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Do auditors charge clients with higher audit fees for blockchain investments?

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ABSTRACT

This study examines the impact of clients' blockchain investments on audit fees. Using a sample of A-share Chinese listed firms spanning the 2015–2019 period, we find a positive association between blockchain investments and audit fees, which is stronger for client firms that have adopted blockchain than those that have only invested in this technology. Our channel analysis further reveals that higher audit fees stem from the increase in client firms' audit risk and the greater effort in audit planning and execution by the auditors. The positive association between blockchain investments and audit fees is attenuated by audit firms' extensive information technology (IT) experience and is intensified by considerable external attention to clients' blockchain activities. Our results are robust to a battery of endogeneity and other robustness checks. This research casts new light on the interactions between disruptive technologies and external auditor practices, as reflected in audit fees.

1 Introduction

Blockchain technology has received significant public attention in recent years (Cheng et al., 2019). Although often associated with cryptocurrency mining, blockchain is increasingly being adopted as a fundamental technology that is expected to improve business processes by enhancing trust, transparency, and efficiency (Wang et al., 2019). Accordingly, professional accounting bodies already recognize the importance of independent auditors considering the challenges and opportunities brought about by their clients' involvement in this advanced technology (Chartered Professional Accountants of Canada (CPA Canada), 2016; Association of Chartered Certified Accountants (ACCA), 2017; American Institute of Certified Public Accountants (AICPA) & CPA Canada, 2018; Institute of Chartered Accountants in England and Wales (ICAEW), 2017). However, despite the widespread interest in blockchain adoption and its purported benefits to businesses, empirical research based on corporate blockchain investment and implementation is extremely rare.[1] Thus, the purpose of this study is to provide empirical evidence on the effect of clients' blockchain investments on audit practices, with particular reference to audit fees.

From the agency theory perspective, statutory auditing plays a vital role in monitoring managers to ensure their actions align with the stakeholders' best interests and to scrutinize the company's financial reports (Shan et al., 2019). The appointment of an auditor as a monitoring agent incurs costs that reflect the resources needed for maintaining accountability and transparency in the overall corporate governance framework. Blockchain technology—with its unique attributes of transparency, accuracy, and immutability—serves to mitigate the information asymmetry resulting from managers' moral and ethical hazards (Pimentel & Boulianne, 2020), and by preventing data manipulation also contributes to more efficient monitoring and auditing processes (Yermack, 2017). As the resulting efficiency could lead to a reduction in audit fees, one could anticipate a negative association between clients' blockchain investments and audit fees.

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[1] As blockchain technology has sparked varying levels of engagement among firms, we denoted these levels as interest, investment, and adoption. The "interest" category refers to the mention of blockchain in corporate disclosures without any financial commitment or implementation. Blockchain investment involves allocating financial resources towards blockchain related projects or companies, reflecting a strategic decision to capitalize on blockchain's potential for future returns. In contrast, blockchain adoption signifies the practical integration of blockchain technology into business operations to enhance processes, such as supply chain management, financial transactions, and data security.

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On the other hand, the complexities and risks associated with auditing blockchain based systems might counteract the aforementioned benefits. This issue is particularly pronounced if auditors are not familiar with blockchain technology and lack the requisite competencies. According to Simunic (1980), audit fees reflect the extent of the audit work and/or the expected losses. Therefore, the technical intricacies inherent in blockchain technology, the need for specialized expertise for the evaluation of blockchain's impact on internal controls and the assessment of the business risk from blockchain implementation, and the lack of official auditing and compliance guidance from standard setters, could exacerbate the audit risks and lead to higher audit fees. Thus, while the impact of clients' blockchain investment on audit fees has not been tested in practice, based on the above reasoning, we hypothesize a positive association between clients' blockchain investment and audit fees.

In this work, we test these hypotheses using relevant data pertaining to the Chinese context for three reasons. First, China has actively pursued blockchain related patents and has witnessed rapid integration of this technology across various industries (Xu & Guan, 2023). The abundance of approved blockchain related application patents, as reported by the World Intellectual Property Organization, underscores China's pioneering role in the global blockchain landscape. Our study leverages this distinct positioning of China to explore auditors' reactions to blockchain investments within an environment characterized by both high blockchain adoption and government backed support. Second, as our research focuses on firms investing in blockchain for business purposes, the Chinese context allows us to ex ante eliminate most firms that only engage in cryptocurrency related activities because the Chinese government has banned Bitcoin trading and mining while supporting blockchain adoption and investments for business entities. These aspects are not captured in extant studies involving United States (US) based data in which blockchain and cryptocurrency investments are not separated (Cheng et al., 2019). Third, through Chinese Research Data Services (CNRDS) Platform, we were able to accurately identify a sample of client firms investing in blockchain technology based on the content analysis of their corporate disclosures. We could also use the data from CNRDS to segregate firms that have adopted blockchain technology from those that have only invested in blockchain as a strategic business decision.

Our sample consists of 3,405 A-share Chinese listed firms with 13,259 firm year observations spanning the 2015–2019 period. In our models, blockchain investment is considered a dummy variable coded one if the firm's corporate disclosure indicates that it has invested in and/or adopted blockchain technology, and zero otherwise. We find that clients' blockchain investments are positively associated with audit fees. However, auditors charge blockchain adopters higher audit fees than blockchain non adopters (i.e., client firms that only invest in blockchain without adoption). Our channel analysis also shows that this positive association is mediated by audit risk and audit effort, attenuated by a high level of audit firms' experience in auditing technology intensive client firms, and intensified by a high level of external attention on clients'behaviors. Our results remain robust after controlling for endogeneity issues.

This research contributes to the auditing literature by investigating the impact of blockchain technology on auditing. The effect of blockchain on auditing has largely remained unexplored (Risius & Spohrer, 2017; Fedyk et al., 2022). While a few studies have examined the effect of information technology (IT) investment on audit (Han et al., 2016; Johnston & Zhang, 2018; Banker et al., 2020), the results are inclusive. Moreover, it is not clear whether these results could be generalized to blockchain technology, given its unique features. Currently, there are debates on how blockchain could affect fees. Some commentators argue that blockchain technology can reduce audit fees by mitigating information asymmetry and risks and facilitating auditor monitoring (Yermack, 2017; Farouk et al., 2020; Pimentel & Boulianne, 2020). By contrast, other commentators (e.g., Toufaily et al., 2021) hold that blockchain investments are associated with significant risks, given its complexity, costly nature and high uncertainty, thereby potentially increasing audit fees. Notably, most of the debate is speculative and conceptual, lacking large sample based empirical evidence (Risius & Spohrer, 2017; Alkhudary et al., 2020). Our study contributes to this debate by providing fresh empirical evidence that blockchain investments (especially blockchain adoption) increase audit fees. We show that blockchain investments are factored into audit pricing. Thus, our study also contributes to the theoretical of audit pricing by extending the foundational work of Simunic (1980). Moreover, our empirical results are not contaminated by mixing blockchain technology with cryptocurrencies, which has resulted in inconsistent empirical results in prior studies (Cheng et al., 2019; Klöckner et al., 2022).

This research also enriches the blockchain literature by providing empirical evidence on the impact of blockchain investments from an auditor's perspective. There are few empirical studies on blockchain's application, and they primarily focus on the stock market effects of corporate blockchain-related announcements (Cheng et al., 2019; Autore et al., 2021). Our study makes a unique contribution by investigating the impact of blockchain investments on auditors, a crucial group of market participants.

Our findings also have important implications for various stakeholders. Specifically, a positive association between blockchain investments and audit fees implies that standard setters should develop detailed guidance for the audit of clients that have made blockchain investments and/or have adopted this technology. Strict requirements on disclosures of blockchain investment and adoption by client companies should also be put in place to reduce audit risk and effort. As IT experience can mitigate the increase in audit fees caused by blockchain investments, auditors need to acquire specialized knowledge and undergo continuous training to effectively assess blockchain-related risks and integrate them into audit processes. Guided by these findings, corporate executives can align budgets with potential audit cost increases, while financial analysts may need to classify companies by their level of blockchain involvement (interested, invested, or fully adopted) to provide more accurate financial assessments and forecasts. Likewise, investors need to understand the risks and costs associated with this technology and must balance them with the blockchain's potential benefits.

The remainder of the paper is organized into six sections. In Section 2, we discuss the China's institutional background, and then review the literature on blockchain implementation and its impact on auditing profession in Section 3. In Section 4, we develop the research hypotheses while Section 5 explains the research methodology. We report the results of the main and supplementary tests in Section 6. Section 7 concludes the paper by outlining the study's key findings and their implications, as well as its limitations, before offering suggestions for future research in this domain.

2. Institutional background

2.1. Blockchain technology in China

The Chinese blockchain technology sector has developed rapidly in recent years, largely due to the significant government support (Xu & Guan, 2022). Key government initiatives in this domain include the establishment of the Blockchain-Based Service Network (BSN) in 2020, aimed at providing a standardized and robust infrastructure for blockchain applications across industries (Sigley & Powell, 2023). The 13th Five-Year Plan and the "China Standards 2035" initiative further underscore the strategic importance of blockchain technology for national development (Xu & Guan, 2022). This strategy is also reflected in the large number of blockchain patents granted to Chinese inventors (Clarke et al., 2020).

China's regulatory framework is another vital aspect shaping the development and application of blockchain technology, particularly in financial services and auditing (Liu et al., 2022). The Ministry of Industry and Information Technology (MIIT) and the Cyberspace Administration of China (CAC) have been instrumental in formulating policies to foster blockchain innovation while ensuring strict regulatory oversight. The government has also issued several guidelines to standardize blockchain applications, reflecting its commitment to position China as a global leader in this technology (China Daily, 2021).

This strategic plan is already yielding results, given that blockchain technology is being utilized in diverse domains of Chinese economy (Zheng et al., 2022). For instance, in the financial sector, blockchain adoption in cross border payments, trade finance, and digital currencies is enhancing the efficiency and security of transactions (Guo & Liang, 2016). In supply chain management, blockchain is being used to enhance transparency and traceability, ensuring the authenticity of products and reducing fraud. Companies like Alibaba and JD.com are relying on blockchain solutions to track the origin and movement of goods, thereby improving consumer trust and operational efficiency (Wang et al., 2019). In public services, blockchain applications are improving data management and service delivery. Blockchain technology is also revolutionizing the energy sector as it facilitates peer to peer energy trading, thereby improving the efficiency of renewable energy integration into the grid and helping China achieve its sustainability and energy efficiency goals (Hou et al., 2020). Overall, the rapid development and diverse applications of blockchain technology in China, supported by a robust regulatory framework, demonstrate the country's commitment to leveraging this technology for economic and social advancement.

2.2. Audit market overview and influence of technology on auditing

The market for independent auditing in China has evolved significantly since the 1980 s, driven by economic reforms and increasing foreign investments (Xiao et al., 2000). Major auditing firms operate under the Chinese Accounting Standards (CAS) and Auditing Standards for CPAs of China, which align with international norms such as International Financial Reporting Standards (IFRS) and International Standards on Auditing (ISA), although they are tailored to the local context (Chen et al., 2023). Since 2001, Chinese listed companies have been mandated to disclose their audit fees in annual reports (Simunic & Wu, 2009), enabling empirical investigations into the factors influencing these fees. Generally, audit fees in China are influenced by audit input, risk premiums, market competition, and the reputation of auditors (Wu & Xiao, 2021).

Technological advancements, particularly blockchain, are transforming auditing practices in China (Zhang et al., 2022). Blockchain enhances transparency, reduces fraud, and streamlines audit processes, posing both opportunities and challenges for auditors. As blockchain is rapidly changing how financial information is communicated to users and how assurance is provided on that information, the audit industry is increasingly being disrupted by the digital revolution, particularly blockchain technology (Yermack, 2017). However, so far, few studies have explored the impact of this technology on audit risks and audit fees.

3. Literature review

3.1. Blockchain technology

While the benefits and drawbacks of blockchain technology have been extensively discussed in pertinent literature (Han et al., 2023), research in this domain remains largely conceptual and descriptive (Risius & Spohrer, 2017; Alkhudary et al., 2020). Nonetheless, the obtained findings indicate that blockchain technology can be leveraged to enhance business processes and reduce firm risk through improved trust, transparency, and efficiency (Wang et al., 2019; Farouk et al., 2020). Smart contracts, for instance, streamline operations by eliminating redundancy and reducing error rates. Still, due to its developmental and complex nature, organizations attempting blockchain implementation face multiple risks stemming from the technical, organizational, and legal requirements, as well as the high cost of adoption and inherent uncertainties (Toufaily et al., 2021).

Yet, recent quantitative research has primarily focused on how companies' blockchain announcements affect the stock market, thus overlooking the impact on other market participants. Notably, Cheng et al. (2019) explored the effects of firms' 8-K disclosures concerning blockchain, cryptocurrency, or Bitcoin on the US stock market, revealing an immediate positive investor response that gradually reverses within a month. Cahill et al. (2020) similarly observed a substantial positive investor reaction upon firms' disclosure of blockchain investments, accompanied by unexpected responses to Bitcoin performance. Autore et al. (2021) also revealed significant, short term stock price reactions to blockchain related disclosures on the US stock market. More recently, Liu et al. (2022) found that blockchain investment/adoption announcements generate a significantly positive market response on the release day, with technical innovation and strategic-level announcements experiencing a more positive reaction compared to those related to non-technical innovation. As a part of their investigation, Klöckner et al. (2022) analyzed 175 firm announcements spanning the 2015–2019 period to assess the impact of blockchain initiatives on market value, revealing a significant average abnormal return of 0.30 % on the announcement day and indicating positive long term effects. Contrary to prior research which focused on market reactions, our study uniquely considers the implications of blockchain investment on the audit process and the associated fees.

3.2. Financial statement auditing and audit fees

In extant auditing literature, agency theory is typically adopted to justify the necessity of external audit services (DeAngelo, 1981), given that the separation of ownership and management can lead to managerial opportunism and significant agency issues (Fama & Jensen, 1983). Consequently, contractual arrangements are vital to ensure that the management acts in the stakeholders' best interests, with paid external auditors providing essential independent oversight (Jensen & Meckling, 1979).

The audit pricing literature, long renowned for its emphasis on transparency in audit pricing benefiting both providers and users of audit services, can be traced back to Simunic's (1980) seminal audit fee model, which delineated audit fees into two essential components: audit effort and the anticipated loss from litigation. This model has since been further refined by incorporating diverse audit fee determinants, such as client size, complexity, and risk (Xue & O'Sullivan, 2023). Notably, additional risk factors, such as accrual based and real earnings management (Choi et al., 2022), internal control deficiencies (Bae et al., 2021), business risk (Ranasinghe et al., 2023), and management characteristics (Oradi, 2021), typically feature in the modern pricing models.

Researchers have also extended their focus to exploring the intricate relationship among firms' IT adoption, audit risk, and audit fees, highlighting the contrasting nature of these associations. For example, Chen et al. (2014) established that by strengthening internal controls, firms' robust IT capabilities reduce audit fees. Likewise, Johnston and Zhang (2018) found that IT can be harnessed to improve the efficiency of the production and audit of financial reports. More recently, Fedyk et al. (2022) reported that artificial intelligence (AI) contributes to improved audit quality while reducing audit fees. In contrast, Han et al. (2016) found that clients' traditional IT investments positively correlate with audit fees, abnormal audit fees, the probability of auditors issuing a going concern opinion, and the likelihood of auditors' Type II errors. These assertions are supported by Banker et al. (2020), whose findings indicate that cloud computing users bear an audit fee premium of approximately 5 % compared to non-users. However, despite the growing body of literature on the interplay between firms' IT use and audit fees, the potential influence of emerging technologies, particularly blockchain, on audit fees remains largely unexplored, as pointed out by Risius and Spohrer (2017). This critical gap serves as the impetus for the current study focusing specifically on the potential associations between blockchain investments and audit fees.

In summary, while existing studies focus on blockchain's potential and challenges, empirical research on its impact on accounting, auditing process, and fees remains limited. Although the impact of blockchain on stock markets is the subject of several empirical studies, its effects on other market participants are usually neglected. This literature gap motivated us to empirically investigate the audit implications of blockchain investments. Our study is both timely and relevant, given the evolving landscape of blockchain technology and its potential impact on audit practices.

4. Hypotheses development

It can be argued that blockchain technology may have both positive and negative impacts on audit fees. The beneficial role of blockchain is supported by the agency theory and the prevalent view that its adoption has the potential to revolutionize the financial system and improve the efficiency and effectiveness of financial reporting and auditing (Pimentel & Boulianne, 2020). First, the automation of tasks involved in evidence collection and verification and the secure and transparent nature of blockchain ledgers facilitate efficient recording and auditing processes, enabling auditors to save monitoring costs (Rozario & Thomas, 2019). Second, the immutability of on-chain data ensures the reliability of accounting information, minimizes reconciliations, and deters tampering, which results in more effective monitoring processes and lowers the cost of external audits (Pimentel & Boulianne, 2020). Thus, blockchain has the capacity to enhance the audit process and decrease the audit fees.

However, due to the complexity of blockchain technology, its deployment poses challenges and risks for clients and auditors, which is reflected in higher audit fees. First, auditors' lack of familiarity with on-chain transaction review and asset verification processes, along with the multidisciplinary nature of this novel technology, hinders effective risk assessment and client scrutiny (Swan, 2017; Pimentel et al., 2021). Second, as blockchain investments carry substantial costs and uncertainties, auditors need to grasp these risks to plan audits effectively and assess the likelihood of material misstatements (Johnstone, 2000). Auditors also need to account for the technical challenges related to blockchain adoption, given that very few projects move beyond the pilot phase despite significant investments (Stratopoulos et al., 2022). Consequently, auditors may increase audit effort or charge a risk premium to account for potential losses stemming from heightened business risk associated with blockchain investments. Third, automated controls enabled by emerging technologies like blockchain increase system complexity and vulnerability (Banker et al., 2020). Finally, the lack of relevant official auditing and compliance guidance from standard setters dealing with emerging issues related to blockchain also imposes a major challenge for auditors and clients (Vincent & Wilkins, 2020).

Therefore, based on the above reasoning, we expect to observe a positive association between blockchain investment and audit fees and hypothesize the following:

Hypothesis 1: Blockchain investment is positively associated with audit fees.

As previously outlined, our study focuses on firms that have made blockchain investments, with and without adoption. While firms that have already adopted blockchain may experience reduced monitoring costs associated with audit fees, auditors may also perceive them as riskier, given the early stages of blockchain application. Considering the potential contrasting implications of blockchain adoption on the associated risks, we formulate the following related null hypothesis:

Hypothesis 2: The positive association between blockchain investment and audit fees is unaffected by the firms' level of involvement in this technology (adoption vs. investment).

5. Data and research design

5.1. Data and sample

Blockchain investment data recording on the CNRDS platform began in 2015 and ended in early 2020. Thus, our sample consists of firms that listed on the Shanghai and Shenzhen stock exchanges during the 2015–2019 period. After excluding financial firms and firm year observations with missing data related to control variables, we formed an initial sample of 3,405 firms and 13,259 firm year observations. Blockchain investment data, blockchain related news data, and investor inquiry data were retrieved from the Blockchain Investment Database of Listed Companies which is included in the CNRDS platform, allowing us to distinguish firms with real blockchain investments from those showing only an interest in blockchain technology. Furthermore, by reading 654 blockchain related disclosures provided by the CNRDS, we were able to manually separate the blockchain investment sample (*BC_Investment*) into two subgroups: the adoption subgroup (*BC_Adopter*) and the non-adoption subgroup (*BC_Non-Adopter*). The 654 blockchain-related disclosures included regulated financial reports and filings, management forecasts, earnings conference calls, and both mandatory and voluntary press releases. Bitcoin price information was sourced from INVESTING (https://www.investing.com/). Data related to audit fees, analyst following, and the remaining firm's financial data were obtained from the China Stock Market & Accounting Research (CSMAR) database. To mitigate the effect of outliers, we winsorized all continuous variables at 1 % and 99 % level. The winsorization was performed for all our empirical tests.

5.2. Variable measurement

5.2.1. Dependent variable – audit fees

Following the strategy adopted by Hay et al. (2006) and Banker et al. (2020), we use the natural logarithm of audit fees (*LnAudFees*) as a measure of audit fees.

5.2.2. Independent variable – blockchain investment

In our model, *BC_Investment* is a dummy variable coded one for firms that have invested in and/or adopted blockchain, and 0 otherwise. We code *BC_Non-Adopter* as one if a firm has invested but has not adopted blockchain and zero otherwise, and we code *BC_Adopter* as one if a firm has already adopted blockchain and zero otherwise. These two additional variables enable us to gain a dynamic perspective on the impact of blockchain investments on audit fees from the investment to the adoption stage. For a robustness check, we also add a control variable (*BC_Interest*) to distinguish the firms that have actually invested in and/or adopted blockchain from those that have merely expressed an interest in this technology, since this difference might influence audit fees (Banker et al., 2020). Accordingly, we code *BC_Interest* as one if a firm has mentioned "blockchain(s)" in corporate disclosures without having made a blockchain investment or having adopted the technology and zero otherwise.

5.2.3. Control variables

We follow the approach adopted in prior literature on audit fees and include control variables in three categories: client size, risk, and complexity (Han et al., 2016; Banker et al., 2020). Client size is measured as the natural logarithm of total assets (*Size*). Client risk is controlled for via the client's current ratio (*Current*), ratio of receivables and inventory to total assets (*RECINV*), return on assets (*ROA*), a loss indicator (*Loss*), market-to-book ratio (*MTB*) and operating leverage (*Leverage*). Our regression model incorporates other indicators of risk, such as the presence of a modified audit opinion (*Opinion*) or a material weakness opinion (*ICW*) (Banker et al., 2020). Client complexity is controlled for by capturing the presence of foreign Segments (*Foreign*), the number of business segments (*Segment*), ratio of intangible assete to total assets (*Intangible*), firm age (*FirmAge*) and the information on client growth (*SalesGrowth*), and new securities issuance (*Issue*). We also control for state ownership (*SOE*) since it has been shown to influence audit pricing in China (Wu & Ye, 2020). We further control for financial reporting quality, which is measured as the absolute value of discretionary accruals (*DACC*), as it has been shown to impact on audit pricing (Han et al., 2016). Finally, we control for auditor characteristics that could affect audit fees, namely auditor switching (*Initial*), auditor tenure (*Tenure*), auditor size (*Big4*), and whether the auditor is an industry specialist (*Specialist*).

5.3. Regression model

To test H1 and H2, we estimate the following model:

$$LnAudFees_{i,t} = \alpha + \beta' BI_{i,t} + \gamma' X_{i,t} + \sum Industry_k + \sum Year_t + \varepsilon_{i,t} \quad (1)$$

where *BI* indicates a vector of different measures of the client's blockchain investment in year *t*, including *BC_Investment*, *BC_Non-Adopter*, and *BC_Adopter*. In line with the strategy adopted by other authors (e.g., Han et al., 2016; Banker et al., 2020), year and industry fixed effects are incorporated in all empirical models to control for unobserved heterogeneity across industries and years that may affect audit fees.

6. Results

6.1. Descriptive statistics

Table 1 provides the descriptive statistics for the variables used in our analyses. Consistent with the results reported in the prior literature (Cahan et al., 2015), the mean value of the natural logarithm of audit fees (*LnAudFees*) is 13.916, which is equivalent to an average of RMB1,105,711.98.[2] The mean value of blockchain investments (*BC_Investment*) is 0.037, indicating that 3.7 % of our firm year observations pertain to blockchain technology. When classifying blockchain investment by type, we observe that the mean value of firms that have made blockchain investments without adoption (*BC_Non-Adopter*) is approximately twice that of the group that has proceeded to blockchain adoption (*BC_Adopter*). Approximately 22.5 % of the firm-year observations feature corporate disclosures that refer to interest in blockchain without investment in this technology. In just over 54 % of the firm-year observations, audits were performed by audit firms that have at least two IT clients, and the average audit firm tenure is 5.61 years.

The pairwise correlations between variables reported in Table 2 show that audit fees are positively related to the aforementioned blockchain investment measures, providing intuitive support for H1. In addition, compared with the *BC_Non-Adopter* group, the investment measures pertaining to the *BC_Adopter* group are more strongly correlated with *LnAudFees*. The value of variance inflation factors (VIFs) is below 10, suggesting that multicollinearity is not a serious concern.

6.2. Regression results

6.2.1. Tests for blockchain investments and audit fees (H1 and H2)

In Panel A of Table 3, we present the regression results obtained by testing H1 and H2. Column (1) includes the *BC_Investment* and industry/year fixed effects, while Column (2) includes other control variables. As Column (1) shows, the coefficient of *BC_Investment* is significantly positive, indicating that blockchain investments increase audit fees. In Column (2), the coefficient of *BC_Investment* is 0.073 at a significance level of 1 %, indicating that firms that have made blockchain investments pay a 7.6 % (=e0.073 − 1) premium on audit fees relative to firms that have not made such investments. For an average firm with blockchain investment, this equates to an increase in audit fees of RMB84,034.11 (7.6 % × RMB1,105,711.98) when compared with firms

[2] All currency values are presented in Renminbi (RMB), and the exchange rate used for conversion is based on the approximate average rate of 6.6 RMB to 1 USD for the 2015–2019 sample period, providing international readers with a contextual understanding of the figures.

Table 1
Summary Statistics.

	N	Mean	Std. Dev.	p25	Median	p75
Dependent Variables						
LnAudFees	13,259	13.916	0.691	13.459	13.816	14.254
Test Variables						
BC_Investment	13,259	0.037	0.189	0	0	0
BC_Non-Adopter	13,259	0.025	0.158	0	0	0
BC_Adopter	13,259	0.012	0.106	0	0	0
BC_News	13,259	0.012	0.107	0	0	0
BC_Inquiry	13,259	0.139	0.346	0	0	0
Bitcoin_corr	13,259	0.061	0.544	−0.463	0.094	0.593
IT_Clients	13,259	0.541	0.498	0	1	1
Tenure	13,259	1.749	0.858	1.386	1.946	2.303
Control Variables						
Size	13,259	22.337	1.320	21.429	22.177	23.061
Leverage	13,259	0.429	0.207	0.267	0.418	0.577
ROA	13,259	0.029	0.096	0.013	0.034	0.063
Loss	13,259	0.109	0.312	0	0	0
MTB	13,259	0.613	0.258	0.415	0.607	0.807
SalesGrowth	13,259	0.187	0.488	−0.020	0.104	0.267
RECINV	13,259	0.267	0.164	0.143	0.248	0.365
Current	13,259	0.215	0.241	0.060	0.217	0.378
Intangible	13,259	0.048	0.061	0.017	0.034	0.057
Opinion	13,259	0.039	0.193	0	0	0
ICW	13,259	0.012	0.111	0	0	0
DACC	13,259	0.063	0.082	0.018	0.040	0.076
Foreign	13,259	0.017	0.130	0	0	0
Segment	13,259	6.144	3.079	4	6	7
Issue	13,259	0.102	0.303	0	0	0
FirmAge	13,259	2.218	0.766	0.693	2.302	3.135
SOE	13,259	0.342	0.475	0	0	1
Big4	13,259	0.055	0.228	0	0	0
Specialist	13,259	0.072	0.054	0.023	0.061	0.116
Tenure	13,259	1.749	0.858	1.386	1.946	2.303
Initial	13,259	0.104	0.305	0	0	0
Supplemental variables						
BC_Interest	13,259	0.016	0.127	0	0	0
Restatement	13,259	0.225	0.418	0	0	0
LnAudLag	13,259	4.587	0.216	4.466	4.663	4.736
BC_treat	13,259	0.110	0.313	0	0	0
Digital	13,258	1.003	1.139	0	0.693	1.792
Research	11,383	0.023	0.024	0.009	0.019	0.029
BoardSize	13,059	2.117	0.200	1.946	2.197	2.197
BoardIndep	13,059	0.377	0.056	0.333	0.364	0.429
Top1	13,061	0.341	0.145	0.229	0.319	0.435
Dual	13,061	0.282	0.450	0	0	1
INST	13,061	0.396	0.234	0.204	0.403	0.573

Notes: See Appendix for variable definitions.

Table 2
Correlation Matrix.

		(1)	(2)	(3)	(4)
(1)	LnAudFees	1			
(2)	BC_Investment	0.07***	1		
(3)	BC_Non-Adopter	0.03***	0.82***	1	
(4)	BC_Adopter	0.08***	0.56***	−0.02**	1

Notes: Table 2 reports Pearson correlations for the key dependent and independent variables used in our analyses. Statistical significance is indicated by ***, **, and * for 1%, 5%, and 10%, respectively.

Table 3
Audit fees and blockchain investment.

Panel A: Regression Results

Variables	(1) **LnAudFees**	(2) **LnAudFees**	(3) **LnAudFees**	(4) **LnAudFees**	(5) **LnAudFees**	(6) **LnAudFees**
BC_Investment	0.200***	0.073***	0.069***	0.074***		
	(4.63)	(2.90)	(2.82)	(2.96)		
BC_Non-Adopter					0.049*	
					(1.75)	
BC_Adopter					0.166***	0.088*
					(3.08)	(1.76)
BC_Interest				0.037	0.036	
				(1.03)	(1.00)	
Size		0.381***	0.382***	0.381***	0.380***	0.384***
		(39.48)	(40.16)	(39.49)	(39.54)	(13.37)
Leverage		−0.001	0.014	−0.001	−0.001	−0.189
		(−0.02)	(0.22)	(−0.02)	(−0.02)	(−0.79)
ROA		−0.374***	−0.386***	−0.372***	−0.371***	−0.484*
		(−5.87)	(−6.05)	(−5.84)	(−5.79)	(−1.93)
Loss		0.055***	0.057***	0.055***	0.055***	−0.016
		(3.54)	(3.73)	(3.54)	(3.51)	(−0.23)
MTB		−0.177***	−0.174***	−0.176***	−0.174***	−0.229*
		(−4.69)	(−4.73)	(−4.68)	(−4.63)	(−1.76)
SalesGrowth		0.028***	0.028***	0.028***	0.028***	−0.041
		(3.06)	(3.17)	(3.07)	(3.09)	(−0.94)
RECINV		0.123**	0.124**	0.124**	0.125**	0.295
		(2.23)	(2.30)	(2.24)	(2.27)	(1.35)
Current		−0.103**	−0.106**	−0.103**	−0.104**	−0.216
		(−2.22)	(−2.33)	(−2.22)	(−2.25)	(−1.26)
Intangible		0.223**	0.254**	0.224**	0.222**	−0.570
		(1.99)	(2.33)	(2.00)	(1.99)	(−1.19)
Opinion		0.087***	0.080***	0.087***	0.086***	0.214*
		(3.19)	(2.98)	(3.17)	(3.15)	(1.85)
ICW		0.093**	0.107***	0.093**	0.094**	0.015
		(2.32)	(2.70)	(2.31)	(2.34)	(0.07)
DACC		−0.031	−0.037	−0.031	−0.030	−0.172
		(−0.57)	(−0.70)	(−0.57)	(−0.55)	(−0.67)
Foreign		0.465***	0.471***	0.465***	0.465***	0.430
		(6.02)	(6.14)	(6.03)	(6.06)	(1.16)
Segment		0.009***	0.009***	0.009***	0.009***	0.004
		(3.24)	(2.93)	(3.24)	(3.23)	(0.45)
Issue		0.010	0.008	0.009	0.009	−0.083
		(0.85)	(0.69)	(0.83)	(0.83)	(−1.09)
FirmAge		0.038	0.037	0.038	0.038	0.156*
		(1.52)	(1.48)	(1.52)	(1.52)	(1.74)
SOE		−0.083***	−0.067***	−0.083***	−0.082***	−0.043
		(−4.93)	(−4.03)	(−4.92)	(−4.87)	(−0.82)
Big4		0.592***	–	0.593***	0.592***	0.596***
		(14.34)	–	(14.35)	(14.37)	(4.01)
Specialist		0.760***	0.212	0.759***	0.755***	1.280***
		(6.23)	(0.84)	(6.23)	(6.20)	(2.60)
Tenure		0.005***	0.003**	0.005***	0.005***	0.005
		(3.61)	(1.98)	(3.61)	(3.58)	(0.84)
Initial		0.004	−0.002	0.004	0.004	0.098
		(0.32)	(−0.15)	(0.31)	(0.31)	(1.53)
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Audit Firm FE	NO	NO	Yes	NO	NO	NO
Firm Clustering	Yes	Yes	Yes	Yes	Yes	Yes
Observations	13,259	13,259	13,259	13,259	13,259	490
R-squared	0.097	0.664	0.676	0.664	0.664	0.728

Panel B: Wald Test Results

H_0: BC_Non-Adopter − BC_Adopter = 0
F(1, 3404) = 4.00
Prob > F = 0.05

Notes: This table reports the results of regressions estimating the impact of blockchain investments on audit fees. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. Variable definitions are in the Appendix.

that have not made such an investment. In Column (3), even if we include audit firm fixed effects in the baseline model, the coefficient of *BC_Investment* still remains at the 1 % significance level.

To validate our argument that expressing interest in blockchain does not inherently raise the perceived risk, we introduce *BC_Interest* as a control variable in the model. The non-significant coefficients of *BC_Interest* in Column (4) and (5) align with our initial expectations. Consequently, *BC_Interest* is excluded from subsequent analyses. Our results support H1. This is in line with the findings of Stratopoulos et al. (2022), based on their analyses of the US market documenting the early-stage risks associated with blockchain adoption.

The results reported in Column (5) of Table 3 indicate that, while auditors charge increased audit fees for both groups, the fees are higher for firms that have actually adopted blockchain. Specifically, *BC_Non-Adopter* firms and *BC_Adopter* firms pay 5.0 % (RMB55,288.60 on average) and 18.1 % (RMB200,133.87 on average) higher audit fees, respectively, than firms not involved in blockchain investments. The Wald test results reported in Panel B further show that the coefficients of *BC_Non-Adopter* and *BC_Adopter* are significantly different at the 5 % level, supporting the argument that auditors respond differently to the business practices of *BC_Non-Adopter* and *BC_Adopter* firms.

In Column (6) of Table 3, we replace our full sample with that containing only firms that have made a blockchain investment and regress *BC_Adopter* on audit fees, while adopting *BC_Non-Adopter* (rather than *BC_Adopter*) as the benchmark. The obtained values are similar to those reported in Column (5). Thus, our results generally support H2, given that the positive association between blockchain investments and audit fees is more pronounced for firms that have already adopted blockchain. Still, it should be noted that the coefficient of *BC_Adopter* is significant at only the 10 % level, as shown in Column (6).

The results pertaining to the control variables are mostly consistent with those obtained in prior studies on audit fees. Across Columns (2) to (6), the adjusted R-squared ranges from 66 % to 73 %, concurring with the values reported by other authors (Beck & Mauldin, 2014; Doogar et al., 2015).

Overall, the results in Table 3 are consistent with our prediction that clients' blockchain investments are positively associated with audit fees. Moreover, our analysis indicates that blockchain adopters incur higher audit fees than firms that have made blockchain investments without adopting this technology. This finding aligns with the available evidence suggesting that the adoption of emerging technologies, such as cloud computing, often leads to increased audit complexity and risk (Banker et al., 2020). We argue that the higher audit fees incurred by blockchain adopters may be attributed to several factors, including the need for auditors to gain specialized knowledge and expertise in assessing blockchain-related risks, the implementation of additional audit procedures to verify blockchain transactions, and the increased scrutiny of internal controls surrounding blockchain usage. These observations extend the classic audit pricing model proposed by Simunic (1980) by introducing blockchain investments as a novel determinant.

6.2.2. *The moderating effect of auditor IT experience and external attention*

To identify heterogeneities in the effect of blockchain investment on audit fees, we explore two moderating factors: auditor IT experience and external attention. Prior studies demonstrated that audit quality and efficiency increase with auditor experience as the auditor gains a better understanding of the client's systems, business and industry environments, and internal controls (Johnson et al., 2002). To assess whether the effect of blockchain investments on audit fees varies across different levels of auditor experience, we introduce two measures: *Tenure* (the duration of the auditor tenure for a given client) and *IT_Clients* (a dummy variable coded one if the audit firm has at least two clients from the IT industry and zero otherwise). As can be seen from the findings presented in Columns (1) and (2) of Table 4, the interaction terms *BC_Investment*Tenure* and *BC_Investment*IT_Clients* are negative and significant at the 5 % level, suggesting that experienced auditors are adept at conducting blockchain audits efficiently, resulting in lower audit fees despite the greater complexity of the auditing process.

Guided by prior research, we also explore the impact of external attention on audit pricing (Johnson et al., 2002; Wu & Ye, 2020). Because listed firms with blockchain investments tend to attract considerable attention from the public, investors, and the media (Cheng et al., 2019), such external pressure is reflected in auditors' risk assessments and is incorporated in audit fees (Wu & Ye, 2020). Additionally, investors tend to relate Bitcoin performance in the cryptocurrency market with the blockchain development (Cheng et al., 2019). Indeed, Cahill et al. (2020) recently documented a significant increase in the co-movement between firms' stock prices and Bitcoin returns after blockchain-related announcements. Given that the Bitcoin price fluctuated dramatically during our sample period, we expect clients' blockchain investments to increase auditor-assessed risk due to the perceived connection between this technology and the risky and hyped Bitcoin market. For example, the Bitcoin price increased dramatically in 2017, and subsequently crashed in 2018.

To examine the impact of external attention on the association between blockchain investments and audit fees, we consider three measures: *BC_News*, *BC_Inquiry*, and *Bitcoin_corr*. *BC_News* is an indicator coded one if a news article on a listed firm clearly mentions blockchain and zero otherwise. *BC_Inquiry* is an indicator coded one if at least one investor inquiry on the Easy Interaction online platform toward a listed firm clearly mentions blockchain and zero otherwise. Finally, *Bitcoin_corr* denotes the correlation between monthly firms' stock returns and monthly Bitcoin prices.

The results reported in Table 4 reveal significant positive coefficients of the interaction terms *BC_Investment*BC_News* and *BC_Investment*BC_Inquiry* at the 1 % and 5 % levels, respectively, indicating that the

Table 4
Moderating effect of auditor IT experience and external attention.

Panel A: Moderating Effect of Auditor IT Experience

Variables	(1) LnAudFees	(2) LnAudFees
BC_Investment*Tenure	−0.063**	
	(−2.33)	
Tenure	0.038***	
	(3.94)	
BC_Investment*IT_Clients		−0.126**
		(−2.04)
IT_Clients		0.030**
		(2.36)
BC_Investment	0.176***	0.176***
	(3.40)	(2.99)
Control Variables	Yes	Yes
Industry Fixed Effects	Yes	Yes
Year Fixed Effects	Yes	Yes
Firm Clustering	Yes	Yes
Observations	13,259	13,259
R-squared	0.664	0.663

Panel B: Moderating Effect of External Attention

Variables	(1) LnAudFees	(2) LnAudFees	(3) LnAudFees
BC_Investment*BC_News	0.213***		
	(2.84)		
BC_News	−0.093		
	(−1.64)		
BC_Investment*BC_Inquiry		0.080*	
		(1.65)	
BC_Inquiry		0.028**	
		(2.08)	
BC_Investment*Bitcoin_corr			0.054*
			(1.77)
Bitcoin_corr			−0.037***
			(−4.24)
BC_Investment	0.049*	0.113***	0.067***
	(1.86)	(2.93)	(2.67)
Control Variables	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
Firm Clustering	Yes	Yes	Yes
Observations	13,259	13,259	13,259
R-squared	0.664	0.664	0.664

Notes: This table reports the moderating effect of auditor experience and external attention. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. Variable definitions are in the Appendix.

association between blockchain investments and audit fees is more pronounced when firms' blockchain initiatives attract media coverage and investor attention. Additionally, the positive interaction term *BC_Investment*Bitcoin_corr* (significant at the 10 % level) in Column (3) suggests that the link between blockchain investments and audit fees is more prominent during periods of fluctuation in the Bitcoin market.

6.3. Sensitivity tests

6.3.1. Propensity score matching (PSM), entropy balancing, and difference-in-difference (DiD) approaches

To handle the selection bias and strengthen the model design and the potential for causal inferences, we repeat our H1 analysis by using a propensity score matching (PSM) sample, entropy matching sample, and staggered difference-in-difference (DiD) approach. The results of PSM and entropy balancing tests are provided in Panel A and B of Table 5. The differences for all covariates are not statistically significant, suggesting relatively good matching. The results of the DiD regressions with PSM and entropy balancing samples are presented in Panel C. In both columns, the coefficients of *BC_Treat*Post* and BC_Treat_{it} are significant with expected positive signs, providing additional support for the robustness of our results presented in Table 3. Jointly, the evidence based on PSM, entropy balancing, and the staggered DiD method indicates a treatment-specific increase in audit fees after clients invest in blockchain, supporting our previous interpretation of the findings.

6.3.2. Instrumental variable approach

In line with the methodology adopted by Xu and Guan (2023), we employ frequency of words related to digital technology application appearing in the annual report one year before the blockchain investment year (*Digital*) as a proxy for the indicator of a firm's digital technology development willingness and as an instrumental variable to alleviate the endogeneity problem (resulting from omitted variables and reverse causality) inherent in the baseline regression.

As shown in the Appendix, *Digital* is measured by the lagged value of the natural logarithm of the total number of occurrences in annual reports of the terms/entries related to digital technology applications. Firms exhibiting digital transformation willingness (measured by the word counts) may implement similar digital innovation strategies, which leads to a certain degree of correlation between the digital transformation willingness index (*Digital*) and blockchain investments in the next year. On the other hand, digital technology-related word frequency may not directly affect audit fees (and the error term) because this factor alone is not sufficient evidence of a firm's substantial involvement in digital technologies that may affect audit considerations. Thus, we consider that *Digital* is not directly associated with audit fees and the error term. This view is in line with the argument made by Cheng et al. (2019) that the frequency of digital technology-related words in corporate reports expresses only the firms' willingness to pursue digital transformation in the future, rather than being indicative of actual investments. Accordingly, such content should not directly affect audit fees.

In Panel A of Table 6, we report the first- and second-stage regression results and the statistics pertaining to the instrumental variable regression. The Kleibergen–Paap rk LM statistic is significant at the 1 % level, thus, failing to provide support for the null hypothesis that the incorporated instruments have insufficient explanatory power. The Cragg–Donald Wald F-statistic value is 56.80, which is much larger than the critical value of 16.38 at a 10 % significance level of the Stock–Yogo weak instrumental variable identification F test, suggesting that *Digital* is not a weak instrumental variable. The regression results reported in Column (2) of Table 6 further show that the coefficient of instrumented *BC_Investment* is significantly positive at the 1 % level.

6.3.3. System generalized method of moments (GMM) model

Given that there may be serial correlations in audit fees at the firm level (Munsif et al., 2011), we adopt a system generalized method of moments (GMM) model to check the robustness of the causality of the relationship predicted in H1. The test statistics presented in Panel B of Table 6 show that both the AR (2) statistic and the Hansen statistic are greater than 0.1, indicating compliance with the GMM requirements. The estimation results show that, after controlling for the serial correlation characteristics of audit fees, the coefficient of BC_Investment is still significant at the 1 % level, indicating that our conclusions of H1 are robust.

6.3.4. Heckman two-step test

There is also the possibility that a firm's decision to invest in blockchain technology is associated with unobservable characteristics that are also correlated with the unexplained portion of our audit fee model. In this case, endogeneity could cause the resulting coefficients to be estimated inconsistently. To address this concern, we implement the Heckman two-stage approach to estimate the likelihood of a firm investing in blockchain ($BC\_Investment = 1$) using a first-stage model. Next, we include the inverse Mills ratio (Lambda) generated based on this first-stage regression as a control in our second-stage audit fee model. In the first step of the selection equation, in addition to the control variables defined in our baseline model, we also include the lagged firm digital transformation willingness index (*Digital)* and the lagged firm research and development (R&D) investment amount (*Research*) as the explanatory variables. This approach is taken because prior studies in this field found that these factors are positively associated with blockchain investments (Guo et al., 2021; Xu & Guan, 2023). The results reported in Panel C of Table 6 show that the inverse Mills ratio (Lambda) coefficient is significant, and after considering the selection bias, blockchain investment still has a positive effect on audit fees at the 1 % level of significance.

6.3.5. Alternative fixed effects

As a robustness check, we run the baseline regressions with control variables and control for client firm fixed effects (i.e., unobserved and constant client characteristics, such as company culture and registration place). We also extend our standard specification to replace year and industry fixed effects by industry*year interacted fixed effects in order to control for time-varying factors particular to an industry. Standard errors are clustered at the client level. The values reported in Columns (1) and (2) in Panel A of Table 7 indicate that the effects of blockchain investments are unaffected by the inclusion of these fixed effects.

6.3.6. Additional control variables

Following the approach adopted by Oradi (2021), to enhance the robustness of our findings, we incorporate governance and ownership structure controls into our model, including board size (*BoardSize*), board independence (*BoardIndep*), company CEO and board of directors (BoD) chairman dual position (*Dual*), ownership concentration (*Top1*), and institutional ownership (*INST*) (as defined in the Appendix). As can be seen from Panel B of Table 7, the coefficient of blockchain investment remains statistically unchanged across these additional controls. This consistency underscores the reliability and stability of our main findings.

6.3.7. Impact threshold for a confounding variable (ITCV)

In line with the strategy adopted by Busenbark et al. (2022), we conduct ITCV analysis to ascertain the influence of potential unobservable omitted variables. As reported in Panel C of Table 7, at 0.031, Size has the largest impact, indicating that it is the most influential control variable included in the audit fee model. Simunic (1980) and other authors have consistently emphasized the dominant role of client firm size in determining audit fees. According to our analyses, the ITCV for *BC_Investment* is the second largest (0.008) which is greater than the absolute value of the impact factor of all remaining control variables. In other words, the influence of omitted variables would need to exceed

Table 5
PSM, Entropy Balancing, and DID.

Panel A: PSM

Variables	After PSM Treat Mean	Control Mean	Diff.
Size	22.448	22.451	−0.003
Leverage	0.429	0.429	0
ROA	0.020	0.025	−0.005
Loss	0.121	0.112	0.009
MTB	0.573	0.567	0.006
SalesGrowth	0.249	0.230	0.019
RECINV	0.275	0.276	−0.001
Current	0.241	0.242	−0.001
Intangible	0.041	0.041	0
Opinion	0.044	0.045	−0.001
ICW	0.015	0.015	0
DACC	0.075	0.075	0
Foreign	0.012	0.008	0.004
Segment	6.305	6.206	0.099
Issue	0.132	0.142	−0.01
FirmAge	2.906	2.902	0.004
SOE	0.287	0.277	0.01
Big4	0.042	0.046	−0.004
Specialist	0.078	0.078	0
Tenure	7.073	7.148	−0.075
Initial	0.107	0.100	0.007

Panel B: Entropy Balancing

	After Entropy Matching								
	Treat Mean	Control Mean	Diff.	Treat Variance	Control Variance	Diff.	Treat Skewness	Control Skewness	Diff.
Size	22.560	22.560	0.000	1.901	1.901	0.000	0.603	0.603	0.000
Leverage	0.442	0.442	0.000	0.046	0.046	0.000	0.735	0.735	0.000
ROA	0.005	0.005	0.000	0.024	0.024	0.000	−6.009	−6.009	0.000
Loss	0.160	0.160	0.000	0.135	0.135	0.000	1.856	1.851	0.005
MTB	0.639	0.639	0.000	0.065	0.065	0.000	0.065	0.065	0.000
SalesGrowth	0.175	0.175	0.000	0.239	0.239	0.000	3.801	3.801	0.000
RECINV	0.275	0.275	0.000	0.028	0.028	0.000	0.535	0.535	0.000
Current	0.229	0.229	0.000	0.059	0.059	0.000	−0.617	−0.617	0.000
Intangible	0.039	0.039	0.000	0.002	0.002	0.000	5.148	5.148	0.000
Opinion	0.067	0.067	0.000	0.062	0.062	0.000	3.470	3.467	0.003
ICW	0.020	0.020	0.000	0.020	0.020	0.000	6.813	6.808	0.005
DACC	0.075	0.075	0.000	0.007	0.007	0.000	3.272	3.272	0.000
Foreign	0.014	0.014	0.000	0.014	0.014	0.000	8.221	8.214	0.007
Segment	6.777	6.777	0.000	8.401	8.402	−0.001	1.241	1.242	−0.001
Issue	0.067	0.067	0.000	0.062	0.062	0.000	3.470	3.467	0.003
FirmAge	2.939	2.939	0.000	0.080	0.080	0.000	−0.335	−0.334	−0.001
SOE	0.267	0.268	−0.001	0.196	0.196	0.000	1.052	1.049	0.003
Big4	0.045	0.045	0.000	0.043	0.043	0.000	4.416	4.412	0.004
Specialist	0.074	0.074	0.000	0.003	0.003	0.000	0.461	0.461	0.000
Tenure	7.328	7.328	0.000	28.290	28.290	0.000	1.022	1.022	0.000
Initial	0.138	0.138	0.000	0.119	0.119	0.000	2.103	2.099	0.004

Panel C: PSM, Entropy Balancing, and DiD

Variables	PSM+DiD (1) LnAudFees	Entropy Balancing+DiD (2) LnAudFees
BC_Treat_{it}		0.070***
		(2.89)
BC_Treat*Post	0.084**	
	(2.03)	
BC_Treat	0.031	
	(1.10)	
Post	−0.042*	
	(−1.75)	
Control variables	Yes	Yes
Industry Fixed Effects	Yes	Yes
Year Fixed Effects	Yes	Yes
Firm Clustering	Yes	Yes
Observations	2,652	13,259
R-squared	0.693	0.683

Notes: Panel A reports the results of the balance test after PSM. Panel B reports the results of the DiD regression with the PSM sample and entropy balancing sample. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. Variable definitions are in the Appendix.

Table 6
Sensitivity tests.

Panel A: Instrumental Variable Approach

Variables	First Stage (1) BC_Investment	Second Stage (2) LnAudFees
Digital	0.023***	
	(7.54)	
BC_Investment		1.351***
		(4.29)
Control Variables	Yes	Yes
Industry Fixed Effects	Yes	Yes
Year Fixed Effects	Yes	Yes
Firm Clustering	Yes	Yes
Observations	13,258	13,074
Kleibergen–Paap rk LM statistic	50.93***	
Cragg-Donald Wald F statistic	56.80	
Stock-Yogo	[16.38]	

Panel B: System GMM

Variables	(1) LnAudFees
Lag_LnAudFees	0.699***
	(12.34)
BC_Investment	0.035***
	(2.58)
Control Variables	Yes
Year Fixed Effects	Yes
Number of observations	9530
AR(1)	0.000
AR(2)	0.285
Hansen	0.767

Panel C: Heckman' Two-stage Method

	First Step (1) BC_Investment	Second Step (2) LnAudFees
Digital	0.280***	
	(9.27)	
Research	4.323***	
	(4.53)	
BC_Investment		0.210***
		(3.06)
Inverse Mills ratio (Lambda)		−0.082***
		(−2.73)
Control Variables	Yes	Yes
Industry Fixed Effects	Yes	Yes
Year Fixed Effects	Yes	Yes
Firm Clustering	Yes	Yes
Number of observations	11,383	11,383

Notes: This table reports the results of three robustness tests. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. Variable definitions are in the Appendix.

0.008 in order to invalidate the significant association between blockchain investment and audit fees. Based on this result, because we have incorporated in our regression widely acknowledged control variables (evidenced in prior literature to affect audit fees), the ITCV analysis alleviates concerns regarding the potential influence of unobserved omitted variables on our findings, although it does not fully eliminate such possibility.

6.4. *Additional tests*

6.4.1. *Effect of auditor size*

Large audit firms with more resources and greater capabilities may be able to better manage the challenges brought by auditing clients involved in the blockchain sector, leading to a lower probability of audit failure and a greater cost advantage in audit pricing. Accordingly, to determine whether our results are sensitive to auditor size, we next compare the effect of blockchain investments on the audit fees charged by large and small auditors. For this purpose, we partition auditors into two groups, whereby Big 4 firms and Top 10 domestic firms form the subsample of large auditors and the remaining firms are included in the subsample of small auditors. We then repeat the baseline regressions separately for the two subsamples.

Surprisingly, the results presented in Columns (1) and (2) in Panel D of Table 7 and the Chow test result indicate that the positive association between blockchain investments and audit fees holds for both large and small auditor firms, suggesting that clients' blockchain investments remain a significant concern for all auditors due to their inherent uncertainty and complexity. This finding indicates that the high risks of auditing blockchain firms are significant enough to override the impact of auditor size.

6.4.2. *Channel analysis for H1*

We propose that blockchain investments influence audit fees through audit risk and audit effort. To delve deeper into these underlying mechanisms, we conduct channel (mediating) analysis, following the systematic technique and framework suggested by Iacobucci et al. (2007). This strategy entails regressing mediators (*Restatement* and *LnAudLag*) on our independent variable (*BC_Investment*) and subsequently regressing dependent variables (*LnAudFees*) on both the independent variables and the mediators. To ascertain the significance of the mediating effects, we employ the Sobel test (Sobel, 1982).

We follow the approach adopted by Han et al. (2016) and use financial report restatement (*Restatement*) to measure audit risk. In our models, *Restatement* is a dummy variable coded one if the client subsequently restates its year-end financial statements and zero otherwise. Similar to Knechel and Payne (2001) and Ettredge et al. (2006), we use the natural logarithm of the lag days between the date of the auditor's signature and the date of the fiscal year end (*LnAudLag*) to measure audit effort.

The results of the mediating tests are presented in Table 8. The values reported in Column (1) demonstrate that the coefficients of *BC_Investment* are positive and significant at the 1 % level, indicating a positive association between clients' blockchain investments and the likelihood of subsequent financial restatements. In Column (2), the coefficients of *BC_Investment* and *Restatement* are also positive and statistically significant at the 1 % level. The Sobel z statistic and the indirect effect are both significant at the 1 % level, supporting the argument that blockchain investments increase the risk of audit failure and consequently lead to higher audit fees. As shown in Column (3) and (4), similar results are obtained for the mediated paths of audit effort, indicating that blockchain investments trigger a longer delay in audit reporting, and audit effort serves as a channel for blockchain investments to affect audit fees.

7. Conclusion and discussions

This study examined the effect of blockchain investment and adoption on audit fees, given that blockchain is perceived as one of the most promising digital technologies and has often been proclaimed as the greatest innovation since the advent of the internet (Perera et al., 2020). Using a sample of Chinese companies that have made blockchain investments, we provide empirical evidence that such a business decision leads to an increase in audit fees. We further find that, compared with the subgroup of firms that have made blockchain investment without adoption of this technology, the clients that have proceeded to blockchain adoption tend to be charged higher audit fees. Our channel analysis reveals that clients' blockchain investments contribute to higher audit fees by elevating the audit risk and necessitating increased effort from the external auditors. We also find that the impact of blockchain investments on audit fees is attenuated by audit firms' IT

Table 7
Sensitivity and additional robustness tests.

Panel A: Alternative Fixed Effects

	(1) **LnAudFees**	(2) **LnAudFees**
BC_Investment	0.034***	0.069***
	(2.37)	(2.70)
Control Variables	Yes	Yes
Industry*Year Fixed Effects	NO	Yes
Client firm Fixed Effects	Yes	NO
Firm Clustering	Yes	Yes
Number of observations	13,072	13,072
R-squared	0.933	0.665

Panel B: Additional control variables

	(1) **LnAudFees**	(2) **LnAudFees**	(3) **LnAudFees**	(4) **LnAudFees**	(5) **LnAudFees**	(6) **LnAudFees**
BC_Investment	0.069***	0.068***	0.068***	0.069***	0.067***	0.067***
	(2.71)	(2.70)	(2.70)	(2.71)	(2.67)	(2.64)
BoardSize	−0.028					−0.010
	(−0.79)					(−0.22)
BoardIndep		0.115				0.084
		(1.03)				(0.60)
Dual			0.009			0.006
			(0.67)			(0.45)
Top1				−0.013		0.004
				(−0.25)		(0.07)
INST					−0.047	−0.046
					(−1.45)	(−1.37)
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm Clustering	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	13,059	13,059	13,061	13,061	13,061	13,059
R-squared	0.668	0.668	0.668	0.668	0.668	0.668

Panel C: Impact threshold for a confounding variable (ITCV)

	Dep. Var. = LnAudFees	
	(1) **ITCV**	(2) **Impact**
BC_Investment	0.008	
Size		0.031
Leverage		0.000
ROA		0.003
Loss		0.000
MTB		0.000
SalesGrowth		0.000
RECINV		0.000
Current		−0.001
Intangible		−0.001
Opinion		0.000
ICW		0.000
DACC		0.000
Foreign		−0.001
Segment		0.003
Issue		0.000
FirmAge		0.000
SOE		0.004
Big4		−0.007
Specialist		0.001
Tenure		−0.001
Initial		0.000

Panel D: Effect of Auditor Size

Variables	**Large Auditors** (1) **LnAudFees**	**Small Auditors** (2) **LnAudFees**
BC_Investment	0.074**	0.061*
	(2.42)	(1.73)
Control Variables	Yes	Yes
Industry Fixed Effects	Yes	Yes
Audit firm Fixed Effects	Yes	Yes
Year Fixed Effects	Yes	Yes
Firm Clustering	Yes	Yes
Number of observations	7,795	5,458

(*continued on next page*)

Table 7 (*continued*)

Panel D: Effect of Auditor Size		
	Large Auditors	Small Auditors
	(1)	(2)
Variables	**LnAudFees**	**LnAudFees**
R-squared	0.718	0.565
P value (Chow test)	0.673	

Notes: The large auditor subsample includes client firms audited by one of the following audit firms: Deloitte Touche, Ernst and Young, KPMG, PricewaterhouseCoopers, and top 10 domestic auditors ranked by annual revenue. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. Variable definitions are in the Appendix.

Table 8
Channel Analysis results.

	(1)	(2)	(3)	(4)
Variables	**Restatement**	**LnAudFees**	**LnAudLag**	**LnAudFees**
BC_Investment	0.109***	0.069***	0.046***	0.069***
	(4.73)	(2.78)	(3.99)	(2.73)
Restatement		0.038***		
		(3.33)		
LnAudLag				0.102***
				(4.38)
Control Variables	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Firm Clustering	Yes	Yes	Yes	Yes
Number of observations	13,259	13,259	13,259	13,259
R-squared	0.118	0.664	0.122	0.665
Sobel	0.004***		0.005***	
Direct effect (c')	0.069***		0.069***	
Indirect effect (a*b)	0.004***		0.005***	
Total effect (c)	0.074***		0.074***	

Notes: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. Variable definitions are in the Appendix.

experience and that auditors exhibit a stronger propensity to increase audit fees when their clients' blockchain investments attract media coverage, investor inquiries, and interest from the Bitcoin market.

Apart from the significant contributions to the literature discussed in the Introduction, our study also has several important practical implications. Our finding that the blockchain investment by listed firms is associated with higher audit fees provides empirical guidance for auditors and clients in their audit fee determination processes, which should account for the impact of emerging technologies. We also find that auditors' IT experience significantly moderates the impact of blockchain investment on audit fees. This result highlights the necessity for auditors to possess the specialized skills and knowledge needed for understanding the complexities and functions associated with blockchain technology so that they are able to recognize the specific risks associated with the investments and adoption by their clients. Auditors also need to undergo continuous training, allowing them to incorporate the audit risks associated with these technologies into audit processes, including tailored plans, robust testing procedures, and adjusted risk assessments.

Our findings linking blockchain investments to audit fees also suggest the need for auditing standard setters to address the distinctive challenges posed by emerging technologies in their frameworks. In particular, they should provide auditors with specific auditing guidance and client firms with disclosure requirements related to the investment in and adoption of such emerging technologies. These measures would allow auditors to more effectively manage the risks emerging from the new information technologies which would in turn enhance monitoring effectiveness.

Beyond the realm of audit practice, our research holds relevance for other market participants, such as corporate executives, financial analysts, and investors. Executives should consider our results to ensure that their budgets align with potential increases in audit costs and fees. Financial analysts, in particular, should differentiate their evaluations based on a firm's level of engagement with blockchain (e.g., interested in, invested in, or adopted this technology). This nuanced approach allows for more accurate forecasts and recommendations. Our results are also beneficial for investors as they allow them to make informed investment decisions based on a thorough understanding of the challenges and risks arising from blockchain technology and the corresponding increases in audit costs.

However, when interpreting our results, several limitations need to be considered, which also indicate future research directions. With the increasing adoption of blockchain technology, the nature of its application and the specific industry (e.g., retail, finance, manufacturing, energy, etc.) in which it is implemented will likely affect the impact on audit fees, and such relationships deserve further investigation. Thus, authors of future studies in this domain could explore the long-term effects of blockchain investments on audit practices across different industries and organizational contexts. Additionally, examining the role of specific blockchain applications, along with their benefits and risks, in both clients' operational frameworks and auditor methodologies could offer further insights for auditors and regulators. Likewise, research focusing on the development of auditing standards and guidelines tailored to blockchain-related activities could help address emerging challenges facing the audit profession.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix. . Variable definitions

Variable	Definition
Dependent variables	
LnAudFees	Natural logarithm of total audit fees (in millions of RMB).
Test variables	
BC_Investment	Dummy variable coded 1 if in the firm's corporate disclosure references its investment in and/or adoption of blockchain technology, and 0 otherwise.
BC_Non-Adopter	Dummy variable coded 1 if in the firm's corporate disclosure references its blockchain investment without the actual adoption of blockchain technology, and 0 otherwise.
BC_Adopter	Dummy variable coded 1 if in the firm's corporate disclosure references blockchain technology adoption, and 0 otherwise.
BC_News	Dummy variable coded 1 if a news article on a firm clearly mentions blockchain technology in fiscal year *t*, and 0 otherwise.
BC_Inquiry	Dummy variable coded 1 if an investors' inquiry of a firm clearly mentions blockchain in fiscal year *t*, and 0 otherwise.
Bitcoin_corr	Correlation between firms' monthly stock return and monthly Bitcoin price in fiscal year *t*.
IT_Clients	Dummy variable coded 1 if a client firm is audited by an audit firm with at least two clients from the IT industry in fiscal year *t*, and 0 otherwise.
Tenure	Natural logarithm of the total number of years the auditor has worked with the client in fiscal year *t*.
Control variables	
Size	Natural logarithm of total assets (in millions of RMB) in fiscal year *t*.
Leverage	Total debt divided by total assets in fiscal year *t*.
ROA	Income before extraordinary items divided by average total assets in fiscal year *t*.
Loss	Dummy variable coded 1 if net profit is negative in fiscal year *t*, and 0 otherwise.
MTB	Shareholder's equity divided by market capitalization in fiscal year *t*.
SalesGrowth	Change in total revenue divided by total assets in fiscal year *t*.
RECINV	Total receivables plus total inventory, all scaled by total assets in fiscal year *t*.
Current	Current assets divided by current liabilities in fiscal year *t*.
Intangible	1 minus the ratio of property, plant, and equipment to total assets in fiscal year *t*.
Opinion	Dummy variable coded 1 if a firm receives a modified audit opinion in fiscal year *t*, and 0 otherwise.
ICW	Dummy variable coded 1 if firm (or the firm's auditor) reports an internal control material weakness in fiscal year *t*, and 0 otherwise.
DACC	Absolute value of discretionary accruals in fiscal year *t*, following Richardson et al. (2005) as represented in Dechow et al. (2011).
Foreign	Dummy variable coded 1 if firm has at least one foreign segment in fiscal year *t*, and 0 otherwise.
Segment	Number of business segments of a client firm in fiscal year *t*.
Issue	Dummy variable coded 1 if firm issues new equity in fiscal year *t*, and 0 otherwise.
SOE	Dummy variable coded 1 if a client is a state-owned enterprise (SOE) in fiscal year *t*, and 0 otherwise.
FirmAge	Natural logarithm of the total years since the firm was founded.
Big4	Dummy variable coded 1 if the firm is audited by a Big 4 auditor, and 0 otherwise.
Specialist	Dummy variable coded 1 if auditor has the largest market share (based on client firm size) within an industry, and 0 otherwise.
Tenure	Natural logarithm of the total number of years the auditor has worked with the client in fiscal year *t*.
Initial	Dummy variable coded 1 if the fiscal year *t* is the first year with a new auditor, and 0 otherwise.
Supplemental variables	
BC_Interest	Dummy variable coded 1 if the corporate disclosure of a listed firm simply mentions the word "blockchain(s)" without blockchain investment in fiscal year *t*, and 0 otherwise.
Restatement	Dummy variable coded 1 if the client subsequently restates its year-end financial statement in fiscal year *t* and zero otherwise.
LnAudLag	Natural logarithm of the number of days between the signature date of the opinion and the fiscal year end in fiscal year *t*.
BC_treat	Time-variant indicator variable (used in the DiD model) coded 1 for client firms that invest in blockchain only after the investment-event years, and 0 otherwise.
Digital	Lagged value of the natural logarithm of the total number of occurrences in annual reports of the terms/entries related to digital technology applications, including Mobile Internet, Industrial Internet, Mobile Internet, Internet Medical, E-commerce, Mobile Payment, Third Party Payment, NFC Payment, B2B, B2C, C2B, C2C, O2O, Netlink, Smart Wearing, Smart Agriculture, Smart Transportation, Smart Medical, Smart Customer Service, Smart Home, Smart Investment Advisor, Smart Culture and Tourism, Smart Environmental Protection, Smart Grid, Smart Energy, Smart Marketing, Digital Marketing, Unmanned Retail, Internet Finance, Digital Finance, Fintech, Financial Technology, Quantitative Finance, and Open Banking.
Research	Lagged value of total R&D investments divided by total assets in fiscal year *t*.
BoardSize	Number of board of directors (BoD) members in fiscal year *t*.
BoardIndep	Ratio of independent directors in fiscal year *t*.
Top1	Largest owner's shareholding as a percentage of total shares in fiscal year *t*.
Dual	Dummy variable coded 1 if the CEO also holds the position of the BoD chairman in fiscal year *t*, and 0o otherwise.
INST	Percentage of institutional investors' shareholding in fiscal year *t*.

Data availability

Data will be made available on request.

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