectancy, social influence, facilitating conditions, personal innovativeness, financial literacy, and uncertainty avoidance shaping users' intentions and loyalty towards FinTech.

While existing research often discusses technological triggers and organizational adaptations (Adner and Kapoor, 2016; Aggarwal et al., 2017; Triulzi et al., 2018), there remains a research gap in how Jordanian banks disclose their I4.0 transformations. This study examines the influence of corporate governance on narrative disclosures related to the I4.0 transformation within Jordan's banking sector during the COVID-19 pandemic. Employing a multi-theoretical approach, this research draws on agency theory, stakeholder theory, resource-based theory, and resource-dependence theory. This approach, recommended by scholars such as Christopher (2010), Abdelhak et al. (2023), AbuGhazaleh et al. (2012), and Abed et al. (2014), leverages multiple theories to provide a more robust analysis. As Cormier et al. (2005) and Tagesson et al. (2009) have suggested, no single theory can completely address corporate voluntary disclosure practices. Instead, the combination of these theories allows for a more detailed exploration of the issue, offering both competing and complementary perspectives, thereby enriching our hypotheses development.

2.2 Hypotheses development

2.2.1. COVID-19 Pandemic. The COVID-19 pandemic has significantly transformed corporate governance, profoundly influencing disclosure practices related to I4.0. Research by Albitar et al. (2020) and Deliu (2020a, 2020b) underscores the rapid shift toward digital governance and transparency due to the pandemic's disruptions. This evolving environment provides a crucial context for analyzing the effects of governance adaptations on corporate narrative reporting of I4.0 technologies.

The concept of 'going concern', as discussed by Mathew and Sivaprasad (2020) and Nurunnabi (2020), has become increasingly relevant. The uncertainties of COVID-19 have heightened the need for enhanced disclosures about financial health and operational sustainability, critical elements as companies pivot their strategies towards I4.0. This need for detailed reporting is vital for reassuring stakeholders of a company's ability to adapt and thrive amid technological changes.

Additionally, Patel and Patel (2020) highlight that the strategic reallocation of capital directly correlates with investments in I4.0 technologies such as automation, data analytics, and cybersecurity. These areas are essential for maintaining a competitive edge and operational resilience and must be clearly communicated through corporate disclosures to emphasize the strategic shift driven by pandemic-induced challenges.

Regulatory adaptations, as noted by Atici and Gursoy (2020) and Zetzsche et al. (2020), have also influenced corporate narratives. The relaxation of certain regulations has allowed companies greater flexibility to accelerate digital transformations and adjust their business models, further facilitating the disclosure of transformation strategies toward I4.0. This regulatory leniency aligns with new governance norms and supports a proactive approach to technological adoption.

The interplay between the COVID-19 pandemic and corporate governance changes has clearly influenced corporate reporting and transition strategies towards I4.0. The literature reflects a trend towards more transparent disclosures and strategic realignment in response to the pandemic's challenges. This adaptation is part of a broader strategic embrace of I4.0 technologies, crucial for future resilience and competitiveness.

Based on this analysis, we propose the following hypothesis for further investigation:

H1: The COVID-19 pandemic significantly impacts the disclosure of Corporate Transformation towards I4.0 (CTTI4.0).

2.2.2. Board Size .According to agency theory, a larger board size can enhance monitoring and improve corporate disclosures by increasing the awareness of potential risks, as highlighted by Elzahar and Hussainey (2012) and Saggar and Singh (2017). Additionally, resource-based theory posits that a diverse and sizable board contributes a breadth of expertise and knowledge, which positively influences disclosure practices (Abeysekera, 2010; Adam et al., 2005; Elzahar and Hussainey, 2012). However, there are contrasting views within agency theory itself, which suggest that smaller boards might be more effective due to enhanced coordination and reduced free-riding issues (Jensen, 1993; Jensen and Meckling, 1976). Despite these theoretical discrepancies, empirical evidence generally supports the idea that larger boards tend to provide more comprehensive disclosures (Elazahar and Hussainey, 2012; Elshandidy et al., 2018; Saggar and Singh, 2017).

Given these varied insights, the following hypothesis is proposed:

H2: The board size (BM) positively influences the disclosure of Corporate Transformation towards I4.0.

2.2.3. Size of the audit committee. The relationship between the size of the audit committee (AC) and disclosure practices has been explored in various studies, yielding mixed results. On one side, a larger AC, as suggested by resource-dependence theory, provides a wealth of resources, enhancing the company's expertise and consequently improving the quality of accounting and disclosures (Alshabibi et al., 2021; Rifai and Sireger, 2021; Al Lawati et al., 2021). This view is supported by several studies which report a positive correlation between AC size and disclosure practices (Alkurdi et al., 2019; Ashfaq and Rui, 2019; Al Lawati et al., 2021; Rifai and Sireger, 2021; Alshabibi et al., 2021). Conversely, agency theory posits potential drawbacks of a large AC, such as increased agency costs, reduced communication and coordination among members, and heightened conflicts of interest, despite the benefit of increased expertise and diversity. Furthermore, some research, such as that by Naimah and Mukti (2019), indicates no significant link between AC size and disclosure quality. Considering these conflicting findings, the following hypothesis is proposed:

H3: The size of the audit committee (ACZ) positively affects the disclosure of Corporate Transformation towards I4.0.

2.2.4. 'Big Four' firm (BIG4). Audit quality is influenced by the size and type of the audit firm, with larger firms generally providing higher-quality audits to maintain their reputation and independence (Francis et al., 1999; Vaziri and Azadi, 2017; De Angelo, 1981). While some research indicates that firm type has little effect on audit quality (Ali and Aulia, 2015), other studies suggest that Big 4 firms may vary in quality. (Lowensohn et al., 2007). Research also shows that larger firms are likelier to disclose critical concerns due to higher litigation risks (Dye, 1993), and Big N firms are noted for reducing information asymmetry and managing earnings effectively in regions like Taiwan and China (Wang et al., 2014). Thus, the capacity of Big 4 firms to detect key audit matters and issue reliable reports is enhanced by their superior resources and qualified personnel. Given this background, the following hypothesis is proposed:

H4: Banks audited by a 'Big Four' firm (BIG4) exhibit a greater degree of disclosure about their Corporate Transformation towards I4.0.

2.2.5. Gender diversity. Research on the impact of gender diversity on corporate boards shows mixed outcomes. Agency and stakeholder theories suggest that female board members enhance board effectiveness and fulfill the informational demands of stakeholders (Assenga et al., 2018). Resource dependence theory also supports the idea that female directors bring valuable expertise, potentially boosting firm performance (Sarhan and Ntim, 2019). Numerous studies affirm the positive influence of board gender diversity on corporate disclosure (Hasan et al., 2022; Al-Shaer et al., 2021; Elmarzouky et al., 2021a, 2021b; Peng et al., 2021; Ben Fatma and Chouaibi, 2021; Albitar et al., 2022; Radu and Smaili, 2021; Seebeck and Vetter, 2021), although some research, such as that by Ashfaq and Rui (2019), reports a negative impact. Given these varied insights, the following hypothesis is proposed:

H5: Gender diversity affects levels of Corporate Transformation towards I4.0 disclosure.

2.2.6. Nationality. The significance of the nationality and cultural backgrounds of board members is well-documented, with diverse boards linked to enhanced corporate governance

and decision-making (Zhuang et al., 2018). Zaid et al. (2020) define this diversity as the presence of directors from various nationalities within the boardroom. Such diversity is crucial for bringing a wealth of new networks, skills, and perspectives, which are invaluable for fostering innovative thinking and strategic decisions. The infusion of global talents and diverse insights not only enriches the decision-making process but also positively impacts the management practices and the quality of corporate disclosures (Fuente et al., 2017; Maretno Agus Harjoto et al., 2018). This range of contributions from board members of different nationalities ultimately drives the firm's strategic outcomes and enhances corporate transparency. Given this context, the hypothesis is formulated as:

H6: Nationality diversity affects Corporate Transformation towards I4.0 disclosure.

3. Methodology

3.*1 Sample and data collection*

Our research provides a detailed examination of the changes in corporate narrative reporting (CNR) trends, focusing on the period before, during, and after the COVID-19 pandemic. This timeframe allows us to deeply explore how the pandemic has impacted the reporting of I4.0 technologies.

We examined all 15 commercial banks in Jordan that have consistently published their annual reports from 2010 to 2022, resulting in a total dataset of 180 bank-year observations. To ensure a complete overview of the sector, no banks were excluded from our study.

While some studies such as Fisher et al. (2020), Albitar et al. (2021), and Karim et al. (2021) have employed computer-based content analysis, our choice to utilize manual content analysis for evaluating the narrative sections of these annual reports is well-supported by prior research, including Shehadeh et al. (2024). This method allows us to accurately measure the extent of CTTI4 information disclosure and evaluate various subcategories in detail. Our preference for manual analysis is confirmed by its proven capability for thorough examination, enabling us to develop a deeper and more comprehensive understanding.

3.2.2. The measurement of I4.0 disclosure

In this study, we adopted an integrative manual approach to measure the disclosure of I4.0 strategies within Jordanian commercial banks. This approach combined methodologies and insights from prior research (Loughran & McDonald, 2011; Andreou et al., 2020; Karim et al., 2021; Alkaraan et al., 2022; Hussainey et al., 2022) with qualitative analysis techniques and a deep understanding of industry-specific terminologies and practices. The measurement process was divided into three stages:

Initial Phase: We analyzed Industry 4.0 strategy frameworks from top professional bodies like Boston Consulting Group, McKinsey & Company, Deloitte, KPMG, and i-SCOOP, using Hussainey et al. (2022) as a methodological guide. We identified inconsistencies in terminologies across these frameworks, which led us to adapt them to the specific needs of the banking sector. This adaptation resulted in a refined list of I4.0 strategy components better suited to banking applications, summarized in Table 1. This table illustrates the practical implementation of Industry 4.0 technologies in banking, reflecting the sector's unique challenges and context.

Second Stage: We refined the initial list by adding synonyms and making necessary revisions, following the approaches of Andreou et al. (2020), Karim et al. (2021), and Hussainey et al. (2022). By manually analyzing a collection of annual reports from various years, we validated the relevance and usage frequency of these terms, ensuring the reliability of our index for the banking sector.
Final Stage: We categorized the refined index into four primary proxies: mechanisms of business model transformation via I4.0 strategic practices, elements of I4.0, and the associated benefits and challenges. Each bank's annual report was then evaluated and scored based on these proxies using manual content analysis, as detailed by Shehadeh et al. (2024) and Alkaraan et al. (2022).

This combination of established methodologies and sector-specific insights provides a robust, comprehensive, and contextually relevant framework for assessing I4.0 strategy disclosures. We preferred manual content analysis to computerized methods to better capture the subtle meanings required for the varied and dynamic nature of I4.0 strategies in the banking sector.

Insert Table 1 about here

3.3 Variables measurement

3.3.1 Transition to I4.0 Disclosure (Tscore). We adopt a manual textual examination technique to create a metric, using a predetermined list of words (Appendix 1), which assesses the scope of CTTI4 reporting in the narrative portions of the annual reports.

3.3.2 Research model

To examine the determinant of CNR on I4.0 technologies, we use the following Ordinary Least Square (OLS) model:

Tscore = $\beta_0 + \beta_1$COVID-D + β_2BM + β_3ACZ + β_4GN + β_5BZ + β_6JB + β_7BIG4 + β_8LEV + β_9SIZE + β_{10}AGE + β_{11}MB + β_{12} ROA+ Year Fixed Effects + e.
(1)

Where:
Tscore: Authors' self-constructed CTTI4.0 reporting index calculated as the sum of the four individual CTTI4.0 proxies:

1. **CTTI4.0-Strategy Component:** Indicates the presence of I4.0 strategies.
2. **BBMT (Banking Business Model Transformation):** Reflects the adaptation of I4.0 strategies within the bank's business model.
3. **CTTI4.0-Challenges:** Highlights obstacles in implementing I4.0 strategies.
4. **CTTI4.0-Benefits:** Represents the benefits of implementing I4.0 strategies.

Table 2 lists each explanatory variable used in our research model, along with its definition and source

Insert Table 2 about here

4. Findings

4.1 . I4.0 disclosure in Jordanian banks.

A review of the annual reports of several Jordanian banks sheds light on the range and detail of I4.0 disclosure. Appendix 2 provides a more detailed view, but here, we briefly sample some of these disclosures.

The disclosures in the annual reports of Jordanian banks demonstrate their strong awareness and strategic implementation of I4.0 technologies in their operations. Reviewing these reports shows how each bank is individually adapting to this new environment, giving a clear picture of the overall state of the banking sector in Jordan.

The importance of these disclosures from the annual reports of Jordanian banks is multi-faceted. It's not only significant for shareholders and potential investors who gain insights into the banks' strategic plans, operational changes, and risk management practices, but it also plays a critical role in the broader context of the financial industry's adoption of I4.0 technologies.

Discussing the CTTI4.0-Strategy Component, for example, gives stakeholders an understanding of the banks' direction in terms of their digital transformation initiatives. As evidenced by Bank al Etihad's disclosure, a clear vision supported by a robust digital strategy ensures alignment with customer needs and market trends. They highlight in their disclosures, *"The bank's vision is supported by a digital strategy that focuses on creating new, easily accessed services and products that match our customers' lifestyles and expectations."* This commitment to creating a digital-friendly environment for their customers is highlighted by their increased use of data analytics and the introduction of personalized digital solutions.

When it comes to the BBMT-Banking Business Model Transformation, disclosures like Ahli Bank's provide evidence of the bank's agility and adaptability, particularly in response to external events like the COVID-19 pandemic. It's a reflection of the bank's resilience and its dedication to serving customer needs despite difficult circumstances.

Ahli Bank, for example, has introduced new digital services such as mobile and online banking and redesigned its website to improve user experience, all in response to the COVID-19 pandemic. Their statement, *"In conjunction with the COVID-19 pandemic, throughout the year 2020, the Innovation department worked on delivering exceptional new digital services to the bank's customers..."* reflects their commitment to digital innovation.

Furthermore, disclosing the CTTI4.0 challenges, as The Housing Bank did, provides a clear view of the potential risks and obstacles faced during the digital transformation process. It shows the bank's proactive approach to managing these challenges, reassuring stakeholders of the bank's risk management capability and resilience. *"The Housing Bank was a pioneer and took the initiative in adopting government measures related to the Covid-19 pandemic, and worked to provide various incentives..."*.

Lastly, discussing the CTTI4.0 benefits, such as Arab Bank's emphasis on enhanced customer experience, underscores the advantages gained from investing in and implementing I4.0 technologies. This can influence investor confidence and customer loyalty, both of which are

crucial for the bank's long-term success, and is a common theme in the banks' disclosures. Arab Bank states in their report: *"In 2021, Arab Bank continued to invest in digital banking by providing solutions and services that enhance customers' experience and meet their needs beyond standard banking."* It's an explicit declaration of the bank's commitment to enhancing customer experience through digital transformation.

Overall, the state of Jordanian banks, as shown by their I4.0 disclosures, appears progressive and forward-looking. They recognize the importance of I4.0 technologies and are taking strategic steps toward their integration. Their disclosures reflect a commitment to digital transformation, a proactive approach to challenges, and an understanding of the benefits that come with I4.0. This forward-thinking approach is likely to place these banks in a competitive position in the increasingly digital global banking landscape.

4.2. Descriptive statistics

Table 3, Panel A shows the change in disclosure levels between banks over time. It shows that the overall level of I4.0 disclosure increased over time during the sample period 2010-2022. The mean I4.0 disclosure for Year 2010 is 1.06 with a minimum of 0 sentences and a maximum of 3 sentences. There is quantitative evidence that the mean I4.0 disclosure increased over the years from 1.06 in 2010 to 95.06 in 2022. This finding resonates with Hussainey et al., (2022), who also observed increased adoption of I4.0 technologies by Middle Eastern banks during the pandemic, underscoring the strategic imperative of technology integration in ensuring business resilience.

It is also noted that I4.0 disclosure score slightly decreased in 2020 to 69.2 before a sharp increase in 2021 (79.6) and 2022 (95.06). This analysis indicates that the awareness of the importance of I4.0 disclosure has increased over the years in the banking sector of Jordan. Panels B-E shows the descriptive statistics for the sub-categories of the I4.0 disclosure index. Similar to Panel A, Panels B-E show an increase in I.40 strategy, I4.0 Business transformation; I4.0 benefits and 1.40 challenges scores. The panels also show that Jordanian banks report more information about their strategy related to the adoption of I.4.0 technologies. The discussion related to the other three I4.0 technologies is much lower than the discussion related to the I4.0 strategy adopted by banks. We note that the discussion related to I.40 challenges is the lowest in our sample.

Insert Table 3 about here

Table 4 shows the descriptive analysis of our variables. It shows that the mean overall I4.0 score is 36.47 with a minimum of 0 sentences and a maximum of 180 sentences. Looking at different categories of I4.0 disclosure, Table 4 shows that the I4.0 strategy category has the highest score with a mean of 15.62, then the I4.0 business transformation model with a mean of 8.53, then I4.0 benefits with a mean of 7.47, and finally I4.0 challenges with a mean of 4.76. The mean board meeting is 7.51 meetings a year. The minimum number of board meeting is 4, while the maximum number is 15. The mean audit committee size is 3.79. Some banks have two audit committee members, while others have 7 directors on the audit committee. The mean gender diversity is 0.81. Some banks have no female directors on the board while other banks have a maximum of three female directors. The mean board size is 10.67 with a minimum of

5 directors and a maximum of 14 directors on the board. The mean percentage of women on the board is 6.9% with a minimum of 0% and a maximum of 28%. The mean Jordanian nationality on the board is 68.1% with a minimum of 16% ad a maximum of 100%. 94.2% of the sampled banks are audited by Big 4 companies. The table also shows that, on average, banks in our sample are highly leveraged, large in size, old (average age is 42 years); highly growing, and profitable.

Insert Table 4 about here

Table 5 shows the correlation analysis. It shows that board meetings, audit committee size, gender diversity, board size, and the percentage of female directors positively affect total the level of I4.0 disclosure. The table also shows that the percentage of Jordanian directors and the quality of external auditors have no impact on I4.0 disclosure. Looking at other bank characteristics, the table shows that leverage, bank size, and bank age positively affect I4.0 disclosure while bank growth rate and profitability has no impact on I4.0 disclosure. The correlations between the independent variables are less than 70% indicating that there is no multicollinearity problem.

Insert Table 5 about here

Table 6 reports our findings related to the determinants of I4.0 disclosure. The coefficient on COVID-DM is positive and statistically significant for the total I4.0 score, I.4.0 strategy component, I4.0 bank transformation component, and I4.0 benefit component. This indicates that Jordanian banks have improved levels of disclosure on I.40 technologies during the Covid-19 pandemic. The findings are in line with Alkhwaldi et al. (2022) which concluded that I4.0 related technologies are heavily used by financial institutions during the Covid-19 pandemic to sustain risk-free and smooth financial transactions. Our findings suggest that Jordanian banks are keen to communicate the usage of technologies in their annual report narratives to reduce information asymmetry between managers and stakeholders. This is consistent with agency theory. The table also shows that board meetings have no impact on I4.0 disclosure, while board size positively affects total I.4.0 disclosure and both I4.0 strategy and benefits categories This finding resonates with research by Elzahar and Hussainey (2012) and Saggar and Singh (2017), which suggests that larger boards enhance monitoring and contribute to more comprehensive disclosures, aligning with agency theory principle. Audit committee size positively affects the total I4.0 score as well as I.40 strategy, challenges, and benefits components This finding is consistent with the resource-dependence theory perspective, emphasizing the role of larger audit committees in providing expertise and enhancing disclosure quality, as noted by Alshabibi et al. (2021) and Rifai and Sireger (2021). The impact of the percentage of female directors on all I4.0 scores is only significant for I4.0 disclosure scores related to banks transformation toward I4.0 technologies This finding aligns with the divergent outcomes reported in previous literature, reflecting the complex interplay between gender diversity and disclosure practices, as noted by Assenga et al. (2018) and Sarhan and Ntim (2019). The quality of external audit has no impact on disclosure levels, except in model 3 where the coefficient is positive and significant at the 10% level This finding contrasts with

expectations drawn from prior research highlighting the superior resources and expertise of Big Four firms in delivering high-quality audits, as suggested by Francis et al. (1999) and Vaziri and Azadi (2017) . The impact of corporate governance variables on I4.0 disclosure is in line with Hussainey et al. (2022) and the agency theory.

Insert Table 6 about here

Additional Analysis:

The impact of external audits

Following Yan et al. (2022), the 2019 annual reports for public companies might be affected by the busy season of auditors due to the outbreak of the COVID-19 pandemic. To address this concern, the sample related to 2019 is excluded to provide a robustness test. The findings are reported in Table 7. Our analysis reveals that the findings are consistent with the original results reported in Table 6.

Insert Table 7 about here

High Tscore vs. Low Tscore

To ensure that our results of the influence of corporate governance on the narrative reporting of I4.0 transformations in Jordan's banking sector is not affected by the level of the evolution of I4.0 technology narrative reporting, the analysis is re-conducted by splitting the sample into two samples (High Tscore sample vs. Low Tscore sample). High Tscore sample represents firms with Tscore above the median, while Low Tscore sample represents firms with Tscore below the median. The findings are reported in Tables 8&9. For companies with high T-scores, our analysis indicates that board meetings and audit quality do not significantly affect disclosure levels in models 1 through 5. However, board size does demonstrate a significant impact on disclosure levels in models 2, 4, and 5, albeit at a significance level of 10%. Additionally, our findings suggest that audit committee size does influence total I4.0 disclosure and disclosure related to banks' strategies for adopting new technologies. Furthermore, we observe that board diversity affects disclosure in models 1 and 3, whereas nationality diversity shows no statistically significant impact on disclosure levels. For companies with low Tscore, we noted that board meetings affect disclosure in models 2, 4 and 5. Audit committee size affects disclosure in models 1, 2 and 4, while board size negatively affects all proxies for I4.0 disclosure. The analysis shows that gender diversity only affects the level of disclosure related to the benefits of technologies, while nationality diversity has a negative impact on all technologies-related disclosure types. It also shows a negative association between audit quality and disclosure (e.g. bank transformation towards I4 and benefits of using technologies).

Insert Tables 8&9 about here

Endogeneity

One concern related to our analysis is that the results might be driven by the endogeneity issue due to firm-specific characteristics rather than by the impact of corporate governance and COVID-19. To address the endogeneity concern, Heckman sample selection method is employed to provide a robustness test. In the first stage, we use a probit regression on the probability of disclosing the narrative reporting of I4.0 transformations in Jordan's banking sector (see Table 10). In the second stage, we run the regression by adding the inverse Mill ratio obtained from the first stage regression (see Table 11). Our analysis reveals that the findings are consistent with the original results reported in Table 6.

Insert Tables 10 & 11 about here

5. Conclusion

This research has analyzed the evolving disclosure practices concerning I4.0 within Jordanian commercial banks over a significant period from 2010 to 2022. The findings indicate a clear increase in I4.0 disclosure levels, underscoring a growing recognition of the importance of these technologies in the sector. The descriptive statistics reveal a substantial rise in the overall I4.0 disclosure from a minimal presence in early years to a robust engagement by 2022, particularly emphasizing strategic initiatives and business transformations aligned with I4.0.

Our correlation and regression analyses further clarify the significant determinants of I4.0 disclosure. Corporate governance factors, notably audit committee size, board size, and the representation of female directors, positively influence the breadth and depth of I4.0 disclosure. These elements suggest that stronger governance frameworks facilitate better communication regarding technological adoptions and strategies, which aligns with the agency theory. Interestingly, external audit quality and nationality diversity were not consistent predictors of disclosure levels, indicating possible variances in influence depending on other contextual factors or governance attributes.

Moreover, the COVID-19 pandemic emerged as a critical driver for increased I4.0 technology disclosures. The pandemic's impact, reflecting in heightened disclosure during these times, aligns with findings from the literature suggesting that crises periods accelerate technological adoption and transparency in financial institutions. This adaptation appears driven by the necessity to maintain robust and smooth operations during disruptive periods.

This research offers valuable practical implications for bank executives, regulators, and policymakers in Jordan and potentially other emerging markets. The clear linkage between corporate governance and increased disclosure of I4.0 initiatives suggests that banks should consider enhancing their governance structures to improve transparency. Specifically, banks might benefit from increasing the diversity and size of their boards and audit committees, which have been shown to influence the level of disclosure positively.

Regulators and policymakers could use these findings to guide the development of guidelines or policies that encourage or mandate detailed reporting on technology adoption and strategy.

Such policies could not only enhance transparency but also promote a more competitive banking sector that is responsive to technological advancements.

Theoretically, this study enriches the existing literature on the agency theory by demonstrating how corporate governance mechanisms reduce information asymmetry between bank managers and stakeholders, particularly in the context of emerging technologies like I4.0. It also contributes to understanding how external shocks, such as the COVID-19 pandemic, can act as catalysts for changing corporate behavior, particularly in technology adoption and disclosure practices.

However, the study is not without limitations. Its focus on Jordanian banks may limit the findings to other regions with different cultural, regulatory, or economic conditions. Reliance on publicly disclosed information may also introduce bias, as firms often have discretion over what they choose to report.

Future research could build on these findings by exploring cross-country comparisons to test the universality of these relationships or by integrating qualitative methods to gain deeper insights into corporate motivations and strategies behind disclosures. Additionally, assessing the actual impact of implemented technologies on operational and financial performance could provide a more holistic view of the effectiveness of these disclosures. Finally, investigating the dynamic nature of corporate governance and its impact on technology disclosure could offer further valuable insights, particularly in response to evolving regulatory or economic landscapes. Such studies would greatly enrich our understanding of the strategic interplay between governance, technology adoption, and disclosure in the banking sector.

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Appendix 1

CTTI4.0: Strategy Component
digital strategy, digital evolution, digital transformation, digital journey, digital initiatives , long term goals and strategies, long term strategy, new business model; roadmap;; a customer centric approach, foster customer centricity, a client-centric approach, strategic control; strategic decision; strategic digitization, strategic objectives; strategic plan; strategic portfolio; strategic priorities; The Information Technology Governance Committee, the Information Technology, technology strategy; the fourth industrial revolution; transformation journey; artificial intelligence; APIs, automation; automated systems, Blockchain, cloud computing, data analytics;; digital modelling, digital technologies and analytics; emerging technology; hybrid technology; technology adoption, digitization, innovation processes; integrated data platform; machine learning; new technologies; next generation technology; next technology; novel computing technologies; process automation; robotic; robots; digital infrastructure, digital future, Internet of things (IoT), smart analytics; technological advancement; technological.
CTTI4.0: Banking Business Model Transformation (BBMT)
digital banking, Electronic Banking Solutions, digital banking initiatives, digital banking capabilities, digital services, digital solutions, digital account, digital wallets, digital

channels, digital technology, digital saving/deposit products, digital platform, automate banking processes, create new banking products, improve regulatory compliance in banking, transform the experiences of their customers, disrupt key components of the banking value chain, digital banking services, online banking services, online and digital platform, digitized banking, universal banking model, fintech, digital offerings, Mobile app for banking, mobile banking, digital financial services, digital products, digital payments, digital lending platform, digital self-service branches, digital distribution, digital and electronic channels, modern banking technology, digital bank Services, digital branch.
CTTI4.0: Challenges cyber risk; cybersecurity challenges, cyber-attacks, cybercrime; disruptive technology; emerging risks, electronic risks , emerging challenges, new threat; operational challenge; real threat, protected from possible threats; cybersecurity challenges in banking, security risks, operational challenge in banking, digital culture in banking, digital attackers, digital awareness, technology risks in banking.
CTTI4.0: Benefits accelerate product development; achieve sustainable growth, achieve sustainable profits, serve customers efficiently and to streamline our internal operations, agile decision making; attractiveness with respect to tax; augmented decision support; better connected; communicating data; confidentiality and integrity; cost efficiency; demand-driven supply chain; enhance communication; enhance our banking services and deliver a new savings tool to youth customers, enhance decision making; enhance risk mitigation capabilities; flexible resource allocation; improve data analytics capability; improve data governance; improve decision making; improve overall customer experience; the enhancement of customer experience, and continued support for fast, affordable service, to enhance our customer experience, by enriching the customer experience , revamped customer journeys, secure contactless payments solutions, enhancing customer experience and engagement, enrich customer experience and convenience, improvement of the business; increase collaboration; increasing customer satisfaction; to our ability to serve customers efficiently, more flexible resource allocation; to give customers a convenient, flexible and enjoyable banking experience, using digital innovative tools and interactive screens, most value to our customers; new digital service model; new opportunities; operational decision; optimise business processes; product innovation; reduce operating costs; reduce turnaround times; revenue growth and profitability; to achieve strong profitability levels and sustain the growth of revenues and operating income, simplify and improve processes; simplifying systems; help customers stay safe , stay competitive; strengthen our competitive edge, improve our customers' satisfaction. support decision making; support operational process, Increased revenues from innovative new offers and business models, introduce innovative products and services , Customer on Boarding , introduce digital customer on boarding to enable new customers to submit most of the account opening requirements through the bank's website and mobile application, effectively manage related risks, support process optimization, and maximum automation of customer acquisition/on boarding, digital onboarding process, credit underwriting, In addition to increased product penetration across the customer base, develop its strong customer base , open an account digitally.

Source: Created by author

Appendix 2

CTTI4.0: Strategy Component
"It was a year unlike any other. Despite the pandemic, we managed to respond to COVID-19 through innovation. We were also awarded the "Best Digital Bank" in Jordan, the "Most Innovative Digital Bank" in Jordan and the Middle East by New York's Global Finance Magazine, and the "Best Socio-Economic Impact Bank" by Business Vision Magazine in London." Bank al Etihad, 2021. "As part of its strategy for digital transformation, the bank launched during the year the banking robot system (Iskan robot), in line with the latest electronic systems in banking. " "The Housing Bank also launched a number of promotional campaigns for the bank's e-channels and the most prominent services related to digital transformation, in order to enhance continuous and effective communication with customers and continuously updating them on the latest services and products offered by the bank. These campaigns included the new Iskan mobile app, eFAWATEERcom, and Western Union services through Iskan Mobile app, Iskan Online, the promotion of new ATMs and their services, advantages, and advanced technology, the Iskan 24/7 call center, and an introductory campaign for the self-service digital branch Iskan Engage, in addition to creating a Facebook page for the bank's branches operating in Palestine." "The COVID-19 pandemic had many repercussions on all businesses and organizations. Even though it was difficult to implement programs and services, the Foundation was able to provide its services and programs as usual, while adhering to all public health measures. This year, driven by the constant risk of public closures because of the pandemic, the Foundation was able to spread culture and learning by digitizing its services and enriching its online content." Arab bank, 2021. "AHLI FINTECH incubated the internally innovated AI and Blockchain - based eKYC - as - a - Service platform, Meen World, and the AnaMeen digital identity mobile app, leveraging 5th generation technologies including Deep Learning, Machine Learning and Artificial Intelligence to aid in validating and authenticating the digital identities of its users. The service was launched in March 2020."
CTTI4.0: Banking Business Model Transformation (BBMT)
"As the whole world is still recovering from the consequences of the Corona Pandemic… After years of establishing and developing the needed technical infrastructure, Jordan Ahli Bank was ready to launch several mobile applications and electronic payment platforms, which gave the bank an advantage to benefit from the growing demand and reliance on digital services. That strengthened the opportunities of exploring new horizons for the banking sector by increasing the base of financial inclusion for the local communities. Jordan Ahli Bank launched several smartphone applications, including the "In conjunction with the COVID-19 pandemic, throughout the year 2020, the Innovation department worked on

delivering exceptional new digital services to the bank's customers, most notably, the ahli mobile and ahli online banking services. "
CTTI4.0: Challenges "Developing and deploying mechanisms and tools that are able to effectively protect the bank's assets and its customers by identifying, detecting, responding and recovering from any electronic cyber-attacks." Ahli bank, 2021. "With the pace of technological advances the world is witnessing, information is quickly becoming the lifeblood for business. In this context, JAB continues its pursuit to upgrade its electronic services while reducing the risk associated with cyber and information security and to build the cyber resilience of the Bank. The Cybersecurity/Information Security Department works on strengthening the monitoring and security environment and on building a cyber breach response framework that protects the confidentiality, security and accuracy of the Bank's data. The Department also works on promoting the utilization of best acceptable security practices in relation to the use of technology in a secure operating environment." Ahli, 2020.

Source: Created by author

Table 1. Professional organizations proposed terminologies related to Industry 4.0.

Consulting Firm	Potential Applications in Banking
Boston Consulting Group (BCG)	Analytics and big data, AI (artificial intelligence), simulation techniques, process automation via robotics, augmented reality applications, integration of horizontal/vertical systems, cloud technologies and cybersecurity.
McKinsey and Company	Management of digital performance, optimization of real-time supply chains, advanced control of processes, management of digital quality, predictions based on data for demand, smart approaches to energy consumption, and virtually guided self-services.
Deloitte	Internet of Things (IoT), artificial intelligence (AI), cloud infrastructure, big data analysis, blockchain.
KPMG	Utilization of big data, cloud technology, cybersecurity measures, robotics, communication between machines, IoT (Internet of Things), and augmented decision support systems.
i-SCOOP Organization	Digital transformation, big data, cloud computing, cybersecurity, artificial intelligence, digitization.

sourse: (Hussainey et al, 2022)

Table .2 Variables definition

Variable	Description	Source

COVID-D	Dummy for observation during the COVID-19 pandemic (1 for 2020 onwards, 0 otherwise).	Mehmood & De Luca, 2023
BM	Number of board meetings.	Shehadeh (2015), Shehadeh et al. (2022)
BZ	Total number of directors in the board.	Allini *et al*., 2016; Albitar *et al*., 2020; Hussainey *et al*, 2022
ACZ	Audit committee size, larger committees might improve oversight and accountability.	Alkurdi et al., 2019; Ashfaq and Rui, 2019
GN	Percentage of female directors on the board	Hussainey *et al*, 2022; Shatnawi *et al*., 2022
JB	Percentage of Jordanian directors on board.	----
BIG4	Dummy for the auditor being a Big Four firm.	Bley et al. (2019)
LEV	Leverage Debt ratio (liabilities by total assets)	Allini et al. (2016), Hussainey et al. (2022)
SIZE	Firm size, Natural logarithm of total assets.	Hussainey et al. (2022)
AGE	Firm age	Hussainey et al. (2022)
ROA	Return on assets, profitability ratio calculated as net income divided by total assets.	Hussainey et al. (2022)

Source: Created by authors

Table 3: The change in disclosure levels between banks over time.

Panel A: T-score													
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Mean	1.06	2.26	5.6	9.86	13	20.4	24.7	39.9	48.9	62.9	69.2	79.6	95.06
SD	1.03	3.10	4.86	7.72	8.90	10.4	10.9	18.9	24.1	31.8	33.6	39.4	36.70
Min	0	0	1	1	1	3.0	1.0	7.0	9.0	12.0	13.0	16.0	42
Max	3	12	21	32	36	39.0	40.0	83.0	96.0	139.0	142.0	171.0	180
N													

Panel B: ctti40strategycomponent													
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Mean	0.26	0.80	1.66	3.13	4.20	7.5	9.0	15.5	19.7	28.5	33.3	36.9	42.53
SD	0.70	1.42	1.44	2.74	2.70	5.3	4.0	9.0	11.1	15.7	18.5	20.4	18.81
Min	0	0	0	0	0	0.0	0.0	3.0	5.0	7.0	7.0	10.0	20
Max	2	4	4	10	8	17.0	15.0	38.0	50.0	63.0	70.0	85.0	90
N													

Panel C: bankingbusinessmodeltransformati													
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Mean	0.20	0.40	1.46	2.73	2.86	4.9	5.7	8.3	11.1	15.7	15.5	18.9	22.86
SD	0.41	0.82	2.69	4.04	2.85	3.7	4.0	4.3	7.7	11.7	11.7	13.5	12.91
Min	0	0	0	0	0	1.0	0.0	2.0	3.0	3.0	3.0	3.0	7
Max	1	3	11	15	10	13.0	12.0	17.0	32.0	45.0	45.0	54.0	55
N													

Panel D: ctti40challenges													
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Mean	0.06	0.06	0.13	1.13	2.33	3.4	4.3	6.6	7.3	7.2	7.9	9.3	11.93
SD	0.25	0.25	0.35	1.59	3.33	3.2	3.4	4.9	5.4	5.4	5.5	5.9	6.51
Min	0	0	0	0	0	0.0	0.0	0.0	0.0	1.0	2.0	2.0	3
Max	1	1	1	5	12	12.0	12.0	17.0	17.0	18.0	19.0	19.0	25
N													

Panel E: ctti40benefits													
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Mean	0.5	1.0	2.3	2.8	3.6	4.5	5.8	9.5	10.8	11.6	12.4	14.3	17.7
SD	0.6	1.2	2.25	2.1	2.3	2.6	3.4	5.4	7.1	6.5	8.0	8.8	9.3
Min	0.0	0	0	0	1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	5
Max	2	4	6	6	8	9.0	14.0	21.0	25.0	23.0	33.0	33.0	35
N													

Source: Compiled by the authors

Table 4: Descriptive statistics for all variables included in the Analysis

	Mean	SD	Min	Max
Tscore	36.374	37.489	0.000	180.000
ctti40strategycomponent	15.621	18.107	0.000	90.000
bankingbusinessmodeltransformati	8.528	10.411	0.000	55.000
ctti40challenges	4.759	5.504	0.000	25.000
ctti40benefits	7.467	7.525	0.000	35.000
BM (board meeting)	7.511	1.839	4.000	15.000
ACZ (audit committee size)	3.789	1.131	2.000	7.000
GND (gender)	0.805	0.822	0.000	3.000
BZ (board size)	10.668	2.282	5.000	14.000
%WB (%Women on Board)	0.069	0.072	0.000	0.280
%JB (%Jordanian nationality on Board)	0.681	0.222	0.160	1.000
BIG4	0.942	0.234	0.000	1.000
LEV (debt ratio)	86.635	4.060	59.016	93.352
SIZE (natural logarithm of total assets)	21.619	0.896	19.407	24.049
AGE (firm age)	42.267	16.754	13.000	92.000
MB (market to book ratio)	0.959	0.469	-1.290	2.441
ROA (return on assets)	0.011	0.005	-0.013	0.025
N	195			

Source: Compiled by the authors

Table 5. Correlation matrix

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
Tscore	(1)	1																
ctti40strategy component	(2)	0.94***	1															
Bankingbusinessmodel transformati	(3)	0.85***	0.72***	1														
ctti40challenges	(4)	0.85***	0.76***	0.63***	1													
ctti40benefits	(5)	0.88***	0.76***	0.68***	0.81***	1												
BM	(6)	0.35***	0.36***	0.26***	0.35***	0.24***	1											
ACZ	(7)	0.26***	0.27***	0.14	0.21**	0.29***	0.27***	1										
GEND	(8)	0.40***	0.36***	0.26***	0.43***	0.43***	0.26***	0.24***	1									
BZ	(9)	0.35***	0.28***	0.36***	0.28***	0.35***	0.24***	0.27***	0.39***	1								
%WB	(10)	0.35***	0.32***	0.22**	0.38***	0.38***	0.22**	0.24***	0.96***	0.29***	1							
%JB	(11)	0.03	0.02	0.03	0.01	-0.09	0.24***	-0.11	0.08	0.18*	0.06	1						
BIG4	(12)	0.13	0.15*	0.18	0.06	0.07	0.19**	0.15*	-0.16*	-0.15*	-0.14	-0.15*	1					
LEV	(13)	0.23**	0.22**	0.15*	0.29***	0.17*	0.10	-0.08	0.06	-0.24***	0.08	-0.07	-0.11	1				
SIZE	(14)	0.34***	0.24***	0.38***	0.30***	0.34***	-0.10	0.06	0.06	0.26***	0.04	-0.21**	-0.01	0.23**	1			
AGE	(15)	0.35***	0.25***	0.48***	0.28***	0.25***	0.05	0.06	0.07	0.41***	-0.02	0.15*	-0.07	-0.07	0.62***	1		
MB	(16)	0.11	0.08	0.23**	0.08	0.14*	-0.15*	0.08	0.11	0.26***	0.07	-0.14	-0.01	0.04	0.37***	0.06	1	
ROA	(17)	0.02	-0.06	0.06	0.06	0.04	-0.21**	0.01	0.04	0.17*	-0.03	-0.06	-0.03	-0.06	0.13	-0.04	0.57***	1

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Source: Compiled by the authors

Table 6: The determinants of CNR on Industry 4.0 technologies

VARIABLES	(1) tscore	(2) ctti40strcompo	(3) bankmdltrans	(4) challenges	(5) benefits
COVID-DM	62.728***	30.047***	11.166***	5.058***	12.800***
	(12.237)	(13.206)	(7.061)	(5.552)	(9.580)
BM	-0.731	0.152	0.062	0.174	-0.151
	(-1.082)	(0.508)	(0.296)	(1.451)	(-0.859)
ACZ	3.430***	2.108***	0.388	0.405**	1.275***
	(3.618)	(5.011)	(1.326)	(2.406)	(5.160)
BZ	1.900***	0.618**	0.189	0.068	0.601***
	(3.295)	(2.416)	(1.061)	(0.663)	(4.002)
%WB	14.235	-6.460	13.225***	0.448	-6.187
	(0.914)	(-0.934)	(2.751)	(0.162)	(-1.523)
%JB	11.142**	6.046***	0.315	0.581	5.067***
	(2.157)	(2.636)	(0.198)	(0.633)	(3.762)
BIG4	6.834	1.060	2.582*	-0.060	-0.679
	(1.460)	(0.510)	(1.788)	(-0.073)	(-0.557)
LEV	0.353	-0.114	0.197**	0.021	0.071
	(1.222)	(-0.894)	(2.208)	(0.401)	(0.945)
SIZE	3.192*	2.075***	-0.344	0.712**	1.103**
	(1.805)	(2.644)	(-0.630)	(2.266)	(2.393)
AGE	0.037	-0.083**	0.115***	-0.026	-0.062***
	(0.404)	(-2.038)	(4.081)	(-1.586)	(-2.606)
MB	-5.309*	-4.770***	3.749***	0.662	-1.932***
	(-1.921)	(-3.889)	(4.398)	(1.348)	(-2.681)
ROA	-484.094*	-101.846	-142.609*	-123.419***	-305.642***
	(-1.942)	(-0.920)	(-1.854)	(-2.786)	(-4.704)
Constant	-129.641***	-45.869***	-21.652*	-18.783***	-34.180***
	(-3.526)	(-2.811)	(-1.909)	(-2.875)	(-3.567)
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes
Observations	190	190	190	190	190
R-squared	0.860	0.865	0.797	0.633	0.782
Adj. R-squared	0.840	0.846	0.769	0.582	0.752

t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.10

COVID-DM: a dummy variable equals 1 for years 2020 and 2021, and zero otherwise
Source: Compiled by the authors

1. Additional Analysis - the impact of external audits

Following Yan et al. (2022), the 2019 annual reports for public companies might be affected by the busy season of auditors due to the outbreak of the COVID-19 pandemic. To address this concern, the sample related to 2019 is excluded to provide a robustness test.

Table 7: The determinants of CNR on Industry 4.0 technologies, excluding the 2019 sample.

VARIABLES	(1) tscore	(2) ctti40strcompo	(3) bankmdltrans	(4) challenges	(5) benefits
COVID-DM	62.666***	30.519***	14.684***	5.073***	12.863***
	(13.745)	(15.004)	(9.751)	(5.449)	(9.625)
BM	-0.346	0.160	0.176	0.180	-0.265
	(-0.548)	(0.567)	(0.844)	(1.394)	(-1.431)
ACZ	2.902***	2.031***	0.104	0.378**	1.150***
	(3.269)	(5.127)	(0.355)	(2.087)	(4.419)
BZ	1.884***	0.575**	0.092	0.071	0.646***
	(3.583)	(2.450)	(0.528)	(0.659)	(4.192)
%WB	1.864	-7.723	9.814**	0.565	-6.810
	(0.130)	(-1.207)	(2.072)	(0.193)	(-1.620)
%JB	7.504	4.837**	-0.725	0.606	3.964***
	(1.570)	(2.269)	(-0.459)	(0.621)	(2.830)
BIG4	5.368	0.865	2.090	-0.061	-0.466
	(1.275)	(0.460)	(1.503)	(-0.070)	(-0.377)
LEV	0.394	-0.060	0.156*	0.018	0.081
	(1.506)	(-0.516)	(1.801)	(0.337)	(1.053)
SIZE	1.950	1.553**	-0.425	0.691**	0.980**
	(1.203)	(2.148)	(-0.793)	(2.087)	(2.063)
AGE	0.054	-0.071*	0.120***	-0.026	-0.053**
	(0.652)	(-1.913)	(4.383)	(-1.514)	(-2.180)
MB	-4.899*	-4.032***	3.419***	0.717	-2.100***
	(-1.926)	(-3.553)	(4.070)	(1.381)	(-2.817)
ROA	-537.206**	-171.262*	-81.455	-115.987**	-259.608***
	(-2.351)	(-1.680)	(-1.079)	(-2.486)	(-3.877)
Constant	-103.525***	-37.986**	-14.497	-18.233***	-31.699***
	(-3.113)	(-2.560)	(-1.320)	(-2.685)	(-3.252)
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes
Observations	175	175	175	175	175
R-squared	0.884	0.890	0.830	0.636	0.778

Adj. R-squared	0.867	0.874	0.805	0.584	0.746

t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.10

COVID-DM: a dummy variable equals 1 for years 2020 and 2021, and zero otherwise
Source: Compiled by the authors

2. Additional Analysis - High Tscore vs. Low Tscore

To ensure that our results of the influence of corporate governance on the narrative reporting of Industry 4.0 transformations in Jordan's banking sector is not affected by the level of the evolution of Industry 4.0 technology narrative reporting, the analysis is re-conducted by splitting the sample into two samples (High Tscore sample vs. Low Tscore sample). High Tscore sample represents firms with Tscore above the median, while Low Tscore sample represents firms with Tscore below the median.

Table 8: The determinants of CNR on Industry 4.0 technologies, for High Tscore sample.

VARIABLES	(1) tscore	(2) ctti40strcompo	(3) bankmdltrans	(4) challenges	(5) benefits
COVID-DM	47.403**	28.902**	2.845	10.904**	9.832
	(2.181)	(2.264)	(0.510)	(2.074)	(1.352)
BM	-1.056	0.148	0.078	0.200	-0.322
	(-0.848)	(0.202)	(0.245)	(0.663)	(-0.773)
ACZ	5.692***	2.469**	0.387	-0.010	0.756
	(3.237)	(2.391)	(0.858)	(-0.024)	(1.285)
BZ	2.576	1.686*	0.385	0.675*	1.071*
	(1.589)	(1.771)	(0.925)	(1.720)	(1.975)
%WB	72.784*	6.030	18.352*	11.435	19.893
	(1.964)	(0.277)	(1.930)	(1.276)	(1.605)
%JB	14.685	9.133	-1.397	3.064	-2.704
	(1.225)	(1.297)	(-0.454)	(1.056)	(-0.674)
BIG4	8.394	4.915	1.585	0.474	-0.025
	(0.612)	(0.611)	(0.451)	(0.143)	(-0.005)
LEV	0.668	0.664	-0.389	1.054***	0.106
	(0.655)	(1.108)	(-1.487)	(4.273)	(0.310)
SIZE	10.564***	4.937**	1.420	1.517*	2.709**
	(2.870)	(2.284)	(1.503)	(1.704)	(2.200)
AGE	0.020	-0.155	0.253***	0.001	-0.024
	(0.108)	(-1.459)	(5.425)	(0.013)	(-0.400)
MB	-10.143*	-9.176***	5.658***	-3.019**	-3.961**

	(-1.791)	(-2.760)	(3.894)	(-2.204)	(-2.092)
ROA	-261.735	22.977	-530.304***	178.560	-15.995
	(-0.481)	(0.072)	(-3.797)	(1.356)	(-0.088)
Constant	-317.246**	-186.444**	-4.114	-138.985***	-71.044
	(-2.307)	(-2.309)	(-0.117)	(-4.178)	(-1.545)
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes
Observations	96	96	96	96	96
R-squared	0.644	0.563	0.706	0.420	0.377
Adj. R-squared	0.555	0.453	0.632	0.275	0.221

t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.10

COVID-DM: a dummy variable equals 1 for years 2020 and 2021, and zero otherwise
Source: Compiled by the authors

Table 9: The determinants of CNR on Industry 4.0 technologies, for Low Tscore sample.

VARIABLES	(1) tscore	(2) ctti40strcompo	(3) bankmdltrans	(4) challenges	(5) benefits
COVID-DM	14.950***	8.750***	3.217***	1.681***	1.404
	(3.971)	(5.351)	(4.729)	(3.838)	(1.060)
BM	0.162	0.571***	0.085	0.128**	0.370**
	(0.377)	(3.067)	(1.102)	(2.563)	(2.454)
ACZ	1.070*	-1.270***	0.143	-0.477***	0.208
	(1.961)	(-5.358)	(1.451)	(-7.509)	(1.085)
BZ	-0.414*	-0.415***	-0.112***	-0.083***	0.139*
	(-1.829)	(-4.216)	(-2.739)	(-3.137)	(1.748)
%WB	6.759	3.089	-1.663	0.974	-6.712***
	(0.998)	(1.051)	(-1.360)	(1.237)	(-2.816)
%JB	-6.493**	-6.274***	-1.523***	-1.292***	-1.170
	(-2.588)	(-5.758)	(-3.361)	(-4.429)	(-1.324)
BIG4	0.522	0.834	-0.738**	-0.030	-2.144***
	(0.299)	(1.101)	(-2.341)	(-0.149)	(-3.492)
LEV	-0.020	-0.095*	0.020	-0.018	-0.040
	(-0.155)	(-1.708)	(0.888)	(-1.190)	(-0.885)
SIZE	-0.511	-0.497	-0.089	0.048	0.469
	(-0.499)	(-1.117)	(-0.481)	(0.405)	(1.302)
AGE	0.104*	0.083***	0.005	0.005	-0.041**
	(1.895)	(3.476)	(0.483)	(0.855)	(-2.125)
MB	3.560**	0.719	1.637***	0.392**	0.987*
	(2.458)	(1.143)	(6.256)	(2.327)	(1.936)
ROA	102.760	204.104***	-61.941***	45.898***	-104.061**
	(0.838)	(3.831)	(-2.795)	(3.217)	(-2.410)

Constant	9.258	21.433***	1.478	2.065	-5.715
	(0.577)	(3.075)	(0.510)	(1.106)	(-1.012)
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes
Observations	93	93	93	93	93
R-squared	0.821	0.814	0.871	0.882	0.644
Adj. R-squared	0.765	0.756	0.831	0.844	0.532

t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.10

COVID-DM: a dummy variable equals 1 for years 2020 and 2021, and zero otherwise

Source: Compiled by the authors

3. Additional Analysis - Endogeneity

One concern related to our analysis is that the results might be driven by the endogeneity issue due to firm specific characteristics rather than by the impact of corporate governance and COVID-19. To address the endogeneity concern, Heckman sample selection method is employed to provide a robustness test. In the first stage, we use a probit regression on the probability of disclosing the narrative reporting of Industry 4.0 transformations in Jordan's banking sector. In the second stage, we run the regression by adding the inverse Mill ratio that obtained from the first stage regression.

First stage: using probit regression on the probability of disclosing the narrative reporting of Industry 4.0 transformations in Jordan's banking sector

Table 10. The probability of disclosing the narrative reporting of Industry 4.0 transformations

VARIABLES	**High-Tscore**
BIG4	1.049**
	(2.392)

LEV	0.090***
	(2.898)
SIZE	0.006
	(0.039)
AGE	0.025***
	(3.057)
MB	0.330
	(1.222)
ROA	26.539
	(1.136)
Constant	-10.602***
	(-2.782)
Observations	190
LR chi2	36.39
Pseudo R2	0.1382
Log likelihood	-113.46
Prob > chi2	0.0000

z-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.10

High-Tscore: is a dummy variable that equals 1 if the firm's tscore is above the median tescore, and 0 otherwise.

Source: Compiled by the authors

Second stage regression: Association between KAM and earnings management in the period of 2017-2021 (overall period), after addressing the endogeneity using Heckman test.

Table 11. The determinants of CNR on Industry 4.0 technologies, after addressing the endogeneity.

VARIABLES	(1) tscore	(2) ctti40strcompo	(3) bankmdltrans	(4) challenges	(5) benefits
COVID-DM	62.728***	30.047***	11.166***	5.058***	12.800***
	(12.237)	(13.206)	(7.061)	(5.552)	(9.580)
Inver-Mills ratio	-18.241*	-3.838	-5.374*	-4.651***	-11.517***
	(-1.942)	(-0.920)	(-1.854)	(-2.786)	(-4.704)
BM	-0.731	0.152	0.062	0.174	-0.151
	(-1.082)	(0.508)	(0.296)	(1.451)	(-0.859)
ACZ	3.430***	2.108***	0.388	0.405**	1.275***
	(3.618)	(5.011)	(1.326)	(2.406)	(5.160)
BZ	1.900***	0.618**	0.189	0.068	0.601***
	(3.295)	(2.416)	(1.061)	(0.663)	(4.002)
%WB	14.235	-6.460	13.225***	0.448	-6.187
	(0.914)	(-0.934)	(2.751)	(0.162)	(-1.523)
%JB	11.142**	6.046***	0.315	0.581	5.067***

	(2.157)	(2.636)	(0.198)	(0.633)	(3.762)
BIG4	25.977**	5.087	8.222**	4.820**	11.407***
	(2.426)	(1.070)	(2.489)	(2.534)	(4.088)
LEV	2.003**	0.233	0.683**	0.441***	1.113***
	(2.306)	(0.604)	(2.547)	(2.859)	(4.915)
SIZE	3.306*	2.099***	-0.310	0.741**	1.175**
	(1.868)	(2.672)	(-0.568)	(2.355)	(2.546)
AGE	0.487**	0.012	0.248***	0.089**	0.222***
	(2.080)	(0.115)	(3.428)	(2.138)	(3.638)
MB	0.714	-3.503	5.524***	2.198**	1.871
	(0.143)	(-1.579)	(3.582)	(2.474)	(1.436)
Constant	-323.023***	-86.553*	-78.620**	-68.085***	-156.275***
	(-3.163)	(-1.910)	(-2.495)	(-3.752)	(-5.871)
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes
Observations	190	190	190	190	190
R-squared	0.860	0.865	0.797	0.633	0.782
Adj. R-squared	0.840	0.846	0.769	0.582	0.752

t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.10

COVID-DM: a dummy variable equals 1 for years 2020 and 2021, and zero otherwise

Source: Compiled by the authors