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Digital transformation and accounting information quality: The role of environmental uncertainty in the era of digital

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ABSTRACT

Amid accelerating digitalization, we examine how digital transformation (DT) shapes accounting information quality (AIQ) through environmental uncertainty (EU), and how innovation investment (R&D) and industry competition (PMC) condition these effects. Using 19,925 firm-year observations for Chinese A-share firms (2013–2022), we construct a text-mined DT index with entropy weights, proxy AIQ via discretionary accruals from a modified Jones model, and measure EU with industry-adjusted rolling residual volatility. Firm and year fixed-effects regressions show: (1) DT significantly improves AIQ by reducing earnings management; (2) EU partially mediates the DT–AIQ link, as DT lowers EU and, in turn, curbs managerial opportunism; (3) R&D and PMC jointly exhibit non-linear moderation, forming an inverted U-shaped pattern whereby DT's uncertainty-reduction benefits peak under moderate competition and balanced innovation. Robustness checks with alternative measures, lags, and clustering support these results. Theoretically, we reveal a novel transmission channel—DT reduces EU to enhance AIQ—extending research on uncertainty and information production. Practically, firms should pursue holistic DT and disciplined R&D to strengthen reporting quality, while regulators enhance digital infrastructure and disclosure standards to improve market transparency and investor protection.

1. Introduction

Information is currently one of the most valuable resources of a company. It is important in all three fields of a company's activity - operational, tactical and strategic. Effective information management is an increasingly important competence, especially since today it is necessary to deal with the uncertainty and unpredictability of the determinants of economic activity. Information can be understood as data that is grouped and processed in order to improve decision-making processes (Jabbar et al., 2020; Raghunathan, 1999). High-quality information is deemed useful. Lee (2002) believe that the quality of information covers several dimensions and therefore it is indispensable to use different techniques and instruments to assess it. Financial records possess predictive value when they can be utilized as input for methodologies employed by their users to forecast future outcomes. Financial information possesses confirmatory worth when it serves as feedback for prior evaluations. (Sunarta & Astuti, 2023; Huang et al., 2025). Accounting information is not only the financial information of the enterprise's financial status, operating results and changes in funds (Dechow &

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Schrand, 2004), but also a bridge connecting the information users with the data and information of the enterprise, accounting information provides investors and creditors with important information about the enterprise, helps them make rational decisions, and also helps enterprise managers understand the operation status of the enterprise, find out the existing problems, and formulate effective business strategies and management measures accordingly (Zhai & Wang, 2016).

The importance of accounting information quality commenced to be emphasised in 1980, when the FASB first treated the quality of accounting information as a special research project and systematic studies were gradually established. There is no doubt that the improvement of accounting records structures has a big have an effect on the effectivity and effectiveness of the strategies applied by way of the agency (Huy, 2020; Saad, 2023). However, a high-quality accounting information system is a prerequisite, providing the ability to process data quickly and reliably, thus implying high-quality information. The effectiveness of the accounting information system can be measured by the effectiveness of reducing uncertainty (Al-Okaily, 2024). Higher accounting information quality alleviates the information asymmetry between internal managers and external investors, thus directly affecting the operating performance of enterprises and investors' decision-making (Chen et al., 2024; Mbanyele et al., 2024).

In the technology of fast improvement of digital technology, the digital economy has grow to be an vital driving force to improve the country's future development pattern (Li et al., 2023; Yuan & Pan, 2023; Liu et al., 2025), according to the information industry research organization IDC (International Data Corporation) predicted that by 2023 the digital economic output value will account for 62 % of the global GDP, the world is about to enter the digital economy age. In the comprehensive layout plan for the construction of Digital China, it is articulated that the effective integration and seamless connectivity of digital technologies and infrastructure bolster the robust advancement and optimization of the digital economy's growth. The evolution of the digital economy represents a strategic decision aimed at embracing the emerging opportunities presented by the ongoing wave of scientific and technological revolution and industrial transformation (Ding et al., 2024), with the deepening of the new spherical of technological progress and industrial transformation, leading the wave of information technology revolution in the digital transformation of enterprises has become a general trend, which is not only regarded as a strong engine to promote economic growth, but also can effectively optimize the enterprise's operation mode (Klos et al., 2021), and affect the entire economic system development (Yang et al., 2024).

At present, the academic community has given diverse conceptual definitions of enterprise digital transformation with different research contents and perspectives, and in summary enterprise digital transformation is relying on artificial intelligence (Shang et al., 2024), big data, cloud computing (Chang et al., 2021), Internet of Things (Pino et al., 2024), blockchain (Fang et al., 2023) new-generation digital technologies to reshape and drive innovation in enterprise management, business, and business models (Ansong et al., 2019). Existing literature on enterprise digital transformation mainly includes aspects of economic consequences such as enterprise innovation (Chen et al., 2024), enterprise performance (Yu et al., 2024), and investment efficiency (Peng & Lu, 2022). Meanwhile, there is a scarcity of scholarly research examining the influence that enterprise digital transformation exerts on the quality of accounting information.

The businesses listed on the Shanghai and Shenzhen A-Stock Exchanges from 2013 to 2022 had been chosen for this study. Based on the hassle of environmental uncertainty, the influence of digital transformation of firms on accounting data high-quality was once investigated, and the moderating outcomes of innovation contribution and enterprise competitiveness depth between digitization and environmental uncertainty had been discussed. The overall conclusion from the study is that digital transformation not only facilitates the improvement of accounting information quality, but also improves it by mitigating environmental uncertainty. This reinforcement effect is especially pronounced under the conditions of high competition intensity and innovation.

This study examines the relationship between digital transformation, environmental uncertainty, and accounting information quality, while exploring the moderating effects of innovation investment and industry competition intensity. Our research makes the following three significant contributions:

This study pioneers the systematic connection between digital transformation and accounting information quality—a classic topic in financial accounting research—thereby addressing a significant gap in the literature. While previous studies have predominantly focused on how digital transformation affects operational efficiency, organizational structure, and financial performance, limited attention has been paid to its impact on accounting information quality. By constructing a theoretical framework linking "digital transformation→ environmental uncertainty → accounting information quality," our research not only enriches digital economy theory but also provides new perspectives on the determinants of accounting information quality in the digital era.

We introduce and empirically verify environmental uncertainty as a critical mediating mechanism, unveiling the "black box" of how digital transformation influences accounting information quality. Departing from existing literature that views digital transformation merely as a direct pathway to enhanced information processing capabilities, our findings demonstrate that digital transformation indirectly reduces earnings management behaviors by mitigating the environmental uncertainty faced by firms. This discovery organically integrates uncertainty theory with information quality research, extending the theoretical depth of both domains and providing a more nuanced understanding of information production processes in digitally transformed enterprises.

Our research transcends the single-moderator research paradigm by exploring the interactive effects between innovation investment and industry competition intensity, and their compound moderating impact on the digital transformation-environmental uncertainty relationship. Notably, we discover an inverted U-shaped relationship between industry competition intensity, innovation investment, and the effectiveness of digital transformation in mitigating environmental uncertainty. This non-linear effect suggests that the efficacy of digital transformation has optimal competitive and innovative boundaries. These findings enrich the intersection of competition theory and innovation economics, offering theoretical guidance for firms making innovation decisions under varying competitive intensities.

The subsequent sections of this paper are organized in the following manner. Section 2 presents a comprehensive review and synopsis of the theoretical foundations employed throughout the course of this study, while Section 3 succinctly presents the literature

review and formulates the hypotheses. Section 4 measures the variables and designs the model. Sections 5 and 6 provide an in-depth analysis of the data using empirical methods. Section 7 draws research conclusions and policy implications based on the analysis.

2. Theoretical background

Since the 1970s, the problem of information asymmetry has gradually received attention (Vickrey, 1961). Economist initially introduced the theory of information asymmetry, figuring that knowledge of relevant information in the marketplace varies across categories of people. Those who possess more comprehensive information often occupy a more advantageous position, whereas those who are less informed find themselves in a relatively disadvantageous position. Furthermore, Stiglitz (1981), Spence (1978), and Akerlof have further supplemented the theory of information asymmetry through their research, put forward to obtain sufficient information on the party, will seek their own greater interests and make the other party's interests are harmed, so as to make their own in the market to occupy an advantageous position. In other words, information asymmetry creates "moral hazard".

The information asymmetry theory is widely used in various fields, including the capital market, the labor market, and the insurance market. For example, in modern capital markets, the management rights and ownership of enterprises are separated. Shareholders will hire managers to be responsible for the management and decision-making of the company in order to ensure the operation of the enterprise. Managers are accountable for the daily operations of the enterprise and have a thorough understanding of its operational status, while shareholders can only understand the details of the company through the financial reports released by the managers, which constitutes the information asymmetry between shareholders and managers. At the same time, there is also information asymmetry between the internal management of the company and external investors. For the purpose of maximizing personal gains, managers may selectively reveal only the favorable information, ultimately impacting investors' decision-making abilities and diminishing overall market efficiency.

The theory emphasizes the importance of information, which is regarded as a valuable resource, and differences in its access and use can significantly affect the decision-making process and outcomes of market participants. This theory not only reveals the prevalence of uneven distribution of information in the market, but also analyzes in depth how such unevenness affects the behavior of market participants, market efficiency, and resource allocation.

The theory of information asymmetry underscores the importance of information while simultaneously highlighting the disparities in risks and benefits borne by market participants due to the different channels of obtaining information and the amount of information. Inequality is particularly prominent in the field of accounting information, seriously affecting the accuracy and reliability of accounting information, the theory that managers manipulate the disclosure of information is the main cause of information bias, damage to the use of information users, and therefore the behavior of corporate managers or professional managers need to be effectively regulated and supervised in order to ensure the healthy operation of the market economic environment.

The problems and risks caused by information asymmetry are particularly prominent and serious in the transition of developing countries to a market economy, where human behavior is difficult to fathom and the problem of moral hazard is rampant. This indicates the need to accelerate the transformation of enterprises, adjust the industrial structure, and achieve the effect of constraints through science and technology supported by the digital economy to mitigate the adverse impacts of morality and preference with science and technology.

The theory of information asymmetry posits that information holds a pivotal role in shaping the trajectory of future sustainable economic and social development, so regulatory measures for managers should be strengthened in the market to ensure the quality of information. The digital-driven economy epoch, digital transformation for the strengthening of internal processes as well as management of enterprises provides a new way to improve the quality of accounting information. The study integrates information with new digital technology and explores the role of digital technology on information quality to reflect the practical application and significance of information asymmetry theory in the stable development of market economy.

3. Literature review

China provides a unique institutional setting for examining digital transformation's impact on accounting information quality. The Chinese government has implemented comprehensive digital economy strategies, including the "Digital China" initiative (2017), "Internet Plus" action plan (2015), and the 14th Five-Year Plan emphasizing digital infrastructure development. These policies create both opportunities and challenges for Chinese firms' digital transformation efforts.

3.1. Digital transformation and the quality of accounting information

Enterprise digital transformation as a cutting-edge transformation mode during the digital economy age, leveraging the innovative "ABCD" technologies to comprehensively empower businesses in their development and operations (Liu, H et al., 2024), on the positive side, digital transformation can bolster the process of information gathering, collation, and application processes, expanding accounting information transmission channels effectively, making enterprises able to collect and process a large amount of accounting information faster and more accurately (Qiu et al., 2024), and form a corresponding complete new information to improve information reliability (Ding et al., 2024). By reshaping traditional business models, processes, and technologies and improving the speed of information transfer, enterprises can update accounting information in real time, improve the accuracy and reliability of data (Quattrone, 2016), and realistically grasp the industry development trend and adjust the enterprise development planning. Additionally, the employment of digital technology can drastically curtail accounting timelines and furnish a crucial technological

underpinning for minimizing errors in accounting and information transmission. Another aspect, digital transformation can regulate the behavior of managers, compression of corporate surplus management space. The digital transformation undertaken by enterprises has the potential to mitigate the agency issues arising between shareholders and managers, thereby enhancing the quality of accounting information through diminished levels of information asymmetry (Li et al., 2024). Because digital transformation can reduce the possibility of surplus management by management by increasing the transparency of information (Xu et al., 2023) and achieving traceability and non-tampering of financial data through means such as blockchain technology (Garanina et al., 2022).

The advancement and utilization of digital technology can instigate a favorable internal governance impact, potentially limiting firms' discretionary practices in applying accounting standards, thereby influencing the comparability of financial information (Zhang et al., 2024). The development of digital technology is conducive to the realization of real-time and transparent internal management process, R&D process, production process, financial control and other important activities of enterprises, which improves the visibility of corporate information, reduces managerial tendencies towards surplus management and suppresses the tendency of internal opportunism.

Therefore, by enhancing the quality of their internal control, it becomes evident that the enterprises' digital transformation acts as a deterrent to surplus management behaviors, thus alleviating the information asymmetry of enterprises, improving the relevance, comparability and robustness of accounting information, and thus enhancing the quality of accounting information. Accordingly, hypothesis 1 is proposed:

H1. The extent of digital transformation is positively correlated with the overall enhancement in the quality of accounting information.

3.2. The mediating role of environmental uncertainty

In the era of the digital economy, we have ushered in new opportunities for development, while at the same time there exists a growing prominence of unknown challenges and uncertainties (Han et al., 2024). The rise of a novel cohort of digital technologies post-2018, coupled with the 2020 pandemic, businesses are facing new environments that make digitalization pervasive in business operations while at the same time placing them deep in an uncertain environment (Yasin et al., 2024), which is evident in the digital transformation is inseparable from environmental uncertainty. Digital transformation for enterprises can not only serve as a defense mechanism to buffer the damage and threat brought by the external environment and poor competition in the market (Feng et al., 2024), but also serve as an offensive mechanism to help enterprises grasp the opportunities brought by the environmental changes when the external environment changes so as to create value for the enterprise (Gao et al., 2017), doubly alleviating the environmental uncertainty.

At the same time, elevated environmental uncertainty exacerbates the various risks faced by firms, increases management's risk aversion, increases management's incentives to manipulate and whitewash (Gul et al., 2010), and makes it more difficult to regulate managers' behavior (Ghosh & Olsen, 2009), resulting in an increase in information asymmetry. To mitigate the adverse effects of uncertainty risk, the degree of surplus management by management increases (Ozili, 2021; Yung & Root, 2019; Zuo & Lin, 2022), and excessive surplus management diminishes the trustworthiness and uniformity of accounting data, affecting its reliability and comparability negatively, and the difficulty of management to develop decision-making programs, the lack of sufficient information to assess, the level of transparency offered by the financial reports will be diminished. The less transparent the financial reports provided will be. From the perspective of information users, the increase in environmental uncertainty will make it difficult for investors to accurately assess the future earnings of the enterprise, amplifying the disparity of information between the enterprise and its investors as well as creditors, and at the same time will increase the difficulty of obtaining accurate information for the company's managers (Li et al., 2021), which will reduce the accuracy of the accounting staff's practical judgment and accounting estimates, and the differences in the accounting information disclosed by the company and that of its peers will become larger and larger. The difference between the accounting information disclosed by the company and that of its peer companies will become bigger and bigger, which will reduce the quality of accounting information. In summary, digital transformation has the potential to elevate the quality of accounting information by alleviating the negative impacts of external environmental challenges faced by enterprises, mitigating the impact of environmental uncertainty, and improving the information asymmetry faced by enterprises. Drawing upon the conclusions of the preceding analysis, we have devised Hypothesis 2:

H2. Environmental uncertainty mediates between digital transformation and accounting information quality.

3.3. Moderating variables: innovation inputs and industry competitive intensity

The level of industry competition reflects the competitive position of the enterprise in the current industry, when competitiveness of the industry increases, the enterprise may lose its original competitive position, and the risk faced by the enterprise increases (Wang et al., 2023), and the operation of the enterprise in the industry becomes unstable, which aggravates the environmental uncertainty (Guiso et al., 2018). When the competition in the industry is fierce, enterprises will face the survival and competitive pressure of being eliminated, therefore, they will adopt specific strategies to address the pressure, sustain their competitive edge, and ensure stable growth (Xin et al., 2023), and digital transformation that can minimize expenses and extend effectivity and enhance operational flexibility becomes an inevitable choice for enterprises (Bin-Feng et al., 2024; Chen, Tu, et al., 2024). In a competitive marketplace where companies will leverage new technologies for digital transformation, visualize data through higher technology, and alleviate the complex external environment faced by enterprises.

When the external environment changes significantly, enterprises will consider changing the status quo through innovation (Liao et al., 2024; Yuan & Pan, 2023), to mitigate the negative influence of environmental uncertainty on enterprises (Nidumolu et al., 2009). Enterprise digital transformation is more prone to garnering market favor in the age of premium digital economic development, and in order to actively fit the market orientation, enterprises tend to have a heightened inclination towards boosting investments in the field of research and development (Zhu et al., 2024), laying a good foundation for digital transformation. With increased investment in innovation, enterprises have sufficient financial and technical support for digital transformation, which improves their development potential, supplements their innovation resources, and mitigates the risk of facing environmental uncertainty.

At the same time, there exists an inverse U-shaped correlation between industry competition and innovation investment. When the signal strength of industry competition is within the acceptable range of firms, firms tend to increase innovation investment spontaneously as competition continues to intensify (Zhang & Liu, 2012), but when the signal strength of industry competition exceeds a certain threshold and threatens the survival of firms, decision makers will adopt conservative business strategies to seek survival (Gaba & Joseph, 2013), especially when firms are on the verge of bankruptcy, and will reduce their willingness and motivation to take risks because the benefits from innovation are insufficient to ensure that the firms continue to operate in the short term through the risks (Liebman & Reynolds, 2019; Nguyen & Vu, 2024). Whether digital transformation will still mitigate environmental uncertainty in a situation where the level of competition in the industry increases and investment in innovation decreases. Drawing from the aforementioned analysis, hypotheses 3 and 4 are proposed:

H3. The intensity of industry competition exhibits an inverted U-shaped relationship with investment in innovation - firms tend to boost innovation investment as the intensity of competition rises, up until a critical threshold is reached, thereafter, the trend reverses, with firms reducing their innovation investment.

H4. Innovation investment and industry competitive intensity produce different moderating effects at different stages between digital transformation and environmental uncertainty.

Fig. 1 shows the two main ways for each variable to improve the accounting information quality.

4. Data and models

4.1. Samples and data

Article selects the A-share listed firms in Shanghai and Shenzhen stock markets from 2013 to 2022 as the sample and treats the sample as follows: (1) excluding samples of financial industry companies; (2) excluding the sample of companies in the ST and *ST categories; (3) excluding the sample of firms with missing data. Finally, this paper obtains 19,925 valid sample observations. Considering that extreme values may affect the experimental results, this paper applies 1 % and 99 % shrinkage to all continuous variables to mitigate the possible interference of outliers. All the raw data utilized in this paper have been sourced from the WIND, CSMAR, alongside the annual reports of individual publicly listed companies.

4.2. Measurement of variables

4.2.1. Dependent variable: accounting information quality (abs_DA)

Current assessments of accounting information quality frequently rely on measures pertaining to earnings management, disclosure quality, stock returns, robustness, and comparability. Referring to the existing literature, by changing the degree of surplus management, it enhances the information asymmetry and misleads stakeholders, thereby exerting a pronounced influence on accounting information quality. Therefore, this paper adopts the modified Jones model to measure accounting information quality from the perspective of surplus management, and the formula operates as follows:

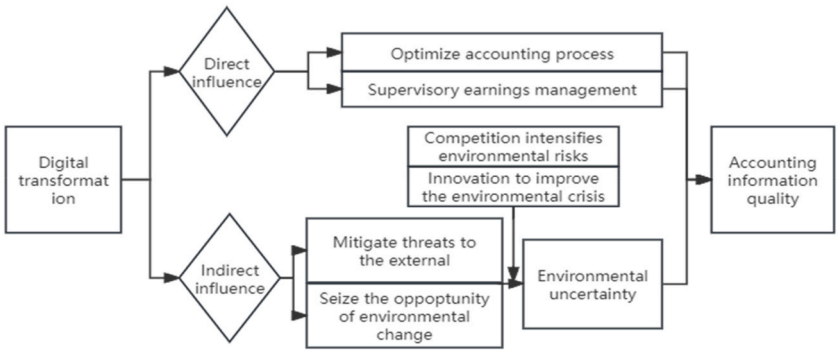

Fig. 1. Analysis of the mechanisms by which digital transformation affects accounting information quality.

$$\frac{TA_{i,t}}{A_{i,t}} = \beta_0 \frac{1}{A_{i,t-1}} + \beta_1 \frac{\Delta REV_{i,t}}{A_{i,t-1}} + \beta_2 \frac{PPE_{i,t}}{A_{i,t-1}} + \varepsilon_{i,t} \tag{1}$$

$$NDA_{i,t} = \widehat{\beta}_0 \frac{1}{A_{i,t-1}} + \widehat{\beta}_1 \frac{\Delta REV_{i,t} - \Delta REC_{i,t}}{A_{i,t-1}} + \widehat{\beta}_2 \frac{PPE_{i,t}}{A_{i,t-1}} \tag{2}$$

$$DA_{i,t} = \frac{TA_{i,t}}{A_{i,t}} - NDA_{i,t} \tag{3}$$

Where $TA_{i,t}$ is the total accrued profit, $NDA_{i,t}$ is the non-manipulable accrued profit, $\Delta REV_{i,t}$ is the change in operating income, $\Delta REC_{i,t}$ is the change in accounts receivable, and $PPE_{i,t}$ denotes the net fixed assets in period t. Firstly, formula (1) is used to calculate the coefficients of the annual industry regression, and then the coefficients are brought into formula (2), and finally the manipulable accrued profit $DA_{i,t}$ is calculated by formula (3). As the manipulability of accrual profits rises, so does the level of earnings management within the enterprise, leading to an increase in information asymmetry and subsequently, a decline in the quality of accounting information. Specifically, when examining the absolute value of manipulable accrual profit, a larger absolute value translates into poorer quality of accounting information.

4.2.2. Independent variable: digital transformation (DCG)

At present, there is no clear unification for the measurement method of digital transformation, the more commonly used one is to use the CSMAR database digital transformation indicators for measurement, the 2nd is to use the percentage of digital intangible property to intangible belongings, and the third approach involves utilizing text analysis methods to condense and identify the key terms associated with digital transformation within the annual reports of publicly listed companies. Utilizing the widespread adoption of text analytics, it becomes scientifically sound and practically feasible to employ Python web scraping technology to extract and quantify the word frequencies related to digital technology within the annual reports of listed corporations. This approach effectively portrays the digital transformation undertaken by enterprises, thereby facilitating a more accurate assessment of the degree of their digital transformation. Hence, this paper refers to the practices proposed by creates five digital segmentation components as the top five metrics for measuring digital transformation, summarize the keyword word frequency of the five parts, and increment the total word frequency by 1 and subsequently calculate its natural logarithm.

4.2.3. Neutral variable: environmental uncertainty (EU)

The arithmetic of this paper utilizes five consecutive years of sales revenue data of the firms as the environmental uncertainty used in the study of this paper. The arithmetic formula is as follows:

$$Sale = \varphi_0 + \varphi_1 year + \varepsilon \tag{4}$$

Sale, in this formula, refers to sales revenue, and the residual of equation (4) is the required abnormal sales revenue, which is obtained by rolling the regression with the standard deviation of the abnormal sales revenue over the past five consecutive years to obtain the unindustry-adjusted environmental uncertainty, and then, based on the methodology of Ghosh and Olsen (2009), calculating the industry-adjusted environmental uncertainty involves dividing the unadjusted environmental uncertainty by the industry's environmental uncertainty, resulting in a specific EU (Environmental Uncertainty) metric employed in this paper.

4.2.4. Moderating variables: innovation inputs and industry competitive intensity

(1) Innovation inputs (RDI)

Table 1
Variables definition.

Symbol	Variables Measures
abs_DA	Introduced according to equation (1) (2) (3), taking absolute values
DCG	Natural logarithm of total digitized related word frequencies
EU	Introduced by equation (4)
RDI	R&D investment/revenue
LN	Industry Lerner Index
Size	Logarithm of total business assets
Lev	Total corporate liabilities divided by total corporate assets
ROA	The firm's net income divided by average total assets
Cashflow	Ratio of net cash flows generated from operating activities to average total assets
Growth	Growth rate of the enterprise's operating income in the current year relative to the operating income of the previous year
Top1	The percentage of total share capital held by the largest shareholder in terms of the number of shares.
Big4	1 if the enterprise engages an international Big 4 accounting firm in the current year, 0 otherwise
Opinion	Audit opinion is 1 for standard audit opinion and 0 otherwise
Dual	The value of 1 is taken when the chairman and general manager are both appointed, otherwise 0.
SOE	The value is 1 if it is a state-owned enterprise, and 0 otherwise.

Referring to Zhu et al. (2024), a widely used methodology that is representative of innovation investment is to use "R&D investment" as the core indicator. In short, the higher the intensity of R&D investment, the greater the investment in technological innovation, product development, etc., which may indicate a stronger innovation capability.

(2) Industry Competitive Intensity (LN)

In this paper, the industry Lerner index is chosen as the metric to quantify the level of competition within the industry, drawing on the Lerner index formula proposed by Peress (2010), the higher the index, the more advantageous position the firm holds in the industry competition, and the weaker the competition intensity the firm encounters.

4.2.5. Control variables

In this paper, firm size, gearing ratio, earnings on assets, cash flow ratios, firm growth, shareholding ratio of the largest shareholder, Big4, CEO-chair duality, nature of ownership, audit opinion as control variables with controls for industry and year. The measurements of each variable are shown in Table 1.

4.3. Research model

To confirm whether or not digital transformation can enhance accounting information quality, we hooked up model (1) for inspection:

$$abs\_DA_{i,t} = \alpha_0 + \alpha_1 DCG_{i,t} + \alpha_2 Controls_{i,t} + \Sigma year + \Sigma ind + \varepsilon_{i,t} \quad (1)$$

Drawing on the mediation effect model utilized by Zhang et al. (2024) as well as the testing methodology, models (2) and (3) were developed to jointly test the mediating role of environmental uncertainty with model (1):

$$EU_{i,t} = \mu_0 + \mu_1 DCG_{i,t} + \mu_2 Controls_{i,t} + \Sigma year + \Sigma ind + \varepsilon_{i,t} \quad (2)$$

$$abs\_DA_{i,t} = \gamma_0 + \gamma_1 DCG_{i,t} + \gamma_2 EU_{i,t} + \gamma_3 Controls_{i,t} + \Sigma year + \Sigma ind + \varepsilon_{i,t} \quad (3)$$

Further, to test the moderating effect of innovation investment and the degree of industry competition on the relationship between digital transformation and environmental uncertainty, model (4) was constructed to test hypotheses 3 and 4:

$$\begin{aligned} EU_{i,t} = {} & \delta_0 + \delta_1 DCG_{i,t} + \delta_2 RDI_{i,t} + \delta_3 LN_{i,t} + \delta_4 RDI_{i,t} * LN_{i,t} + \delta_5 DCG_{i,t} * RDI_{i,t} \\ & + \delta_6 DCG_{i,t} * LN_{i,t} + \delta_7 DCG_{i,t} * RDI_{i,t} * LN_{i,t} + \delta_8 Controls_{i,t} + \Sigma year + \Sigma ind + \varepsilon_{i,t} \end{aligned} \quad (4)$$

In the model, abs_DA denotes the explanatory variable accounting information quality, DCG denotes the explanatory variable digital transformation, EU denotes the mediator variable environmental uncertainty, LN denotes the intensity of competition in the industry, RDI is the innovation input, and year and ind denote the dummy variables.

5. Empirical results

5.1. Descriptive statistics

As depicted in Table 2, the descriptive statistics pertaining to the primary variables reveal a distinct right-skewed distribution in the overall accounting information quality. Remarkably, despite the marked contrast between the peak value of 0.44 and the nadir of 0, this trend remains consistent, but it can be seen that the overall quality of accounting information of the Chinese listed companies selected for the sample is low. Digital transformation also shows a right-skewed pattern, which shows that some sample enterprises

Table 2
Descriptive statistics.

Variables	N	Mean	SD	Min	Median	Max.
Abs_DA	19925	0.05	0.05	0	0.03	0.44
DCG	19925	1.58	1.4	0	1.39	5.01
EU	19925	1.28	1.15	0.11	0.96	9.96
RDI	19925	0.04	0.05	0	0.03	0.26
LN	19925	0.12	0.07	−0.47	0.12	0.53
Size	19925	22.48	1.29	20.03	22.29	26.46
Lev	19925	0.44	0.2	0.07	0.44	0.9
ROA	19925	0.05	0.06	−0.15	0.05	0.25
Cashflow	19925	0.15	0.39	−0.57	0.09	2.47
Growth	19925	0.03	0.07	−0.25	0.03	0.22
Top1	19925	0.33	0.15	0.08	0.3	0.73
Big4	19925	0.06	0.24	0	0	1
Opinion	19925	0.26	0.44	0	0	1
Dual	19925	0.38	0.48	0	0	1
SOE	19925	0.97	0.17	0	1	1

have a higher degree of digital transformation, but there is still a certain gap in the progress of digital transformation among different enterprises. The mean value of environmental uncertainty is higher than the median, demonstrating that the environmental uncertainty of enterprises in China is high. The values of the variables are all inside sensible limits and fulfill the necessities of the research endeavor.

5.2. Regression analysis

Table 3 displays the regression analysis outcomes exploring the correlation between digital transformation and the quality of accounting information. The regression results of model (1), adjusted solely for industry and year, are presented in Column (1), while Column (2) displays the regression results with additional control variables added to the model based on Column (1). Since the lower the abs_DA index, the greater the level of quality in accounting information, the coefficients of abs_DA and DCG in columns (1) and (2) are −0.003 and −0.002 respectively, which are significantly negative at the 1 % level, which preliminarily validates that the digital transformation of enterprises can mitigate the extent of surplus management and reinforce accounting information quality, and verifies hypothesis 1.

5.3. Heterogeneity test

5.3.1. Property rights heterogeneity

There exist notable disparities between state-owned and non-state-owned enterprises in relation to the external business environment, internal governance structures, and principal-agent approaches. These differences directly affect the decision-making process, business strategy and innovation ability of enterprises (Xiao, Xu, & Li, 2024). With their special shareholder background, state-owned enterprises can often take a clear advantage in the external business environment. And non-state-owned enterprises may be more flexible and sharp, able to adapt to market changes more quickly and possess stronger innovative power. Therefore, in the case of information asymmetry, there may also be variations in the impact of digital transformation on the improvement of accounting information quality between SOEs and non-SOEs enterprises, and it is imperative to analyze the heterogeneity in accordance to the kind of organisation ownership. According to the results of columns (1) and (2) in Table 4, the significance test of digital transformation passes at the 1 % level across enterprises with varying attributes, and all of them can promote the improvement of accounting information quality, which indicates that although enterprises have different property rights and different abilities to obtain information, to bolster their competitiveness and adaptability, all of them will promptly adjust their strategic orientations and management tactics, embarking on digital transformation endeavors.

Table 3
Regression analysis of basic variables.

	(1) abs_DA	(2) abs_DA
DCG	−0.003***	−0.002***
	(-8.08)	(-6.63)
Size		−0.004***
		(-12.01)
Lev		0.011***
		(4.73)
ROA		−0.208***
		(-31.87)
Cashflow		0.019***
		(3.20)
Growth		0.021***
		(23.00)
Top1		0.002
		(0.73)
Big4		−0.003**
		(-2.03)
Opinion		−0.019***
		(-9.37)
Dual		0.001
		(1.55)
SOE		−0.006***
		(-7.71)
Constant	0.053***	0.162***
	(16.04)	(20.30)
ind FX	Yes	Yes
year FX	Yes	Yes
N	19925	19925
Adj.^{2}	0.024	0.132

Note:*, **, and *** represent 10 %, 5 %, and 1 %, respectively.

Table 4
Heterogeneity analysis.

	SOEs	Non-SOEs	High-Tech	Non-High-Tech
	(1) abs_DA	(2) abs_DA	(3) abs_DA	(4) abs_DA
DCG	−0.002***	−0.002***	−0.001***	−0.003***
	(-4.63)	(-5.36)	(-3.26)	(-6.37)
Controls	Yes	Yes	Yes	Yes
Constant	0.174***	0.147***	0.147***	0.190***
	(15.98)	(12.59)	(14.41)	(16.68)
year FX	Yes	Yes	Yes	Yes
ind FX	Yes	Yes	Yes	Yes
N	7478	12447	11857	8068
Adj.^{2}	0.120	0.140	0.135	0.145

Note: *, **, and *** represent 10 %, 5 %, and 1 %, respectively.

5.3.2. Heterogeneity of scientific and technological attributes

High-tech enterprises, with their robust technical capabilities and extensive technological reserves, are typically adept at swiftly mastering and integrating innovative technologies like artificial intelligence, big data, and cloud computing into their digital transformation efforts. On the contrary, non-high-tech enterprises may encounter difficulties such as high technological barriers and a shortage of technological talents, and non-high-tech enterprises may invest relatively little in these areas, resulting in a slow process of digital transformation and a relatively backward transformation of accounting processes. On this basis, as the level of digital transformation intensifies, the effect of non-high-tech firms on the improvement of accounting information quality will be more significant than that of high-tech enterprises. Referring to Zhang et al. (2024), we classify the manufacturing industry, the information transmission, software and information technology service industry, and the scientific research and technology Service Industry, totaling three categories, 19 major categories of industries as high-tech enterprises, the remaining enterprises are categorized as non-high-tech firms. Under columns (1) and (2) of Table 4, digital transformation is significant at the 1 % level, but the coefficient of column (2) is larger, indicating that in the context of non-high-tech enterprises, the intensification of digital transformation has markedly enhanced the integrity and reliability of corporate accounting information.

5.4. Robustness check

5.4.1. Replacement of core explanatory variables

Digital transformation as the core explanatory variable of this paper, to ensure the robustness of the findings, this paper employs various methodological metrics for regressing the benchmark model. Combined with the existing research results, the construction of digitalize indicators using the entropy method for objective weighting, as a replacement variable for testing, column (1) in Table 5 displays the regression outcomes pertaining to the substitution variable, the replacement of the digital transformation indicators at the 5 % level is significantly negative, underscoring the continued prominence of digital transformation in enhancing the quality of accounting information, and the results of the previous test are robust.

5.4.2. Hysteresis effect test

Since the application of digital transformation may have a certain lag, the advantages of digital technology owned by enterprises after transformation for enterprises to enhance accounting information quality may only be shown after a period of time, therefore, we adopts lagging the independent variable by one period, as a replacement variable with accounting information quality to carry out

Table 5
Robustness test results.

	(1) abs_DA	(2) abs_DA	(3) abs_DA
DCG_New	−0.060**		
	(-1.99)		
L.DCG		−0.001***	
		(-4.00)	
DCG			−0.002***
			(-7.00)
TQ			0.004***
			(13.40)
Controls	Yes	Yes	Yes
Constant	0.167***	0.159***	0.113***
	(21.04)	(17.96)	(12.75)
year FX	Yes	Yes	Yes
ind FX	Yes	Yes	Yes
N	19925	15885	19925
Adj.^{2}	0.130	0.141	0.154

Note:*, **, and *** represent 10 %, 5 %, and 1 %, respectively.

basic regression. The outcomes of the test are presented in column (2) of Table 5, where the substitution variable exhibits a statistically enormous negative effect at the 1 % level, thereby validating the lag test and confirming that Hypothesis 1 remains valid.

5.4.3. Adding missing variables

To mitigate the potential influence of omitted variables that could affect the regression analysis, this paper builds upon the research conducted by incorporating the Tobin's Q measure into the analysis. As proven in column (3) of Table 5, the coefficient between DCG and abs_DA, at −0.002, is notably negative at the 1 % level, reinforcing the robustness of the preceding findings.

5.5. Mediating effects of environmental uncertainty

Table 6 presents the regression analysis results for testing the mediating role of environmental uncertainty based on models (2) and (3). In column (2) digital transformation is significantly negative at the 1 % level, indicating that firms' digital transformation reduces environmental uncertainty, and the higher the level of digitization, the lower the environmental uncertainty faced by firms. In Column (3), digital transformation is positively negative at the 1 % level, and the coefficient of 0.006 between environmental uncertainty and accounting information quality is markedly effective at the 1 % level, illustrating that as the extent of digital transformation becomes more widespread, its capacity to mitigate environmental uncertainty becomes more pronounced, resulting in decreased information asymmetry and enhanced accounting information quality, which suggests that the environmental uncertainty plays a partially mediating role between the digital transformation and the quality of accounting information, and verifies Hypothesis 2.

6. Further analysis

6.1. Moderating effects of innovation inputs, industry competitive intensity

As shown in Fig. 2 and Table 7, the test of innovation investment and industry competitive intensity reveals that there is an inverted U-shaped relationship between the two, and both curves are significant at the 1 % level. According to the extreme points of the curves, the sample size is divided into stage 1, in which the intensity of industry competition promotes innovation investment, and stage 2, in which the intensity of industry competition inhibits innovation investment (see Table 8).

Table 7 presents the regression outcomes pertaining to the moderating influences of innovation investment and the intensity of industry competition in the two respective states, as can be observed in row(5) of Table 7, the coefficients pertaining of the interaction terms of digital transformation with innovation investment and industry competitive intensity are −9.572 and −9.775, respectively,

Table 6
Mediating effects of environmental uncertainty.

	(1) abs_DA	(2) EU	(3) abs_DA
DCG	−0.002***	−0.045***	−0.002***
	(-6.63)	(-7.00)	(-5.80)
EU			0.006***
			(17.47)
Size	−0.004***	−0.063***	−0.004***
	(-12.01)	(-8.25)	(-11.06)
Lev	0.011***	−0.120**	0.011***
	(4.73)	(-2.53)	(5.08)
ROA	−0.208***	−2.751***	−0.192***
	(-31.87)	(-19.79)	(-29.37)
Cashflow	0.019***	−0.810***	0.024***
	(3.20)	(-6.39)	(4.01)
Growth	0.021***	1.372***	0.013***
	(23.00)	(70.56)	(12.90)
Top1	0.002	0.108**	0.001
	(0.73)	(2.00)	(0.49)
Big4	−0.003**	−0.058*	−0.003*
	(-2.03)	(-1.81)	(-1.82)
Opinion	−0.019***	−0.704***	−0.015***
	(-9.37)	(-16.45)	(-7.36)
Dual	0.001	−0.023	0.001*
	(1.55)	(-1.32)	(1.72)
SOE	−0.006***	−0.103***	−0.006***
	(-7.71)	(-5.89)	(-7.03)
Constant	0.162***	3.239***	0.143***
	(20.30)	(19.12)	(17.92)
ind FX	Yes	Yes	Yes
year FX	Yes	Yes	Yes
N	19925	19925	19925
Adj.^{2}	0.132	0.234	0.145

Note:*, **, and *** represent 10 %, 5 %, and 1 %, respectively.

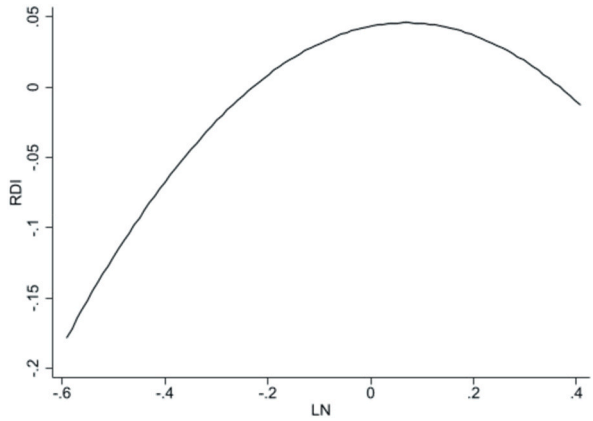

Fig. 2. Inverted U relationship between innovation investment and industry competitive intensity.

Table 7
Inverted U relationship between innovation investment and industry competitive intensity.

	Stage1	Stage2
Slope	0.5509	−0.2692
t-value	21.99895	−18.30072

Table 8
The moderating role of innovation inputs and the intensity of industry competition.

	Stage 1	Stage2
	(1)	(2)
	EU	EU
DCG	−0.097***	−0.105**
	(-6.08)	(-2.42)
RDI	−4.180***	−5.209**
	(-5.23)	(-2.36)
LN	−0.546***	−0.790
	(-2.66)	(-1.36)
RDI_LN	29.039***	33.066**
	(5.68)	(2.26)
DCG_RDI_LN	−9.572***	−9.775*
	(-4.88)	(-1.83)
Controls	Yes	Yes
year FX	Yes	Yes
ind FX	Yes	Yes
Constant	3.373***	3.239***
	(18.44)	(19.12)
N	17668	2257
Adj.^{2}	0.223	0.271

Note:*, **, and *** represent 10 %, 5 %, and 1 %, respectively.

which are distributed to be significant at the 1 % and 10 % levels and pass the significance test. Since the higher the LN index, the lower the industry competitive intensity, the higher the RDI, the higher the innovation investment, and the coefficients of the interaction term of model (8) in column (1) and (2) are negative, it illustrates that as the industry competitive intensity increases, the greater the mitigating effect of digital transformation on with the environmental uncertainty, and the more firms will carry out digital transformation reforms in order to distinguish themselves from competitors or to maintain a stable course of development. Even though innovation investment gradually decreases in the later stages of more competitive industries, it still has a significant weakening effect on environmental uncertainty as long as it exists. This implies that the level of industry competition serves as a pivotal moderating factor between digital transformation and environmental uncertainty.

7. Conclusions and policy recommendations

Drawing upon a sample of China's A-share companies listed in Shanghai and Shenzhen spanning from 2013 to 2022, we delves into

the influence of digital transformation on the first-rate of accounting information. Discovery: (1) The transformation towards digitalization within enterprises has prominently enhanced accounting information quality by advancing the internal digital technology capabilities, mitigating managerial surplus management, and minimizing the level of information asymmetry. This conclusion holds true even after undergoing rigorous robustness testing. Between firms with different property rights, digital transformation helps reduce surplus management and improve information quality, but between high-tech firms and non-high-tech firms, digital transformation proves to be more efficacious in enhancing accounting information quality for non-high-tech enterprises. (2) Environmental uncertainty plays a pivotal role in linking digital transformation to the enhancement of accounting information quality. In essence, the augmentation of digital penetration within enterprises aids businesses in elevating the visibility of external information, reduces the environmental uncertainty they face, reduces managers' incentives for risk-averse surplus management, and elevates accounting information quality. (3) Industry competition intensity and innovation investment can positively moderate the influence of digital transformation on environmental uncertainty, and the intensity of industry competition accounts for the main moderating role, as the intensity of competition increases, the innovation investment, whether it increases or decreases, the greater the mitigating effect of digital transformation on and environmental uncertainty.

7.1. Policy implication

Based on the empirical results, this paper obtains the following insights:

(1) Create a standard for digital transformation within your organization. Digital transformation, as a key way for enterprises to cope with global digital changes, adapt to the digital economy environment, and achieve business success and growth and development, is an ongoing process that requires continuous optimization and improvement. Simultaneous, enterprises must also keep a watchful eye on shifts in market competition and technological needs, and timely adjust the transformation strategy and direction. The digitalization process should not only improve the construction of data management, data quality and other standardization systems, create standardized data interfaces and data dictionaries, enable data to flow standardizedly within the system, thereby ensuring the security and stability of data during the transformation process, to improve the truthfulness, accuracy and completeness of the accounting information, to promote the integration of business and finance, to achieve resource sharing, so as to promote the enterprise to maintain high-quality development in the new business era.
(2) Strengthen technological research and development and cultivate digital talents. The more in the high uncertainty environment, the more enterprises should integrate resources, actively forge ahead, accelerate the implementation of digital strategy, strengthen technology research and development and application, optimize management processes and organizational structure, innovate business models and product lines, etc., to enhance their own sensitivity and perception of the environment and market changes, and to improve their ability to cope with the environmental changes, and at the same time, to cultivate new technological talents and encourage employees to accept new ideas and new technologies and methods to guarantee the integrity and accuracy of accounting information by alleviating the burden on managers' decision-making processes and mitigating potential opportunistic behaviors.
(3) Emphasis on the digital development of accounting in non-high-tech companies. High-tech enterprises have their own financial and technological advantages, which can be utilized to rapidly carry out innovation and transformation, adapt to market changes and seize development opportunities. While non-high-tech enterprises have a poorer perception of technological innovation, if they cannot seize the opportunity to carry out technological transformation, they will miss market opportunities and may gradually fall behind their competitors.
(4) The establishment of an internal accounting data sharing platform and part of the data open platform information services. Protect the interests of shareholders and investors, mitigate the level of information asymmetry, and to a certain extent, enable the public to supervise the enterprise managers, bolster the credibility of the corporation, and contribute to the sustainable development of the firm.
(5) Guiding digital transformation and strengthening information regulation. The government also needs to support and guide digital transformation, promote data-enabled innovation in accounting and finance systems, automate and intellectualize business processes, improve management efficiency and decision-making, and enhance the standard and scientific nature of information. At the same time, the government and market regulators need to strengthen information disclosure and regulation, improve market transparency, protect the rights and interests of information disadvantaged parties, and maintain market fairness and efficiency.

7.2. Future gap and limitations

While our text-mining approach offers an objective measure of digital transformation, it primarily captures firms' disclosed digital orientation rather than implementation depth or effectiveness. Future research could develop multi-dimensional assessments that combine textual analysis with actual technology adoption metrics, third-party digital footprint data, and manager surveys. Linking such measures to audit evidence would provide a more holistic view of digital maturity. Moreover, distinguishing between technology types may reveal heterogeneous effects on accounting outcomes and control environments.

Declaration of interest statement

All authors declare that no conflict of interest exists.

Data availability

Data will be made available on request.

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