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Returnee CEO and audit fees

Vincent Tawiah [a,*], Hela Borgi [b], Muhammad Usman [c], Francis Osei-Tutu [d]

[a] Dublin City University, Dublin, Ireland
[b] Princess Nourah Bint Abdulrahman University Riyadh, Saudi Arabia
[c] School of Accounting, Nanjing Audit University, Nanjing, China
[d] Paris School of Business, France

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ABSTRACT

We examine the relationship between returnee chief executive officers (CEOs) and audit fees in China using robust econometric modeling with 25,630 firm-year observations between 2008 and 2020. A returnee CEO is a Chinese CEO who has previously worked or studied outside mainland China. Consistent with the supply-side argument that returnees improve governance and reduce audit risk, having a returnee CEO is negatively associated with audit fees. This relationship is not sensitive to the source of foreign experience. Firms with (vs. without) returnee CEOs pay lower audit fees. This effect is particularly pronounced for state-owned enterprises. Poorly governed, highly complex and risky firms benefit most from returnee CEOs in terms of lower audit fees. Our findings are robust across various tests.

1. Introduction

Chief executive officers (CEOs) play a key role in firm outcomes, because their cognitive biases and values influence the process and outcomes of financial reporting (Baatwah et al., 2015; Salehi et al., 2018; Borgi et al., 2021). Prior studies explore how CEO traits, including experience, shape a firm's decisions (Kaur and Singh, 2018; Saidu, 2019; Liu and Jiang, 2020; Quan et al., 2021). The experience and knowledge of the CEO can also affect audit pricing, although these potential effects are less well established. The CEO's experience may indicate the type of internal governance and the level of risk of the firm. CEO attributes may also indicate the financial reporting quality and level of internal control in the firm. Given that audit pricing is a function of risk and effort (Kalelkar and Khan, 2016), CEO experience is likely to influence a firm's audit fees.

* Corresponding author.
E-mail addresses: Vincent.tawiah@dcu.ie (V. Tawiah), haborgi@pnu.edu.sa (H. Borgi), 320335@nau.edu.cn (M. Usman), f.oseitutu@psbedu.paris (F. Osei-Tutu).

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A growing body of research asserts that CEOs' personal characteristics affect audit pricing (Johl et al., 2012; Huang et al., 2014; Kalelkar and Khan, 2016; Judd et al., 2017; Habib et al., 2019; Mitra et al., 2020). Kalelkar and Khan (2016) suggest that CEOs' work experience in accounting- and finance-related roles increases the likelihood that auditors will charge lower fees as auditors' engagement risk decreases. Judd et al. (2017) provide evidence that overconfident CEOs report more aggressively than their non-overconfident counterparts, leading external auditors to charge higher fees to compensate for aggressive reporting. Other factors shown to be related to audit fees include CEO tenure (Mitra et al., 2020), CEO ethnicity (Johl et al., 2012) and CEO gender (Huang et al., 2014). This stream of the literature suggests that external auditors consider CEOs' characteristics when pricing audits (Kalelkar and Khan, 2016). We extend the literature by examining the relationship between returnee CEOs and audit fees.

Building on the emerging literature on CEO characteristics, we are motivated to investigate returnee CEOs for the following reasons. First, in addition to academic and work experience, living abroad confers qualities such as pride and prestige, which CEOs seek to protect. Such qualities are particularly prominent when returnee CEOs have learned from environments perceived to have better systems and higher-quality governance than their home country—in this case, China (Giannetti et al., 2015). The presence of a returnee CEO with exposure to these environments significantly influences internal governance (Wang et al., 2022) and how external actors, such as auditors, view the firm. Consistent with the supply-side perspective on audit pricing, an improvement in internal control leads to a significant change in audit fees due to changes in firm risk. We extend prior studies on CEO work and study experience by exploring whether the source of these experiences matters in audit pricing.

Second, although many firms have an audit committee, Jun Lin et al. (2008) report that in practice, audit committees in Chinese listed firms are rarely involved in appointing auditors or determining audit fees; consequently, investors and stakeholders in China view audit committees as ceremonial (Jun Lin et al., 2008). Based on a survey, Jun Lin et al. (2008) report that audit committees play a relatively small role in monitoring the audit process, including pricing, in China. The responsibility for ensuring high-quality reporting, strengthening internal control and thus reducing audit risk and associated audit fees lies with the CEO, not the audit committee.

Emerging scholarship demonstrates the effects of returnees on firm outcomes (Giannetti et al., 2015; Quan et al., 2021; Khan et al., 2023; Tawiah et al., 2024). Studies indicate that returnee CEOs and directors positively influence firm outcomes because of their exposure to high-quality governance in foreign countries. However, the relationship between returnee CEOs and audit fees is not straightforward, as their exposure to Western business practices and quest to protect their personal reputation could send different signals to external auditors. Therefore, we suggest two competing audit-pricing hypotheses based on the supply and demand sides of audit pricing.

From auditors' perspective (i.e., the supply side), robust internal control environments reduce control risk and in turn lower audit pricing (Hay et al., 2006), indicating a negative association between returnee CEOs and audit pricing. Given their exposure to a governance environment that is perceived to be superior (Giannetti et al., 2015; Zhang et al., 2018; Wen et al., 2020), returnee CEOs face a higher expectation of maintaining high-level financial reporting than do non-returnees (Wen et al., 2020). This is particularly true in China, which highly values Western countries' experience and education (Giannetti et al., 2015).

Returnee CEOs may seek to implement robust internal control systems to maintain an acceptable level of reporting risk and because they have seen such systems implemented or learned about them abroad. Moreover, as the emphasis on strong internal control is perceived to originate in the West, a returnee CEO is likely to insist on implementing a robust internal control system to showcase their rich experience from the West (Wen et al., 2020). In addition, returnee CEOs may manage firms more efficiently, as their foreign experience renders them relatively independent of the local business environment, management personnel and governments (Chen et al., 2021). Therefore, compared with their non-returnee counterparts, returnee CEOs are likely to be better monitors, to more accurately detect extreme reporting risks and to more efficiently maintain an acceptable level of control risk, thereby reducing audit pricing. According to Hu et al. (2022), returnee CEOs may also have higher information quality and lower systematic risk, which reduces the risk of material misstatement and clients' business risk. In other words, having a returnee GEO seems to reduce auditors' engagement risk, with suggests that firms with such CEOs may incur lower audit fees than their counterparts with non-returnee CEOs.

However, from the perspective of directors' reputation (the demand side), Habib et al. (2019) suggest that managers who are concerned about protecting their reputational capital and avoiding sanctions from the labor market for failing to discharge their monitoring responsibilities may ask for higher-quality audit services, thus increasing audit fees (Hay et al., 2006).

Given the preceding competing arguments, we use 25,630 firm-year observations from the 2008–2020 period to examine the relationship between returnee CEOs and audit fees. A returnee CEO is defined as a Chinese CEO who has previously worked or studied outside mainland China. Our results show a negative and significant relationship between returnee CEO and audit fees. This relationship is more pronounced for state-owned enterprises (SOEs) than non-state-owned enterprises (non-SOEs). These results imply that returnee CEOs are significantly associated with low audit fees. Our additional analyses show that poorly governed, risky and highly complex firms benefit most from having a returnee CEO in terms of audit fees. These results suggest that the significant association between returnee CEOs and low audit fees is attributable to the improvement in governance and reduction in risk due to the perceived qualities of returnees. Our results are consistent with the supply-side perspective on audit pricing. As previously stated, due to their exposure to superior governance practices, returnee directors improve firms' internal control environments and performance (Chen et al., 2021), thereby reducing control risk and, in turn, audit fees.

This study contributes to the literature by providing evidence of how returnee CEOs influence audit pricing, a relationship largely ignored by previous studies. We contribute to the growing body of literature (Johl et al., 2012; Hribar et al., 2014; Huang et al., 2014; Kalelkar and Khan, 2016; Habib et al., 2019; Mitra et al., 2020) on the potential effect of CEO experience on audit pricing. We also extend the literature on the effects of returnees on the decisions of firms in emerging economies. We confirm the "brain gain" phenomenon noted by recent research in the context of audit pricing. Our findings have important implications not only for Chinese firms but also for firms in other emerging markets. By appointing returnee CEOs, firms are likely to enjoy lower audit fees, because returnee directors are associated with stronger internal control and governance systems.

Our paper complements and extends prior studies on foreign experience and audit pricing (Li et al., 2021). We also provide new insights into how firms can benefit from returnee directors, thereby diverging from prior research. While Li et al. (2021) and Shan et al. (2023) find that audit committee foreign experience increases audit fees, we document a decrease in audit fees for firms with returnee CEOs. The time and effort required for an audit, which are the key determinants of audit pricing, depend on business risk (Hay et al., 2006; Kalelkar and Khan, 2016), which is a function of how the firm is run. As CEOs are the individuals with the greatest responsibility in firms, their personal characteristics are more relevant than the characteristics of audit committees. Accordingly, as CEOs are responsible for the internal control and preparation of accounts, their foreign experience is a more significant driver of audit fees than the experience of the audit committee. After all, an audit committee is just a subset of the board that meets a few times per year to review operations and make recommendations to the board and CEO. The responsibility for ensuring high-quality reporting, strengthening internal control and thus reducing business risk and the associated audit fees lies with the CEO.

Furthermore, given that the audit committee is just one of many committees of the board and is not involved in the day-to-day running of the firm, its effect on audit pricing is secondary to that of the firm's CEO, who directly influences the firm's reporting system. This is particularly true in China, where audit committees are viewed as ceremonial (Jun Lin et al., 2008). In summary, our analysis of the relationship between returnee CEOs and audit fees indicates a more robust and direct effect of foreign experience on audit fees than reported in prior studies.

The paper is organized as follows. Section 2 presents related literature and hypotheses. Section 3 presents the sample selection, variable measurements and research design. Section 4 reports the main results and the results of robustness checks and additional tests. Section 5 concludes the study and discusses its implications.

2. Literature review and hypothesis development

The price of auditing, as for any professional service, is primarily driven by the client's demand and the supply of services by audit firms (Carcello et al., 2002; Ittonen et al., 2010; Harjoto et al., 2015; Lai et al., 2017). Audit fees increase when a client demands more audit services (requiring greater effort from the audit

firm) or when audit firms need to supply more services because the client's risk is higher (Kalelkar and Khan, 2016). These relationships reflect the demand and supply sides of audit pricing, respectively (Hay et al., 2006).

A returnee CEO, defined as an individual who studied or lived outside their home country before being appointed CEO in their home country, possesses unique qualities and experience that may significantly influence the demand for and supply of auditing and, subsequently, its pricing. While emerging research posits that returnee CEOs/directors have a positive influence on firm outcomes (Giannetti et al., 2015; Usman et al., 2020; Wen et al., 2020; Quan et al., 2021), we argue that their effect on audit pricing may depend on circumstances related to both demand and supply in the audit market.

2.1. Supply-side perspective

On the supply side, audit pricing is based on how the auditor perceives the client's (e.g., the firm's) risk profile. When perceived risk is higher, more resources are required for assurance services, leading to higher audit fees (Hay et al., 2006). The audit literature indicates that firms' level of risk is usually associated with their internal control and governance systems, which are driven by the individuals responsible for managing the firm, particularly the CEO.

A returnee CEO may possess unique qualities that affect audit pricing. Indeed, emerging research suggests that returnee CEOs can improve firm performance and operational efficiency, which decreases business risk (Giannetti et al., 2015; Yuan and Wen, 2018). Reduced business risk often leads to lower audit fees, as external auditors notice less risk and therefore require fewer resources to perform their services (Hogan and Wilkins, 2008; Hoitash et al., 2008).

In addition, according to top management team theory, the backgrounds and experiences of top executives significantly shape their strategic decisions and overall influence on the firm (Hambrick and Mason, 1984). Having acquired educational and professional experience abroad, a returnee CEO often brings diverse and sophisticated perspectives that enhance the firm's strategic capabilities and governance practices. Their international exposure is likely to imbue them with a deep understanding of global best practices in corporate governance, risk management and financial transparency, which can contribute to a stronger internal control environment and higher-quality financial reporting (Daily et al., 2000). This improved internal control environment under the leadership of a returnee CEO reduces the perceived risk associated with the firm. Recognizing the firm's commitment to robust governance and transparent financial practices, driven by the returnee CEO's influence, auditors may perceive a lower risk of financial misstatements and irregularities. This can lead to lower perceived audit risk and in turn reduced audit fees, as auditors require fewer resources to verify the accuracy and reliability of the firm's financial statements (Wen et al., 2020). Additionally, returnee CEOs may improve financial reporting quality (Wen et al., 2020), reducing the likelihood of material misstatements and thus decreasing audit engagement risk (Ghosh and Tang, 2015). As a returnee CEO is likely to improve internal control and reporting systems, auditors may limit the scope of their audit, leading to lower fees.

2.2. Demand-side perspective

The demand-side perspective reflects what the client may expect the audit firm to do or produce. When a client demands more effort from an audit firm, the price of the audit may increase (Hay et al., 2006). The decision to demand more effort from auditors is likely to be driven by the person in charge of the firm's management—in most cases, the CEO.

From the demand perspective, the impact of returnee CEOs on audit fees can be explained by imprinting theory. According to Stinchcombe (1965), imprinting theory posits that organizations are deeply influenced by their conditions and experiences during critical formative periods. These early influences leave a lasting imprint that shape organizational practices, values and structures over time. From this perspective, a returnee CEO brings with them diverse international experiences that can significantly influence the organization. These global experiences exert long-lasting effects on the CEO's leadership style, strategic priorities and risk management approaches (Marquis and Tilcsik, 2013). When a returnee CEO assumes leadership, they are likely to introduce or reinforce practices and values shaped by their international exposure, which can have a profound impact on the auditing practices and costs associated with the firm. One potential impact of a

returnee CEO is the introduction of international best practices in corporate governance and financial reporting. Having been exposed to different regulatory environments and financial standards abroad, returnee CEOs may prioritize stringent internal control, enhanced transparency and rigorous financial oversight. These heightened standards often necessitate more comprehensive audit processes, which can increase audit fees due to the additional time and resources required for thorough examination (Harjoto et al., 2015).

Furthermore, returnee CEOs, influenced by their exposure to international markets with intense stakeholder scrutiny, usually bring a heightened awareness of the importance of credibility and reliability in financial reporting (Giannetti et al., 2015). This awareness can lead to a more meticulous approach to audits, ensuring that financial statements meet high standards for accuracy and compliance. Therefore, the demand for detailed and extensive audit work can drive up audit fees (Pomeroy and Thornton, 2008).

In addition, a CEO can directly influence audit pricing based on the level of audit work they demand. As the key person in a firm, the CEO is responsible for providing investors and other stakeholders with timely and accurate information. Hence, some CEOs may opt for higher-quality audits to avoid liability claims and protect their reputational capital (Carcello et al., 2002). A recent study by Habib et al. (2019) suggests that directors who are more concerned about their reputation and potential sanctions from the labor market may request higher-quality audit services, thus increasing audit fees.

For returnee CEOs, the drive to maintain their value and reputation may lead them to consistently engage in good reporting practices even when there are no Western forms of external monitoring. Consistent with arguments regarding managers' reputational incentives (Abbott et al., 2003), we argue that the incentive to reduce misreporting, even in the absence of Western-style external monitoring, is intrinsic and linked to the desire of managers (in this case, returnee CEOs) to protect their personal reputation. According to Harjoto et al. (2015), most CEOs prefer audit quality to match reporting quality. Similarly, Cao et al. (2012) show that more reputable firms have higher audit fees, as they are willing to pay more for audit services to protect their reputation.

Based on the discussion above, we posit the following competing hypotheses:

H1a: All else being equal, there is a negative association between returnee CEOs and audit fees.

H1b: All else being equal, there is a positive association between returnee CEOs and audit fees.

3. Research methods

3.1. Sample selection

We select our sample from all A-share firms listed on the Shanghai and Shenzhen stock exchanges. After excluding financial institutions and firms with missing data, we obtain a final sample of 25,630 firm-year observations. The sample selection procedure is presented in Table 1. The data cover 13 financial years, beginning in 2008 and ending in 2020. Our sample period ends in 2020 because of the limited availability of relevant data, particularly on returnee CEOs. Table 1 also shows the proportion of the sample firms with returnee CEOs. Consistent with prior studies (Alkebsee et al., 2021; Gull et al., 2021), we extract data on the sample firms from the China Stock Market and Accounting Research database and other sources.

3.2. Estimation modeling

Consistent with the audit fees literature (Huang et al., 2016; Alkebsee et al., 2021), we estimate the relationship between returnee CEOs and audit fees using the following model:

Table 1
Sample selection procedure.

Description	No. of firms
Number of A-share listed firms (as of 2018)	3,554
Less financial firms	–725
Less firms with missing variables	–657
Total number of sampled firms (unbalanced panel data)	2,172

$$AUDIT\_FEE_{it} = \beta_0 + \beta_1 ReturneeCEO_{it} + \beta_n Controls_{it} + \beta_n (Firmeffects)_{it} + \beta_n (Yeareffect)_{it} + \varepsilon_{it} \quad (1)$$

In line with prior studies (Huang et al., 2016; Ji et al., 2018; Alkebsee et al., 2021; Gull et al., 2021; Tawiah, 2021), we employ ordinary least squares (OLS) modeling, controlling for industry and year effects. We perform the Hausman test (Hausman, 1989) to choose the appropriate OLS model.

3.3. Other identification strategies

The OLS approach cannot address most potential endogeneity issues common to corporate governance studies. Hence, consistent with prior studies (Wen and Song, 2017; Usman et al., 2020; Quan et al., 2021), we adopt advanced econometric modeling, namely propensity score matching (PSM), Heckman two-step modeling and the two-step system generalized method of moments (S-GMM) approach, to check the robustness of our results.

3.4. Definitions and measurements of variables

Returnee_CEO is a dummy variable equal to 1 for firms whose CEO is a returnee and 0 otherwise. Consistent with previous studies (Giannetti et al., 2015; Zhang et al., 2018; Usman et al., 2020; Quan et al., 2021), we define a returnee CEO as a Chinese CEO who has previously worked or studied outside mainland China.

The variable *Audit_Fees* is measured as the total audit fees paid to external auditors. Consistent with prior studies (Huang et al., 2016; Nekhili et al., 2020; Gull et al., 2021), we take the natural logarithm of audit fees to mitigate the effect of heterogeneity bias on the results.

Control variables: In line with prior studies, we also control for factors likely to influence audit pricing (Huang et al., 2016; Kalelkar and Khan, 2016; Nekhili et al., 2020; Gull et al., 2021). We control for firm economic characteristics, corporate governance variables and auditor characteristics. According to prior studies, larger firms with greater complexity and risk are likely to pay higher audit fees, because much more time and effort is required to gather sufficient and appropriate information on such firms (Huang et al., 2016; Nekhili et al., 2020). Hence, we control for firm size (*Firm_Size*), complexity (*Complexity*) and risk (*Debt_Ratio*). Similarly, older firms (*Firm_Age*) are likely to be associated with higher audit fees because they may have more advanced structures. Huang et al. (2016) suggest that firms in financial distress are likely to pay high audit fees, and thus we include return on assets (*ROA*) and liquidity (*Current_Ratio*) to control for the firm's financial performance. Consistent with prior studies (Gul et al., 2003; Huang et al., 2016), we include discretionary accruals (*Discretionary_Accruals*) to control for the effect of earnings management on audit fees. Prior studies indicate that discretionary accruals are associated with higher audit fees.

Carcello et al. (2002) report that firms with certain board characteristics, such as an independent board and a large board, demand high audit quality, leading to high fees because of the firms' quest to protect their reputation, capital and shareholder interests. In contrast, female directors are found to strengthen internal control and thus reduce audit risk and the associated audit fees (Alkebsee et al., 2021; Gull et al., 2021). To control for these board characteristics, we include board size (*B_Size*), board independence (*B_Independence*), the proportion of female directors on the board (*B_Female*) and CEO gender (*CEO_Gender*). Given the unique Chinese feature of state dominance in corporate ownership, we also include local and central government ownership in our model. Prior studies indicate that audit fees differ significantly between SOEs and non-SOEs (Alkebsee et al., 2021; Gull et al., 2021).

In our final set of controls, we consider auditor characteristics. Following Huang et al. (2016), we include the Big 4 audit firms (*Big_4*); whether the firm is audited by a specialized audit firm (*Specialized_Audit_Firm*); the type of audit opinion issued (*Type_Audit_Opinion*); whether the firm is audited by a local audit firm (*Local_Audit_Firm*); whether the firm switched auditors during the sample period (*Auditor_Switch*); and non-audit fees (*Non-audit_Fees*). Big 4 and specialized audit firms are found to charge high audit fees, while local audit firms are associated with low audit fees. Detailed descriptions of the variables can be found in Table 2.

Table 2
Definitions and measurements of variables.

Variable	Description
1. *Audit_Fees*	The natural log of total audit fees.
2. *Returnee_CEO*	A dummy variable that equals 1 if the firm's CEO has foreign experience (study or work) and 0 otherwise.
3. *Returnee_CEO_Education*	A dummy variable that equals 1 if the firm's CEO has foreign educational experience and 0 otherwise.
4. *Returnee_CEO_Work*	A dummy variable that equals 1 if the firm's CEO has foreign work experience and 0 otherwise.
5. *British_Colony*	A dummy variable that equals 1 if a firm's headquarters are located in a province that had a concession or leased territory established by Great Britain during the late Qing dynasty and 0 otherwise.
6. *B_Size*	The number of members of the board of directors.
7. *B_Independence*	The proportion of independent directors on the board.
8. *B_Female*	The proportion of female directors on the board.
9. *CEO_Gender*	A dummy variable that equals 1 if the firm's CEO is female and 0 otherwise.
10. *SOE*	A dummy variable that equals 1 if the firm's ultimate owner is the local or central government and 0 otherwise.
11. *ROA*	Net profit divided by total assets.
12. *Firm_Size*	The log of total assets.
13. *Firm_Age*	The log of the number of years for which the firm has been listed on the stock exchange.
14. *Debt_Ratio*	Total debt divided by total assets.
15. *Complexity*	The sum of accounts receivable and inventory divided by total assets.
16. *Current_Ratio*	The ratio of current assets to current liabilities.
17. *Discretionary_Accruals*	The residual from the modified Jones model, adjusted by controlling for operating performance (ROA).
18. *Big_4*	A dummy variable that equals 1 if the firm is audited by Big 4 audit firms and 0 otherwise.
19. *Type_Audit_Opinion*	A dummy variable with a value of 1 for a modified audit opinion and 0 otherwise.
20. *Audit_Firm_Tenure*	The number of years for which a firm has been audited by a particular audit firm.
21. *Auditor_Switch*	A dummy variable equal to 1 if the firm switched auditors during the sample period.
22. *Non-audit_Fees*	The natural log of total non-audit fees.
23. *Specialized_Audit_Firm*	A dummy variable equal to 1 if the firm is audited by a specialized audit firm and 0 otherwise.
24. *Local_Audit_Firm*	A dummy variable equal to 1 if the firm is audited by a local audit firm and 0 otherwise.

Note: All continuous variables are winsorized at the 1% and 99% levels, respectively.

4. Results and discussion

4.1. Summary statistics and correlations

Table 3 presents descriptive statistics for and the results of univariate analysis of firms with and without returnee CEOs. Columns 1 and 2 provide the mean values and standard deviations, respectively, for the full sample. The mean of *Returnee_CEO* is 0.069, indicating that 6.9 % of the sample firms had returnee CEOs during the sample period. While this number appears small, the year-wise sample distribution shows that the number of returnee CEOs increased during the sample period. As of 2020, 10.3 % of the sample firms had returnee CEOs, compared with 3.9 % in 2008. The mean audit fee is 1.58 million yuan, with a high standard deviation (4.3 million), indicating significant variation in audit fees among the sample firms.

The univariate comparison of firms with and without returnee CEOs is presented in columns 3 to 5. The mean audit fee for firms without returnee CEOs is 1.9 million yuan, compared with 1.3 million yuan for firms with returnee CEOs. The T-test results in column 5 confirm the significant difference between firms with and without returnee CEOs. We find that firms with returnee CEOs pay approximately 0.6 million yuan less in audit fees than do firms without returnee CEOs.

The correlation matrix between the variables is presented in Table 4. The correlation between the independent variables is within the acceptable limits, suggesting that all the variables are sufficiently independent of each other; hence, there is no threat of multi-collinearity (Tabachnick and Fidell, 2013). For brevity, we do not present the results for all of the variables.

Table 3
Descriptive statistics and mean difference test.

Variable	Descriptive statistics for full sample		Univariate analysis of firms with and without returnee CEOs		
			Firms without returnee CEOs	Firms with returnee CEOs	Mean difference test
	Column 1	Column 2	Column 3	Column 4	Column 5
	Mean	Standard deviation	Mean	Mean	T-value
Audit_Fees	1.583	4.314	1.916	1.341	(6.24)***
Returnee_CEO	0.069	0.461	–	–	–
B_Size	10.413	2.318	10.149	10.232	(1.191)
B_Independence	0.419	0.093	0.372	0.399	(1.68)*
B_Female	0.129	0.376	0.126	0.1271	(1.27)
CEO_Gender	0.078	0.484	0.069	0.680	(0.795)
SOE	0.403	0.583	0.287	0.382	(3.361)***
ROA	0.047	0.178	0.044	0.052	(1.93)*
Firm_Size	26.223	3.042	24.164	25.528	(1.210)
Firm_Age	8.301	3.209	8.657	8.104	(1.60)
Debt_Ratio	0.479	0.228	0.481	0.465	(1.04)
Complexity	0.287	0.109	0.279	0.281	(0.91)
Current_Ratio	0.062	0.072	0.071	0.061	(1.30)
Discretionary_Accruals	0.085	0.078	0.082	0.065	(2.05)**
Big_4	0.069	0.236	0.066	0.068	(0.97)
Type_Audit_Opinion	0.003	4.312	0.003	0.003	(0.03)
Audit_Firm_Tenure	5.32	3.321	5.17	5.09	(1.61)
Auditor_Switch	0.108	2.356	0.098	0.102	(1.57)
Non-audit_Fees	1.023	5.871	1.031	1.123	(2.03)**
Specialized_Audit_Firm	0.085	8.113	0.081	0.092	(1.83)**
Local_Audit_Firm	0.416	0.531	0.409	0.408	(1.53)

Note: All variables are as defined in Table 2. Average audit fees are given in millions of yuan.
*, ** and *** represent significance at the 0.1, 0.05 and 0.01 levels, respectively.

4.2. Main results

The baseline regression results are presented in column 1 of Table 5. The coefficient of *Returnee_CEO* is negative at a high significance level of 1 %, suggesting that the presence of a returnee CEO has an inverse relationship with audit fees. The results indicate that, on average, firms with returnee CEOs are likely to pay lower audit fees than firms without returnee CEOs. In economic terms, the audit fees paid by firms with returnee CEOs are likely to be 2.68[1] percentage points lower than those paid by firms without returnee CEOs. The results support H1a, which states that having a returnee CEO is associated with lower audit fees. This negative association between returnee CEOs and audit fees is consistent with the supply-side perspective on audit pricing. As returnees increase firm performance and operational efficiency (Giannetti et al., 2015; Yuan and Wen, 2018), business risk also decreases, leading to lower audit fees. In addition, the presence of a returnee CEO increases the firm's quality and image in the eyes of external stakeholders, including auditors (Zhang et al., 2018). Given their exposure to superior business practices and reporting systems, returnees can improve financial reporting quality (Wen et al., 2020). Increased reporting quality decreases the effort and time required for auditors to provide assurance, thus decreasing audit fees.

The results for most of the control variables are consistent with standard assumptions and the literature. For instance, firm size and age are positively associated with audit fees. However, high performance, measured as return on assets, has an inverse relationship with audit fees. This is consistent with the argument that higher-performing firms are less likely to fail, reducing business risk and possible litigation loss for the auditor.

[1] Consistent with prior studies (Adhikari and Agrawal, 2016; Tawiah and Gyapong, 2021), we calculate economic significance as (coefficient * standard deviation)/mean of the dependent variable.

Table 4
Correlation matrix.

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1. *Audit_Fees*	1																	
2. *Returnee_CEO*	−0.047*	1																
3. *B_Size*	0.314*	−0.038*	1															
4. *B_Independence*	0.001	0.027*	−0.117*	1														
5. *B_Female*	−0.069*	0.032*	−0.056*	0.046*	1													
6. *CEO_Gender*	−0.097*	0.062*	−0.154*	0.111*	0.112*	1												
7. *Current_Ratio*	−0.030*	0.015	0.023*	0.008	0.013	0.006*	1											
8. *SOE*	−0.010*	−0.163*	0.226*	−0.135*	−0.194*	−0.314*	0.036*	1										
9. *Discretionary_Accruals*	0.021*	−0.004	0.040*	−0.011	0.01	0.013*	−0.043*	−0.036*	1									
10. *Big_4*	0.592*	0.021*	0.122*	0.005	−0.077*	−0.074*	0.064*	0.150*	−0.046*	1								
11. *ROA*	−0.038*	0.026*	−0.085*	0.038*	0.032*	0.049*	0.198*	−0.116*	−0.153*	0.030*	1							
12. *Firm_Size*	0.748*	−0.002	0.274*	−0.023*	−0.130*	−0.174*	0.232*	0.335*	−0.041*	0.389*	−0.014*	1						
13. *Firm_Age*	0.109*	−0.033*	0.108*	−0.053*	0.027*	−0.083*	−0.001	0.150*	0.061*	0.009	−0.123*	0.160*	1					
14. *Debt_Ratio*	0.414*	−0.057*	0.179*	−0.069*	−0.099*	−0.152*	0.042*	0.219*	0.088*	0.126*	−0.385*	0.462*	0.191*	1				
15. *Complexity*	−0.033*	−0.004	−0.087*	0.042*	−0.002	0.036*	0.001	−0.076*	0.004	−0.073*	−0.053*	−0.019*	−0.002	0.226*	1			
16. *Type_Audit_Opinion*	−0.008*	0.057*	0.044*	0.027*	−0.051*	0.005	0.487*	−0.015*	−0.125*	0.10	0.380*	0.295*	−0.185*	−0.061*	−0.064*	1		
17. *Specialized_Firm*	0.185*	0.035*	−0.050*	0.032*	0.040*	0.090*	−0.067*	−0.157*	0.075*	−0.100*	−0.185*	−0.340*	0.025*	−0.168*	−0.139*	−0.163*	1	
18. Business segment	0.044*	−0.022*	0.01	−0.009	−0.014*	−0.023*	−0.027*	−0.006	0.073*	−0.015*	−0.179*	−0.008	0.082*	0.224*	0.072*	−0.141*	0.123*	1

Note: * represents significance of 0.05 or below. All variables are as defined in Table 2. For brevity, not all variables are included.

Table 5
Baseline regression and endogeneity test.

		Two-stage least squares		PSM		S-GMM
	Baseline results	1st stage	2nd stage	1st stage	2nd stage	
	Column 1					
Returnee_CEO	–0.043***		–0.094***		–0.109***	–0.051***
	(3.35)		(–3.62)		(–3.01)	(4.01)
British_Colony		0.014***				
		(4.12)				
Lagged audit fees						0.870***
						(15.68)
Corporate governance						
B_Size	0.008***	–0.004	0.008***	–0.003	0.006***	0.009***
	(4.15)	(–1.45)	(4.16)	(–1.28)	(4.33)	(4.56)
B_Independence	0.004**	0.027*	–0.006*	0.018*	–0.003*	–0.008**
	(2.15)	(1.69)	(–1.66)	(1.71)	(–1.73)	(–2.16)
B_Female	0.024	0.022**	–0.033	0.028*	–0.029	–0.027
	(1.26)	(2.43)	(–0.81)	(1.77)	(–0.37)	(1.17)
CEO_Gender	–0.015*	0.012	–0.010*	0.011	–0.013*	–0.012*
	(1.63)	(1.19)	(–1.78)	(0.69)	(–1.89)	(–1.93)
Firm characteristics						
SOE	–0.007***	0.015**	–0.007***	–0.021*	–0.012**	–0.013***
	(–7.28)	(2.44)	(–6.25)	(–1.85)	(–2.25)	(–6.11)
ROA	–0.146***	–0.053*	–0.167***	–0.403*	–0.126**	–0.138***
	(–2.65)	(–1.73)	(–2.89)	(–1.95)	(–2.14)	(–3.23)
Firm_Size	0.304***	0.013***	0.313***	0.014*	0.356***	0.329***
	(11.93)	(4.21)	(13.87)	(1.96)	(12.19)	(15.19)
Firm_Age	0.034***	–0.011**	0.037***	–0.080	0.021**	0.028***
	(3.54)	(–2.41)	(3.53)	(–1.24)	(2.24)	(3.17)
Debt_Ratio	0.028**	–0.015**	0.038**	–0.171**	0.024**	0.021***
	(2.15)	(–2.12)	(2.23)	(–1.99)	(2.37)	(2.58)
Complexity	0.052***	–0.012	0.079***	–0.021	0.065**	0.059***
	(3.34)	(–0.68)	(3.17)	(–0.47)	(2.34)	(3.07)
Current_Ratio	–0.139***	0.072	–0.201***	0.057	–0.164**	–0.207***
	(–5.45)	(1.01)	(–6.02)	(0.19)	(–2.17)	(–5.98)
Discretionary_Accruals	0.042***	0.000	0.058***	–0.001	0.064***	0.056***
	(5.30)	(1.18)	(4.15)	(–1.04)	(3.88)	(4.82)
Auditor characteristics						
Big_4	0.329***	0.002*	0.593***	0.060**	0.615***	0.683***
	(9.06)	(1.88)	(11.07)	(2.34)	(12.32)	(18.37)
Type_Audit_Opinion	0.000	0.000	0.001*	0.000	0.001	0.000
	(1.06)	(0.84)	(1.67)	(0.16)	(1.47)	(1.05)
Audit_Firm_Tenure	0.005*	0.001	0.007**	0.002	0.006**	0.007**
	(1.85)	(1.41)	(2.10)	(1.21)	(2.01)	(1.99)
Auditor_Switch	–0.010**	0.001	–0.009**	0.000	–0.012**	–0.013**
	(–1.95)	(0.89)	(–2.03)	(0.81)	(–1.99)	(–2.16)
Non-audit_Fees	–0.213***	0.003	–0.239***	0.030	–0.190***	–0265***
	(–4.17)	(1.51)	(–5.19)	(0.99)	4.38	(–5.01)
Specialized_Audit_Firm	0.019***	0.052	0.024***	0.003	0.040***	0.039***
	(4.35)	(4.11)	(5.13)	(0.80)	(4.25)	(5.32)
Local_Audit_Firm	–0.028**	–0.019*	–0.035***	0.006	–0.041**	–0.029***
	(–3.15)	(1.72)	(–4.04)	(1.39)	(–5.11)	(–4.91)
Constant	2.306***	–0.042	3.013***	–0.061*	4.051***	3.170***
	(17.97)	(–1.08)	(19.07)	(–1.79)	(16.17)	(18.30)
Industry effect	Controlled	Controlled	Controlled	Controlled	Controlled	
Year effect	Controlled	Controlled	Controlled	Controlled	Controlled	
Adjusted R-sq	0.63	0.35	0.41	0.08	0.75	
AR1. (PV)						0.029
AR2. (PV)						0.871
Observations	25,630	25,630	25,630	25,630	5,360	25,630

Note: *, ** and *** represent significance at the 0.1, 0.05 and 0.01 levels, respectively. Detailed descriptions of the variables are provided in Table 2. All of the regressions reported in this table include year and industry fixed effects.

Similarly, Big 4 and specialized audit firms are positively and significantly associated with high audit fees, due to their global reputation and premium charges.

4.3. Endogeneity check

Our finding that returnee CEOs are negatively associated with audit fees may be biased due to omitted variables, reverse causality and/or self-selection bias, which are problems common to many corporate governance studies. The idea that audit fees drives the appointment of a returnee CEO is less plausible than the reverse explanation; hence, we are relatively unconcerned about reverse causality. Furthermore, using many control variables and fixed effects to some extent mitigates omitted variable bias. However, firms with certain characteristics are more likely to hire returnee CEOs. That is, a firm's decision to hire a returnee CEO is not random, potentially introducing self-selection bias. To check the robustness of our results to possible self-selection bias and other unobserved endogeneity threats, we employ three robust econometric models: the Heckman two-step selection model, PSM and the S-GMM approach.

We begin the robustness check with the Heckman two-step selection model. Consistent with prior studies (Wen et al., 2020), we introduce *British_Colony* as an exogenous variable. Prior studies argue that former British colonies have more returnees (Yuan and Wen, 2018; Wen et al., 2020); therefore, firms located in those areas are more likely to appoint a returnee CEO. *British_Colony* is a dummy variable that equals 1 if a firm's headquarters are located in a province that had a concession established by Great Britain during the late Qing dynasty and 0 otherwise. In the first stage, we run a probit model based on all of the control variables and the exogenous variable to estimate the probability of having a returnee CEO (*Returnee_CEO*). We then calculate the Mills ratio (*Mills_Ratio*) from the first stage using the standard Heckman procedure and include this ratio in the main equation (second stage) to control for sample selection bias. The results of Heckman's two-step method are reported in column 2 (first stage) and column 3 (second stage) of Table 4. The coefficient of *Returnee_CEO* in column 2 remains negative and significant, supporting our main finding that having a returnee CEO is associated with low audit fees and is not driven by self-selection bias.

Arguably, Heckman's two-step selection model may not address all endogeneity concerns, particularly reverse causality. Furthermore, the selection of instrumental variables may be problematic. Therefore, we conduct PSM to further allay endogeneity concerns. We begin by running a probit model to match firms with returnee CEOs (the treatment group) with firms without returnee CEOs (the control group). PSM is not affected by reverse causality or the selection of instrumental variables. The results are presented in column 4 of Table 4. Next, we calculate the propensity score for all sample firms to select one control firm for each treatment firm. We perform univariate analyses to ensure that our matching strategy is reliable. The untabulated results reveal that there are no significant differences in the means of the variables, except for audit fees. Having established the reliability of our matching, we examine the relationship between returnee CEOs and audit fees using the matched sample and report the results in column 5 of Table 4. The coefficient of *Returnee_CEO* is negative and significant, confirming our main finding that firms with returnee CEOs pay low audit fees. This result still holds after accounting for observable differences between firms with returnee CEOs and firms without returnee CEOs.

In our final robustness test, we use the S-GMM approach. This model helps to address any contemporary effect of prior years' audit fees on the results. S-GMM can also address problems related to endogeneity and weak instruments (Arellano and Bond, 1991; Arellano and Bover, 1995). It controls for simultaneity bias caused by the potential endogeneity of the explanatory variables. The instrumental variables are the one-year lagged values of the dependent variable and the predetermined variables (Arellano and Bond, 1991). The results are presented in column 6 of Table 4. The coefficient of *Returnee_CEO* remains negative and significant, confirming our main findings.

4.4. Additional analyses

In our main analysis, we assume that the characteristics of the sample firms are homogenous. Similarly, we assume that all returnee CEOs have similar foreign experiences. However, prior studies demonstrate that the influence of returnee directors on firms' outcomes can differ based on the type of foreign experience obtained

and other firm characteristics (Giannetti et al., 2015). Therefore, in this section, we examine the relationship between returnee CEOs and audit fees in light of certain firm characteristics and types of foreign experience.

4.4.1. Type of ownership structure

The influence of directors' or CEOs' personal experience on firms' outcomes is likely to differ across firms and industries (Hambrick and Finkelstein, 1987). Hambrick (2018) argues that some environments provide more latitude in actions and managerial discretion than others. Therefore, the role of returnee CEOs in improving internal control and thereby decreasing audit fees may differ between SOEs and non-SOEs. On the one hand, non-SOEs are likely to give directors more managerial discretion to shape the firm's procedures and activities based on their experiences. On the other hand, non-SOEs are perceived to have stronger internal control and better governance than SOEs (Tam, 2000); hence, the presence of a returnee CEO may not significantly impact non-SOEs.

Based on these arguments, we test whether the association between returnee CEOs and audit fees differs between SOEs and non-SOEs. Consistent with prior studies (Giannetti et al., 2015; Shailer and Wang, 2015; Yuan and Wen, 2018; Wen et al., 2020), we classify firms into SOEs and non-SOEs based on the majority shareholding. SOEs are firms in which the majority shareholder is the local or central government. The results are presented in columns 1 and 2 of Table 6. The coefficient of *Returnee_CEO* is negative and significant for both SOEs and non-SOEs. However, the coefficient is larger and more significant for SOEs than non-SOEs, indicating that returnee CEOs have more influence on audit fees for SOEs than non-SOEs. In economic terms, having a returnee CEO is associated with a decrease of 2.3 percentage points in audit fees for SOEs, compared with a decrease of 1.2 percentage points for non-SOEs. This is surprising, given that emerging research (Giannetti et al., 2015; Shailer and Wang, 2015; Yuan and Wen, 2018; Wen et al., 2020) indicates that returnee directors have more influence in non-SOEs than SOEs because of the former's more flexible business environment. Returnee CEOs influence audit fees through a signaling effect rather than by influencing firm decision making. Generally, SOEs are known to have weak corporate governance structures (Tam, 2000; Daiser et al., 2017); hence, the introduction of new business practices by the returnee CEO signals a major change that is likely to lead to a change in business risk and performance. While the appointment of a returnee CEO by a non-SOE may have only a small signaling effect, the opposite is true for an SOE, especially as many SOEs wish to improve their corporate governance (Andrés et al., 2013; International Finance Corporation, 2017).

4.4.2. Type of foreign experience

According to Giannetti et al. (2015), returnees acquire their foreign experience by studying or working abroad. These two sources of experience could exert different effects on firm outcomes. Therefore, we classify returnee CEOs based on education and work experience. Next, we estimate a regression by replacing the original measure of *Returnee_CEO* with either *Returnee_CEO_Education* or *Returnee_CEO_Work* in separate models. The results are presented in columns 3 and 4 of Table 6, respectively. The coefficient is negative and significant for both *Returnee CEO_Education* and *Returnee_CEO_Work*, as shown in columns 3 and 4, respectively. These results suggest that returnee CEOs are associated with low audit fees regardless of the source of their foreign experience.

4.4.3. Corporate governance structure

In the next set of additional analyses, we consider the firm's corporate governance structure. Prior studies assert that returnees are the medium through which good corporate governance is transferred from developed to emerging countries (Giannetti et al., 2015; Wen and Song, 2017; Wen et al., 2020; Quan et al., 2021). Returnees are expected to improve corporate governance and hence decrease business risk. Consistent with these arguments, we expect returnee CEOs to exert a greater influence in firms with poor governance than in firms whose corporate governance is already good. As poorly governed firms are risky and likely to face financial reporting issues, they will incur high audit fees. However, hiring a returnee CEO will partly alleviate such problems and signal an improvement in reporting quality; hence, the auditor will charge lower fees. Therefore, it is logical to expect the negative association between returnee CEOs and audit fees to be more pronounced for poorly governed firms than well governed firms. To test these arguments, we divide the sample into firms

Table 6
Additional analyses (type of experience; corporate governance; firm complexity and firm risk).

	Type of ownership structure		Type of experience		Corporate governance		Firm complexity		Firm risk	
	SOE	Non-SOE	Work	Education	Poor governance	Good governance	High complexity sample	Low complexity sample	High risk sample	Low risk sample
	Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9	Column 10
Returnee_CEO	–0.023***	–0.012*			–0.032***	0.011	–0.048***	–0.008*	–0.081***	–0.024*
	(3.13)	(1.84)			(–2.92)	(1.22)	(–4.63)	(–1.91)	(–4.09)	(–1.89)
Returnee_CEO_Work			–0.033***							
			(–3.19)							
Returnee_CEO_Education				–0.021**						
				(–2.38)						
All controls included	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry effect	Controlled	Controlled	Controlled	Controlled	Controlled	Controlled	Controlled	Controlled	Controlled	Controlled
Year effect	Controlled	Controlled	Controlled	Controlled	Controlled	Controlled	Controlled	Controlled	Controlled	Controlled
Constant	2.931***	2.081***	3.491***	3.606***	2.320***	2.961***	3.892***	3.828***	4.091***	5.120***
	(12.27)	(19.01)	(7.06)	(7.24)	(4.32)	(4.43)	(3.56)	(3.18)	(6.51)	(5.97)
Adjusted R-squared	0.51	0.54	0.61	0.63	0.58	0.55	0.61	0.59	0.81	0.68
N	10,508	15,122	25,630	25,630	12,303	13,327	14,056	11,574	13,068	12,562

Note: *, ** and *** represent significance at the 0.1, 0.05 and 0.01 levels, respectively. Detailed descriptions of the variables are given in Table 2. All of the regressions reported in this table include year and industry fixed effects.

with poor and good corporate governance and run a separate regression for each sub-sample. Prior research suggests that the presence of independent directors signals good governance (de Villiers and Dimes, 2021). Therefore, we consider firms to be well governed if the proportion of independent directors is larger than the sample median; otherwise, we regard them as poorly governed (Abdelsalam and Street, 2007; Briano-Turrent and Rodríguez-Ariza, 2016; de Villiers and Dimes, 2021). The results are presented in Table 6. Column 5 provides the results for well governed firms and column 6 provides the results for poorly governed firms. As expected, the coefficient of *Returnee_CEO* is negative and significant only for poorly governed firms. These results suggest that when determining audit pricing, auditors value the presence of a returnee CEO in poorly governed firms more than in well governed firms. The results also indicate that the significant association between returnee CEOs and low audit fees can be explained by the perceived improvement in corporate governance practice that returnees bring to the firm. The relationship is more pronounced for SOEs than non-SOEs, because the former are known to be relatively poorly governed. The results imply that poorly governed firms can reduce their audit fees by appointing a returnee CEO.

4.4.4. Firm risk and complexity

The risk and complexity of a firm are major sources of potential liability loss for auditors (Kalelkar and Khan, 2016). Hence, they are critical determinants of audit fees. More complex and higher-risk firms pay higher audit fees because they have more complex transactions, requiring more effort from auditors. However, auditors of such firms are likely to perceive returnee CEOs as a mitigating factor, given their exposure to advanced business practices from the West. Therefore, in this section, we estimate separate regressions for firms with high and low levels of complexity and risk, respectively. Consistent with prior studies (Menon and Williams, 2001; Huang et al., 2016), we measure firm complexity as the ratio of total inventory and accounts receivable to total assets. Firms with a larger volume of inventory and accounts receivable are more complex, because they have a higher inherent risk of misreporting and manipulation. Following prior studies (Menon and Williams, 2001; Hay et al., 2006), we measure firm risk as total debt divided by total assets. For both complexity and firm risk, we classify firms based on median values. The results are presented in Table 6. The coefficient of *Returnee_CEO* remains negative and significant for firms with both high and low levels of complexity (risk), suggesting that the effect of returnee CEOs on audit fees is similar regardless of the firm's complexity (risk). However, the coefficient is larger and the significance is greater for highly complex (risky) firms than firms with low levels of complexity (risk). This implies that firms with high (vs. low) levels of complexity and risk are likely to benefit more from having returnee CEOs in terms of audit fees.

5. Conclusion

The experience of the CEO, as the firm's leader, represents a signal to the external world of the firm's internal governance type and level of risk. CEO characteristics can also indicate the firm's financial reporting quality and level of internal control. Given that audit pricing is a function of risk and effort (Kalelkar and Khan, 2016), CEO experience is likely to determine the audit fees paid by a firm. Therefore, in this paper, we examine the relationship between returnee CEOs and audit fees.

We analyze a unique panel dataset of 25,630 firm-year observations between 2008 and 2020. We find a negative and significant relationship between returnee CEO and audit fees, implying that firms with (vs. without) returnee CEOs pay lower audit fees. This relationship is more pronounced for SOEs than non-SOEs. Our results are robust to a battery of tests, including firm-year fixed effects specifications, the Heckman selection model and PSM. In additional analyses, we demonstrate that in terms of audit fees, firms that are poorly governed, high-risk and highly complex benefit more than their counterparts from having returnee CEOs. These results indicate that the significant association between returnee CEOs and low audit fees is attributable to the improvement in governance and risk reduction due to returnees' perceived qualities.

This paper extends prior research on CEO characteristics and audit pricing (Kalekar and Khan, 2016). We demonstrate that a non-financial background may be a significant determinant of audit fees. We also complement prior studies on the impact of returnee directors on firms in emerging economies (Giannetti et al., 2015; Yuan and Wen, 2018; Usman et al., 2020; Wen et al., 2020; Quan et al., 2021). We show that firms are likely to

benefit from low audit fees when they appoint a returnee as CEO. Our results support government policies that encourage the return of citizens and the appointment of returnees to top positions in firms.

Our study has significant implications. First, for governments and policymakers, our findings provide empirical support for the brain gain policy championed by emerging economies. Our results show that returnees improve firms' governance and China's overall business environment. Second, for firms, our findings highlight the potential benefits of appointing a returnee CEO. A reduction in audit fees means more profit that can be reinvested for growth or distributed as dividends to investors, which also attracts more investment into the country. Furthermore, returnee CEOs serve as a conduit through which Western corporate governance and internal control systems (perceived to be of high quality) are transferred to emerging economies. Arguably, hiring a returnee CEO is a cheaper option than hiring a foreign CEO. Overall, our results imply that the appointment of returnees as CEOs benefits both firms and the country.

While this paper focuses on CEOs, future studies could consider the effect of returnee chief financial officers or finance directors on audit fees. The foreign experience of the individual responsible for preparing a firm's financial statements may affect the quality of the financial statements and the effort required by auditors to obtain a true and fair view of the firm. In addition, this paper considers neither the financial background of the returnee CEO nor the country in which the returnee CEO gained experience. The impact of returnees from Western countries may differ from that of returnees from non-Western countries. Complete CEO background information will enable future studies to examine whether the association between returnee CEOs and audit fees is most pronounced when the returnee has a financial background.

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Conflict of interest statement

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Tax-related human capital: Evidence from financial reporting aggressiveness of boards with tax officer directors in China

Yong Huang [a,b,c], Kam C. Chan [d], Chunxiang Zhao [e,*]

[a] Center for New Institutional Accounting, School of Accountancy, Zhongnan University of Economics and Law, 182 Nanhu Avenue, Wuhan 430073, China
[b] School of Business, Renmin University of China, Beijing 100872, China
[c] The Innovation and Talent Base for Digital Technology and Finance, Zhongnan University of Economics and Law, 182 Nanhu Avenue, Wuhan 430073, China
[d] Research Center of Finance, Shanghai Business School, 123 Fengpu Avenue, Shanghai, China
[e] Center for Economics and Accounting Regulation, School of Accountancy, Zhongnan University of Economics and Law, 182 Nanhu Avenue, Wuhan 430073, China

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ABSTRACT

We investigate the impact of tax-related human capital (THC) on corporate financial reporting aggressiveness. Using the presence of former or current tax officers from tax authorities on a firm's board of directors as a proxy for THC, we find that firms with tax officer directors report their earnings more aggressively than those without such directors. This relationship remains robust across alternative measures of aggressiveness, model specifications and various methods of addressing endogeneity concerns. Moreover, the level of aggressiveness is more pronounced when tax officer directors have previously served in local tax authorities, have experience in offices overseeing the firm's income tax affairs or have held a senior position in tax authorities, particularly when firms are subject to lenient tax enforcement policies or higher statutory tax rates. These findings support that tax officer directors contribute to firms' aggressive reporting practices through THC. Additional analyses suggest that firms with tax officer directors exhibit lower effective tax rates and a weaker association between effective tax rates and operating cash flows. Our findings collectively demonstrate that firms with tax officer directors possess significant THC and employ aggressive strategies in both financial and tax reporting practices.

* Corresponding author.
E-mail addresses: huangyong@zuel.edu.cn (Y. Huang), johnny.chan@wku.edu (K.C. Chan), adamson.zhao@zuel.edu.cn (C. Zhao).

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1. Introduction

Publicly listed firms often face the dilemma of how to aggressively report accounting earnings while legally minimizing tax payments. Accounting earnings serve as a crucial performance indicator, offering shareholders insights into a firm's growth prospects. Thus, managers are motivated to inflate accounting earnings. However, firms are also motivated to minimize income tax payments through legal means, and consequently may adopt aggressive tax reporting strategies to reduce taxable income. However, it can be challenging for firms to be aggressive in financial and tax reporting simultaneously. When firms inflate accounting earnings upward to satisfy shareholders, the taxable income reported to tax authorities may increase. Hence, managers face a trade-off between these seemingly conflicting reporting incentives (Klassen, 1997; Shackelford and Shevlin, 2001).

In their investigation of the relationship between aggressive financial and tax reporting, Frank et al. (2009) find that inconsistencies between financial accounting standards and tax codes allow firms to inflate book income while reducing taxable income within the same reporting period. Building on Frank et al. (2009), we explore which individuals within firms can exploit these disparities between financial reporting and tax accounting rules. Specifically, we focus on one type of independent director, tax officer directors, who sit on the boards of some listed firms in China and are former, and sometimes even incumbent, tax officers with China's tax authorities. We investigate the impact of tax officer directors on corporate financial reporting, particularly whether their presence enables firms to exploit discrepancies between tax codes and accounting standards, thereby facilitating more aggressive financial reporting practices.

Compared with conventional independent directors, tax officer directors possess a unique form of human capital: tax-related human capital (THC). Throughout their tenure with tax authorities, tax officer directors engage in various activities, including participation in on-the-job training programs, contribution to tax code development and attendance at tax avoidance examinations. These experiences enable them to develop tax expertise, establish interpersonal tax-related political connections and gain familiarity with their corporate employers' tax affairs, which constitute the core elements of THC. According to Becker (1993), human capital can be categorized into general and specific forms. THC, which encompasses professional knowledge of tax codes and policies acquired through working with tax authorities, falls into the category of general human capital. However, THC also has characteristics of specific human capital such as the interpersonal knowledge of fellow officers' styles, focuses and preferences. Even after resigning from their positions at the tax authorities, tax officers often maintain interpersonal networks with other tax officers and stay current with the latest tax codes and standards, thereby continuing to influence the firms they serve.

Zhao et al. (2019) posit that firms with tax officer directors exhibit a lower tax burden. However, they do not discuss financial reporting aggressiveness or provide a THC conceptual framework that reconciles the coexistence of financial and tax reporting aggressiveness. Therefore, we propose a THC framework that elucidates the role of tax officer directors in leveraging the disparity between financial reporting and tax accounting regulations. Under this framework, tax officer directors can guide their corporate employers on how to minimize earnings reported to tax authorities while maximizing earnings reported to shareholders, all without drawing undue attention from tax authorities. Consequently, firms with tax officer directors are more likely than firms without tax officer directors to report accounting earnings aggressively while simultaneously reducing taxable earnings. We hypothesize that firms with tax officer directors adopt aggressive strategies in both financial and tax reporting because of these directors' THC.

To test this hypothesis, we examine a sample of Chinese firms from 2008 to 2021. During this period, 5.5 % of listed firms appointed former or incumbent tax officers from various levels of tax authorities as independent directors. The staggered hiring of tax officers as independent directors at different times enables us to investigate the impact of tax officer directors' THC on corporate financial and tax reporting aggressiveness, using a staggered difference-in-differences (DiD) research design. Following accounting literature conventions, we use a set of discretionary accruals as proxies for financial reporting aggressiveness (Jones, 1991; Dechow et al., 1995; Dechow and Dichev, 2002; McNichols, 2002; Condie et al., 2021).

Following the appointment of tax officer directors to the board, we observe a significant increase in financial reporting aggressiveness, as evidenced by the magnitude of discretionary accruals. This positive association between the presence of tax officer directors and discretionary accruals persists across various measures of aggressiveness and sample specifications and remains robust after addressing endogeneity concerns. Therefore, our results support the hypothesis that tax officer directors' THC influences their corporate employers' reporting strategies.

As part of our efforts to address endogeneity concerns, we use a negative shock induced by an exogenous regulation enacted in 2013, which prohibits government officials from serving on the boards of listed firms. This regulation prompted the resignation of 76.44 % of the tax officer directors on the boards of listed firms. For the period after this regulatory intervention, we observe a significant decline in the magnitude of discretionary accruals among firms that previously had tax officer directors. We attribute the decline in financial reporting aggressiveness to the decrease in directors with THC. This post-regulation evidence, coupled with evidence for the impact of tax officers joining the board, provides robust support for the capacity of the THC framework to explain the effects of tax officer directors on financial reporting aggressiveness.

We conduct a series of cross-sectional tests to gain deeper insights into this relationship. Our heterogeneity tests reveal variations in the positive impact of tax officer directors on financial reporting aggressiveness under specific conditions. In particular, we observe a stronger impact when tax officer directors are affiliated with tax offices in the same province as the firm or have prior associations with such offices. Moreover, the effect of tax officer directors on financial reporting aggressiveness becomes more pronounced when the directors' former tax offices are responsible for collecting income taxes from the firm or when the firm is registered in provinces with less stringent enforcement of tax codes. Additionally, firms that hire high-ranking tax officers tend to be more inclined toward aggressive financial reporting than those that hire low-ranking tax officers. Finally, the positive impact of tax officer directors on financial reporting aggressiveness is more pronounced for firms subject to higher statutory tax rates. These findings align with the implications of the THC framework, highlighting the nuanced dynamics of tax officers' influence on financial reporting strategies.

In line with Zhao et al. (2019) and Cao et al. (2023), our findings indicate that firms with tax officer directors exhibit significantly reduced effective tax rates, and their effective tax rates exhibit less susceptibility to fluctuations in operating cash flows. These analyses collectively suggest that tax officer directors possess substantial THC, enabling them to aid their firms with tax avoidance strategies. In addition to mitigating tax liabilities, we find that tax officer directors leverage their THC to facilitate the inflation of accounting earnings presented to investors.

This study makes three major contributions to the literature. First, we contribute to the discussion surrounding the trade-offs managers face when determining overall reporting strategies. Most studies assume that managers are stuck in the dilemma of either reporting higher book income to shareholders and paying more tax or paying less tax and facing pressure from shareholders (Shackelford and Shevlin, 2001). Hanlon (2005) identifies an increasing gap between income reported to shareholders and that reported to the government by U.S. corporations. Our analyses indicate that by appointing directors with THC as independent directors, public firms in China can navigate this trade-off and pursue aggressive strategies in both financial and tax reporting. Thus, our findings complement discussions on financial and tax reporting trade-offs.

Second, our study contributes to the literature on financial and tax reporting by proposing a THC framework to elucidate the impact of tax officer directors on corporate financial reporting aggressiveness. Our analysis suggests that, in contrast to expertise in accounting standards and tax laws, directors' THC is critical in enabling firms to exploit non-conformities. This complements the findings of Frank et al. (2009). Our results advance the theoretical framework for explaining financial and tax reporting aggressiveness.

Third, we provide new insights into the debate on book–tax conformity (McClelland and Mills, 2007; Hanlon and Maydew, 2009; Hanlon and Heitzman, 2010). Most countries maintain separate book and tax earnings systems. There has been an ongoing debate on whether these two sets of income measures should be harmonized into a single common measure. The upside of reporting two sets of earnings is that it helps satisfy the needs of various stakeholders. Shareholders prioritize the outlook for a firm's value. Therefore, as accounting earnings contain value-related information, shareholders naturally prefer accrual-based accounting systems. Such a system requires subjective estimation and judgment by accounting professionals. As accounting earnings vary with different estimations, taxing based on them may lead to unfair treatment and

disputes. Thus, tax authorities establish their standards for recognizing tax income. However, the lack of conformity between accounting and taxable earnings creates opportunities for firms to exploit the disparity. Our analysis indicates that firms leverage their tax officer directors' THC to exploit this disparity. With the help of tax officer directors, firms can inflate their accounting earnings without incurring additional tax costs.

The remainder of this paper is organized as follows. Section 2 discusses various determinants of financial reporting aggressiveness and develops our hypotheses. Section 3 introduces the data and basic empirical strategy. Section 4 presents the results of the empirical analysis. Section 5 concludes the study.

2. Related literature and hypothesis development

Financial reporting aggressiveness is common among firms (Patelli and Pedrini, 2015; Koreff et al., 2020; Condie et al., 2021). Studies document various determinants of financial reporting aggressiveness, including executive incentives (Baker et al., 2003; Cheng and Warfield, 2005; Bergstresser and Philippon, 2006), debt covenant violations (Rodríguez-Pérez and van Hemmen, 2010; Jha, 2013; Franz et al., 2014) and market value considerations (Perry and Williams, 1994; Payne and Robb, 2000; Beatty et al., 2002). For instance, Bergstresser and Philippon (2006) find that firms manipulate accounting earnings more aggressively when a CEO's potential compensation is closely tied to stock and option-holding values. Franz et al. (2014) discover that firms near or in technical default of debt covenants are more aggressive in financial reporting than those further from covenant violations. Beatty et al. (2002) argue that a high frequency of small earnings increases relative to decreases in public firms can be attributed to earnings management.

However, managers face a trade-off between financial reporting and tax reporting objectives. This is particularly true when firms are subject to high conformity between book and tax recognition criteria (Schipper, 1989; Guenther et al., 1997; Badertscher et al., 2009; Zang, 2012). When firms accelerate income recognition in the current year, they concurrently increase their taxable income, increasing tax costs for the period. In practice, differences exist between financial accounting standards and tax codes regarding income and expense recognition, allowing firms to aggressively report overstated accounting earnings without incurring immediate tax consequences, owing to book–tax nonconformity (Phillips et al., 2003; Desai and Dharmapala, 2006; Frank et al. 2009; Fernandes et al., 2017; Balakrishnan et al., 2019). Frank et al. (2009) argue that firms can simultaneously manage book income upward and taxable income downward within the same reporting period by leveraging the nonconformity between financial accounting standards and tax laws. Based on a sample of publicly traded US firms, they establish a positive relationship between tax and financial reporting aggressiveness.

To exploit opportunities associated with book–tax nonconformity, firms must be equipped with experts proficient in accounting and tax laws. Many listed firms in China employ former tax officers as independent directors. Applying Becker's (1993) theory to our study, we categorize the knowledge and information tax officer directors gain through their work experience into general and specific THCs. General THC consists of tax knowledge and skills that are broadly applicable across all tax-paying firms, regardless of industry- or firm-specific characteristics. This includes a comprehensive understanding of tax regulations, compliance requirements and strategies for legally minimizing tax liabilities. Such general THC enables tax officer directors to provide valuable insights and recommendations that can be implemented across diverse corporate contexts. Furthermore, their tenure within tax authorities enables them to cultivate interpersonal connections and acquire nuanced insights into the working styles, priorities and preferences of tax officials. This interpersonal knowledge constitutes specific THC, which is particularly valuable for firms dealing with the taxation system. When tax officers with specific human capital are employed by firms as independent directors, they may leverage this specific capital when interacting with their former colleagues, thereby seeking benefits for their corporate employers in areas such as tax enforcement (Hillman, 2005).

While the primary rationale for hiring tax officer directors is to leverage their expertise in minimizing tax liabilities by exploiting book–tax nonconformity, we argue that their role in facilitating financial reporting aggressiveness represents an important, indirect and often overlooked impact. Publicly traded firms rely on effective communication with investors to enhance or maintain firm valuations, with accounting earnings and their growth serving as critical inputs for valuation. Consequently, management has strong incentives to inflate accounting earnings while avoiding an increase in taxable earnings—a strategy aligned with the

expertise of tax officer directors. Importantly, tax officer directors may not need to directly instruct the accounting department to inflate earnings. Their expertise in lowering earnings reported to tax authorities inherently creates opportunities for the accounting department to report inflated earnings to investors without triggering regulatory scrutiny. By reducing firms' taxable income, tax officer directors enable firms to present an attractive financial narrative to investors while maintaining compliance with tax regulations. Accordingly, we propose the following hypothesis.

***H1a**: Firms with tax officer directors are more aggressive in financial reporting than firms without tax officer directors.*

Monitoring managerial behavior is a fundamental responsibility of directors in corporate governance. However, not all directors effectively carry out their monitoring duties; independent directors are often more effective than officer directors (Kim et al., 2014). This effectiveness is particularly pronounced when independent directors are incumbent or former government officials. Increased government and public scrutiny motivates independent directors with government experience to enhance their monitoring efforts, creating a more conservative decision-making environment within the companies they serve. Specifically, in the event of corporate scandals, independent directors with government experience face substantial reputational and career repercussions. Therefore, to safeguard their reputational capital and navigate potential headwinds in their political careers, they are motivated to be vigilant monitors, contributing to a culture of conservative decision-making within their organizations.

Although it is acknowledged that government official directors may face limitations in their monitoring capacity owing to a lack of professional expertise, particularly in financial reporting, this challenge does not apply to tax officer directors. Unlike professional politicians, tax officers acquire financial and accounting knowledge through their daily jobs, enhancing their THC, making them ideal candidates for overseeing the financial reporting process and deterring managerial manipulation of earnings. Moreover, while the political connections of independent directors provide tax benefits (Kim and Zhang, 2016), tax evasion carries potential risks. In particular, when firms inflate their accounting earnings without making the corresponding tax payments, they may draw additional scrutiny from tax authorities. When this heightened tax enforcement results in public disclosure or punishment, tax officer directors may incur political and reputational costs. Thus, we propose the following hypothesis.

***H1b**: Firms with tax officer directors are more conservative in financial reporting than firms without tax officer directors.*

3. Sample, variable measurements and descriptive statistics

3.1. Sample and data sources

Our initial sample consists of Chinese firms listed on the Shanghai or Shenzhen stock exchanges between 2008 and 2021. We choose 2008 as the starting year because international financial reporting standards were adopted in China in 2007. Firms subject to special treatment and financial firms are excluded because of their distinct operating and reporting environments. Additionally, we exclude observations lacking sufficient information to construct our variables. The final sample consists of 26,113 firm-year observations. Table 1 presents the annual sample distribution. The number of observations rose from 1048 in 2008 to 2310 in 2021. This upward trend likely reflects the increasing number of Chinese firms going public during the sample period. The data on the identity of tax officer directors are hand-collected from the annual financial reports of listed firms. All financial and accounting data are from the China Stock Market & Accounting Research (CSMAR) database, provided by Shenzhen CSMAR Data Technology Co., Ltd, a leading Chinese data provider.

3.2. Measures of financial reporting aggressiveness

Financial reporting aggressiveness entails upward earnings management that may or may not comply with accounting standards (Frank et al., 2009). Following the literature, our proxy for financial reporting aggressiveness is the extent of upward earnings management (Kothari et al., 2005; Frank et al., 2009; Koreff et al., 2020). To ensure the robustness of our results, we use four variables (*EMJones*, *EMDechow*, *EMDichev* and

Table 1
Sample distribution by year.

Year	Number of listed firms	Percentage	Number of firms with tax office directors
2008	1048	4.01 %	135
2009	1103	4.22 %	136
2010	1261	4.83 %	149
2011	1580	6.05 %	126
2012	1866	7.15 %	216
2013	1965	7.52 %	208
2014	1992	7.63 %	49
2015	2052	7.86 %	55
2016	2148	8.23 %	54
2017	2167	8.30 %	64
2018	2179	8.34 %	54
2019	2197	8.41 %	62
2020	2245	8.60 %	68
2021	2310	8.85 %	72
Total	26,113	100.00 %	1448

This table shows the annual distribution of listed firms and those with tax officer directors on board.

EMMcNichols) to measure the magnitude of discretionary accruals. We compute *EMJones*, *EMDechow*, *EMDichev* and *EMMcNichols,* following Jones (1991), Dechow et al. (1995), Dechow and Dichev (2002) and McNichols (2002), respectively.

3.3. Descriptive statistics

Table 2 reports the descriptive statistics of the sample. To mitigate concerns that extreme values may drive the results, we winsorize all of the continuous variables at the 1st and 99th percentiles. The mean and median of our dependent variable, the discretionary accruals computed from the modified Jones model (*EMJones*), are both 0.006. A mean value of 0.055 is reported for the presence of tax officer directors (*TaxOfficer*), indicating that approximately 5.5 % of our firm-year observations include at least one tax officer on their boards. The descriptive statistics of all of the other variables are not skewed and are similar to those reported by other studies on listed firms in China (Chen et al., 2011; Lennox et al., 2018; Gao et al., 2023).

Table 2
Descriptive statistics.

Variable	N	Mean	P50	SD	Min	P25	P75	Max
EMJones	26,113	0.006	0.006	0.062	−0.394	−0.004	0.018	0.414
EMDechow	26,113	0.007	0.006	0.065	−0.391	−0.006	0.019	0.404
EMDichev	26,113	0.002	0.000	0.065	−0.379	−0.011	0.014	0.400
EMMcNichols	26,113	0.008	0.008	0.066	−0.393	−0.004	0.020	0.393
TaxOfficer	26,113	0.055	0.000	0.229	0.000	0.000	0.000	1.000
FirmSize	26,113	22.069	21.866	1.328	17.875	21.118	22.809	28.626
Leverage	26,113	0.404	0.392	0.207	0.026	0.235	0.559	0.995
ROA	26,113	0.059	0.056	0.057	−0.336	0.032	0.087	0.272
Tobin's Q	26,113	2.040	1.638	1.260	0.804	1.269	2.333	11.404
Cash	26,113	0.198	0.157	0.144	0.009	0.096	0.259	0.841
Intangible	26,113	0.045	0.033	0.049	0.000	0.017	0.056	0.365
FixedAssets	26,113	0.216	0.182	0.161	0.002	0.090	0.306	0.783
BoardSize	26,113	8.747	9.000	1.809	5.000	7.000	9.000	17.000
ClearAudit	26,113	0.981	1.000	0.138	0.000	1.000	1.000	1.000
HHI	26,113	0.167	0.140	0.114	0.013	0.080	0.228	0.592
Tenure	26,113	4.857	4.000	3.442	1.000	2.000	7.000	18.000
SOE	26,113	0.374	0.000	0.484	0.000	0.000	1.000	1.000

This table shows the summary statistics. We define the variables in Appendix A.

4. Empirical results

To test whether firms with tax officer directors are significantly more aggressive in financial reporting, we conduct both univariate and multivariate regression analyses. Each analysis is discussed below.

4.1. Univariate analysis

In the univariate analysis, we form two subsamples based on the presence of former tax officers on a firm's board of directors. Table 3 presents the means and medians of discretionary accruals across the subsamples of firms with and without tax officer directors. Panel A of Table 3 tabulates the means and tests for differences, and Panel B replicates the comparison focusing on the medians. The results from both panels suggest that tax reporting aggressiveness is higher for firms with tax officer directors than for those without. The univariate comparison provides preliminary evidence supporting H1a.

4.2. Multivariate analysis

We interpret the positive association between discretionary accruals and the presence of tax officer directors as a causal effect, as documented in the univariate analysis. We argue that the involvement of tax officer directors allows firms to overstate accounting earnings without triggering a corresponding increase in their income tax obligations. However, one could argue that the observed positive association may stem from firms adopting aggressive financial reporting strategies and intentionally hiring tax officer directors to minimize income tax payments. This raises potential reverse causality concerns. Furthermore, firms motivated to overstate accounting numbers and minimize taxes may simultaneously increase the likelihood of hiring tax officer directors and inflating their accounting earnings.

To address reverse causality concerns, we use a staggered DiD approach in our primary analysis. We designate firms with tax officer directors as the treatment group and firms that have never appointed tax officer directors as the control group. Specifically, we estimate the following DiD model to identify the impact of tax officers on the financial reporting aggressiveness of their corporate employers.

$$AggressiveFR_{i,t} = \alpha_0 + \alpha_1 TaxOfficer_{i,t} + Controls_{i,t} + Industry + Year + \varepsilon_{i,t} \quad (1)$$

Table 3
The difference in discretionary accruals based on the presence of tax officer directors.

	(1)		(2)		(3)
	Firms without tax officer directors ($TaxOfficer = 0$)		Firms with tax officer directors ($TaxOfficer = 1$)		Differences (2)-(1)
Panel A: Difference of means tests for discretionary accruals					
	N	Mean	N	Mean	
EMJones	24,665	0.006	1448	0.012	0.006***
EMDechow	24,665	0.007	1448	0.013	0.006***
EMDichev	24,665	0.002	1448	0.008	0.006***
EMMcNichols	24,665	0.008	1448	0.014	0.006***
Panel B: Difference of medians tests for discretionary accruals					
	N	Median	N	Median	
EMJones	24,665	0.006	1448	0.007	0.002***
EMDechow	24,665	0.006	1448	0.006	0.000***
EMDichev	24,665	0.000	1448	0.004	0.004***
EMMcNichols	24,665	0.008	1448	0.009	0.001***

This table presents the mean (median) discretionary accruals of firms with and without tax officer directors. Panel A shows the means and the tests for mean difference. Panel B shows the median and the tests for the median difference. *, **, and *** indicate significance at the 1%, 5%, and 10% levels, respectively.

Table 4
Tax officer directorship and financial reporting aggressiveness.

	(1) *EMJones*	(2) *EMDechow*	(3) *EMDichev*	(4) *EMMcNichols*
TaxOfficer	0.005***	0.005***	0.006***	0.005***
	(3.91)	(4.27)	(3.05)	(2.99)
FirmSize	−0.011***	−0.010***	−0.013***	−0.011***
	(−12.77)	(−13.03)	(−12.43)	(−10.29)
Leverage	0.057***	0.056***	0.071***	0.069***
	(14.97)	(15.89)	(17.18)	(16.66)
ROA	0.084***	0.069***	0.078***	0.063***
	(9.40)	(8.41)	(8.75)	(6.51)
Tobin'sQ	0.002***	0.002***	0.004***	0.003***
	(4.74)	(4.57)	(9.44)	(8.40)
Cash	−0.044***	−0.040***	−0.029***	−0.034***
	(−13.50)	(−13.54)	(−8.70)	(−11.04)
Intangible	−0.079***	−0.074***	−0.043***	−0.063***
	(−12.02)	(−11.54)	(−6.34)	(−9.24)
FixedAssets	−0.015***	−0.009***	−0.025***	−0.029***
	(−4.21)	(−2.81)	(−6.62)	(−8.62)
BoardSize	−0.001***	−0.001**	−0.001***	−0.001***
	(−2.95)	(−2.22)	(−5.36)	(−5.41)
ClearAudit	−0.000	−0.000	−0.004	−0.003
	(−0.09)	(−0.01)	(−1.28)	(−0.93)
HHI	−0.019***	−0.017***	−0.027***	−0.024***
	(−4.18)	(−4.07)	(−5.88)	(−5.20)
Tenure	−0.000***	−0.000***	−0.001***	−0.001***
	(−3.52)	(−3.34)	(−4.77)	(−4.97)
SOE	−0.003***	−0.003***	−0.002***	−0.003***
	(−3.22)	(−3.34)	(−3.14)	(−3.66)
Constant	−0.188***	−0.174***	−0.224***	−0.167***
	(−12.64)	(−13.02)	(−12.52)	(−9.65)
Industry	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
N	26,113	26,113	26,113	26,113
Adj-R^2	0.058	0.055	0.071	0.058

This table shows the impact of tax officer directors on discretionary accruals. The dependent variables are various measures of discretionary accruals estimated from Jones (1991), Dechow et al. (1995), Dechow & Dichev (2002), and McNichols (2002), respectively. Detailed definitions of all variables are provided in Appendix A. We report robust t-statistics adjusted for two-way clustering in parentheses at both industry and year levels. *, **, and *** indicate significance at the 1%, 5%, and 10% levels, respectively.

where $AggressiveFR_{i,t}$ represents a measure of discretionary accruals. The explanatory variable $TaxOfficer_{i,t}$ takes the value of one if firm i has at least one tax officer (former or incumbent) from a tax authority serving on its board of directors in year t, and zero for the years preceding the inclusion of tax officers on the board and for firms that have never hired tax officer directors.

We include a set of control variables including firm size (*FirmSize*), financial leverage (*Leverage*), return on assets (*ROA*), firm value (*Tobin's Q*), intangible assets (*Intangible*), fixed assets (*FixedAssets*), board size (*BoardSize*), audit opinion (*ClearAudit*), shareholding concentration among top 10 shareholders (*HHI*), CEO tenure (*Tenure*) and state ownership status of the firm (*SOE*). Appendix A provides detailed definitions of all of the variables.

Additionally, Eq. (1) includes industry and year fixed effects. We cluster standard errors by industry and year.[1] The coefficient of interest is α_1, with H1a asserting that α_1 is significant and positive, and H1b indicating a negative α_1.

[1] In unreported results, we find that the size and statistical significance of the key variables do not change qualitatively when clustering at the firm level.

Table 4 presents the estimation results of the model (Eq. (1). Each column applies the regression model to a different measure of discretionary accruals. In column (1), we regress *EMJones* on *TaxOfficer* and other earnings management determinants. The coefficient of *TaxOfficer* is 0.005, which is significant at the 1 % level. In terms of economic significance, this suggests that the presence of a tax officer director on the board increases discretionary accruals by 83.33 % (i.e., 0.005/0.006) on average. In columns (2) to (4), the coefficients of *TaxOfficer* are statistically and economically similar. Thus, regardless of the measure of discretionary accruals, the coefficients of *TaxOfficer* are consistently positive and significant both statistically and economically, supporting H1a. Theoretically, tax officer directors with superior THC contribute to their firms in two key ways: through their general knowledge of tax avoidance (general THC) and their insights into the styles, focus, preferences and personal characteristics of the tax officers responsible for their corporate employer's tax affairs (specific THC). While we do not disregard the influence of general THC, our subsequent analyses reveal that the specific THC of tax officer directors is the primary driver of firms being simultaneously aggressive in both financial and tax reporting.

To validate the parallel pre-treatment trends of the treated and control groups and to analyze the treatment dynamics, we use the following dynamic DiD regression model:

$$AggressiveFR_{i,t} = \alpha_0 + \sum_{\tau=-4}^{4} \alpha_{1,\tau} \times TaxOfficer_{i,t-\tau} + Controls_{i,t} + Industry + Year + \varepsilon_{i,t} \quad (2)$$

where $TaxOfficer_{i,t-\tau}$ is an indicator variable that equals one for the yearly observation in year τ ($-4 \leq \tau \leq 4$) relative to the appointment year ($\tau = 0$) of tax officer directors for firm i. The extent to which the conditional time-variation of firms with tax officer directors deviates from the control firms is captured by the coefficient $\alpha_{1,\tau}$.

In Fig. 1, we visualize estimates of the parallel trends by plotting $\alpha_{1,\tau}$ along with its 90 percent confidence interval for $-4 \leq \tau \leq 4$. For all of the proxies for financial reporting aggressiveness, we find that coefficients on $\alpha_{1,-4}$, $\alpha_{1,-3}$, $\alpha_{1,-2}$ and $\alpha_{1,-1}$ are not statistically significant, which supports the assumption of parallel trends between firms with and without tax officer directors in the pre-appointment period. In contrast, $\alpha_{1,0}$, $\alpha_{1,+1}$, $\alpha_{1,+2}$, $\alpha_{1,+3}$ and $\alpha_{1,+4}$ are all significant and positive, indicating that firms are systematically more aggressive after hiring tax officers as independent directors. These results clearly indicate that the presence of tax officer directors has a causal effect on firms' financial reporting aggressiveness.

4.3. Robustness checks

The baseline regression suggests that firms with tax officer directors adopt more aggressive financial reporting practices. We note that the presence of tax officer directors on boards is concentrated early in the sample period. Over the 14-year sample period (2008 to 2021), approximately 66.99 % of tax officer directors were employed before 2013. Their observed positive impact on financial reporting is likely driven by this pre-2013 subsample. To examine the robustness of the baseline results to the sample distribution, we replicate the baseline regressions using observations from the post-2013 period. The results in Table 5 are qualitatively similar to those in Table 4.

Our sample period begins with the 2008 global financial crisis, which prompted the Chinese government to introduce the world's largest stimulus package. The increased discretionary accruals may result from the supply of money rather than from the impact of tax officer directors. To ensure the robustness of our findings, we exclude the 2008 data and re-run the regression on discretionary accruals, as presented in Table 6. The positive impact of tax officer directors on financial reporting aggressiveness remains qualitatively consistent when excluding the 2008 observations.

4.4. Addressing potential endogeneity concerns

An important concern regarding the baseline results is that our estimates of the relationship between the presence of tax officer directors and financial reporting aggressiveness are limited in elucidating causality because of potential omitted variables and reverse causality. Generally, firms' decision to hire tax officers

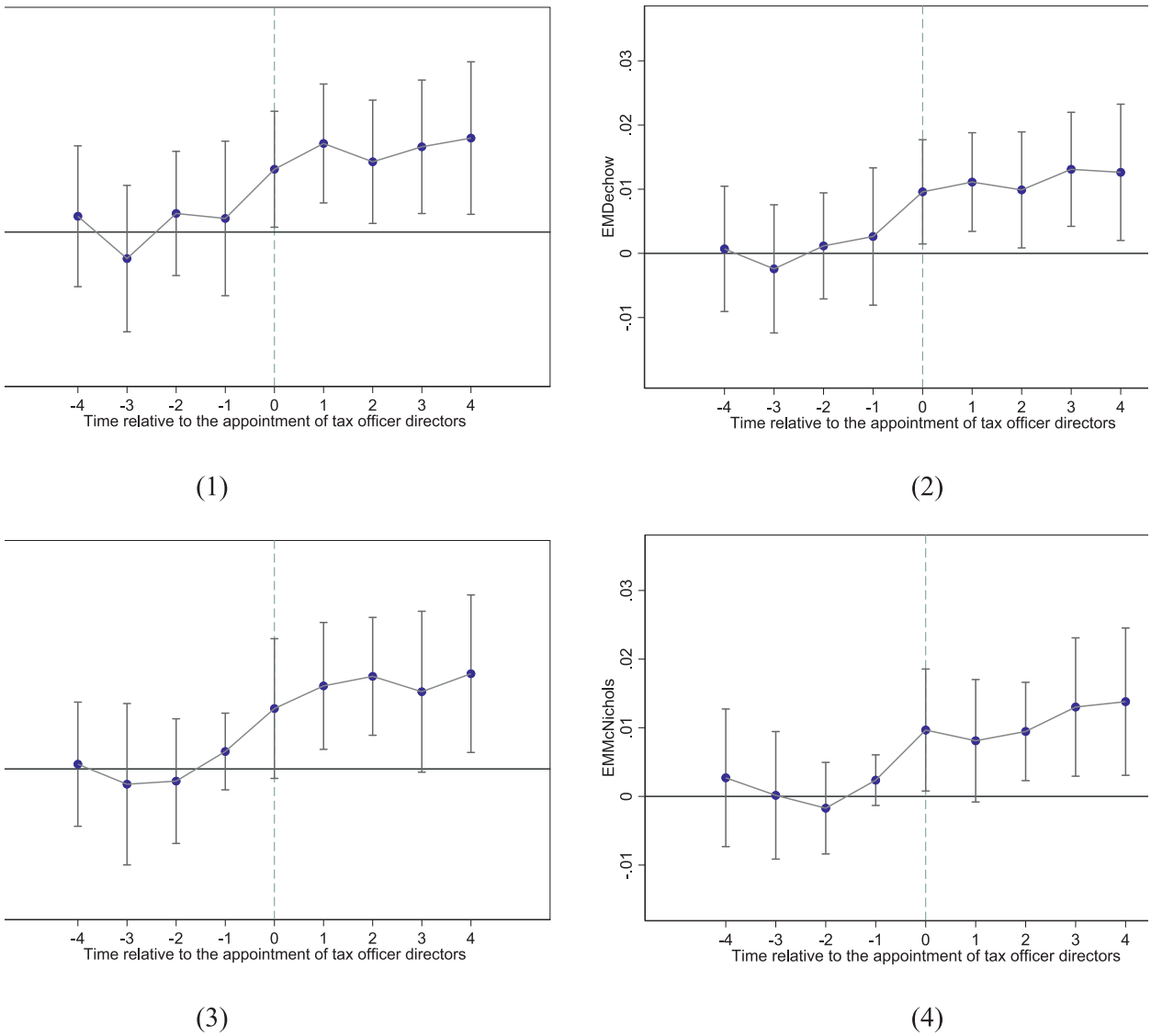

Fig. 1. **The dynamics of corporate financial reporting aggressiveness.** This figure illustrates the parameter $\alpha_{1,\tau}$ with $-4 \leq \tau \leq 4$, and its 90 % confidence level, estimated from model Eq. (2). Aggressive FR is proxied by EMJones, EMDechow, EMDichev, EMMcNichols in panels (1) to (4), respectively. See Appendix A for the detailed definitions. $\alpha_{1,\tau}$ captures the extent to which the conditional time-variation of firms with tax officer directors deviate from the control firms. $\alpha_{1,-5}$ is set to zero in the estimation to avoid collinearity.

as independent directors is not an exogenous concern. Therefore, the estimated positive relationship could result from factors driving both the hiring of tax officer directors and the aggressiveness of financial reporting. Moreover, a high level of discretionary accruals is likely to induce firms to choose tax officers as independent directors. To address these concerns and establish causality, we perform several tests.

4.4.1. Propensity score matching estimates

To mitigate the potential influence of omitted correlated variables on our results, we use the propensity score matching (PSM) approach. We first estimate a logit regression to model the probability of firms hiring former tax officers as independent directors. We include the same independent variables as in Eq. (1) in the PSM model to ensure that all of the known factors that potentially affect financial reporting aggressiveness remain consistent across firms with and without tax officer directors. Next, we calculate the propensity score

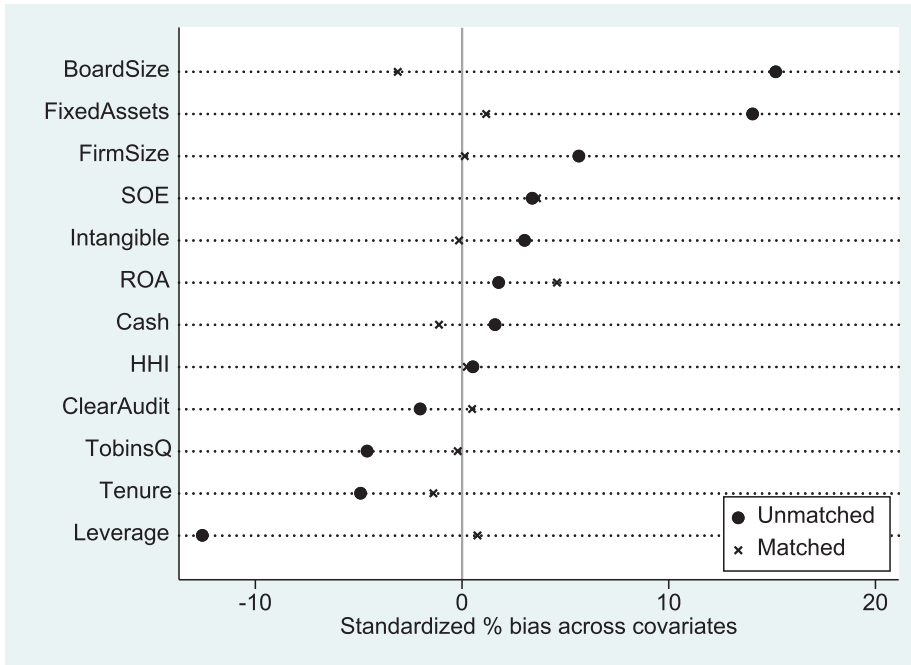

Fig. 2. **PSM and firm characteristics of firms with and without tax officer directors.** This figure shows the impact of PSM on the comparability of characteristics for firms with and without hiring tax officers as independent directors.

for each firm using the predicted probabilities from the logit model. Adopting nearest-neighborhood matching with replacement,[2] we match each firm with tax officer directors to one without such directors and replicate the baseline regression using the PSM-matched samples.[3]

Table 7 presents the PSM results. Regardless of the measure of financial reporting aggressiveness, the coefficients of *TaxOfficer* remain positive and significant, at least at the 5 % level. In column (1), where financial reporting aggressiveness is proxied by discretionary accruals computed from Jones (1991), *TaxOfficer* exhibits a coefficient of 0.006. This implies that the discretionary accruals of firms with tax officer directors are 100 % (i.e., 0.006/0.006) higher than those of an average firm without tax officer directors. Upon examining the other proxies in columns (2) to (4), we observe that the influence of tax officer directors on discretionary accruals is more pronounced than that observed in the baseline regression in Table 4. This is understandable as incomparable firms are filtered out by the PSM method. These results alleviate the concern that the positive impact of tax officer directors on financial reporting aggressiveness stems from biases caused by omitted observables, although it cannot completely eliminate this concern.

4.4.2. Heckman two-stage regressions

Another concern regarding the relationship between hiring former tax officers as independent directors and financial reporting aggressiveness is the potential selection bias resulting from unobservable factors. To address this issue, we use the Heckman two-stage method for regression estimation. We compute the average rate of firms hiring tax officers as independent directors within the same province as the sample firm, denoting it as *PeerEffect*. In the first stage, we use *PeerEffect* and the other control variables in Eq. (1) to estimate the

[2] We do not observe a qualitative change in results when implementing the matching procedure without replacement.

[3] Our tests for differences in the regression covariates of the average treatment firms and control firms show that the two groups differ in certain respects, such as firm size and leverage. Implementing PSM significantly reduces these differences. After applying PSM, we find that the observable determinants of financial reporting aggressiveness in firms with tax officer directors are not statistically different from those in firms without tax officers on their boards. For a detailed evaluation of the PSM matching quality, please refer to Appendix B, and see Fig. 2 for a visual representation of the matching quality.

Table 5
Replicating the baseline regression by using the post-2013 sample.

	(1) *EMJones*	(2) *EMDechow*	(3) *EMDichev*	(4) *EMMcNichols*
TaxOfficer	0.003*	0.003*	0.003	0.003*
	(1.89)	(1.94)	(1.67)	(1.74)
FirmSize	−0.010***	−0.009***	−0.011***	−0.010***
	(−13.18)	(−12.98)	(−12.95)	(−10.37)
Leverage	0.054***	0.053***	0.067***	0.065***
	(12.36)	(12.62)	(15.01)	(14.32)
ROA	0.052***	0.040***	0.044***	0.034***
	(5.49)	(4.53)	(4.11)	(3.24)
Tobin's Q	0.001**	0.001**	0.003***	0.003***
	(2.56)	(2.43)	(7.95)	(7.38)
Cash	−0.039***	−0.035***	−0.030***	−0.032***
	(−9.35)	(−9.24)	(−7.04)	(−9.45)
Intangible	−0.072***	−0.070***	−0.041***	−0.060***
	(−9.24)	(−8.77)	(−5.05)	(−8.42)
FixedAssets	−0.018***	−0.012***	−0.023***	−0.028***
	(−4.40)	(−3.13)	(−5.16)	(−7.07)
BoardSize	−0.000	−0.000	−0.001***	−0.001**
	(−1.60)	(−1.18)	(−2.83)	(−2.66)
ClearAudit	0.002	0.002	−0.001	0.001
	(0.90)	(0.67)	(−0.21)	(0.20)
HHI	−0.017***	−0.015***	−0.021***	−0.018***
	(−4.15)	(−3.98)	(−4.66)	(−3.93)
Tenure	−0.000***	−0.000**	−0.000***	−0.000***
	(−2.95)	(−2.75)	(−3.84)	(−4.07)
SOE	−0.002**	−0.002**	−0.002***	−0.002***
	(−2.45)	(−2.65)	(−2.77)	(−3.14)
Constant	−0.173***	−0.158***	−0.203***	−0.160***
	(−13.56)	(−13.12)	(−13.70)	(−10.31)
Industry	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
N	19,255	19,255	19,255	19,255
Adj-R^2	0.046	0.043	0.053	0.048

This table shows the regressions of discretionary accruals based on the sample observed from 2014 to 2021. The dependent variables are various measures of discretionary accruals estimated from Jones (1991), Dechow et al. (1995), Dechow & Dichev (2002), and McNichols (2002), respectively. Detailed definitions of all variables are provided in Appendix A. We report robust t-statistics adjusted for two-way clustering in parentheses at both industry and year levels. *, **, and *** indicate significance at the 1%, 5%, and 10% levels, respectively.

probit regression, with *TaxOfficer* (the indicator variable for firms with tax officer directors) as the dependent variable, which yields the inverse Mills ratio (*IMR*). Subsequently, we re-run the analysis with *IMR* to control for potential sample selection bias. Table 8 presents the results. Consistent with our baseline findings, the coefficients of *TaxOfficer* remain positive and significant. We note that *IMR* exhibits marginally significant coefficients, indicating that our baseline results may be affected by some unobservable factors. Nevertheless, our baseline results are not driven by selection bias.

4.4.3. Forced resignation of tax officer directors and financial reporting aggressiveness

In our baseline analysis, we use tax officers joining a firm's board of directors as a key variable and construct a staggered DiD model to test the impact of tax officer directors on financial reporting aggressiveness. In this section, we further explore an exogenous regulatory event that forced the resignation of tax officer directors, enabling us to conduct reverse verification. Specifically, on 19 October 2013, the Communist Party of China introduced a new regulation governing the involvement of incumbent and newly retired government officials as independent directors of listed firms. This regulation prohibits incumbent officials from serving as independent directors and bars retired officials from assuming positions in firms within the geographical area

Table 6
The 2008 financial crisis and the effect of tax officer directors.

	(1)	(2)	(3)	(4)
	EMJones	*EMDechow*	*EMDichev*	*EMMcNichols*
TaxOfficer	0.005***	0.005***	0.006***	0.005***
	(3.97)	(4.35)	(3.17)	(3.41)
FirmSize	−0.011***	−0.010***	−0.012***	−0.010***
	(−12.57)	(−12.77)	(−12.65)	(−10.17)
Leverage	0.055***	0.054***	0.070***	0.068***
	(13.35)	(13.97)	(16.94)	(15.66)
ROA	0.076***	0.062***	0.072***	0.058***
	(8.79)	(7.68)	(7.61)	(5.90)
Tobin's Q	0.002***	0.002***	0.004***	0.003***
	(4.63)	(4.44)	(10.07)	(8.71)
Cash	−0.042***	−0.039***	−0.028***	−0.032***
	(−10.87)	(−10.88)	(−8.15)	(−9.65)
Intangible	−0.072***	−0.068***	−0.039***	−0.056***
	(−10.67)	(−10.23)	(−5.55)	(−7.82)
FixedAssets	−0.017***	−0.011***	−0.023***	−0.030***
	(−4.55)	(−3.25)	(−6.32)	(−8.93)
BoardSize	−0.001***	−0.001**	−0.001***	−0.001***
	(−2.76)	(−2.15)	(−5.01)	(−4.73)
ClearAudit	0.000	0.000	−0.004	−0.002
	(0.15)	(0.12)	(−1.30)	(−0.66)
HHI	−0.016***	−0.014***	−0.024***	−0.022***
	(−3.82)	(−3.72)	(−5.77)	(−5.06)
Tenure	−0.000***	−0.000***	−0.001***	−0.000***
	(−2.99)	(−2.85)	(−4.21)	(−4.28)
SOE	−0.003***	−0.002***	−0.002***	−0.003***
	(−2.91)	(−3.01)	(−2.79)	(−3.53)
Constant	−0.186***	−0.170***	−0.218***	−0.166***
	(−12.80)	(−12.98)	(−13.13)	(−9.90)
Industry	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
N	25,065	25,065	25,065	25,065
Adj-R^2	0.055	0.051	0.066	0.057

This table replicates the main regression of discretionary accruals by removing observations from 2008. The dependent variables are various measures of discretionary accruals estimated from Jones (1991), Dechow et al. (1995), Dechow & Dichev (2002), and McNichols (2002), respectively. Detailed definitions of all variables are provided in Appendix A. We report robust t-statistics adjusted for two-way clustering in parentheses at both industry and year levels. *, **, and *** indicate significance at the 1%, 5%, and 10% levels, respectively.

or sphere of influence of their former government positions for 3 years after retirement. Even those who have been retired for 3 years must obtain approval from the party, which can be challenging. Consequently, many independent directors employed by the Chinese government and related institutions were forced to resign from listed firms.

Firms experiencing the forced resignation of tax officer directors suffered a sudden loss of the THC resources that helped them exploit nonconformities between accounting standards and corporate income tax laws. Consequently, any changes in financial reporting aggressiveness following this event can be attributed to the loss of THC and associated resources, rather than to unobserved firm characteristics. To compare the changes in financial reporting aggressiveness after the implementation of this regulation between firms with tax officer directors and those without such politically connected directors, we estimate the following model.

$$AggressiveFR_{i,t} = \beta_0 + \beta_1 Treat_{i,t} \times Post2013 + \beta_2 Treat_{i,t} + Controls_{i,t} + Industry + Year + v_{i,t} \quad (3)$$

where $Treat_{i,t}$ takes the value of one for firms whose tax officer directors resigned after the 2013 regulatory shock, and zero for control firms that never hired any directors who were employed by the government

Table 7
Addressing potential selection bias resulting from functional form misspecification.

	(1) *EMJones*	(2) *EMDechow*	(3) *EMDichev*	(4) *EMMcNichols*
TaxOfficer	0.006**	0.006**	0.007***	0.007**
	(2.12)	(2.15)	(3.11)	(2.65)
FirmSize	−0.009***	−0.008***	−0.013***	−0.010***
	(−5.30)	(−5.07)	(−7.93)	(−6.81)
Leverage	0.049***	0.049***	0.073***	0.071***
	(4.33)	(4.79)	(6.67)	(7.02)
ROA	0.135***	0.120***	0.137***	0.137***
	(4.76)	(4.44)	(5.03)	(4.72)
Tobin's Q	0.001	0.001	0.004***	0.003*
	(0.87)	(0.64)	(3.12)	(1.98)
Cash	−0.045***	−0.042***	−0.020**	−0.030***
	(−5.29)	(−5.00)	(−2.40)	(−3.09)
Intangible	−0.046	−0.046	−0.011	−0.036
	(−1.67)	(−1.69)	(−0.31)	(−1.08)
FixedAssets	−0.027**	−0.021**	−0.029***	−0.033***
	(−2.68)	(−2.18)	(−3.62)	(−3.90)
BoardSize	0.000	0.000	−0.001	−0.001*
	(0.27)	(0.40)	(−1.66)	(−1.72)
ClearAudit	−0.007	−0.007	−0.008	−0.008
	(−0.62)	(−0.72)	(−1.30)	(−1.17)
HHI	−0.023***	−0.019**	−0.033***	−0.029**
	(−2.99)	(−2.47)	(−3.45)	(−2.67)
Tenure	−0.000	−0.000	−0.000	−0.000
	(−1.07)	(−1.10)	(−1.36)	(−0.93)
SOE	−0.004	−0.004	−0.005	−0.005
	(−1.03)	(−1.06)	(−1.58)	(−1.43)
Constant	−0.153***	−0.138***	−0.223***	−0.158***
	(−4.84)	(−4.46)	(−8.11)	(−5.77)
Industry	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
N	2809	2809	2809	2809
Adj-R^2	0.057	0.054	0.081	0.068

This table replicates the baseline regressions using propensity score matching (PSM) samples. Detailed definitions of all variables are provided in Appendix A. We report robust t-statistics adjusted for two-way clustering in parentheses at both industry and year levels. The models include industry and year indicators, though we do not report their coefficients. *, **, and *** indicate significance at the 1%, 5%, and 10% levels, respectively.

and its controlled entities.[4] *Post2013* is an indicator variable with a value of one for years following the 2013 regulation and zero otherwise; other variables are consistent with those in Eq. (1).[5] The impact of the regulation is captured by the interaction term between firms hiring tax officer directors subject to the 2013 regulation (i.e., $Treat_{i,t}$) and the post-regulation indicator variable (i.e., *Post2013*).

Consistent with the results of the baseline model (Eq. (1)), the coefficients on $Treat_{i,t}$ are all significant and positive (Table 9), indicating that firms with tax officer directors were aggressive in financial reporting before their forced resignation due to the 2013 regulation. For the specific proxies for financial reporting aggressive-

[4] We require firms in the control group to have never employed directors affiliated with the government or its controlled entities to mitigate the influence of the 2013 regulatory shock on non-tax officer directors and their potential impact on the financial reporting of corporate employers. However, even after excluding such firms from the control group, the use of the 2013 regulatory shock as the basis for our DiD model has inherent limitations. Specifically, this regulatory change may have had implications for corporate operations and financial reporting beyond the scope of tax officer directors. As such, results derived from this regulatory event should be interpreted with caution and are presented as complementary evidence supporting our primary findings. We are grateful to Professor Yiran Kang for highlighting this important limitation.

[5] As year fixed effects are included in the model, the effect of *Post2013* is absorbed by the regression and is therefore not controlled for separately.

Table 8
Addressing potential selection bias resulting from unobservable factors.

	(1) *TaxOfficer*	(2) *EMJones*	(3) *EMDechow*	(4) *EMDichev*	(5) *EMMcNichols*
TaxOfficer		0.005***	0.005***	0.005***	0.005***
		(4.17)	(4.59)	(3.36)	(3.42)
PeerEffect	2.203***				
	(10.69)				
FirmSize	0.103*	−0.012***	−0.011***	−0.013***	−0.011***
	(1.81)	(−12.47)	(−12.64)	(−12.58)	(−10.14)
Leverage	0.222***	0.055***	0.055***	0.070***	0.067***
	(3.83)	(14.12)	(14.95)	(17.23)	(16.86)
ROA	−0.460***	0.081***	0.066***	0.075***	0.060***
	(−2.71)	(9.04)	(8.00)	(8.47)	(5.93)
Tobin's Q	0.035***	0.002***	0.002***	0.004***	0.004***
	(4.23)	(5.25)	(5.17)	(10.07)	(8.33)
Cash	0.051	−0.044***	−0.040***	−0.028***	−0.033***
	(0.67)	(−13.46)	(−13.46)	(−8.66)	(−11.05)
Intangible	0.859***	−0.072***	−0.067***	−0.038***	−0.055***
	(4.74)	(−9.58)	(−9.10)	(−5.11)	(−7.87)
FixedAssets	0.138**	−0.014***	−0.008**	−0.024***	−0.028***
	(2.01)	(−4.16)	(−2.66)	(−6.61)	(−8.50)
BoardSize	0.009*	−0.001**	−0.000*	−0.001***	−0.001***
	(1.79)	(−2.57)	(−1.87)	(−4.90)	(−4.94)
ClearAudit	−0.127**	−0.001	−0.001	−0.005	−0.004
	(−2.05)	(−0.42)	(−0.35)	(−1.46)	(−1.19)
HHI	−0.667***	−0.024***	−0.023***	−0.031***	−0.030***
	(−8.07)	(−4.51)	(−4.42)	(−5.79)	(−5.48)
Tenure	0.024***	−0.000	−0.000	−0.000***	−0.000**
	(9.32)	(−1.61)	(−1.41)	(−3.11)	(−2.52)
SOE	0.018	−0.003***	−0.002***	−0.002***	−0.003***
	(0.99)	(−3.13)	(−3.25)	(−3.11)	(−3.56)
IMR		0.011*	0.010*	0.008	0.012**
		(1.97)	(1.92)	(1.51)	(2.32)
Constant	−2.628***	−0.222***	−0.207***	−0.249***	−0.204***
	(−12.89)	(−10.38)	(−10.16)	(−11.24)	(−8.56)
Industry	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes
N	26,113	26,113	26,113	26,113	26,113
Adj/Pseudo-R^2	0.049	0.058	0.055	0.071	0.059

This table shows the Heckman (1979) two-stage regressions. *PeerEffect* is the average rate of firms hiring tax officers as independent directors for firms in the same province as the sample firm. Detailed definitions of all variables are provided in Appendix A. The t-statistics are adjusted for clustering at both industry and year levels in parentheses. *, **, and *** indicate significance at the 1%, 5%, and 10% levels, respectively.

ness, the coefficients on $Treat_{i,t} \times Post2013$ range from −0.004 to −0.005 and are statistically significant at the 1 % level. Collectively, these findings suggest that firms exhibit greater aggressiveness in financial reporting when tax officer directors are present, and this tendency diminishes after their departure. Consistent with the predictions of THC theory, these results reinforce Hypothesis H1a, which asserts that firms with tax officer directors are more aggressive in financial reporting than those without such directors.

4.5. Cross-sectional tests

Broadly, two possible, not mutually exclusive, explanations exist for the positive impact of tax officer directors on financial reporting aggressiveness. One explanation is that tax officer directors leverage their specific THC insights into the styles, focuses, preferences and personal characteristics of tax officers, developed through political connections with tax authorities, to reduce these officers' alertness to the co-existence of

Table 9
The impact of tax officer directors' forced resignation on financial reporting aggressiveness.

	(1) EMJones	(2) EMDechow	(3) EMDichev	(4) EMMcNichols
Treat × *Post2013*	−0.004***	−0.004***	−0.005***	−0.005***
	(−3.45)	(−3.24)	(−3.33)	(−3.23)
Treat	0.006**	0.005**	0.006**	0.006**
	(2.71)	(2.48)	(2.27)	(2.31)
FirmSize	−0.011***	−0.010***	−0.013***	−0.011***
	(−11.26)	(−11.63)	(−10.65)	(−9.17)
Leverage	0.059***	0.058***	0.071***	0.070***
	(13.62)	(14.18)	(14.19)	(14.42)
ROA	0.083***	0.069***	0.078***	0.062***
	(7.94)	(7.21)	(7.30)	(5.29)
Tobin's Q	0.002***	0.002***	0.004***	0.003***
	(3.72)	(3.66)	(7.91)	(6.84)
Cash	−0.044***	−0.041***	−0.029***	−0.034***
	(−13.35)	(−12.92)	(−7.48)	(−9.75)
Intangible	−0.074***	−0.069***	−0.041***	−0.061***
	(−9.01)	(−8.36)	(−5.60)	(−7.67)
FixedAssets	−0.014***	−0.008**	−0.024***	−0.028***
	(−3.64)	(−2.28)	(−5.49)	(−7.48)
BoardSize	−0.001**	−0.001*	−0.001***	−0.001***
	(−2.57)	(−1.98)	(−4.54)	(−4.80)
ClearAudit	0.000	0.000	−0.005	−0.004
	(0.06)	(0.09)	(−1.35)	(−1.07)
HHI	−0.017***	−0.016***	−0.027***	−0.024***
	(−3.39)	(−3.22)	(−5.31)	(−4.34)
Tenure	−0.000***	−0.000***	−0.001***	−0.001***
	(−3.53)	(−3.39)	(−4.32)	(−4.73)
SOE	−0.002	−0.002*	−0.001	−0.001
	(−1.63)	(−1.73)	(−1.33)	(−1.66)
Constant	−0.192***	−0.177***	−0.227***	−0.171***
	(−10.35)	(−10.80)	(−10.13)	(−7.95)
Industry	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
N	20,086	20,086	20,086	20,086
Adj-R^2	0.059	0.056	0.072	0.059

This table shows how the relationship between tax officer directors and corporate financial reporting aggressiveness is shocked by the Communist Party of China regulation in 2013 that forbids political officials from sitting on board. $Treat_{i,t}$ takes the value of one for firms whose tax officer directors resigned after the 2013 regulatory shock, and zero for control firms that never hired any directors who were ever employed by the government and its controlled entities. *Post2013* equals one if the observation is in years after 2013, and zero otherwise. Since the year fixed effects are controlled for, the effect of Post2013 is absorbed by these fixed effects and, therefore, omitted from the regression output. Detailed definitions of the variables are provided in Appendix A. We report robust t-statistics adjusted for two-way clustering in parentheses at both industry and year levels. The models include industry and year indicators, though we do not report their coefficients. *, **, and *** indicate significance at the 1%, 5%, and 10% levels, respectively.

overstated accounting earnings and deflated taxable earnings, thereby decreasing the likelihood of tax enforcement actions being taken. Another explanation is that tax officer directors use their general THC (expertise in the nonconformity of tax laws and accounting standards) to satisfy shareholders with inflated earnings while legally avoiding taxes. In this section, we conduct cross-sectional tests using variations in several characteristics of tax officer directors and hiring firms to shed light on the forms of THC underlying our main findings.

4.5.1. Advantages of local vs. Non-local officers

First, we conduct a cross-sectional comparison between firms that employ local and non-local tax officers. Local tax officers serve in the tax bureaus within the same province as the hiring firm, whereas non-local tax officers have experience in tax bureaus outside the firm's province. Since firms across different provinces in

China adhere to the same tax laws, we do not expect a systematic variance in tax avoidance expertise between local and non-local tax officers. However, local tax officer directors may have an advantage over their non-local counterparts in terms of political connections with tax collectors. Therefore, we argue that local tax officer directors possess more specific THC than their non-local counterparts. If specific THC drives our findings, we expect firms with local tax officer directors to be more aggressive in financial reporting than those hiring tax officer directors from other provinces.

Based on the locations of tax offices, we construct two indicator variables: *LocalOfficer* and *NonLocalOfficer*. *LocalOfficer* indicates firms whose tax officer directors previously served in a local tax bureau within the same province as the hiring firm, while *NonLocalOfficer* represents firms employing tax officer directors with experience in tax offices outside the hiring firm's province. We substitute the two indicator variables for *TaxOfficer* and replicate the regression analysis for financial reporting aggressiveness. Table 10 presents the results. The coefficient of *NonLocalOfficer* is not significant, whereas that of *LocalOfficer* is significant at the 1 % level across the regressions using various measures of financial reporting aggressiveness. In an untabulated analysis, we observe that the coefficients of *LocalOfficer* are statistically greater than those of *NonLocalOfficer*, suggesting that the effect of tax officer directors stems from specific THC rather than general THC.

4.5.2. Advantages of employing directors with previous tax collector experience

In the heterogeneity analysis, we assume that municipal tax bureaus collect income tax from firms within their locality. Although this assumption is reasonable, it may not always hold. Between 1994 and 2018, China's tax collection system was run by two government departments: the National Tax Bureau (and its local branches) and local tax bureaus (and their branches). Each department handled taxation affairs for different types of firms. Specifically, before 2002, the National Tax Bureau collected income tax from foreign-owned enterprises, from state-owned enterprises (SOEs) owned by the central government and from financial institutions, while the remaining firms paid income tax to their local tax bureaus. In 2002, the National Tax Bureau gained more authority over taxation. Except for SOEs owned by local governments and non-SOEs, all firms established after 2002 pay taxes to the National Tax Bureau (Tang et al., 2017; Cai et al., 2018). Thus, if a firm pays its income tax to a local tax bureau and its tax officer director is a tax officer affiliated with the local tax bureau system, the director's specific THC (developed through political connections with tax authorities) may prove particularly advantageous for tax avoidance.

To further examine whether the specific THC of previous tax collector directors boosts financial reporting aggressiveness, we construct two indicator variables (i.e., *NationalBureau* and *LocalBureau*) that capture the former government employer of the tax officer director. *NationalBureau* signifies firms whose tax officer directors previously worked in the national tax bureau system. *LocalBureau* denotes firms whose tax officer directors are affiliated with a local tax bureau. We divide our sample firms into two subsamples based on tax collectors' backgrounds and regress our proxies for financial reporting aggressiveness against *NationalBureau* and *LocalBureau*. The results are summarized in Table 11.

The first set of columns displays the regression results for the subsample of firms that pay income tax to the National Tax Bureau. The coefficients of *NationalBureau* are significant and positive, while those of *LocalBureau* are not significant at the conventional level. These findings suggest that firms with tax officer directors affiliated with the National Tax Bureau exhibit increased aggressiveness in financial reporting when their income taxes are collected by the National Tax Bureau.

The second set of columns pertain to the subsample of firms paying taxes to local tax bureaus. We observe that only the coefficients of *LocalBureau* are statistically significant, while those of *NationalBureau* are not significant at the conventional level. This indicates that tax officer directors' previous employment in local tax bureaus significantly increases the financial reporting aggressiveness of firms paying taxes to local tax bureaus. Conversely, hiring a former tax officer who was not previously employed at the local tax authority does not significantly impact financial reporting aggressiveness. These results highlight the significance of specific THC and its role in driving the baseline findings.

Table 10
The incremental impact of local tax officer directors on financial reporting aggressiveness.

	(1) *EMJones*	(2) *EMDechow*	(3) *EMDichev*	(4) *EMMcNichols*
LocalOfficer	0.006***	0.006***	0.006***	0.007***
	(4.39)	(4.76)	(3.14)	(3.43)
NonLocalOfficer	0.003	0.002	0.002	0.002
	(1.07)	(1.08)	(0.84)	(0.70)
FirmSize	−0.011***	−0.010***	−0.013***	−0.011***
	(−12.81)	(−13.08)	(−12.46)	(−10.33)
Leverage	0.057***	0.056***	0.071***	0.069***
	(15.01)	(15.94)	(17.22)	(16.71)
ROA	0.084***	0.069***	0.078***	0.063***
	(9.40)	(8.41)	(8.74)	(6.51)
Tobin's Q	0.002***	0.002***	0.004***	0.003***
	(4.73)	(4.56)	(9.43)	(8.40)
Cash	−0.044***	−0.041***	−0.029***	−0.034***
	(−13.54)	(−13.58)	(−8.70)	(−11.05)
Intangible	−0.079***	−0.074***	−0.043***	−0.063***
	(−12.01)	(−11.53)	(−6.34)	(−9.24)
FixedAssets	−0.015***	−0.009***	−0.025***	−0.029***
	(−4.21)	(−2.81)	(−6.61)	(−8.62)
BoardSize	−0.001***	−0.001**	−0.001***	−0.001***
	(−2.94)	(−2.21)	(−5.36)	(−5.41)
ClearAudit	−0.000	−0.000	−0.004	−0.003
	(−0.08)	(−0.00)	(−1.27)	(−0.93)
HHI	−0.019***	−0.017***	−0.027***	−0.024***
	(−4.18)	(−4.07)	(−5.89)	(−5.21)
Tenure	−0.000***	−0.000***	−0.001***	−0.001***
	(−3.52)	(−3.34)	(−4.77)	(−4.96)
SOE	−0.003***	−0.003***	−0.002***	−0.003***
	(−3.24)	(−3.36)	(−3.16)	(−3.69)
Constant	−0.188***	−0.174***	−0.224***	−0.167***
	(−12.69)	(−13.07)	(−12.56)	(−9.68)
Industry	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
N	26,113	26,113	26,113	26,113
Adj-R^2	0.058	0.055	0.071	0.058

This table shows the impact of local and nonlocal tax officer directors on corporate financial reporting aggressiveness. *LocalOfficer* is an indicator variable for firms whose tax officer directors served at local tax offices. *NonLocalOfficer* is an indicator variable for firms whose tax officer directors served at tax offices outside the province of the hiring firm. Detailed definitions of all variables are provided in Appendix A. We report robust t-statistics adjusted for two-way clustering in parentheses at both industry and year levels. *, **, and *** indicate significance at the 1%, 5%, and 10% levels, respectively.

4.5.3. Variations associated with different tax enforcement intensities

It is widely accepted that tax law enforcement intensity varies substantially across different regions in China (Lin et al., 2018; Xiao and Shao, 2020; Chen et al., 2021; Lei, 2021). Lin et al. (2018) find that ties between corporate boards of directors and politicians weaken the effectiveness of tax authorities in restraining tax avoidance in China. The probability of a firm intentionally understating taxable earnings significantly increases for firms with politically connected directors. Following Lin et al. (2018), we conduct another cross-sectional test to explore how tax enforcement intensity affects the relationship between the presence of tax officer directors and financial reporting aggressiveness. We expect that firms in regions with less stringent tax law enforcement will benefit more from hiring tax officers with connections to local tax enforcement authorities than firms in regions with stringent tax law enforcement.

We construct a dummy variable, denoted as *Strict*, to capture the degree of tax enforcement experienced by a firm and interact it with the key explanatory variable *TaxOfficer*. As shown in Table 12, the coefficients of the interaction term $TaxOfficer \times Strict$ are negative and significant, regardless of the measurement of abnor-

Table 11
The affiliation of tax officer directors and financial reporting aggressiveness.

	Paying income tax to the National Tax Bureau				Paying income tax to the Local Tax Bureaus			
	(1) *EMJones*	(2) *EMDechow*	(3) *EMDichev*	(4) *EMMcNichols*	(5) *EMJones*	(6) *EMDechow*	(7) *EMDichev*	(8) *EMMcNichols*
NationalBureau	0.005**	0.006**	0.005**	0.006**	0.000	0.000	0.001	0.002
	(2.27)	(2.57)	(2.16)	(2.39)	(1.01)	(0.08)	(0.80)	(1.27)
LocalBureau	0.001	0.002	0.001	0.000	0.006***	0.006***	0.006***	0.006***
	(0.72)	(0.98)	(0.38)	(0.03)	(3.33)	(3.46)	(3.03)	(2.93)
FirmSize	−0.017***	−0.015***	−0.019***	−0.017***	−0.013***	−0.012***	−0.016***	−0.013***
	(−6.64)	(−6.67)	(−7.76)	(−6.85)	(−15.37)	(−14.59)	(−14.69)	(−12.56)
Leverage	0.099***	0.097***	0.118***	0.116***	0.063***	0.063***	0.080***	0.076***
	(12.06)	(12.39)	(17.96)	(14.57)	(12.09)	(12.93)	(13.31)	(13.39)
ROA	0.104***	0.083***	0.096***	0.077***	0.147***	0.126***	0.144***	0.119***
	(5.95)	(5.48)	(5.31)	(3.73)	(10.97)	(9.95)	(12.69)	(8.63)
Tobin's Q	0.002***	0.002**	0.005***	0.004***	0.003***	0.003***	0.007***	0.005***
	(2.93)	(2.72)	(5.31)	(4.89)	(4.29)	(4.05)	(9.91)	(8.70)
Cash	−0.063***	−0.056***	−0.045***	−0.055***	−0.066***	−0.062***	−0.043***	−0.049***
	(−18.16)	(−19.65)	(−7.62)	(−10.19)	(−9.19)	(−9.10)	(−7.93)	(−7.79)
Intangible	−0.126***	−0.120***	−0.102***	−0.126***	−0.093***	−0.087***	−0.044***	−0.069***
	(−4.79)	(−4.44)	(−4.52)	(−5.20)	(−7.98)	(−7.71)	(−3.26)	(−5.36)
FixedAssets	−0.040***	−0.030***	−0.048***	−0.057***	−0.009	−0.003	−0.023***	−0.027***
	(−4.56)	(−3.68)	(−6.14)	(−8.14)	(−1.50)	(−0.61)	(−4.14)	(−4.61)
BoardSize	−0.001	−0.001	−0.002*	−0.002*	−0.001**	−0.001	−0.002***	−0.002***
	(−0.95)	(−0.72)	(−1.86)	(−1.94)	(−2.09)	(−1.53)	(−5.32)	(−4.69)
ClearAudit	−0.023	−0.019	−0.018	−0.019	0.004	0.004	−0.002	−0.001
	(−1.68)	(−1.48)	(−1.45)	(−1.52)	(0.64)	(0.71)	(−0.42)	(−0.16)
HHI	−0.028***	−0.024***	−0.042***	−0.038***	−0.025***	−0.024***	−0.033***	−0.031***
	(−3.83)	(−3.34)	(−5.41)	(−4.81)	(−3.85)	(−3.79)	(−5.18)	(−4.81)
Tenure	−0.001*	−0.001*	−0.001**	−0.001**	−0.001***	−0.001***	−0.001***	−0.001***
	(−1.78)	(−1.92)	(−2.32)	(−2.68)	(−3.58)	(−3.41)	(−4.27)	(−4.39)
SOE	−0.004***	−0.004**	−0.004**	−0.005***	−0.004***	−0.004***	−0.003***	−0.003**
	(−2.79)	(−2.63)	(−2.56)	(−3.50)	(−2.76)	(−2.82)	(−2.89)	(−2.59)
Constant	−0.266***	−0.247***	−0.312***	−0.254***	−0.246***	−0.227***	−0.292***	−0.223***
	(−5.55)	(−5.57)	(−6.41)	(−5.09)	(−13.06)	(−12.27)	(−14.47)	(−12.12)
Industry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	6959	6959	6959	6959	12,402	12,402	12,402	12,402
Adj-R^2	0.095	0.089	0.114	0.102	0.072	0.069	0.089	0.070

This table shows how the tax office affiliations of independent directors affect their relationship with corporate financial reporting aggressiveness. Columns (1) to (4) show regression results for firms whose income taxes are collected by the local branches of the state tax bureau. Columns (5) to (8) show regression results for firms whose income taxes are collected by the local tax bureaus. *NationalBureau* equals one if the independent director of a firm was affiliated with the National Tax Bureau, and zero otherwise. *LocalBureau* equals one if the independent director of a firm was affiliated with the Local Tax Bureaus, and zero otherwise. Detailed definitions of all variables are provided in Appendix A. We report robust t-statistics adjusted for two-way clustering in parentheses at both industry and year levels. *, **, and *** indicate significance at the 1%, 5%, and 10% levels, respectively.

mal accruals. By summing the coefficients on *TaxOfficer* × *Strict* and *Strict*, we find that strict tax enforcement has a negative impact on the financial reporting aggressiveness of firms, ranging from –0.008 to –0.01. Consistent with the specific THC explanation, firms in regions with strict enforcement are 80 % to 91 % less aggressive in financial reporting than those facing lenient taxation authorities.

4.6. Additional analyses

4.6.1. The political ranking of tax officer directors

As previously discussed, we interpret our baseline results as driven by specific THC (developed through political connections with tax authorities). We argue that the specific THC of tax officer directors, manifested

Table 12
Tax enforcement intensity and the impact of tax officer directors on corporate financial reporting aggressiveness.

	(1) *EMJones*	(2) *EMDechow*	(3) *EMDichev*	(4) *EMMcNichols*
TaxOfficer × *Strict*	−0.007**	−0.006**	−0.005**	−0.006*
	(−2.34)	(−2.42)	(−2.51)	(−2.11)
Strict	−0.003***	−0.003***	−0.003***	−0.003***
	(−4.09)	(−4.00)	(−4.12)	(−4.02)
TaxOfficer	0.011***	0.011***	0.010***	0.010***
	(4.76)	(5.07)	(5.96)	(5.18)
FirmSize	−0.011***	−0.010***	−0.013***	−0.011***
	(−3.69)	(−3.66)	(−4.39)	(−3.80)
Leverage	0.056***	0.056***	0.071***	0.069***
	(3.40)	(3.49)	(3.77)	(3.83)
ROA	0.083***	0.068***	0.077***	0.063***
	(3.33)	(3.16)	(3.04)	(3.05)
Tobin's Q	0.002**	0.002**	0.004***	0.003***
	(2.84)	(2.83)	(3.31)	(3.46)
Cash	−0.044***	−0.040***	−0.028**	−0.033**
	(−3.52)	(−3.42)	(−2.37)	(−2.83)
Intangible	−0.080***	−0.076***	−0.044**	−0.064***
	(−3.32)	(−3.27)	(−2.30)	(−3.04)
FixedAssets	−0.015	−0.009	−0.025**	−0.029**
	(−1.53)	(−1.00)	(−2.27)	(−2.79)
BoardSize	−0.001**	−0.000**	−0.001***	−0.001***
	(−2.62)	(−2.25)	(−3.95)	(−3.89)
ClearAudit	−0.000	0.000	−0.004	−0.003
	(−0.03)	(0.04)	(−1.29)	(−0.95)
HHI	−0.018**	−0.017**	−0.026***	−0.024***
	(−2.43)	(−2.40)	(−3.47)	(−3.27)
Tenure	−0.000**	−0.000**	−0.001***	−0.001**
	(−2.47)	(−2.25)	(−3.37)	(−2.96)
SOE	−0.003**	−0.003**	−0.002**	−0.003**
	(−2.45)	(−2.50)	(−2.20)	(−2.24)
Constant	−0.188***	−0.174***	−0.224***	−0.167***
	(−3.58)	(−3.56)	(−4.34)	(−3.44)
Industry	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
N	26,113	26,113	26,113	26,113
Adj-R^2	0.060	0.057	0.073	0.061

This table shows how the impact of tax officer directors on the extent of financial reporting aggressiveness varies with the intensity of tax enforcement. *Strict* takes the value of one for firms in regions featuring strict tax enforcement, and zero otherwise. Detailed definitions of the variables are provided in Appendix A. We report robust t-statistics adjusted for two-way clustering in parentheses at both industry and year levels. *, **, and *** indicate significance at the 1%, 5%, and 10% levels, respectively.

in their political affiliations with former colleagues within tax authorities, contributes to the financial reporting aggressiveness of their present employers. A natural follow-up question is whether the extent of aggressiveness intensifies as tax officer directors' specific THC increases. To further understand the effect of specific THC, we examine the variance in specific THC associated with the political ranking of tax officer directors within China's cadre system. We expect firms to demonstrate higher financial reporting aggressiveness if their boards include highly ranked tax officer directors (with greater levels of specific THC) than if their boards include low-ranking tax officer directors.

We construct a new variable, *Rank*, to denote the rank of a tax officer director in China's civil service system.[6] The current system has 11 levels, but individuals hired by listed firms generally served at relatively

[6] See the "Reform Plan on Civil Service Salary System" issued by the State Council of China athttp://www.gov.cn/zhengce/content/2019-03/19/content_5375052.htm?ivk_sa=1024320u (in Chinese).

low levels. To better capture the variation, *Rank* takes the value of one for section members and office workers, two for section heads, three for division heads and four for bureau-level directors and above. We regress our proxies for financial reporting aggressiveness against *Rank* and display the results in Table 13. Regardless of the chosen proxy for financial reporting aggressiveness, the coefficient estimates of *Rank* are significant at the 5 % level, which aligns with our expectation that firms with tax officer directors possessing high levels of THC exhibit greater financial reporting aggressiveness than those with tax officer directors possessing low levels of THC.

4.6.2. Impact of statutory tax rates

Firms in the U.S. are subject to uniform statutory tax rates. In contrast, China's statutory tax rates vary substantially, influenced by factors such as geographical location, ownership type, age and industry (Wu et al., 2007; Tang and Firth, 2011; Shevlin et al., 2012). Consequently, the scope for tax officer directors to exploit differences between accounting earnings and taxable income varies across statutory tax rates. There-

Table 13
The political ranking of tax officer directors and financial reporting aggressiveness.

	(1)	(2)	(3)	(4)
	EMJones	*EMDechow*	*EMDichev*	*EMMcNichols*
Rank	0.001**	0.001**	0.002**	0.002**
	(2.26)	(2.45)	(2.25)	(2.38)
FirmSize	−0.011***	−0.010***	−0.013***	−0.011***
	(−12.77)	(−13.04)	(−12.41)	(−10.28)
Leverage	0.057***	0.056***	0.071***	0.069***
	(15.00)	(15.93)	(17.19)	(16.68)
ROA	0.084***	0.069***	0.078***	0.063***
	(9.40)	(8.41)	(8.75)	(6.51)
Tobin's Q	0.002***	0.002***	0.004***	0.003***
	(4.75)	(4.59)	(9.44)	(8.39)
Cash	−0.044***	−0.041***	−0.029***	−0.034***
	(−13.52)	(−13.57)	(−8.72)	(−11.08)
Intangible	−0.079***	−0.074***	−0.043***	−0.063***
	(−11.97)	(−11.50)	(−6.36)	(−9.26)
FixedAssets	−0.015***	−0.009***	−0.025***	−0.029***
	(−4.21)	(−2.80)	(−6.63)	(−8.63)
BoardSize	−0.001***	−0.001**	−0.001***	−0.001***
	(−2.92)	(−2.19)	(−5.34)	(−5.40)
ClearAudit	−0.000	−0.000	−0.004	−0.003
	(−0.09)	(−0.01)	(−1.28)	(−0.94)
HHI	−0.019***	−0.017***	−0.027***	−0.024***
	(−4.18)	(−4.07)	(−5.88)	(−5.20)
Tenure	−0.000***	−0.000***	−0.001***	−0.001***
	(−3.53)	(−3.34)	(−4.78)	(−4.97)
SOE	−0.003***	−0.003***	−0.003***	−0.003***
	(−3.32)	(−3.47)	(−3.32)	(−3.85)
Constant	−0.188***	−0.174***	−0.224***	−0.167***
	(−12.64)	(−13.02)	(−12.50)	(−9.63)
Industry	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
N	26,113	26,113	26,113	26,113
Adj-R^2	0.057	0.054	0.071	0.058

This table shows how the civil service rank of a tax officer in the ranking system of China's civil servants affects discretionary accruals of the firm where they serve as independent directors. *Rank* takes the value of 1 for section members and ordinary staff, 2 for section heads, 3 for division heads, 4 for bureau-level directors and those above. Detailed definitions of the variables are provided in Appendix A. We report robust t-statistics adjusted for two-way clustering in parentheses at both industry and year levels. *, **, and *** indicate significance at the 1%, 5%, and 10% levels, respectively.

fore, we expect firms subject to high statutory tax rates to benefit more from hiring tax officer directors than firms subject to low statutory tax rates.

To evaluate the impact of statutory tax rates, we construct an indicator variable, *HighTax*, which takes the value of one when the statutory tax rate surpasses the average, and zero otherwise. In Table 14, we interact *HighTax* with our key explanatory variable *TaxOfficer* and regress the proxies for financial reporting aggressiveness against the interaction term. The coefficients of $TaxOfficer \times HighTax$ are positive and significant across all four columns. Consistent with our prediction, the evidence suggests that the impact of tax officer directors on financial reporting aggressiveness intensifies under high statutory tax rates. Hence, the effect of THC on financial reporting aggressiveness is strong when the need for directors' THC is high.

Table 14
Statutory tax rates and the impact of tax officer directors on financial reporting aggressiveness.

	(1)	(2)	(3)	(4)
	EMJones	*EMDechow*	*EMDichev*	*EMMcNichols*
TaxOfficer × *HighTax*	0.005**	0.004**	0.004**	0.005**
	(2.17)	(2.27)	(2.39)	(2.34)
HighTax	0.001***	0.001***	0.001***	0.001***
	(4.13)	(4.04)	(4.07)	(4.05)
TaxOfficer	0.001	0.001	0.002	0.001
	(1.15)	(1.17)	(1.30)	(1.14)
FirmSize	−0.011***	−0.010***	−0.013***	−0.011***
	(−3.69)	(−3.66)	(−4.39)	(−3.80)
Leverage	0.056***	0.056***	0.071***	0.069***
	(3.40)	(3.49)	(3.77)	(3.83)
ROA	0.083***	0.068***	0.077***	0.062***
	(3.32)	(3.15)	(3.04)	(3.04)
Tobin's Q	0.002**	0.002**	0.004***	0.003***
	(2.86)	(2.88)	(3.32)	(3.46)
Cash	−0.044***	−0.040***	−0.028**	−0.033**
	(−3.52)	(−3.42)	(−2.37)	(−2.83)
Intangible	−0.080***	−0.076***	−0.044**	−0.064***
	(−3.31)	(−3.27)	(−2.33)	(−3.08)
FixedAssets	−0.015	−0.009	−0.025**	−0.029**
	(−1.52)	(−1.00)	(−2.26)	(−2.78)
BoardSize	−0.001**	−0.000**	−0.001***	−0.001***
	(−2.59)	(−2.21)	(−3.99)	(−3.89)
ClearAudit	−0.000	0.000	−0.004	−0.003
	(−0.04)	(0.04)	(−1.31)	(−0.96)
HHI	−0.018**	−0.017**	−0.026***	−0.024***
	(−2.43)	(−2.40)	(−3.42)	(−3.27)
Tenure	−0.000**	−0.000**	−0.001***	−0.001***
	(−2.46)	(−2.24)	(−3.33)	(−3.02)
SOE	−0.003**	−0.003**	−0.002**	−0.003**
	(−2.41)	(−2.46)	(−2.20)	(−2.19)
Constant	−0.194***	−0.179***	−0.230***	−0.173***
	(−3.61)	(−3.59)	(−4.35)	(−3.47)
Industry	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
N	26,113	26,113	26,113	26,113
Adj-R^2	0.060	0.057	0.073	0.061

This table shows how the impact of tax officer directors on corporate financial reporting aggressiveness differs across firms faced with different statutory tax rates. *HighTax* is a dummy variable taking the value of one if the statutory tax rate of a firm is greater than that of an average firm, and zero otherwise. Detailed definitions of the variables are provided in Appendix A. We report robust t-statistics adjusted for two-way clustering in parentheses at both industry and year levels. *, **, and *** indicate significance at the 1%, 5%, and 10% levels, respectively.

4.6.3. Impact of tax officer directors on tax reporting aggressiveness

Given consistent tax rates, firms may have different effective tax rates due to tax planning strategies and leveraging favorable provisions within the tax code (Tang, 2020). The motives behind listed firms hiring former or current tax officers as independent directors can be categorized into two types. In addition to avoiding taxes arising from the aggressive overstating of accounting earnings, another equally—if not more—important objective is to avoid tax.

To avoid paying taxes, firms need to aggressively report low taxable earnings to the tax authorities. In column (1) of Table 15, we regress the book–tax difference (denoted as *BTD*) on *TaxOfficer*. Consistent with our prediction, the coefficient on *TaxOfficer* is positive and significant at conventional levels, indicating that firms with tax officer directors exhibit a wider gap between accounting and taxable earnings. If aggressive tax reporting is effective, we expect firms with tax officer directors to pay lower taxes. To test this, we construct two

Table 15
Tax officer directors and tax reporting aggressiveness.

	(1) *BTD*	(2) *Tax1*	(3) *Tax2*	(4) *Tax1*	(5) *Tax2*
TaxOfficer	0.003**	−0.011***	−0.015***	−0.007*	−0.009
	(2.26)	(−3.32)	(−3.14)	(−1.97)	(−1.68)
TaxOfficer × OCF				−0.007***	−0.010**
				(−3.18)	(−2.09)
OCF				0.015***	0.023***
				(3.28)	(3.37)
FirmSize	−0.002***	0.003**	0.002**	0.003**	0.002**
	(−7.84)	(2.60)	(2.11)	(2.48)	(2.03)
Leverage	−0.002***	0.034***	0.065***	0.035***	0.066***
	(−2.88)	(4.83)	(6.91)	(4.86)	(6.96)
ROA	0.202***	0.417***	0.298***	0.411***	0.290***
	(19.29)	(23.35)	(12.15)	(24.28)	(12.30)
Tobin's Q	−0.000*	−0.006***	−0.007***	−0.006***	−0.006***
	(−1.75)	(−9.51)	(−9.25)	(−9.45)	(−9.28)
Cash	0.019***	−0.002***	−0.035***	−0.003***	−0.037***
	(8.92)	(−3.31)	(−4.41)	(−3.55)	(−4.72)
Intangible	0.023***	0.062***	0.023**	0.060***	0.020**
	(3.22)	(3.41)	(2.26)	(3.26)	(2.14)
FixedAssets	0.048***	−0.011***	−0.065***	−0.012***	−0.068***
	(21.29)	(−5.40)	(−8.09)	(−5.62)	(−8.26)
BoardSize	−0.000	−0.000	−0.001	−0.000	−0.001
	(−0.20)	(−0.54)	(−0.93)	(−0.50)	(−0.90)
ClearAudit	0.007**	0.031***	0.045***	0.031***	0.045***
	(2.62)	(7.52)	(6.24)	(7.47)	(6.19)
HHI	−0.002	−0.006	−0.014	−0.005	−0.014
	(−0.54)	(−0.86)	(−1.31)	(−0.83)	(−1.28)
Tenure	−0.000	0.000*	0.000	0.000*	0.000
	(−0.57)	(1.87)	(0.49)	(1.88)	(0.50)
SOE	0.000	−0.000	−0.002	−0.000	−0.002
	(0.28)	(−0.12)	(−1.52)	(−0.13)	(−1.56)
Constant	−0.086***	0.037	0.094**	0.038	0.096**
	(−15.48)	(1.65)	(2.49)	(1.66)	(2.50)
Industry	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes
N	26,113	26,113	26,113	26,113	26,113
Adj-R^2	0.159	0.235	0.133	0.235	0.133

The table shows whether and how tax officer directors affect their corporate employers' aggressiveness in tax reporting. Column (1) shows the impact of the tax officer director on the book-tax difference. Columns (2) and (3) examine whether tax officer directors affect the level of corporate effective tax rates. Columns (4) and (5) show the moderating effect of tax officer directors on the relationship between operating cash flows and effective tax rates. Detailed definitions of the variables are provided in Appendix A. We report robust t-statistics adjusted for two-way clustering in parentheses at both industry and year levels. *, **, and *** indicate significance at the 1%, 5%, and 10% levels, respectively.

versions of effective tax rates (denoted as *Tax1* and *Tax2*) and examine whether the presence of tax officer directors is associated with lower effective tax rates. In columns (2) and (3) of Table 15, the coefficients on *TaxOfficer* are significant and negative, suggesting that firms with tax officer directors incur less income tax. This evidence indicates that THC influence extends to tax avoidance.

Together with our baseline results on financial reporting aggressiveness, the results regarding effective tax rates provide compelling evidence that firms that hire tax officer directors successfully achieve their objective of decreasing effective tax rates. In columns (4) and (5) of Table 15, we interact *TaxOfficer* with the ratio of operating cash flow over sales (denoted as *OCF*) in the regression of effective tax rates. The coefficients of the resulting interaction term $TaxOfficer \times OCF$ are negative and significant at the conventional level. This indicates that relative to firms without tax officer directors, firms with tax officer directors can aggressively overstate earnings while paying less taxes by reducing the sensitivity of effective tax rates to operating cash flows.

5. Conclusion

This study examines the impact of tax officer directors' THC on financial reporting aggressiveness. Our results align with the THC framework, indicating that tax officer directors can assist firms in inflating their accounting earnings without incurring the corresponding tax costs. Therefore, firms with tax officer directors are more aggressive in financial reporting. Specifically, we find that firms employing former tax officers as independent directors report significantly higher discretionary accruals than their counterparts. Our results remain robust to discretionary accruals based on alternative models and sample specifications. Additionally, we address potential biases associated with endogeneity. After confirming the robustness of our baseline results, we conduct a series of cross-sectional analyses. We find that the positive impact of tax officer directors on discretional accruals is stronger when they hold high ranks in the political ranking system than when they hold low ranks, when the tax office where the director previously served is responsible for collecting income tax from their current corporate employer, and when firms are subject to less stringent tax enforcement and high statutory tax rates. The cross-sectional analyses suggest that political connections between tax officer directors and tax authorities are the main drivers of financial reporting aggressiveness. Finally, we find that firms with tax officer directors have significantly lower effective tax rates and a weaker association between effective tax rates and operating cash flows than firms without tax officer directors. The results suggest that tax officer directors encourage firms to be more aggressive in financial and tax reporting primarily by leveraging their specific THC.

Our study contributes to the literature by proposing a novel conceptual framework for THC. We offer new insights into the trade-offs managers face when navigating financial and tax reporting decisions, the mechanisms through which tax officer directors facilitate corporate financial reporting aggressiveness and the debate surrounding book–tax conformity. Our findings highlight the importance of specific THC with tax authorities for understanding the impact of tax officer directors on firms' tax and financial reporting. Overall, our study underscores the need for policymakers and regulators to consider the potential effects of political connections on corporate financial reporting practices.

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 A. Variable definitions

This table describes our dependent and independent variables.

Variable	Definition
EMJones	Discretionary accruals computed from the Jones (1991) model.
EMDechow	Discretionary accruals computed from the Dechow et al. (1995) model.
EMDichev	Discretionary accruals computed from the cash flow model of Dechow & Dichev (2002).
EMMcNichols	Discretionary accruals computed from the McNichols (2002) model.
TaxOfficer	Indicator variable equal to one for firm-years with (incumbent or retired) tax officers as independent directors, and zero for firm-years without tax officer directors.
FirmSize	The natural logarithm of total assets.
Leverage	Total liabilities divided by total assets.
ROA	Earnings before interest and tax divided by total assets.
Tobin's Q	The market value of total assets divided by total book assets.
Cash	Cash divided by total assets.
Intangible	Intangible assets divided by total assets.
FixedAssets	Fixed assets divided by total assets.
BoardSize	The number of board directors for a firm in certain year.
ClearAudit	A dummy variable which equals one if the firm receives an unqualified audit opinion, and zero otherwise.
HHI	The sum of the squares of the proportion of shares held by the top 10 shareholders.
Tenure	The number of years since the incumbent CEO is in office.
SOE	Indicator variable equal to one for firms ultimately controlled by the state, and zero otherwise.
LocalOfficer	Indicator variable equal to one for tax officer directors with the experience of serving at local tax offices, and zero otherwise.
NonLocalOfficer	Indicator variable equal to one for tax officer directors who served at the tax offices of other provinces, and zero otherwise.
NationalBureau	Indicator variable equal to one for tax officer directors who served in the National Tax Bureau system of China, and zero otherwise.
LocalBureau	Indicator variable equal to one for tax officer directors who served in the Local Tax Bureau system of China, and zero otherwise.
Rank	Indicator variable representing tax officer director's position in the civil service system of China with numbers from 1 to 4 corresponding to different levels within the hierarchy: 1 for section member, 2 for section head, 3 for division head, and 4 for bureau director and those above levels, respectively.
HighTax	The indicator variable equal to one for firms subject to above-average statutory tax rates, and zero otherwise.
LenientEnforce	A dummy variable taking the value of one when the tax enforcement of a region where the firm is headquartered is lower than the average, and zero otherwise. The tax enforcement index is a region's actual tax ratio divided by the estimated tax ratio estimated from the following model: $\frac{T_{it}}{GDP_{it}} = \beta_0 + \beta_1 \times \frac{IND1_{it}}{GDP_{it}} + \beta_2 \times \frac{IND2_{it}}{GDP_{it}} + \beta_3 \times \frac{OPENNESS_{it}}{GDP_{it}} + \varepsilon$where T_{it} is the tax revenue of region i where a firm is headquartered in year t. GDP_{it} is the GDP. $IND1_{it}$ is the output value of the primary industry (including the agriculture, forestry, pasture and fishery sectors). $IND2_{it}$ is the output value of the secondary industry (including the mining, manufacturing, electricity, water and gas sectors). $OPENNESS_{it}$ refers to the total value of imports and exports.

(*continued on next page*)

Appendix A. (*continued*)

Variable	Definition
OCF	Operating cash flow divided by sales.
Tax1	Total income tax expenses divided by the pre-tax income
Tax2	$\frac{\text{Total income tax expenses}}{\text{Pretax income}-\frac{\text{Deferred tax expenses}}{\text{Statutory tax rate}}}$

Appendix B. Balance checks before and after propensity score matching (PSM)

This table shows tests for the balance of covariates before and after the implementation of PSM in Table 7. Column (2) reports the mean values of potential determinants for corporate financial reporting aggressiveness between the treatment group (i.e., firms with tax officer directors) and the control group (i.e., firms without tax officer directors). Column (3) reports t-values and the corresponding p-values associated with the statistical significance of mean differences.

Variables	(1)	(2)		(3)	
	Unmatched VS	Mean		T-test	
	Matched	Treated	Control	T	p>|T|
FirmSize	U	−21.997	–22.073	2.12	0.034
	M	−21.997	−21.998	0.04	0.971
Leverage	U	−0.429	−0.403	−4.71	0.000
	M	−0.429	−0.431	0.20	0.844
ROA	U	0.059	0.058	0.64	0.520
	M	0.059	0.057	1.20	0.230
Tobin's Q	U	1.985	2.043	−1.70	0.089
	M	1.985	1.988	−0.06	0.954
Cash	U	0.200	0.198	0.61	0.543
	M	0.200	0.202	−0.30	0.767
Intangible	U	0.047	0.045	1.13	0.257
	M	0.047	0.047	−0.04	0.969
FixedAssets	U	0.238	0.215	5.28	0.000
	M	0.238	0.236	0.30	0.763
BoardSize	U	9.008	8.732	5.65	0.000
	M	9.008	9.065	−0.82	0.412
ClearAudit	U	0.978	0.981	−0.77	0.439
	M	0.978	0.977	0.13	0.900
HHI	U	0.167	0.167	0.19	0.845
	M	0.167	0.167	0.06	0.951
Tenure	U	4.702	4.866	−1.76	0.079
	M	4.702	4.749	−0.38	0.704
SOE	U	0.390	0.373	1.26	0.207
	M	0.390	0.372	0.98	0.329

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The aggregate release of third-party online sales data and audit quality improvement

Ning Chen [a], Junxiong Fang [b,*]

[a] School of Finance, Shanghai University of International Business and Economics, 1900 Wenxiang Road, Shanghai 201620, China
[b] School of Accounting, Zhejiang University of Finance & Economics, 18 Xueyuan Road, Hangzhou 310018, China

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ABSTRACT

Corporate online sales data are embedded with high informational value. Focusing on auditors who are concerned about information quality, this paper systematically tests the governance effect of releasing third-party online sales data on audit quality. Using the first aggregate release of online sales data in 2018 as an exogenous shock, we use the difference-in-differences model and empirically demonstrate that the audit quality of firms with released online sales data improves significantly after 2018. Subsequent analyses demonstrate that releasing online sales data has a governance effect by improving internal control quality, audit efficiency and audit prudence. The findings demonstrate that the aggregate release of third-party online sales data could have positive economic consequences.

1. Introduction

With the extensive and profound application of Internet and digital technologies in both commercial and social domains, alternative data, which differ from traditional financial data, are characterized by their timely release, fine granularity and low level of structure (Zhu, 2019). Furthermore, such data feature broad and intense dissemination of diverse information sources and strong interactivity (Jia et al., 2020). These characteristics significantly transform the ways in which information is produced, disseminated and utilized. They also weaken insiders' control over information and reduce the information asymmetry between internal and external stakeholders (Blankespoor et al., 2022; Chen et al., 2014; Miller, 2016). Research demonstrates that alternative data, such as satellite data, investor interaction data from Twitter, professional investor

* Corresponding author.
E-mail addresses: chenning@suibe.edu.cn (N. Chen), jxfang@fudan.edu.cn (J. Fang).

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interaction data from the SA Platform, employee interaction data from Glassdoor and consumer complaint data, exert positive effects by improving managerial investment decisions, employee relations and investor information processing efficiency (Ang et al., 2021; Dube and Zhu, 2021; Nguyen, 2021). However, auditors, who serve as the gatekeepers of the capital market, are generally neglected. Auditors endeavor to use various types of information to verify whether there are material misstatement risks in financial reports, and alternative data with incremental informational value constitute a crucial source of information. Therefore, this paper investigates the governance effect of alternative data on auditor quality from the perspective of auditors.

Different from other research, this paper focuses on third-party online sales data that directly relate to firms' operational performance. First, with the groundbreaking advancements in mobile Internet and digital technologies, the online sales business model increasingly influences firms' behaviors and decisions. Auditors, who are faced with clients' constantly evolving operation and information environment, are also experiencing rapid changes in the way audit evidence is formed and audit procedures are executed (Xie and Cheng, 2023). Second, third-party online sales data are the overlapping product of alternative data and online sales business models. Hence, whether auditors can respond to the profound impact of alternative data on firms' internal information and auditors' audit procedures, and whether they can effectively use such new alternative data to ensure financial information quality and maintain audit quality, becomes particularly critical.

This paper proposes that the aggregate release of third-party online sales data can effectively reduce information asymmetry and mitigate moral hazard. First, by restraining managers' self-interested motivations and capabilities, it prevents them from overriding the internal control system and helps to maintain the system's effectiveness. Second, auditors can easily use the aggregate online sales data to verify and analyze firms' sales revenue and operational performance, which is important to ensure the relevance and reliability of audit evidence and ultimately improves audit efficiency. Third, the external attention attracted by the disclosure of online sales data exerts reputational pressure on auditors, encouraging them to adopt a more cautious approach and reducing the acceptable audit risk level. Therefore, improvements in internal control quality, audit efficiency and the reinforcement of the prudence principle in audit procedures enhance audit quality accordingly.

However, while online sales data directly reflect consumer behavior, corporate revenue and socio-economic conditions, their vast volume, real-time updates and extreme dispersion make it challenging to systematically extract, integrate and analyze such data. This limitation hinders auditors and other information users from further interpreting and using these data. Fortunately, in China, where online sales have developed rapidly, the Wind Financial Terminal (WFT) began releasing online sales data in 2018. As a professional data service provider, the WFT scrapes online sales data from e-commerce platforms such as Tmall and JD.com. This aggregate release provides an ideal research context in which to empirically examine the governance effects of third-party online sales data disclosure on audit quality. Utilizing the WFT's 2018 disclosure of aggregate third-party online sales data, this study uses the difference-in-differences (DID) method to investigate changes in sample firms' audit quality after 2018. The results indicate that compared with the control group, firms whose third-party platform online sales data have been aggregated and disclosed since 2018 experience a decline in financial restatements and an improvement in audit quality. Robustness tests are conducted using alternative definitions of independent variables, the inclusion of firm fixed effects, propensity score matching (PSM), entropy balancing, Heckman two-stage model, parallel trend test, placebo test, and alternative measures of the dependent variables. Subsequent mechanism tests reveal that following the aggregate release of third-party online sales data, firms show a significant increase in the internal control index, a notable decrease in audit delay days, and a substantial rise in media coverage. These results suggest improvements in internal control quality and audit efficiency, with increased external scrutiny that imposes reputational pressure on auditors. Heterogeneity analyses indicate that our main result is evident across firms with varying proportions of online sales but is more pronounced among firms with severe agency problems, those audited by accounting firms with more signing auditors with big data audit capabilities, firms with low individual investor attention and firms not subjected to institutional investors' site visits.

This paper offers several important contributions to the literature. First, it enriches the literature on the economic consequences of alternative data. Research on alternative data primarily focuses on satellite imagery, search engine data, social media data, consumer behavior data and employee review data (Da et al., 2011; Bartov et al., 2018; Ding et al., 2018a, 2018b; Zhu, 2019; Huang et al., 2020; Ang et al., 2021; Dube

and Zhu, 2021; Blankespoor et al., 2022; Dichev and Qian, 2022; Dessaint et al., 2024). However, it largely ignores the unique data on third-party online sales from the WFT, which are specific to the Chinese market. These data are distinct from other types of data, combining features of both alternative data and traditional financial data, and benefit from the platform advantages of the WFT. Thus, exploring the economic consequences of these alternative data within the context of China is important and necessary.

Second, this paper broadens research on the impact of the aggregate release of third-party online sales data. Liao et al. (2021) find that third-party online sales data can predict unexpected earnings and stock price reactions, validating the informational value of these data. However, subsequent studies primarily use online sales data to define whether listed firms adopt e-commerce sales or "Internet+" models (Peng and He, 2021), neglecting the potential economic consequences of these special alternative data for capital market participants. Li and Liu (2022) explore how the release of online sales data restricts managerial earnings management behavior, while our paper is the first to focus on the informational effects of aggregate third-party online sales data disclosure on auditors.

Third, we extend research on the factors influencing audit quality. The literature explores the impact on audit quality from various perspectives, including firm characteristics, auditor characteristics and the external environment (DeAngelo, 1981; Francis, 2004; Zhang, 2010; Liu, 2013; Liu et al., 2017; Dong et al., 2022). However, with ongoing changes in the business and information environment, the audit evidence and audit procedures that auditors use and implement may also have undergone significant transformations. Hence, introducing third-party online sales data as an alternative data source to study their impact on audit quality is timely and forward-looking.

2. Background and research hypotheses

2.1. Research on alternative data

Various forms of alternative data, such as satellite imagery, web search data, social media interactions, consumer behavior data and employee reviews, can reflect corporate performance and predict unexpected earnings, and are significantly and positively correlated with cumulative abnormal returns (Agarwal et al., 2021; Da et al., 2015; Bartov et al., 2018; Mukherjee et al., 2021; Geng et al., 2022). The established informational value of alternative data further validates their economic consequences. First, alternative data serve as a valuable external information source for firms, enabling managers to acquire new insights and incorporate them into their business decisions. For example, Shen et al. (2013) use posts from Guba to construct an opposition index and find that negative online sentiment triggers both market discipline and regulatory scrutiny. Consequently, firms facing online opposition experience negative abnormal stock returns following the announcement and have a significantly lower probability of successfully passing private placement proposals. Similar findings are observed in the U.S., where Cookson et al. (2022) identify a significant relationship between investor sentiment on the StockTwits social platform and the likelihood of withdrawing from mergers and acquisitions (M&A). Specifically, negative reactions on the platform increase the probability of firms abandoning the M&A deal.

Second, alternative data could correct managers' improper information disclosure. Specifically, alternative data related to corporate transactions reveal true operational performance, making it difficult for management to conceal such information from investors (Blankespoor et al., 2022). Moreover, the dissemination of information via social media can help investors to promptly identify improper actions, which enhances the efficiency of incorporating firm-specific information into stock prices and hinders managers' ability to conceal bad news, thereby reducing stock price crash risk (Li and Liu, 2022; Wu et al., 2022).

Third, alternative data reduce the information acquisition cost, providing more accurate signals for earnings forecasts (Verrecchia, 1982). Chi et al. (2024) find that analysts frequently cite alternative data in their reports, especially when timely information is needed and traditional data are ambiguous. The results indicate that the use of alternative data by analysts improves forecast accuracy and elicits a more significant market response.

Fourth, alternative data influence investor decisions. Ding et al. (2018a, 2018b) study the Shanghai Stock Exchange E-Interaction platform and find that the Q&A interactions between investors and listed firms

enhance investors' ability to acquire and interpret information, thus improving market earnings forecast accuracy, reducing investor disagreement and ultimately lowering stock price crash risk. For institutional investors, Nguyen (2021) suggest that investor sentiment on Twitter affects corporate brand image and future operational performance, prompting institutional investors to adjust their holding strategies accordingly. Particularly when faced with negative sentiment on social platforms, short-sighted institutional investors tend to reduce their holdings in relevant stocks.

Although the WFT began aggregating and releasing third-party online sales data in 2018, research in this area remains limited. Liao et al. (2021) were the pioneers in verifying the informational value of these data, finding that e-commerce sales data from 2015 to 2018 could predict unexpected revenue, unexpected earnings and cumulative abnormal returns. This indicates that the third-party online sales data released by the WFT provide valuable insights into performance fundamentals. Li and Liu (2022) further investigate the governance effects of releasing third-party online sales data on management behaviors. They argue that such data significantly reduce earnings management. Peng and He (2021) examine the impact of online sales data on management earnings forecasts quality. They use these data to identify whether listed firms adopt the online sales business model and find that such a strategic move leads to timely, albeit less accurate, management earnings forecasts.

In the field of alternative data, particularly third-party online sales data, the literature has explored their informational value and their impact on various stakeholders. These impacts include adjusting corporate decisions, constraining management's disclosure behavior, improving analysts' earnings forecasts and influencing investors' strategies. However, the effect of these data on auditors—the key participants in the capital market—has been largely overlooked. This paper examines how the aggregate release of alternative data enhances audit quality, introducing a new perspective to the literature.

2.2. Research hypothesis

As a fusion of the traditional and digital economies, online sales not only signify a profound transformation in business models but also generate alternative data that are distinct from traditional financial information. These data reshape corporate behavior at both the operational and informational levels, influencing auditors' procedures. On the one hand, driven by evolving Internet and digital technologies, the rapid development of the "Internet +" initiative and online sales models imposes new demands on internal control systems, which is crucial for risk prevention and fraud avoidance. The authenticity, consistency and accuracy of internal business data have become focal points for external and IT audits. On the other hand, the simultaneous operation of online and offline sales models adds complexity to corporate accounting and information processing systems, increasing the risk of material misstatements. Auditors should move beyond traditional ledger reconciliation procedures to consider the impact of big data on corporate information and auditing processes, making timely and necessary adjustments. The challenges posed by the online sales model underscore the importance of aggregating and releasing online sales data that could yield unique governance effects, enhance internal control effectiveness, improve audit efficiency and reinforce the principle of audit prudence. Ultimately, audit quality could be improved.

First, the aggregation and dissemination of third-party online sales data play a crucial role in reducing firm information asymmetry, mitigating management opportunistic behaviors and enhancing internal control effectiveness. This, in turn, leads to decreased audit risks and improved audit quality. Insiders typically possess information advantages, while external investors may receive potentially distorted earnings information, which is not only relatively lagging but also subject to data inaccuracies. By providing detailed insights into monthly online sales metrics such as unit price, quantity and total sales, third-party online sales data enable external investors to make informed predictions about firm performance well in advance of financial report disclosures. This early access to fundamental information helps bridge information gaps, prevent management from overriding internal control systems for self-interest motives and uphold the integrity of internal control systems (Lin et al., 2014). At this point, the quality of internal control, which is a key focus of external audits, is ensured (Leventis et al., 2005), leading to a reduction in audit control risks and improvements in audit quality.

Second, the aggregation and dissemination of third-party online sales data not only reduces auditors' costs of obtaining reliable data but also streamlines the execution of audit procedures, ultimately enhancing audit efficiency and quality. While auditors traditionally rely on physical evidence to form audit evidence, the increasing importance of electronic evidence due to the rapid advancement of Internet and digital technologies presents new challenges in risk assessment and substantive analytical procedures. Accessing timely, accurate and comprehensive aggregate online data directly impacting sales revenues presents a significant technical barrier for auditors, as it requires substantial time and effort. The WFT's aggregated third-party online sales data, a unique data type in the Chinese market, are freely available to authorized users, significantly reducing auditors' search and analysis costs. These data, characterized by their vast volumes, frequent updates and detailed granularity, serve as a valuable supplement to industry data statistics at the firm level (Liao et al., 2021), which meets the data relevance requirements. Moreover, these data are less susceptible to managers' manipulation, minimizing the risks of data fabrication, distortion and selective release timing, thus ensuring their reliability. Consequently, auditors can access these relevant and reliable data at a lower cost, enabling them to compare and analyze the revenue composition of the audited firm and thereby improving audit efficiency, reducing inspection risks and ultimately enhancing audit quality.

Moreover, the aggregation and dissemination of third-party online sales data could attract external attention, prompting auditors to enhance audit prudence to mitigate reputational risks and reduce the acceptable level of audit risk, thereby leading to audit quality improvement. Establishing auditor reputation is a formidable task, and any audit failures can result in immediate and severe damage. The external pressure and scrutiny faced by audited firms can even exacerbate this process (Chen et al., 2018). Given that third-party online sales data hold substantial informational value in predicting unexpected earnings and future market reactions (Liao et al., 2021), the media are inclined to pay close attention to these firms to meet the information demand from the public. In response to the potential reputational harm stemming from audit failures, auditors are compelled to adopt a more cautious approach in conducting audit procedures, thereby reducing the acceptable audit risk level for firms with released third-party online sales data and ultimately enhancing audit quality.

Therefore, our hypothesis is stated as follows.

Hypothesis: *Ceteris paribus*, firms' audit quality improves after the aggregate release of third-party online sales data.

3. Sample and research design

3.1. Sample and data

In 2018, the WFT launched a dataset covering online sales data dating back to 2015 for nearly 200 firms listed on the Chinese stock markets (including the Hong Kong Stock Exchange). It collects daily online sales for each brand from major e-commerce platforms such as Tmall, Taobao, JD.com and YHD.com, covering more than 95 % of China's e-commerce market (Liao et al., 2021; Li and Liu, 2022), and then aggregates them at the firm and month levels. These data are collected from third-party e-commerce platforms and are therefore less influenced by the firms themselves. Before 2018, these data were costly to acquire because they were privately owned by e-commerce platforms. Thus, the commercial availability of such data serves as a suitable exogenous information shock to enable our research design's DID analysis.

The study period spans from 2015 to 2021, with 2015 selected as the starting point due to it being the earliest year for which the WFT's aggregate online sales data are available. The sample is filtered by excluding financial and B-share companies, as well as observations with missing variables, resulting in a final sample of 13,633 observations. All financial, stock trading and corporate governance data are sourced from the China Stock Market & Accounting Research database. To mitigate the impact of outliers, all continuous variables are winsorized at the 1 % and 99 % levels. Additionally, standard errors are clustered at the firm level.

3.2. Models and variable definitions

We investigate whether the third-party online sales release improves audit quality.

To test our hypothesis, we use the commercial availability of online sales data provided by the WFT as an exogenous information shock and examine its impact on firm audit quality. In our DID analysis, the treatment firms are those with online sales data available on the WFT and the control firms are those without such data available. We then compare the changes in audit quality for the treatment firms before and after the public availability of online sales data as of 2018 against the equivalent changes in the control firms. Specifically, we test our hypothesis with the following regression:

$$RESTATE_{i,t} = \beta_0 + \beta_1 ONLINE_{i,t} + \beta_2 ONLINE \times POST_{i,t} + \beta_3 CONTROLS_{i,t} + \sum YEAR + \sum INDUSTRY + \varepsilon_{i,t} \quad (1)$$

Rajgopal et al. (2021) compare various audit quality indicators used in the literature and conclude that financial restatements consistently predict audit deficiencies. Consequently, we use financial restatements (*RESTATE*) as a proxy for audit quality. Our focus is on $ONLINE \times POST$. β_2 captures the incremental effect associated with the governance effect of releasing third-party online sales data on audit quality. Year fixed effects subsume the main effect of *POST*. When *RESTATE* is the dependent variable, a negative coefficient β_2 indicates improved in audit quality for firms with released third-party online sales data, relative to the control firms.

Firm-level controls are included following previous research and comprise firm size (*LNTA*), financial leverage (*LEV*), inventory (*INVR*), accounts receivable (*RECR*), quick ratio (*QUICK*), related party loan balance ratio (*BALANCE*), return on assets (*ROA*), operating cash flow (*COCF*), market-to-book ratio (*MTB*), an indicator for M&As (*M&A*), an indicator for seasoned equity offerings (*SEO*), controlling ownership percentage (*OWNER*), private ownership (*PRIVATE*), an indicator for cross-listing (*BH*), firm age (*AGE*), an indicator for modified audit opinions (*MAO*), an indicator for Top 10 audit firms (*BIG10*) and an indicator for auditor switch (*SWITCH*). Additionally, the model controls for year and industry fixed effects.

3.3. Descriptive statistics

Table 1 presents the industry distribution of listed companies whose third-party platform online sales data were aggregated and released in 2018. It shows that online sales are primarily concentrated in the food and beverage, textile and garments and manufacturing industries.

Table 2 provides descriptive statistics for the main variables used in our sample. Among the sample firms, 12.1 % experienced financial restatements. The mean value of *ONLINE* is 0.086, indicating that approximately 8.6 % of the listed firms in the sample had their online sales data aggregated and released by WFT in 2018. Other control variables are largely consistent with the results reported in the literature. Specifically, the sample firms have an average leverage ratio of 45.2 % and a mean quick ratio of 1.67, indicating good solvency.

Table 1
Industry distribution of firms with online sales data in 2018.

Industry	No. of firms
Food & Beverage	65
Textiles & Garments	23
Manufacturing	40
Pharmaceutical & Biological Products	16
Wood, Furniture & Other Manufacturing	18
Construction	1
Information Technology	3
Wholesale & Retail Trade	4
Real Estate	1
Social Work	2
Culture, Sports & Entertainment	1
Total	174

Notes: This table presents the industry distribution of firms with online sales data in 2018, where the industry classification is defined by the WFT.

Table 2
Descriptive statistics.

Variable	Mean	Std. dev.	25 %	Median	75 %	Obs.
ONLINE	0.086	0.281	0	0	0	13,633
POST	0.521	0.500	0	1	1	13,633
ONLINE_PRO	0.033	0.158	0	0	0	13,633
RESTATE	0.121	0.326	0	0	0	13,633
LNTA	22.343	1.282	21.473	22.217	23.073	13,633
LEV	0.452	0.212	0.287	0.441	0.600	13,633
QUICK	1.666	1.743	0.734	1.139	1.866	13,633
INVR	0.150	0.136	0.064	0.115	0.186	13,633
RECR	0.121	0.105	0.037	0.099	0.176	13,633
BALANCE	0.008	0.029	0	0	0.001	13,633
ROA	0.023	0.090	0.009	0.031	0.061	13,633
COCF	0.044	0.075	0.003	0.043	0.088	13,633
NLOSS	0.149	0.356	0	0	0	13,633
MTB	4.149	4.736	1.696	2.782	4.703	13,633
M&A	0.683	0.465	0	1	1	13,633
SEO	0.085	0.280	0	0	0	13,633
OWNER	0.353	0.155	0.235	0.330	0.453	13,633
PRIVATE	0.576	0.494	0	1	1	13,633
BH	0.049	0.216	0	0	0	13,633
AGE	2.406	0.674	1.946	2.485	2.996	13,633
MAO	0.067	0.250	0	0	0	13,633
BIG10	0.406	0.491	0	0	1	13,633
SWITCH	0.049	0.217	0	0	0	13,633

Notes: This table presents the summary statistics for the variables used in the regression analysis over the sample period from 2015 to 2021. Appendix 1 provides detailed variable definitions.

Nearly 58 % of the sample consists of privately owned enterprises, with a controlling shareholder ownership percentage of 35.3 %, and approximately 6.7 % of the sample firms had received modified audit opinions.

4. Empirical results

4.1. Baseline regression results

Table 3 presents the regression results of estimating Eq. (1). Column (1) does not include the control variables, whereas columns (2) and (3) incorporate financial and corporate governance characteristics as control variables, respectively. After controlling for year and industry fixed effects, we find that the coefficients of the interaction term $ONLINE \times POST$ are all significant and negative at the 1 % level. This suggests that after the online sales data became commercially available, audit quality significantly improves for the treatment firms relative to the control firms.

4.2. Robustness tests

We perform the following robustness tests to further verify the reliability of the main results.

4.2.1. Alternative independent variable measure

The identification of the treatment and control groups relies on whether a firm's third-party online sales data were aggregated and released by the WFT in 2018. However, this approach may overlook different proportions of online sales among the firms and across the years. Hence, we use the continuous variable of the proportion of online sales (*ONLINE_PRO*) to replace the dummy variable *ONLINE*. The results, shown in Panel A of Table 4, indicate that the new interaction term $ONLINE\_PRO \times POST$ remains significant and negative, demonstrating the robustness of our findings.

Table 3
The impact of online sales data on audit quality.

	RESTATE		
	(1)	(2)	(3)
ONLINE	–0.323	–0.077	0.012
	(–1.302)	(–0.316)	(0.051)
ONLINE × POST	–0.698***	–0.744***	–0.797***
	(–3.060)	(–3.067)	(–3.170)
LNTA		–0.074*	0.003
		(–1.783)	(0.074)
LEV		1.141***	0.817***
		(3.872)	(2.753)
QUICK		–0.042	–0.046
		(–1.393)	(–1.526)
INVR		–1.732***	–1.380***
		(–3.798)	(–3.182)
RECR		–0.591	–0.472
		(–1.529)	(–1.168)
BALANCE		2.472**	1.251
		(2.530)	(1.149)
ROA		–2.719***	–1.314***
		(–6.703)	(–3.146)
COCF		–3.126***	–2.858***
		(–6.682)	(–6.050)
NLOSS		0.543***	0.491***
		(5.587)	(4.797)
MTB		–0.007	–0.023***
		(–0.899)	(–2.695)
M&A			0.377***
			(4.839)
SEO			–0.161
			(–1.434)
OWNER			–0.991***
			(–3.134)
PRIVATE			0.585***
			(5.591)
BH			–0.506*
			(–1.803)
AGE			0.215***
			(2.662)
MAO			1.243***
			(10.323)
BIG10			–0.136
			(–1.566)
SWITCH			0.501***
			(4.634)
CONSTANT	–1.440***	0.023	–2.318**
	(–5.538)	(0.024)	(–2.358)
YEAR FE	YES	YES	YES
INDUSTRY FE	YES	YES	YES

Table 3 (*continued*)

	RESTATE		
	(1)	(2)	(3)
Pseudo R^2	0.059	0.134	0.173
N	13,633	13,633	13,633

Notes: This table presents the results of testing our main hypothesis regarding the impact of online sales data on audit quality over the sample period from 2015 to 2021. *ONLINE* is a dummy equal to one for firms with online sales data available on the WFT and zero otherwise. *POST* is a dummy equal to one for 2018 and all subsequent years and zero otherwise. Appendix 1 provides detailed variable definitions. The *t*-statistics in parentheses are adjusted for heteroscedasticity and clustered at the firm level. *, ** and *** represent significance levels of 10%, 5% and 1%, respectively.

4.2.2. Firm fixed effects

To address the endogeneity of omitted variables, we include firm fixed effects and re-estimate Eq. (1). As shown in Panel B of Table 4, the coefficient of the interaction term $ONLINE \times POST$ remains negative and significant at the 1 % level, suggesting that our main conclusions are not influenced by omitted variables, thereby maintaining robustness.

4.2.3. Propensity score-matched sample

Table 4, Panel C, presents the DID analyses using the PSM approach, which serves two purposes. First, our treatment firms are those with online sales data available on the WFT and the control firms are those without such data available. These two types of firms may not be fundamentally comparable. Second, our main regression tests use traditional multi-linear regressions. If the linear relationship between the explained and explanatory variables is violated, the model may suffer from functional form misspecification and produce biased coefficients. To address these econometric concerns, we use the PSM approach (see Shipman et al., 2017), which matches treatment and control pairs with similar firm characteristics that are likely to relate to the availability of online sales data, but the matched pairs differ in such data's actual availability. This means that any differences between the two groups in terms of changes in audit quality following the disclosure of online sales data can be more appropriately attributed to the online sales data rather than differences in other firm characteristics, regardless of the underlying functional form. We perform a logit regression to estimate propensity scores using the sample from 2018, when the WFT first released the online sales data. In the logit model, the dependent variable is *ONLINE*, which equals one for firms with online sales disclosure in 2018 and zero otherwise. The independent variables are the *CONTROLS* included in Eq. (1). The re-estimation results in column (1) show that the coefficient on $ONLINE \times POST$ is significant and negative, consistent with the results for our main hypothesis tests in Table 3. The PSM sample results show that our main findings are not driven by differences in the characteristics of the treatment and control firms or by bias resulting from the potential functional misspecification of our linear model.

4.2.4. Entropy balancing test

Similarly, we conduct an entropy balancing test on the covariates of the treatment and control groups to ensure the exogeneity of the DID model and thereby enhance the validity of the regression results. After reweighting the covariates, the regression results presented in column (2) of Panel C in Table 4 show that the interaction term $ONLINE \times POST$ remains significant and negative, consistent with the baseline regression results and further confirming the robustness of our main conclusion.

4.2.5. Heckman two-stage approach

Table 4, Panel D, presents the results of the Heckman two-stage approach. The commercial availability of third-party online sales data is exogenous to firms, while the option to sell online is endogenous. We use the

Table 4
Robustness tests.

Panel A: Alternative independent variable measure			
	RESTATE		
	(1)	(2)	(3)
ONLINE_PRO	–0.522	–0.219	–0.203
	(–1.007)	(–0.437)	(–0.408)
ONLINE_PRO × POST	–0.964**	–1.081***	–1.078***
	(–2.339)	(–2.604)	(–2.596)
CONSTANT	–1.435***	0.027	–2.331**
	(–5.528)	(0.029)	(−2.367)
FINANCIAL CONTROLS	NO	YES	YES
CG CONTROLS	NO	NO	YES
YEAR FE	YES	YES	YES
INDUSTRY FE	YES	YES	YES
Pseudo R^2	0.057	0.133	0.173
N	13,633	13,633	13,633

Panel B: Firm fixed effects			
	RESTATE		
	(1)	(2)	(3)
ONLINE×POST	–0.975***	–1.030***	–1.041***
	(–3.177)	(–3.270)	(–3.275)
CONSTANT	–1.440***	0.023	–2.318**
	(–5.538)	(0.024)	(–2.358)
FINANCIAL CONTROLS	NO	YES	YES
CG CONTROLS	NO	NO	YES
YEAR FE	YES	YES	YES
FIRM FE	YES	YES	YES
Pseudo R^2	0.059	0.134	0.173
N	13,633	13,633	13,633

Panel C: PSM-DID and entropy balancing		
	(1)	(2)
	PSM-DID	Entropy balancing
ONLINE	–0.138	0.037
	(–0.439)	(0.140)
ONLINE×POST	–0.895**	–0.718**
	(–2.049)	(–2.449)
CONSTANT	2.235	0.599
	(0.863)	(0.337)
YEAR FE	YES	YES
INDUSTRY FE	YES	YES
Pseudo R^2	0.288	0.220
N	2,119	13,633

Panel D: Heckman two-stage		
	(1)	(2)
	ONLINE	*RESTATE*
ONLINE		0.012
		(0.048)
ONLINE×POST		–0.796***
		(–3.096)
ONLINE_IND	2.667***	
	(11.286)	
IMR		–0.006
		(–0.031)
CONSTANT	–7.723***	–2.293*
	(–3.989)	(–1.783)
Panel E: Parallel trend assumption		
		RESTATE
ONLINE		0.175
		(0.684)
ONLINE× YEAR2015		–0.343
		(–1.085)
ONLINE× YEAR2016		–0.216
		(–0.852)
ONLINE× YEAR2018		–0.911***
		(–3.364)
ONLINE× YEAR2019		–0.993***
		(–2.740)
ONLINE× YEAR2020		–0.916**
		(–2.182)
CONSTANT		–2.227**
		(–2.267)
YEAR FE		YES
INDUSTRY FE		YES
Pseudo R^2		0.170
N		13,463
Panel F: Placebo test		
		RESTATE
ONLINE		–0.171
		(–0.503)
ONLINE×POST2016		–0.241
		(–0.860)
CONSTANT		–2.299**
		(–2.342)
YEAR FE		YES
INDUSTRY FE		YES
Pseudo R^2		0.172
N		13,633

(*continued on next page*)

Table 4 (*continued*)

Panel G: Alternative dependent variable measure					
	(1)	(2)	(3)	(4)	(5)
	MAO	*FRAUD*	*DA*	*INDSPE*	*CITYSPE*
ONLINE	–1.951**	–0.008	0.005*	–0.020	–0.034*
	(–2.483)	(–0.027)	(1.782)	(–1.638)	(–1.908)
ONLINE×POST	1.772**	–0.682**	–0.018***	0.037***	0.026*
	(2.222)	(–2.439)	(–5.646)	(3.094)	(1.830)
CONSTANT	2.735**	–2.183**	0.051***	–0.100	–0.468***
	(2.005)	(–1.971)	(3.812)	(–1.051)	(–4.574)
YEAR FE	YES	YES	YES	YES	YES
INDUSTRY FE	YES	YES	YES	YES	YES
Pseudo R^2	0.079	0.132	0.075	0.646	0.349
N	13,633	11,914	12,739	694	694

Notes: This table presents the results of robustness tests examining the impact of online sales data on audit quality over the period from 2015 to 2021. Appendix 1 provides detailed variable definitions. Standard errors are adjusted for heteroscedasticity and clustered at the firm level. *CONTROLS* are the same as those in Eq. (1). *, ** and *** represent significance levels of 10%, 5% and 1%, respectively.

Heckman two-stage model to assess whether selection bias from firms' online sales decisions affects our results. In the first stage, we use the industry mean value of online sales (*ONLINE_IND*) as the instrumental variable. *ONLINE_IND* directly relates to a firm's online sales decision but not to firm-specific audit quality, satisfying the exclusion principle of instrumental variables. In the second stage, we include the inverse Mills ratio (*IMR*) estimated in the first stage. The coefficient on *ONLINE* × *POST* remains significant and negative after including *IMR*. This suggests that selection bias arising from firms' online sales decisions does not affect our results.

4.2.6. Parallel trend assumption

The premise for DID analyses is the parallel trend assumption, which we validate by examining dynamic effects. We use the year immediately before the first disclosure of third-party online sales data (2017) as the benchmark and then compare it with other years. Specifically, we replace *POST* with the five indicators *YEAR2015*, *YEAR2016*, *YEAR2018*, *YEAR2019* and *YEAR2020* for the years 2015, 2016, 2018, 2019 and 2020, respectively, and their interaction with *ONLINE* in Eq. (1). The coefficients on *ONLINE* × *YEAR2015* and *ONLINE* × *YEAR2016* are not significantly different from zero. This suggests that there are parallel trends between the treatment and control firms prior to the initial disclosure of online sales data in 2018. In contrast, the coefficients on *ONLINE* × *YEAR2018*, *ONLINE* × *YEAR2019* and *ONLINE* × *YEAR2020* are significant and negative, confirming that the reduction in restatements for the treatment firms relative to the control firms only happened after the WFT made online sales data commercially available. This result further supports our main hypothesis and validates the parallel trend assumption, which ensures the identification ability of the DID analysis.

4.2.7. Placebo test

We conduct a placebo test by setting the event back two years to 2016 and constructing the interaction term *ONLINE* × *POST2016*. In Table 4, Panel F, the interaction term is not significant and negative, suggesting that audit quality does not improve significantly in the absence of online sales data from the WFT. Additionally, we construct a simulated time variable (*POST_r*), by randomly assigning the event year to each firm while keeping the proportion of *POST_r* in the sample consistent with the original *POST* variable. Using *POST_r* and the interaction term *ONLINE* × *POST_r*, we conduct 1,000 regressions, extracting coefficients and standard errors to plot the density of the placebo test coefficients in Fig. 1. After 1,000 iterations, the regression

Table 5
Mechanism tests.

	(1)	(2)	(3)
	IC_INDEX	*AUDITLAG*	*MEDIA*
ONLINE	0.007	0.036**	0.086**
	(1.026)	(2.533)	(2.446)
ONLINE × POST	0.015**	–0.025**	0.255***
	(2.159)	(–2.008)	(5.739)
LNTA	0.020***	0.013***	0.299***
	(9.347)	(4.433)	(26.359)
LEV	–0.041**	–0.003	–0.266***
	(–2.426)	(–0.173)	(–4.497)
QUICK	0.053***	–0.007	–0.006
	(2.904)	(–0.311)	(–1.175)
INVR	0.080***	0.041	–0.140**
	(3.900)	(1.373)	(–2.009)
RECR	–0.001	–0.003	–0.004
	(–0.506)	(–1.394)	(–0.047)
BALANCE	–0.376***	–0.157*	0.451
	(–3.156)	(–1.680)	(1.572)
ROA	0.418***	–0.187***	–0.567***
	(9.302)	(–5.861)	(–4.664)
COCF	0.015	–0.109***	0.090
	(0.558)	(–3.435)	(0.972)
NLOSS	–0.045***	0.045***	0.059**
	(–5.745)	(6.561)	(2.488)
MTB	0.001	–0.002***	0.038***
	(1.229)	(–2.788)	(14.747)
M&A	–0.005	0.008**	0.238***
	(–1.551)	(2.033)	(17.930)
SEO	0.016***	–0.019**	0.120***
	(3.946)	(–2.440)	(7.769)
OWNER	0.045***	–0.001	–0.503***
	(3.954)	(–0.050)	(–9.467)
PRIVATE	–0.012***	0.030***	0.171***
	(–2.923)	(5.040)	(10.051)
BH	0.013	–0.043***	–0.063
	(1.271)	(–3.249)	(–1.405)
AGE	–0.012***	–0.018***	–0.085***
	(–3.926)	(–3.552)	(–6.187)
MAO	–0.282***	0.083***	0.255***
	(–14.229)	(10.192)	(7.588)
BIG10	0.003	–0.002	0.009
	(0.798)	(–0.353)	(0.564)
SWITCH	–0.013	0.005	0.083***
	(–1.631)	(0.537)	(3.714)
CONSTANT	6.010***	4.408***	–3.039***
	(128.485)	(70.438)	(–12.410)
YEAR FE	YES	YES	YES
INDUSTRY FE	YES	YES	YES

(*continued on next page*)

Table 5 (*continued*)

	(1)	(2)	(3)
	IC_INDEX	*AUDITLAG*	*MEDIA*
Adj./ Pseudo R^2	0.240	0.126	0.530
N	12,515	13,570	13,575

Notes: This table presents the results of mechanism tests examining the influence of online sales data on internal control quality, audit efficiency and external attention. *IC_INDEX* represents the natural logarithm of the Dibo internal control index. *AUDITLAG* is the natural logarithm of the number of days from the end of the fiscal year to the audit report date. *MEDIA* is the natural logarithm of the number of times a firm is mentioned in media headlines. Appendix 1 provides detailed variable definitions. The *t*-statistics in parentheses are adjusted for heteroscedasticity and clustered by firm. *, ** and *** represent significance levels of 10%, 5% and 1%, respectively.

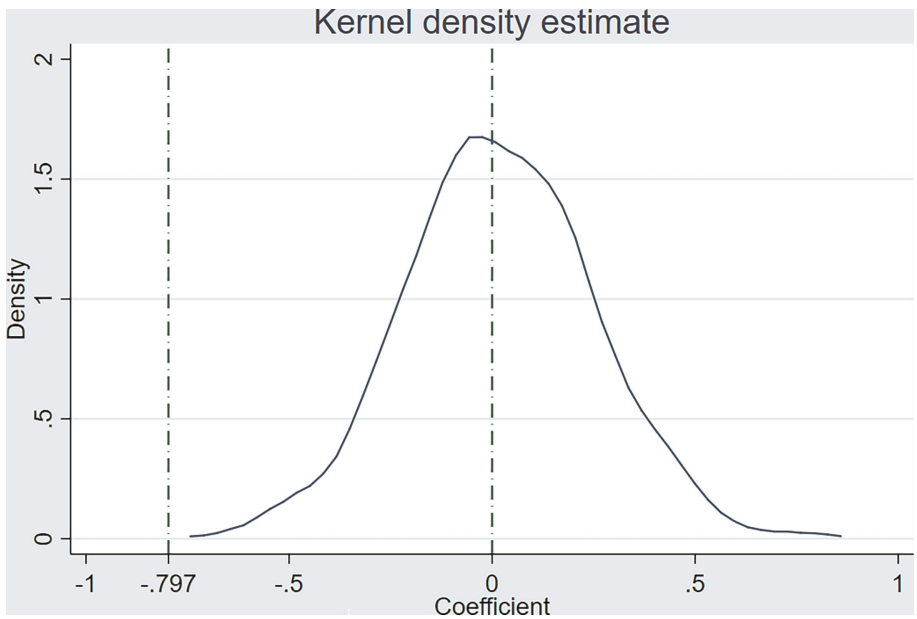

Fig. 1. Placebo test. *Notes*: This figure illustrates the density of the placebo test coefficients after 1,000 iterations. The event year is randomly assigned to each firm. The plotted estimates are the coefficients on the interaction term between the simulated time variable (*POST_r*) and *ONLINE*.

coefficients on *ONLINE* × *POST_r* exhibit a normal distribution centered around zero, indicating that randomly assigned event years do not affect the audit quality of firms with aggregate online sales data available. Our results remain robust.

4.2.8. Alternative dependent variable measure

We also use alternative proxies for audit quality, including modified audit opinions (*MAO*), financial fraud (*FRAUD*), the absolute value of discretionary accruals (*DA*), auditor industry specialization (*INDSPE*) and auditor city specialization (*CITYSPE*), as suggested by Rajgopal et al. (2021). The industry (city) specialization of an auditor is measured by the proportion of the accounting firm's revenue in a given industry (city)

Table 6
Heterogeneity analysis based on online sales importance.

	(1)
	RESTATE
ONLINE_HIGH	–0.073
	(–0.202)
ONLINE_LOW	0.093
	(0.312)
ONLINE_HIGH × POST	–0.934***
	(–3.137)
ONLINE_LOW × POST	–0.674*
	(–1.898)
LNTA	0.004
	(0.099)
LEV	0.823***
	(2.770)
QUICK	–0.045
	(–1.484)
INVR	–1.379***
	(–3.182)
RECR	–0.470
	(–1.163)
BALANCE	1.247
	(1.150)
ROA	–1.320***
	(–3.162)
COCF	–2.844***
	(–6.048)
NLOSS	0.492***
	(4.808)
MTB	–0.023***
	(–2.692)
M&A	0.378***
	(4.872)
SEO	–0.162
	(–1.440)
OWNER	–0.989***
	(–3.126)
PRIVATE	0.585***
	(5.585)
BH	–0.505*
	(–1.800)
AGE	0.215***
	(2.652)
MAO	1.244***
	(10.341)
BIG10	–0.136
	(–1.566)
SWITCH	0.499***
	(4.605)
CONSTANT	–2.349**
	(–2.387)
DIFF	p-value = 0.558

(*continued on next page*)

Table 6 (*continued*)

	(1)
	RESTATE
YEAR FE	YES
INDUSTRY FE	YES
Pseudo R^2	0.173
N	13,633

Notes: This table presents the results of heterogeneity tests examining the influence of online sales data importance on audit quality. *ONLINE_HIGH* is a dummy variable set to one if the proportion of online sales is above the median level, indicating a higher importance of online sales. Appendix 1 provides detailed variable definitions. The *t*-statistics in parentheses are adjusted for heteroscedasticity and clustered by firm. *, ** and *** represent significance levels of 10%, 5% and 1%, respectively.

relative to its total revenue from auditing services that year, with a higher ratio representing more professional audit services and higher audit quality. Given that large accounting firms often have highly diversified practices, resulting in lower proportions of industry (city) revenue that may fail to reflect their actual specialization level, our test of these two alternative variables is restricted to firms audited by the Big 4. The regression results are presented in Table 4, Panel G. After the aggregate release of third-party online sales data, there are significant decreases in the likelihood of receiving a modified audit opinion, financial fraud occurrence and the absolute value of discretionary accruals, and significant increases in both auditor industry and city specialization levels. These results support our main conclusions.

4.3. Mechanism tests

To further validate the theoretical rationale, we examine whether firms' internal control quality, audit efficiency and audit prudence improve after the aggregate release of online sales data by the WFT. Specifically, we measure internal control quality using the internal control index (*IC_INDEX*) and audit efficiency using audit lag (*AUDITLAG*). *IC_INDEX* represents the natural logarithm of the Dibo internal control index, with higher values indicating stronger internal control. *AUDITLAG* is the natural logarithm of the number of days from the end of the fiscal year to the audit report date, where lower values suggest higher audit efficiency. As audit prudence is difficult to measure, we assume that auditors tend to take a more cautious approach to maintain their high reputation when client firms receive more external attention. Hence, we measure external attention using media coverage (*MEDIA*). *MEDIA* is the natural logarithm of the number of times a firm is mentioned in media headlines within a year, with higher values indicating greater media attention. The regression results, presented in Table 5, indicate that after the aggregate release of online sales data, firms show improved internal control quality, reduced audit lag and increased media coverage. These findings align with our expectations, supporting our theoretical framework.

4.4. Heterogeneity analyses

4.4.1. Based on online sales importance

The third-party online sales data aggregated and released by the WFT cover online brands that closely align with offline channels. Liao et al. (2021) further find that when online sales constitute a higher proportion of a firm's total revenue, the data more accurately reflect its operational information and better represent its fundamental value. Hence, we examine the impact of online sales importance on audit quality. Following Zhu (2019), we divide the treatment group by the proportion of online sales in total revenue. Specifically, firms with a proportion of online sales above (below) the median level are categorized as the high ratio (low ratio) group,

Table 7
Heterogeneity analysis based on channel analyses.

	Managerial ownership		Big data capability		Investor attention	
	(1) High	(2) Low	(3) Low	(4) High	(5) High	(6) Low
ONLINE	–0.450	0.269	–0.406	0.266	–0.291	0.263
	(–1.274)	(0.796)	(–0.980)	(0.951)	(–0.939)	(0.764)
ONLINE × POST	–0.394	–1.030***	–0.190	–1.129***	–0.385	–1.520***
	(–1.053)	(–2.740)	(–0.367)	(–3.940)	(–1.219)	(–3.632)
LNTA	0.041	–0.053	–0.023	0.032	0.009	–0.021
	(0.557)	(–0.945)	(–0.359)	(0.573)	(0.148)	(–0.333)
LEV	1.288***	0.761**	1.228***	0.453	0.912**	0.821**
	(2.798)	(2.050)	(2.753)	(1.215)	(2.282)	(2.061)
QUICK	–0.049	–0.023	–0.018	–0.076**	–0.065	–0.021
	(–1.054)	(–0.583)	(–0.443)	(–1.986)	(–1.638)	(–0.534)
INVR	–2.587***	–0.823	–1.465**	–1.327**	–0.946*	–1.758***
	(–3.575)	(–1.629)	(–2.414)	(–2.398)	(–1.777)	(–2.843)
RECR	–0.809	–0.812	0.072	–0.933*	–0.777	–0.134
	(–1.460)	(–1.354)	(0.124)	(–1.855)	(–1.431)	(–0.254)
BALANCE	1.499	1.538	0.292	2.007	0.867	1.218
	(0.728)	(1.284)	(0.182)	(1.471)	(0.567)	(0.829)
ROA	–1.242*	–1.447***	–0.512	–1.936***	–1.720***	–0.584
	(–1.804)	(–2.612)	(–0.750)	(–3.576)	(–3.196)	(–0.889)
COCF	–3.814***	–2.084***	–2.685***	–2.937***	–3.062***	–2.536***
	(–5.241)	(–3.493)	(–3.503)	(–5.131)	(–4.612)	(–3.765)
NLOSS	0.767***	0.273*	0.475***	0.481***	0.489***	0.517***
	(4.919)	(1.909)	(2.953)	(3.641)	(3.294)	(3.455)
MTB	–0.010	–0.026***	–0.027**	–0.021*	–0.019*	–0.030**
	(–0.568)	(–2.663)	(–2.322)	(–1.762)	(–1.671)	(–2.328)
M&A	0.329***	0.348***	0.321***	0.423***	0.348***	0.410***
	(2.873)	(3.374)	(2.651)	(4.467)	(3.198)	(3.834)
SEO	–0.010	–0.422**	0.162	–0.395***	–0.080	–0.278
	(–0.069)	(–2.188)	(0.927)	(–2.591)	(–0.535)	(–1.586)
OWNER	–0.670	–0.989**	–1.473***	–0.653*	–0.449	–1.617***
	(–1.624)	(–2.201)	(–3.121)	(–1.766)	(−1.101)	(–3.794)
PRIVATE	0.173	0.743***	0.620***	0.552***	0.672***	0.448***
	(1.169)	(5.735)	(4.081)	(4.475)	(5.012)	(3.171)
BH	–0.951*	–0.356	–0.462	–0.601*	–0.362	–0.723**
	(–1.900)	(–1.176)	(–1.051)	(–1.771)	(–0.987)	(–1.995)
AGE	0.389***	0.132	0.166	0.219**	0.294***	0.131
	(3.310)	(1.126)	(1.343)	(2.334)	(2.736)	(1.255)
MAO	1.506***	1.108***	1.295***	1.185***	1.405***	1.110***
	(7.709)	(7.201)	(7.468)	(7.253)	(8.600)	(6.194)
BIG10	–0.131	–0.153	–0.240	0.011	–0.065	–0.223*
	(–1.135)	(–1.244)	(–1.472)	(0.107)	(–0.604)	(–1.863)
SWITCH	0.474***	0.516***	0.584***	0.357**	0.485***	0.540***
	(2.869)	(3.587)	(3.545)	(2.342)	(3.450)	(3.155)
CONSTANT	–3.220**	–1.148	–1.608	–2.897**	–3.044**	–1.140
	(–1.985)	(–0.927)	(–1.169)	(–2.369)	(–2.335)	(–0.859)
DIFF	p-value = 0.094*		p-value = 0.044**		p-value = 0.008***	
YEAR FE	YES	YES	YES	YES	YES	YES

(*continued on next page*)

Table 7 (*continued*)

	Managerial ownership		Big data capability		Investor attention	
	(1) High	(2) Low	(3) Low	(4) High	(5) High	(6) Low
INDUSTRY FE	YES	YES	YES	YES	YES	YES
Pseudo R^2	0.187	0.186	0.192	0.164	0.203	0.149
N	6,815	6,816	4,379	9,254	6,979	6,626

Notes: This table presents the results of heterogeneity tests based on channel analyses. Agency cost is proxied by managerial ownership. We divide our sample into high and low sub-samples each year based on the median value, as a lower ratio suggests a more severe agency problem. Audit efficiency is proxied by signing auditors' big data capability, as familiarity with alternative data leads to sufficient usage of online sales data and higher audit efficiency. External attention is proxied by individual investor attention from the Shanghai Stock Exchange E-Interaction and Shenzhen Stock Exchange Easy Interactive platforms, as auditors faced with more external pressure lower their acceptable audit risk. *CONTROLS* are the same as those in Eq. (1). The *t*-statistics in parentheses are adjusted for heteroscedasticity and clustered by firm. *, ** and *** represent significance levels of 10%, 5% and 1%, respectively.

with *ONLINE_HIGH* set to one (zero). Both the dummy variable and its interaction with *POST* are included in Eq. (1), and the results are presented in Table 6. The coefficients on the interaction terms *ONLINE_HIGH* × *POST* and *ONLINE_LOW* × *POST* are both significant and negative and the difference between them is not significant. This indicates that regardless of the online sales-to-revenue ratio, firms' audit quality improves following the aggregate release of third-party online sales data, which underscores the widespread and significant governance effect of aggregate online sales data release on audit quality.

4.4.2. Based on channel analyses

We conduct heterogeneity analyses to examine three channels through which the aggregate release of third-party online sales data may improve audit quality. First, the third-party online sales data could reduce information asymmetry between internal and external stakeholders, thus alleviating internal agency problems, maintaining internal control system effectiveness, lowering audit risk and ultimately improving audit quality. We therefore assume that the governance effect of data release on audit quality should be more pronounced among firms with more severe agency problems. Therefore, we divide firms according to whether their managerial ownership is above the median level, as a higher ratio suggests greater alignment with shareholder interests and lower agency costs (Jensen and Meckling, 1976). The results in columns (1) and (2) of Table 7 show that the regression coefficient on the interaction term *ONLINE* × *POST* is significant and negative only for firms with lower managerial ownership, which aligns with our expectation.

Second, the disclosure of third-party online sales data by the WFT enables auditors to access these relevant and reliable alternative data at a lower cost, which enhances audit efficiency and improves audit quality. The degree to which auditors use these data is likely to affect the design and execution of audit procedures, which in turn depend on auditor characteristics, particularly their familiarity with alternative data and big data. Indeed, accounting firms increasingly prioritize training their staff in digital and big data skills to meet new audit demands.[‡] Although it is challenging to measure big data skills at the individual auditor level, it is likely that knowledge spillover effects exist both among audit partners and between audit partners and their junior staff (Duh et al., 2020). We therefore posit that in firms with a higher proportion of signing auditors skilled in big data analysis, there is a greater emphasis on and use of alternative data, leading to stronger governance effects of aggregate online sales data on audit efficiency and quality. To test this, we group audit firms according to whether they own more signing auditors with expertise in computer science, statistics, digitalization and information management. The results in columns (3) and (4) of Table 7 show that the coefficient on *ONLINE* × *POST* is significant and negative only for firms audited by accounting firms with more signing auditors with high big data capability. This supports our hypothesis.

[‡] For example, EY launched the EY Badges program in 2017, and KPMG launched the KPMG Clara initiative in 2019.

Table 8
Heterogeneity analysis based on external corporate governance mechanism.

	(1) With site visits	(2) Without site visits
ONLINE	–0.576	0.290
	(–1.570)	(0.950)
ONLINE × POST	–0.416	–1.000***
	(–0.923)	(–2.933)
LNTA	–0.024	0.017
	(–0.298)	(0.321)
LEV	1.544***	0.583*
	(2.732)	(1.794)
QUICK	–0.106*	–0.018
	(–1.767)	(–0.536)
INVR	–1.492*	–1.333***
	(–1.864)	(–2.771)
RECR	–0.347	–0.729
	(–0.562)	(–1.462)
BALANCE	–0.341	1.766
	(–0.164)	(1.553)
ROA	–1.690*	–1.221**
	(–1.920)	(–2.561)
COCF	–4.323***	–2.007***
	(–5.012)	(–3.682)
NLOSS	0.478**	0.482***
	(2.370)	(4.016)
MTB	–0.027	–0.020**
	(–1.470)	(–2.127)
M&A	0.318**	0.409***
	(2.236)	(4.543)
SEO	–0.102	–0.226
	(–0.608)	(–1.441)
OWNER	–0.397	–1.407***
	(–0.879)	(–3.490)
PRIVATE	0.503***	0.627***
	(2.997)	(5.165)
AGE	0.027	–0.772**
	(0.065)	(–2.354)
MAO	0.108	0.230**
	(0.817)	(2.478)
BIG10	1.929***	1.065***
	(8.112)	(7.951)
CONSTANT	–6.007***	–5.471***
	(–3.194)	(–4.520)
DIFF	p-value = 0.060*	
YEAR FE	YES	YES
INDUSTRY FE	YES	YES
Pseudo R^2	0.190	0.178
N	5,732	7,887

Notes: This table presents the results of heterogeneity tests based on external corporate governance, which is measured by corporate site visits. *CONTROLS* are the same as those in Eq. (1). The *t*-statistics in parentheses are adjusted for heteroscedasticity and clustered by firm. *, ** and *** represent significance levels of 10%, 5% and 1%, respectively.

Finally, the disclosure of third-party online sales data may attract increasing external attention, imposing reputational pressure on auditors to adopt more cautious approaches and lower acceptable audit risk, thereby improving audit quality. We hypothesize that the additional reputation pressure from the increased visibility of online sales data is more pronounced among firms that lack external investor attention, resulting in stronger governance effects on audit quality. Here, we measure external investor attention by the total number of inquiries that a firm receives on the Shanghai Stock Exchange E-Interaction and Shenzhen Stock Exchange Easy Interactive platforms. Firms with enquiries above (below) the median level are classified as high (low) external attention groups. The regression results in columns (5) and (6) of Table 7 show that the coefficient on $ONLINE \times POST$ is significant and negative only for firms in the low external attention group. These findings again support our hypothesis.

4.4.3. Based on other external governance mechanisms

We have demonstrated that the aggregate release of third-party online sales data could have a governance effect and significantly enhance audit quality. However, while audit assurance is an essential aspect of corporate governance, its effectiveness is also influenced by other external governance mechanisms. Institutional investors, as professional participants in capital markets, are widely recognized for their external governance role. Institutional investors who conduct site visits obtain both public and private information through direct interactions with managers, which, together with third-party online sales data, constitutes the supplementary part of the firm's information environment. Hence, we explore whether the aggregate third-party online sales data are complementary to or substitutive of the governance effect from institutional investors' site visits. In general, institutional investors are equipped with expertise, capital and informational advantages. They perform governance roles by appointing board directors, exercising voting rights, selling shares or threatening to exit (Abramova et al., 2020). Institutional investors' site visits not only help them understand financial performance but also facilitate positive interactions between managers and investors, which can enhance firms' information quality (Tan and Lin, 2016). Therefore, we hypothesize that firms with more site visits from institutional investors only experience a limited incremental effect from the release of online sales data, potentially resulting in a lower than expected impact on audit quality.

To test this, we divide the sample based on whether the firm has been subject to site visits by institutional investors. In columns (1) and (2) of Table 8, the coefficient on the interaction term $ONLINE \times POST$ is significant and negative only for the group without site visits. This indicates the substitution role of the governance effects between institutional investors and the aggregate release of online sales data in improving audit quality. Firms with weaker external governance mechanisms benefit more from the information governance effects of aggregate third-party online sales data.

5. Conclusion

As the digital transformation of business and society deepens, the availability of alternative data has surged dramatically. Compared with traditional financial data, alternative data are timelier, more granular and highly unstructured, and are increasingly drawing researchers' attention due to their economic consequences. As a unique form of alternative data that directly influences operational performance and firm value, online sales data present new challenges for auditors in financial statement assurance. This study investigates whether the aggregate release of third-party online sales data exerts a governance effect by improving internal control quality, audit efficiency and audit prudence, thereby improving overall audit quality. The DID test results indicate that the disclosure of firms' aggregate online sales data by third-party platforms since 2018 has reduced the number of financial restatements and improved audit quality. This finding holds under various robustness checks, including alternative definitions of the independent variables, firm fixed effects, PSM-DID, entropy balancing, a Heckman two-stage model, the parallel trend assumption, placebo tests and alternative dependent variables. The mechanism tests reveal that following the release of aggregate online sales data, firms experience improved internal controls, higher audit efficiency and increased external attention. The heterogeneity analyses show that aggregate online sales data improve audit quality across firms with different levels of online sales, but this improvement is more pronounced for firms with severe agency problems, those audited by

accounting firms with more signing auditors with big data capability, those with less attention from individual investors and those without site visits from institutional investors.

With rapid advancements in big data and cloud computing technologies, auditors, as capital market participants, should quickly adapt to the evolving business models and urgent digital transformation needs by upgrading their professional skills to ensure high-quality information disclosures. For talent development, accounting firms should actively engage in university–industry collaboration to co-develop courses on big data analysis and auditing, cultivating and recruiting talent skilled in both accounting and data analytics. Digital skills training should also be incorporated into ongoing employee development programs, providing digital certifications for auditors. For audit assurance services, accounting firms may integrate information systems into traditional audits, and consider using reliable data from professional data service providers. As such, big data extraction and analysis technologies could be used to enhance audit efficiency and quality.

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 1. Variable definitions

Variable	Definition
AGE	Log value of listing years.
BALANCE	Related party transaction loan balance divided by total assets.
BH	A dummy equal to one if a firm issues B-shares or H-shares and zero otherwise.
BIG10	A dummy equal to one if a firm is audited by one of the Big 10 accounting firms and zero otherwise.
COCF	Operating cash flow divided by total assets.
INVR	Inventory balance divided by total assets.
LEV	Leverage, calculated as total long-term debt divided by total assets at the fiscal year end.
LNTA	Firm size, calculated as the natural logarithm of total assets at the fiscal year end.
MAO	A dummy equal to one if a firm receives a modified audit opinion for the fiscal year and zero otherwise.
MTB	The market value of equity divided by the book value of equity.
M&A	A dummy equal to one for firms with M&As and zero otherwise.
NLOSS	A dummy equal to one for firms with negative profit and zero otherwise.
ONLINE	The indicator for treatment firms, which equals one if firms have online sales data on the WFT and zero otherwise.
OWNER	The number of shares owned by controlling shareholders over the number of total shares at the end of the fiscal year.
POST	The indicator variable for the introduction of online sales data on the WFT, which is equal to one for 2018 and subsequent years and zero otherwise.
PRIVATE	A dummy equal to one for non-state-owned enterprises and zero otherwise.
QUICK	Quick ratio, calculated as current assets minus inventory, divided by current liabilities.
RECR	Calculated as net accounts receivable divided by total assets.
RESTATE	A dummy equal to one for firms with financial restatements over the fiscal year and zero otherwise.

(*continued on next page*)

(*continued*)

Variable	Definition
ROA	Return on assets, measured as income divided by assets at the year end.
SEO	A dummy equal to one for firms with seasoned equity offerings over the fiscal year and zero otherwise.
SWITCH	A dummy equal to one for firms with a change of accounting firm and zero otherwise.

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The cross-board spillover effect of innovation information: Establishment of the Star Market and Main Board analyst forecasts

Chengxin Jiang [a,*], Bin Liu [b], Wenjing He [b]

[a] School of Accounting, Chongqing University of Technology, Chongqing, China
[b] School of Economics and Business Administration, Chongqing University, Chongqing, China

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ABSTRACT

Studies show that innovation information disclosed by listed firms affects the decision of non-listed firms and their stakeholders. This paper explores whether innovation information disclosed within a specific list board (i.e., market) also spills over to other list boards. Based on the establishment of China's Star Market, we conduct an empirical test from the perspective of analyst forecasts. We find that (1) The accuracy of analyst forecasts of Main Board firms with greater information similarity to Star Market firms is significantly higher than that of Main Board firms with lower information similarity. (2) This effect is significantly stronger in samples with a substantially lower listing threshold for innovation firms, for Main Board firms with stronger innovation characteristics and when market innovation information needs are greater. (3) This affect is enhanced by analysts' tendency to track Star Market firms with similar information to their tracked Main Board firms. These results enrich research on the spillover effects of innovation information and factors affecting analyst forecasts.

1. Introduction

Innovation information disclosed by firms has positive externalities and can affect the decisions of other firms and their stakeholders (Lück et al., 2020; Kim and Valentine, 2021; Hegde et al., 2023), i.e., the spillover effect of innovation information. The literature mainly focuses on this spillover effect at the firm level, studying

* Corresponding author at: #69 Hongguang Road, Banan District, Chongqing 400054, China.
E-mail address: ChengxinJiang1996@126.com (C. Jiang).

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how innovation information spills over from firms with higher disclosure levels to firms with lower disclosure levels.[1] Considering that a country's listed boards (i.e., markets) usually focus on different types of firms[2] and provide information with different characteristics, the above-mentioned firm-level innovation information spillover effect is also likely to exist between specific listed boards. Accordingly, this paper explores whether a listed board focusing on innovation firms has innovation information spillover effects on other listed boards.

In 2019, China established the Star Market on the Shanghai Stock Exchange, providing an opportunity to study the above issues. First, the Star Market focuses on supporting high-tech and strategic emerging industries such as the new-generation information technology, high-end equipment, new materials, new energy, energy conservation and environmental protection and biomedicine industries[3]; thus, it has innovative attributes distinct from those of other listed boards in China. Second, from 2019 to 2022, the Shanghai and Shenzhen Main Boards added about 400 listed firms, while the Star Market added about 500 listed firms. The Star Market has a clear and important impact on the number of listed firms in China. Third, the establishment of Star Market has a certain level of exogeneity, which enhances the effectiveness of causal identification of the innovation information spillover effect.

The literature mainly studies the innovation information spillover effect from the perspectives of corporate investment and disclosure, patent transactions and investors' investment (e.g., Badertscher et al., 2013; Wu Cen et al., 2022; Kim and Valentine, 2023). In theory, innovation information spillover may affect any user of innovation information. In particular, innovation information is important for analysts (e.g., Jones, 2007; Palmon and Yezegel, 2012; Bellstam et al., 2021). However, few studies explore the innovation information spillover effect from the perspective of analyst forecasts. In addition, no research on the factors influencing analyst forecasts is focused on the innovation information spillover effect. Therefore, in contrast to the literature, this paper takes the establishment of the Star Market in China as an opportunity to examine whether innovation information has a spillover effect at the level of listed boards from the perspective of analyst forecasts.

Specifically, we use the similarity of management discussion and analysis (MD&A) texts to identify the impact of the establishment of the Star Market on Main Board firms in terms of innovation information and construct a difference-in-differences (DID) model for empirical testing. The results show that (1) After the establishment of the Star Market, the analyst forecasts of Main Board firms with a higher level of information similarity to Star Market firms improve significantly compared with the forecasts of Main Board firms with a lower level of information similarity. The results pass the parallel trend and placebo tests, as well as alternate robustness tests such as controlling for the impact of the ChiNext registration system reform, adjusting the method used to identify the key variable, a time-varying DID and an analysis report level test. (2) This effect is stronger in samples with a substantially lower listing threshold for innovative firms, for Main Board firms with stronger innovation characteristics and when investors' innovation information needs are greater. (3) This effect is also enhanced by analysts' tendency to track Star Market firms that have similar information to the Main Board firms they are tracking.

This paper contributes to the bodies of literature on the spillover effect of innovation information and the factors influencing analyst forecasts. Recent literature confirms the spillover effect of innovation information at the firm level (e.g., Badertscher et al., 2013; Cotei and Farhat, 2013; Li et al., 2022) but does not address whether innovation information also has a spillover effect at the listed board level. In this paper, different listed boards are shown to have differentiated positioning, and a spillover effect of innovation information between listed boards is proposed. This effect is confirmed by the establishment of the Star Market in China, an exogenous shock, and thus contributes to the literature on the spillover effect of innovation information. Furthermore, the literature mainly explores the factors influencing analyst forecasts in terms of the characteristics of the analysts and the analyzed firms (e.g., Christensen et al., 2013; Gu et al., 2019). In contrast, there is little

[1] For example, spillover from listed firms to non-listed firms (Badertscher et al., 2013) or from inventors to citers (Hegde et al., 2023).

[2] For example, Nasdaq claims that it "became home to many of the growth-oriented companies and industries ... providing a market for these innovative companies," and the New York Stock Exchange claims that it has "been the place where world leaders come to raise capital ... include the boldest leaders across all verticals." See https://www.nasdaq50.com/stories/30, https://www.nyse.com/network.

[3] See "Implementation Opinions on Establishing Star Market and Piloting a Registration System at the Shanghai Stock Exchange", https://www.gov.cn/zhengce/zhengceku/2019-10/18/content_5441532.htm.

focus on how innovation information from one listed board can spill over to analysts and affect their forecasts regarding firms on other listed boards. Therefore, this paper fills the gap in the literature on the factors influencing analyst forecasts.

2. Literature review

As noted above, our study stands at the intersection of two strands of literature, namely the strands on the information spillover effect and the factors influencing analyst forecasts.

The information spillover effect can be described as the impact of information disclosed by one firm on the decisions of other related firms and their stakeholders. The relevant literature can be roughly divided into three aspects. The first aspect is the type of information, including accounting statement information (Lu et al., 2019), research and development (R&D) information (Merkley, 2014; Kim and Valentine, 2023), internal control information (Gao and Zhang, 2019), competition information (Fang et al., 2018; Kim et al., 2008), regulated information (Brown et al., 2018) and initial public offering (IPO) inquiry information (Wu et al., 2022). The second aspect concerns the paths of this spillover effect, including a shared industry (Badertscher et al., 2013; Gao and Zhang, 2019; Li et al., 2021; Wu et al., 2022), supply chain (Chiu et al., 2019) and auditors (Christoph et al., 2023). The third aspect comprises economic consequences, including corporate investment (Badertscher et al., 2013), cash holdings (Chen et al., 2014; Di et al., 2020), risk information disclosure (Brown et al., 2018), tax pressure (Dai et al., 2023), accounting manipulation (Gao and Zhang, 2019), earnings forecasts (Kim et al., 2008), stock price synchronization (Wu et al., 2022) and patent transactions (Kim and Valentine, 2023).

The factors influencing analyst forecasts can also be roughly divided into three categories. The first category pertains to the information quality of analyzed firms, including the information disclosure quality (Fang, 2007), information transparency (Christensen et al., 2013), information available to management (Liu and Chen, 2019), annual report readability (Xu et al., 2021; Li et al., 2023) and online sales (Liu et al., 2022). The second category concerns the ability of analysts to obtain and interpret information, including basic characteristics (Clement, 1999), industry expertise (Liu and Gao, 2014), overseas experience (Guan et al., 2020), understanding of IFRS (Barniv and Myring, 2015), attendance of conference calls (Mayew et al., 2013), site visits (Cheng et al., 2016) and personal relationships with management (Gu et al., 2019). The third category involves information sources external to the analyzed firms, including the comparability of accounting information between other firms and the analyzed firms (De Franco et al., 2011), information disclosed by firms with economic ties to the analyzed firms (Guan et al., 2015), media reports (Tan et al., 2016) and economic policy uncertainty (Dai and Yang, 2020).

In summary, different types of information, such as accounting information, innovation information and governance information, can produce spillover effects through multiple paths, such as a shared industry, supply chain and auditor, but few publications focus on innovation information spillover between different listing boards. Furthermore, analyst forecasts are affected by factors such as the quality of information about the analyzed firms, analysts' ability and information sources external to the analyzed firms, but no literature focuses on the listing of innovation firms, an important factor related to the innovation information environment. This paper studies how the IPO wave of the Star Market affects the forecasts of analysts of Main Board firms through the innovation information spillover effect, thus helping to fill the two above-described gaps in the literature.

3. Hypothesis development

3.1. Institutional background

The Star Market has distinct innovation attributes. The *Regulations on the Registration Administration of Initial Public Offering of Stocks on the Star Market (Trial)* state that "priority will be given to supporting enterprises that are in line with national strategies, possess key core technologies, have outstanding scientific and technological innovation capabilities, and mainly rely on core technologies to carry out production and operations ... and have strong growth potential." First, in terms of industry, the Star Market focuses

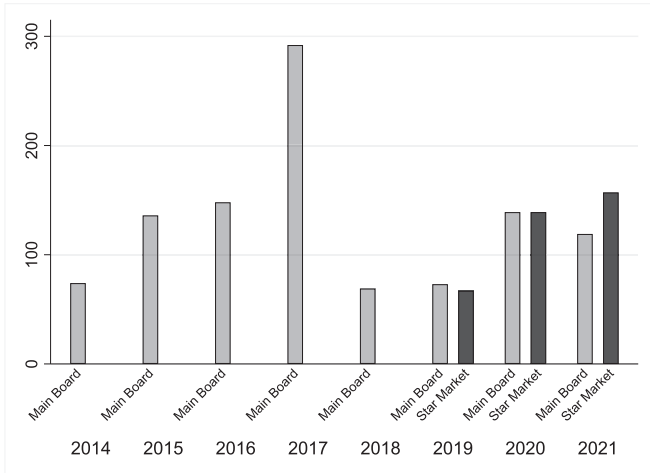

Fig. 1. Numbers of IPOs on the Main Board and the Star Market over time (years).

on supporting the listing of enterprises in high-tech fields such as new-generation information technology, high-end equipment, new materials, new energy, energy conservation and environmental protection and biomedicine. Second, in terms of listing conditions, the Star Market has five financial conditions for listing, among which some clauses do not require net profit, some clauses require R&D investment and some clauses do not require traditional financial indicators such as net profit and operating income but only require innovation indicators. Compared with other boards, the Star Market has substantially weakened traditional financial indicators and strengthened innovation indicators. Third, in terms of the number of IPOs over the years (as shown in Fig. 1), the Star Market and Main Board report similar numbers, and the number of IPOs on the Main Board has not decreased significantly compared with that in previous years, indicating that Star Market firms have not reduced the number of IPOs on the Main Board. Fourth, in terms of the actual financial indicators of listed firms in the IPO year (as shown in Fig. 2), Star Market firms have significantly higher R&D expenditures than Main Board firms but significantly lower net profits, operating income and net cash flow from operating activities, indicating that the Star Market mainly supports innovative firms that cannot easily meet the listing conditions of the Main Board. In summary, based on the listing system arrangements and the actual situations of listed firms, the Star Market has added a batch of innovative listed firms to the capital market.

3.2. Theoretical analysis

First, the Star Market provides incremental information about innovation to the capital market. Compared with non-listed firms, listed firms face extensive and strict information disclosure requirements and are obliged to publicly publish their financial statements and other information related to shareholders' equity (Aghamolla and Thakor, 2022). In addition, given the need to make reasonable valuations and investment decisions for listed firms, investors, analysts and other capital market entities usually have substantial requirements regarding the level and quality of information disclosed by listed firms (Chapman and Green, 2018). In fact, many firms choose not to go public, or to make a trade-off between going public and avoiding information proprietary costs, precisely to avoid the proprietary costs generated by the increased information disclosure requirements after listing (Marra and Suijs, 2004).

In addition, although the disclosure of innovation information generates proprietary costs (Cao et al., 2018) and thus restricts firms after listing, this restriction only occurs after listing leads to an increase in information disclosure. Therefore, even when proprietary costs are considered, the net effect of listing on innovation information disclosure should be positive rather than negative. In short, it can be inferred that the listing of innovative firms should result in an increase in innovation information. Analysis of the institutional background reveals that the Star Market has successfully listed many innovative firms in a short period of time, thus

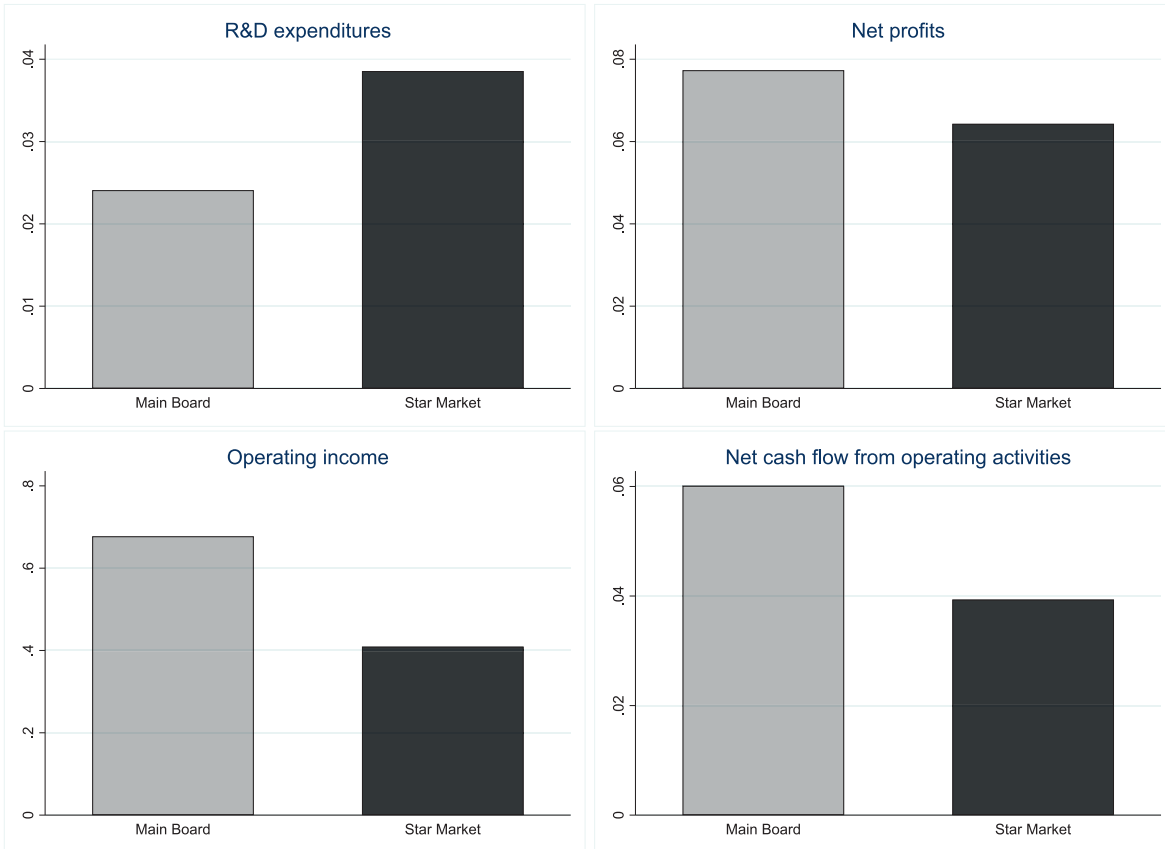

Fig. 2. Financial indicators of firms listed on the Main Board and Star Market in the year of listing.

resolving the paucity of innovative listed firms in China's capital market to a certain extent. In addition, a series of institutional arrangements implemented by the Star Market, such as registration system reform, IPO review inquiry and the disclosure system, have further strengthened the information disclosure of its listed firms. In summary, the Star Market is expected to result in an increase in innovation information within the capital market.

Second, innovation information has positive externalities. In economics, a positive externality is defined as the positive impact of the behavior of an entity on other entities in society. At the firm level, the positive externalities of innovation information are reflected by impacts on similar R&D activities. Information contained in innovation disclosures, such as new technologies, products or business models, can inspire other firms. These other firms can formulate their own innovative ideas, thereby promoting their own innovation activities. Research also supports this point. For example, Lück et al. (2020) show that the disclosure of innovation information can reduce repetitive research, thus reducing the wastage of social resources and subsequently helping other innovators quickly achieve more differentiated innovation results. Kim and Valentine (2018) and Hegde et al. (2023) provide evidence supporting these findings based on the US Inventor Protection Act. Li et al. (2022) show that the innovation information disclosed by listed firms reduces the uncertainty surrounding the innovation activities of non-listed firms. In short, in the context of positive externalities, the innovation information provided by the Star Market should affect the innovation information environment for other related firms.

Finally, the innovation information provided by the Star Market can help analysts make predictions about Main Board firms. First, innovation has a positive impact on the future profitability and market value of enterprises, but this impact is often underestimated by investors (Dong et al., 2021). Therefore, innovation information helps investors and other outsiders estimate the future profitability and value of an enterprise. Research also shows that innovation information is an important supplement to financial statement informa-

tion. Gu and Li (2003) find that when the availability of current profit information decreases or uncertainty about future profits increases, firms increase their innovation disclosure. Merkley (2014) finds that earnings adjusted for R&D expenses are negatively correlated with narrative R&D disclosure. Second, the source of innovation information is very important to analysts. Due to serious information asymmetry, corporate R&D investment reduces the accuracy of analysts' forecasts (Amir et al., 2003; Gu and Wang, 2007; Chalmers et al., 2011). Therefore, analysts who lack sources of innovation information find it difficult to provide useful forecasts for R&D-intensive companies (Palmon and Yezegel, 2012). In contrast, the disclosure of innovation information helps analysts' forecasts. For example, disclosure in the development stage helps reduce uncertainty regarding the conversion of R&D into future sales, thereby improving the accuracy of analysts' forecasts (Jones, 2007). Analysts also use innovation information when describing a company's characteristics (Bellstam et al., 2021). Third, analysts benefit from information complementarity between different firms (Guan et al., 2015). Firms may face certain common challenges and risks in innovation, such as industry competition, technical difficulties and regulatory changes. Analysts can incorporate such information into their forecasts to better understand certain common problems in the innovation field and increase the accuracy and comprehensiveness of their conclusions.

In summary, the Star Market provides the capital market with incremental innovation information, which has positive externalities: It affects the innovation information environment of other firms, and the availability of sufficient innovation information helps analysts make forecasts. Therefore, the Star Market should have a positive impact on the forecast accuracy of analysts of Main Board firms. Based on this, we propose the following research hypothesis:

Hypothesis 1 (H1). The establishment of the Star Market improves the accuracy of analysts' forecasts for Main Board firms.

4. Research design

4.1. Sample selection and data sources

As this paper explores the spillover effect of the establishment of the Star Market, the initial sample should comprise companies listed outside the Star Market, including those listed on the Shanghai Stock Exchange Main Board, Shenzhen Stock Exchange Main Board[4] and ChiNext. However, ChiNext implemented a registration system reform in 2020, which may interfere with the explained variables of the sample companies in the treatment window (see below) and lead to deviations in the results of testing the consequences of the establishment of the Star Market. In addition, the establishment of the Star Market provides the proposed listed companies with additional options regarding the listing board. Main Board firms newly listed before and after the establishment of the Star Market may have systematic differences. For these reasons, we select only companies listed on the Shanghai and Shenzhen Main Boards before 2019 as our sample.

Regarding the time range of sample selection, we follow two principles. First, we ensure that the length of the control window (before the establishment of the Star Market) and the treatment window (after the establishment of the Star Market) are consistent. Second, we include as many observations as possible while not substantially expanding the time window to ensure that the test results best reflect the impact of the establishment of Star Market, rather than other events. In addition, due to a data update situation at the time of the study, the final time range is set from 3 years before and to 3 years after the establishment of the Star Market, or 2016–2021. Following research conventions, we also exclude financial industry companies, special treatment companies and observations with missing variables. As data from 2016 to 2018 are needed to construct variables in subsequent tests, we also exclude companies that do not fully span the time range to ensure balanced panel data.

The MD&A texts are obtained from the annual reports disclosed by listed companies on the Juchao Information Network. Accounting statement data, stock returns, stock prices, book-to-market ratios, analysts'

[4] The Shenzhen Stock Exchange's ChiNext was merged into the Main Board in 2021. Prior to 2021, ChiNext actually assumed the functions of the Main Board; accordingly, we do not list it separately.

forecasts of earnings per share and actual earnings per share are obtained from the China Stock Market & Accounting Research Database, and other data are from the Chinese Research Data Services Platform. Data on the number of innovative questions are obtained from SSE E-interactive and SZSE Interactive Easy. Finally, following research conventions, all the continuous variables are winsorized at the 1% and 99% levels to eliminate the effects of extreme values.

4.2. Empirical model and variable description

We establish the following DID model to test H1:

$$Accuracy_{it} = \beta_0 + \beta_1 Post_t \times Treat_i + \beta_C Control_{it} + Firm_i + Year_t + \varepsilon_{it} \quad (1)$$

where $Accuracy_{it}$ represents the accuracy of the analyst forecast of Main Board company i in year t. $Post_t$ represents a dummy variable indicating whether year t is after the establishment of Star Market. $Treat_i$ represents the intensity of treatment of Main Board company i by the establishment of Star Market. $Control_{it}$ represents a vector composed of control variables, with reference to Han et al. (2018), and includes the number of analysts following (*Follow*), number of analyst research reports (*FCFreq*), number of analyst on-site inspections (*Visits*), company size (*Size*), asset–liability ratio (*Lev*), return on total assets (*ROA*), loss or not (*Loss*), company age (*Age*), number of media reports (*Media*), stock returns (*Stkret*), book-to-market ratio (*BTM*), corporate transparency (*Opacity*), whether the chairman and general manager are the same person (*Dual*), ownership concentration (*Sharehd*) and institutional holdings (*Inst*). *Firm* and *Year* represent firm and year fixed effects, respectively. We mainly focus on the coefficient β_1. A positive and significant coefficient indicates that the establishment of the Star Market improves the accuracy of analyst forecasts for Main Board firms, thus confirming H1.

Referring to the approach of Han et al. (2018), we use the mean value of analyst forecast accuracy at the company-year level to measure *Accuracy*, which is calculated as follows:

$$Accuracy_{it} = -\frac{1}{n_{it}} \sum\nolimits_{1}^{n_{it}} \left| ForecastEPS_{ijt} - EPS_{it} \right| / P_{it}$$

where i represents the company, j represents the analyst, t represents the fiscal year and n_i represents the number of times the analyst predicts the earnings per share of company i in fiscal year t. *Accuracy* represents the accuracy of the forecast, *ForecastEPS* represents the earnings per share predicted by the analyst, *EPS* represents the company's actual earnings per share and P represents the stock price at the end of the year.

In the absence of ideal experimental and control groups, the effectiveness of the DID model depends on the accurate measurement of treatment intensity. It is difficult to determine which Main Board firms are completely unaffected by the incremental innovation information resulting from the establishment of the Star Market. Therefore, empirical testing depends on how the treatment intensity (*Treat*) of the impact of the establishment of the Star Market on Main Board firms is measured. Obviously, the more similar the innovation information disclosed by Main Board firms is to the innovation information resulting from the establishment of the Star Market, the greater the intensity of treatment the Main Board firms will receive. As MD&A texts are important carriers of corporate non-financial information and the main source of information used to measure innovation disclosure in research (Li and Yao, 2020; Zhou et al., 2022), we use the MD&A similarity between Main Board firms and Star Market firms to identify *Treat*. In addition, considering that the MD&A similarity between Main Board firms and Star Market firms may contain time trends, we also use the MD&A similarity between Main Board firms and Main Board firms listed after 2019 for deflation,[5] a process described in detail below.

[5] For example, the industry of Main Board firms x has developed rapidly in recent years, and the number of IPOs has grown rapidly; the situation for Main Board firms y is the opposite. Directly using the MD&A similarity between Main Board firms and Star Market firms to measure *Treat* would result in a value of $Treat_x$ greater than that of $Treat_y$, but this would be caused by the different development trends of the industries described by the two variables, rather than the establishment of the Star Market. The growth in the number of IPOs due to this time trend is not limited to the Star Market. Therefore, using the MD&A similarity between Main Board firms and newly listed Main Board firms from 2019 to 2021 for deflation can eliminate the above time trend to a certain extent.

First, the similarity between the MD&A of the Main Board firms in fiscal year 2018[6] and that of the Star Market firms listed in 2019 in fiscal year 2019[7] (*SimStar19*), of Star Market firms listed in 2020 in fiscal year 2020 (*SimStar20*) or of Star Market firms listed in 2021 in fiscal year 2021 (*SimStar21*) is calculated. Second, the similarity between the MD&A of Main Board firms in fiscal year 2018 and the MD&A of Main Board firms listed in 2019 in fiscal year 2019 (*SimMain19*), of Main Board firms listed in 2020 in fiscal year 2020 (*SimMain20*) or the MD&A of Main Board firms listed in 2021 in fiscal year 2021 (*SimMain21*) is calculated. Finally, *Treat* is calculated as follows:

$$Treat_x = (\frac{1}{m} \times \sum_{y=1}^{m} (SimStar19_{xy} + SimStar20_{xy} + SimStar21_{xy}))/(\frac{1}{n} \times \sum_{z=1}^{n} (SimMain19_{xz} + SimMain20_{xz} + SimMain21_{xz}))$$

where x represents Main Board firms listed before 2019, y represents Star Market firms, z represents Main Board firms listed between 2019 and 2021, m represents the number of y and n represents the number of z.

We use the cosine of the angle between text vectors to measure similarity. The specific calculation steps are as follows. First, segment the MD&A text according to *Jieba*. Second, use the term frequency–inverse document frequency (TF-IDF) method to calculate the inverse document frequency for each word as follows[8]:

$$idf(w) = log(N/df(w))$$

where $idf(w)$ represents the inverse text frequency of word w, N represents the total number of texts and $df(w)$ represents the number of texts in which w appears. Third, calculate the TF-IDF value of all words in each text as follows:

$$TF\text{-}IDF(w) = tf(w) \times idf(w)$$

where $tf(w)$ represents the frequency of word w in the text. Fourth, each text is vectorized: the elements of the vector are all words, and the value of the element is the TF-IDF value of the word. Finally, the cosine of the vector angle is calculated as follows:

$$SIM = cos(\theta) = \sum_{i=1}^{n} (X_i \times Yi) / \sqrt{\sum_{i=1}^{n} (X_i)^2} \times \sqrt{\sum_{i=1}^{n} (Y_i)^2}$$

where n represents the vector length (total number of words), and X_i and Y_j represent the value of each element in the MD&A text vector of firm i and the MD&A text vector of firm j, respectively. The larger the *SIM*, the smaller the angle and the greater the cosine similarity of the text.

The definitions of other variables are shown in Table 1.

5. Empirical results and discussion

5.1. Descriptive statistics

The descriptive statistics are presented in Table 2. The mean value of *Accuracy* is –0.0374, indicating that on average, the absolute value of the ratio of the earnings per share to the stock price predicted by analysts

[6] Factors such as the macroeconomic situation may affect the MD&A of both Main Board firms and Star Market firms simultaneously, thereby affecting the text similarity between the two, and these factors may also affect analysts' forecasts; accordingly, using the MD&A of Main Board firms after the establishment of the Star Market may lead to endogeneity. Therefore, we use the MD&A of Main Board firms in the fiscal year 2018, which is temporally close to but before the establishment of the Star Market.

[7] If the MD&A of the Star Market firms listed in 2019 were used to calculate the *SIM* in 2020, the treatment intensity attributable to 2019 would be absorbed. Therefore, we use the MD&A of the newly listed Star Market firms in that year and do not include the MD&A of the Star Market firms that were listed in the prior year or before.

[8] Using inverse text frequency, lower weights can be assigned to words with higher frequency and higher weights to words with lower frequency. This is based on two empirical observations: the greater the term frequency of a word in a text, the more relevant it is to the text; the more texts a word appears in, the weaker its ability to distinguish texts.

Table 1
Variable definitions.

Variable	Definition
Accuracy	The average of the absolute differences between analysts' forecasts of earnings per share and the firms' actual earnings per share, divided by the stock price; the inverse is taken.
Post	A dummy variable equal to 1 after 2019, and 0 otherwise.
Treat	See above.
Follow	The number of securities firms tracking the firms.
FCFreq	The natural logarithm of the number of analyst research reports plus 1.
Visits	The number of on-site visits by analysts.
Size	The natural logarithm of the total assets.
Lev	The total debts divided by the total assets.
ROA	The net profit divided by the total assets.
Loss	A dummy variable equal to 1 if the net profit is negative, and 0 otherwise.
Age	The number of years the company has been listed.
Media	The number of online media reports about a firm.
Stkret	The annual stock returns.
BTM	The net assets at the end of the period, divided by the market value at the end of the period.
Opacity	Manipulability accruals, calculated using the modified Jones model.
Dual	A dummy variable equal to 1 if the chairman and general manager are the same person, and 0 otherwise.
Sharehd	The shareholding ratio of the top 10 shareholders.
Inst	The shareholding ratio of institutional investors.

Table 2
Descriptive statistics.

Variables	N	Mean	SD	Min	Max
Accuracy	7,026	–0.0374	0.0564	–0.3428	–0.0002
Post	7,026	0.5000	0.5000	0.0000	1.0000
Treat	7,026	0.7650	0.1109	0.5731	1.0812
Follow	7,026	2.4672	0.8115	0.6931	3.8501
FCFreq	7,026	2.4046	1.3780	0.0000	4.9200
Visits	7,026	1.4883	1.9696	0.0000	6.4693
Size	7,026	23.1895	1.2814	20.8735	27.0987
Lev	7,026	0.4666	0.1884	0.0829	0.8845
ROA	7,026	0.0435	0.0557	–0.1876	0.2022
Loss	7,026	0.0796	0.2706	0.0000	1.0000
Age	7,026	2.5785	0.5615	0.6931	3.3673
Media	7,026	4.2683	0.8879	2.5649	7.0405
Stkret	7,026	0.0628	0.4319	–0.5563	1.8561
BTM	7,026	0.6950	0.2656	0.1401	1.2350
Opacity	7,026	0.0483	0.0494	0.0007	0.2647
Dual	7,026	0.2202	0.4144	0.0000	1.0000
Sharehd	7,026	59.4538	14.8094	26.8700	91.7200
Inst	7,026	5.3340	6.0537	0.0005	27.5994

differs from the actual situation by about 3.74%. The mean value of *Post* is 0.5000, which is because we use balanced panel data, and the mean value of *Treat* is 0.7650.

5.2. Baseline results

Table 3 presents the regression results of model (1). When no control variables are included, the coefficient of *Post* × *Treat is* 0.0654, which is significant at the 1% level. After including control variables, the coefficient of *Post* × *Treat* is 0.0525, which is also significant at the 1% level, indicating that the establishment of the Star Market is associated with improved forecast accuracy among the analysts of Main Board firms.

Table 3
Results of testing *H1*.

	(1) *Accuracy*	(2) *Accuracy*
Post × Treat	0.0654***	0.0525***
	(5.69)	(5.85)
Follow		–0.0186***
		(–8.62)
FCFreq		0.0145***
		(14.81)
Visits		0.0019***
		(2.94)
Size		0.0044
		(1.19)
Lev		–0.0086
		(–0.82)
ROA		0.2278***
		(6.33)
Loss		–0.0727***
		(–14.30)
Age		–0.0025
		(–0.43)
Media		–0.0036**
		(–2.16)
Stkret		–0.0129***
		(–5.76)
BTM		–0.0282***
		(–3.57)
Opacity		–0.0973***
		(–5.72)
Dual		0.0011
		(0.49)
Sharehd		0.0005***
		(3.13)
Inst		0.0005***
		(4.19)
Constant	–0.0192***	–0.1059
	(–18.64)	(–1.37)
Observations	7,026	7,026
R-squared	0.098	0.474
Firm	Yes	Yes
Year	Yes	Yes

Note: Asterisks denote the level of statistical significance: ***, $p < 0.01$; **, $p < 0.05$; *, $p < 0.1$. The t values are in parentheses.

5.3. Robustness tests

5.3.1. Parallel trend test

One important prerequisite for using the DID model is that the experimental group and the control group meet the parallel trend condition; that is, before the exogenous shock occurs, the outcome variables of the two groups should have a consistent change trend. To test whether model (1) satisfies the parallel trend assumption, we construct the following model:

$$Accuracy_{it} = \beta_0 + \beta_1 Post2017_t \times Treat_i + \beta_2 Post2018_t \times Treat_i + \beta_3 Post2019_t \times Treat_i + \beta_4 Post2020_t \times Treat_i + \beta_5 Post2021_t \times Treat_i + \beta_C Control_{it} + Firm_i + Year_t + \varepsilon_{it} \quad (2)$$

where *Post2017–Post2021* respectively are dummy variables representing 2017–2021; the definitions of the other variables are the same as in model (1). We focus on the regression coefficients of *Post2017 × Treat*

and *Post2018* × *Treat*. If these are not significant, then within the comparison window, the analyst forecast accuracy of Main Board firms will not be differentiated by a difference in *Treat* and the change trends will be consistent with the parallel trend condition.

The regression results of model (2) are shown in column 1 of Table 4. The coefficients of *Post2017* × *Treat* and *Post2018* × *Treat* are not significant, consistent with the expectations of the parallel trend test. In addition, the coefficients of *Post2019* × *Treat*, *Post2020* × *Treat* and *Post2021* × *Treat* are all positive and significant, and the absolute values of the coefficients exhibit a gradually increasing trend, implying a gradually increasing trend in the effect predicted in H1. This trend may be related to the growing number of firms listed on the Star Market.

5.3.2. Placebo test

A common problem affecting empirical analyses of policy consequences is that due to the complexity of the real economy and society, as well as the policy impacts covered by the research itself, firm behavior may be affected by many unobservable factors. Therefore, even if the model setting satisfies the parallel trend assumption, this does not guarantee that the empirical results are caused by policy implementation. Our results may be similarly affected. For this reason, we designed a placebo test. Generally, we select a year other than the actual year of establishment and set this as the assumed year of establishment and then conduct the same test as in model (1). If the result is not significant, then the results of model (1) do not exist without policy implementation; in other words, the placebo test is passed.

To set the macro-environment of the alternative sample as closely as possible to model (1) and obtain as sufficient a sample as possible, while ensuring that the assumed treatment window does not coincide with the actual treatment window, we use 2016, 2017 and 2018, the years the closest to the actual treatment win-

Table 4
Robustness testing.

	(1) *Accuracy*	(2) *Accuracy*	(3) *Accuracy*	(4) *Accuracy*	(5) *Accuracy*	(6) *Accuracy*	(7) *Accuracy1*
Post2017 × *Treat*	–0.0040						
	(–0.56)						
Post2018 × *Treat*	0.0030						
	(0.37)						
Post2019 × *Treat*	0.0305***						
	(2.89)						
Post2020 × *Treat*	0.0360***						
	(3.27)						
Post2021 × *Treat*	0.0621***						
	(4.76)						
Post × *Treat*		–0.0068	0.0598***				0.4300***
		(–0.95)	(5.94)				(3.99)
Post × *ChiNext*			0.0157				
			(1.64)				
Post × *Treat1*				0.0027***			
				(4.00)			
Post × *Treat2*					0.0585***		
					(5.00)		
Star						0.0280***	
						(5.79)	
Control	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	–0.0235	0.0360	–0.1076	–0.1354*	–0.1855*	–0.1376*	2.9114***
	(–1.31)	(0.69)	(–1.39)	(–1.72)	(–1.75)	(–1.78)	(2.97)
Observations	7,026	6,840	7,026	7,026	4,752	7,026	348,654
R-squared	0.465	0.431	0.474	0.472	0.382	0.474	0.211
Firm	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: Asterisks denote the level of statistical significance: ***, $p < 0.01$; **, $p < 0.05$; *, $p < 0.1$. The t values are in parentheses.

dow, as the assumed treatment window, and use 2013, 2014 and 2015 as the comparison window. We trace *Treat* in model (1) back to the time window of the placebo test; that is, *Treat* for each company remains unchanged, and only the value of *Post* is changed. The other settings are consistent with model (1). The regression results are shown in column 2 of Table 4. The coefficient of *Post* × *Treat* is not significant, indicating that the regression results of model (1) do not exist without policy implementation, and the placebo test is passed.

5.3.3. Controlling the impact of the ChiNext registration system reform

One year after the establishment of the Star Market, on 24 August 2020, the Shenzhen Stock Exchange organized the first batch of companies under the ChiNext registration system to go public. Compared with the period before the registration system reform, the listing conditions of ChiNext have undergone significant changes since the reform, including clauses without profit requirements and clauses requiring R&D performance. The ChiNext registration system reform may also result in an increase in innovative listed firms, which would produce the same effect as H1 and thus threaten our baseline results. To this end, we incorporate ChiNext-related variables into model (1): We use the same method as that used to construct *Treat* and calculate the ChiNext impact variable *ChiNext* using firms listed on ChiNext after 2020, and construct the following model:

$$Accuracy_{it} = \beta_0 + \beta_1 Post_t \times Treat_i + \beta_2 Post_t \times ChiNext_i + \beta_C Control_{it} + Firm_i + Year_t + \varepsilon_{it} \quad (3)$$

The regression results are shown in column 3 of Table 4. The coefficient of *Post* × *Treat* is positive and significant at the 1% level, indicating that the effect indicated in H1 holds even if the impact of the ChiNext registration system reform is considered.

5.3.4. Adjust the method of identifying Treat

The previous identification of *Treat* is mainly based on the MD&A similarity between Main Board firms and Star Market firms. We next adjust the method of identifying *Treat*. First, Badertscher et al. (2013) find that the number of listed companies in an industry is positively related to the industry's information environment. Therefore, the greater the number of newly listed companies in the same industry on the Star Market, the more impact Main Board analysts should have on the establishment of the Star Market. Second, we focus on the innovation information provided by the Star Market rather than on general information, allowing us to further identify the similarity of innovative texts in MD&A based on the similarity of the MD&A texts. Accordingly, we use the natural logarithm of the number of listed companies on the Star Market in the same industry plus 1 to identify the treatment intensity of the establishment of the Star Market (*Treat1*); we also determine whether a sentence comprises innovative text based on whether it contains innovative keywords, obtain the innovative text in MD&A and calculate the treatment intensity variable (*Treat2*) using the same method used to calculate *Treat1*. In model (1), *Treat* is replaced by *Treat1* or *Treat2*. The regression results are shown in columns 4 and 5 of Table 4. The coefficients of *Post* × *Treat1* and *Post* × *Treat2* are positive and significant at the 1% level.[9]

5.3.5. Using multi-period DID model

Model (1) treats the establishment of the Star Market as an exogenous shock to the DID model and constructs a firm-level treatment intensity variable, *Treat*, that does not change over time. In essence, this model assumes that the impact of Star Market firms on Main Board analysts is uniformly distributed within the treatment window. However, the number of Star Market listings fluctuates within the treatment window, and thus the information provided may not be uniformly distributed. Therefore, to ensure the robustness of the conclusion as much as possible, we treat the Star Market IPOs in each year as an exogenous shock

[9] The industry classification used to calculate *Treat1* is the 2012 version of the industry classification of the China Securities Regulatory Commission; when calculating *Treat2*, the MD&A texts of A-share listed firms from 2016 to 2021 are used as the corpus, and word2vec is used to expand the seed words "innovation" and "R&D" to obtain the following innovation keywords: technology, cutting-edge, industry-university-research, original, creation, new type, key breakthroughs, scientific research, research, development, science, patents, processes, intellectual property rights, research and development, new projects, new products and new businesses. The reduction in sample size is due to the elimination of some samples with insufficient innovative texts.

and construct a firm-year level variable of treatment intensity, *Star*, that changes over time. We then construct a multi-period DID model:

$$Accuracy_{it} = \beta_0 + \beta_1 Star_{it} + \beta_C Control_{it} + Firm_i + Year_t + \varepsilon_{it} \quad (4)$$

where $Star_{it}$ represents the impact of the IPOs of Star Market firms on Main Board firm i in fiscal year t. This measurement method is basically the same as the method previously used to measure *Treat*. It differs in that here, *Treat is* a firm-level variable, while *Star* is a firm-year level variable. The other variable definitions are consistent with model (1). The regression results of model (4) are shown in column 6 of Table 4. The coefficient of *Star* is positive and significant at the 1% level, which is in line with the expectations of H1.

5.3.6. Test at the analysis report level

Some studies use the data structure at the analysis report level when testing the factors influencing analysts' forecasts. As our main explanatory variable is a firm- or firm-year level variable, the firm-year level variable (*Accuracy*) is used in model (1). To ensure robustness, we also include the analysis report level variable (*Accuracy1*):

$$Accuracy1_{ijt} = \beta_0 + \beta_1 Post_t \times Treat_i + \beta_C Control_{ijt} + Firm_i + Year_t + \varepsilon_{ijt} \quad (5)$$

where *Accuracy1* represents the absolute value of the difference between analysts' predicted earnings per share and the actual earnings per share, which is calculated as the inverse of the difference after dividing by the stock price. The definitions of the other variables are consistent with model (1). The regression results of model (5) are shown in column 7 of Table 4. The coefficient of *Post* × *Treat* is positive and significant at the 1% level, which is also in line with the expectations of H1.

6. Further analysis

6.1. Cross-sectional analysis

We argue that the logical chain of H1 contains three influencing factors. First, the premise that the Star Market provides incremental innovation information is that before the establishment of the Star Market, the Main Board restricted the listing threshold for innovation firms' IPOs. The stronger this restriction, the stronger the innovation information spillover effect caused by the establishment of the Star Market would be. Second, because the incremental information provided by the Star Market has distinct attributes of scientific and technological innovation, the affected Main Board firms should mainly be firms with strong innovation characteristics. Third, the greater the demand of information users for innovation information provided by Main Board firms, the greater the impact of the incremental innovation information provided by the Star Market on these users' decision-making. We conduct a cross-sectional analysis to address these three factors.

6.1.1. Extent to which the listing threshold is lowered

One of the premises of H1 is that the Star Market has lowered the listing threshold for innovative enterprises. As mentioned in the institutional background section, the traditional financial indicators of Star Market firms are significantly worse than those of Main Board firms in the year of listing. The larger this gap, the greater the extent to which the establishment of Star Market has lowered the listing threshold for innovation firms and the more it helps Main Board firms utilize innovation information; that is, the effect of H1 should be stronger when this gap is larger. We test this using the following specific approach.

Based on the three financial indicators included in the Main Board listing financial conditions, namely net profit, operating income and net operating cash flow, we calculate the difference between the listing financial indicators of the Star Market firms and the Main Board firms (*Diff*). The formula is as follows:

$$Diff_i = \sum_{z=1}^{3} (MeanX_{zt} - X_{zit})$$

where i represents the Star Market firms, and t represents the listing year. X_1, X_2 and X_3 represent the net profits, operating income and net operating cash flow, respectively (all deducted by total assets). *MeanX* rep-

Table 5
Cross-sectional analysis.

	(1) Greater reduction *Accuracy*	(2) Lesser reduction *Accuracy*	(3) Innovative *Accuracy*	(4) Non-innovative *Accuracy*	(5) Greater needs *Accuracy*	(6) Lesser needs *Accuracy*
Post × Treat	0.0601***	0.0387**	0.0573***	0.0302**	0.0736***	0.0296**
	(5.13)	(2.31)	(4.93)	(2.25)	(5.96)	(2.32)
Difference		0.0214*		0.0271*		–0.0440***
P-value		0.08		0.06		0.000
Control	Yes	Yes	Yes	Yes	Yes	Yes
Constant	–0.1938*	–0.0594	–0.0454	–0.2028**	0.0273	–0.1919*
	(–1.80)	(–0.54)	(–0.43)	(–2.03)	(0.24)	(–1.69)
Observations	3,558	3,468	3,679	3,347	3,558	3,468
R-squared	0.495	0.462	0.465	0.473	0.458	0.497
Firm	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes

Note: Asterisks denote the level of statistical significance: ***, $p < 0.01$; **, $p < 0.05$; *, $p < 0.1$. The t values are in parentheses.

resents the mean of X for all newly listed Main Board firms in that year. Obviously, the larger the value of *Diff*, the stronger the effect of the Star Market in terms of lowering the listing threshold. Subsequently, using *SIM* as the weight, *Diff* is "mapped" to the Main Board firm level[10]:

$$Threshold_i = 1/n \sum_{j=1}^{n} Diff_j * SIM_{ij}$$

where *i* represents a Main Board firm, *j* represents a Star Market firm, *n* represents the number of Star Market firms and *Threshold* represents the degree to which the Star Market reduces the listing threshold. Finally, according to whether *Threshold* is above or below the industry median, the full sample is divided into two sub-samples having either a greater or lesser reduction in listing thresholds (greater or lesser reduction, respectively).

The regression results of model (1), run using the two sub-samples, are shown in columns 1 and 2 of Table 5. Compared with the lesser reduction sample, the absolute value of the coefficient of *Post × Treat* for the greater reduction sample is larger, and the difference is significantly different from 0 at the 10% level. This means that as the negative effect of the establishment of the Star Market on the listing threshold for innovation firms increases, its positive effect on the accuracy of analysts' forecasts for Main Board firms is strengthened, which is in line with previous expectations.

6.1.2. Innovation characteristics of Main Board firms

Another important premise of H1 is that the establishment of the Star Market provides incremental innovation information to the capital market. Here, "information" refers to innovation information rather than general information. Therefore, not all Main Board firms are affected by the establishment of the Star Market. For innovation-poor Main Board firms, the innovation information provided by the Star Market is less relevant, and its usefulness for analysts' forecasts may no longer hold or be relatively weak. We expect that the effect of H1 is stronger among innovation-focused Main Board firms.

We use the ratio of R&D investment to total assets (*RD*) to measure the innovation characteristics of enterprises. Specifically, to avoid the possible impact of the establishment of the Star Market on the R&D investment of Main Board firms, we use the ratio of Main Board firms before the establishment of the Star Market to measure innovation characteristics. Based on whether *RD* is above or below than the industry median, we divide the full sample into two sub-samples with (innovative) or without innovation characteristics (non-innovative).

[10] To conduct a cross-sectional test, it is necessary to construct a cross-sectional difference variable for Main Board firms. *Diff* is a Star Market firm-level variable and thus needs to be converted into a Main Board firm-level variable. *SIM* enables this conversion.

The regression results of model (1) using the two sub-samples are shown in columns 3 and 4 of Table 5. Compared with the non-innovation sample, the absolute value of the coefficient of *Post* × *Treat* for the innovation sample is greater, and the difference is significantly different from 0 at the 10% level. This means that the positive effect of the establishment of the Star Market on the accuracy of analysts' forecasts is stronger among Main Board firms with more prominent innovation characteristics, which is in line with previous expectations.

6.1.3. Market innovation information needs

Investors of different firms vary in their demands for innovation information. It is difficult for non-professional investors to understand when a company's innovation activities have a certain technical threshold; accordingly, innovation information disclosure is necessary. Additionally, companies are located in different information environments. When the information environment is poorer, investors need more innovation information related to the company. Investors' demand for innovation information determines the marginal benefits of firms' disclosed innovation information. The greater the demand, the greater the marginal benefits. Therefore, we expect that the effect of H1 is stronger for Main Board firms whose investors have a greater demand for innovation information.

In recent years, exchanges' online platforms have become important means of communication between investors and listed firms. By asking questions on an online platform, investors can obtain the required information directly from the managers of listed firms (Tan et al., 2016). Accordingly, we use the number of questions about innovation activities posted on the exchange network platform (deflated by the total number of questions) to measure investors' demand for innovation information from Main Board firms. Using this variable, the full sample is divided into two sub-samples with greater (greater needs) and lesser innovation information needs (lesser needs).

The regression results of model (1) for the two sub-samples are shown in columns 5 and 6 of Table 5. Compared with the lesser needs sample, the absolute value of the coefficient of *Post* × *Treat* for the greater needs sample is larger, and the difference is significantly different from 0 at the 1% level. This means that the positive effect of the establishment of the Star Market on the accuracy of analysts' forecasts is stronger when innovation information needs are greater, which is in line with previous expectations.

6.2. Transmission path analysis

According to our theoretical analysis, a possible transmission path by which the establishment of the Star Market affects the forecasts of Main Board analysts is as follows. First, since the establishment of the Star Market, the analysts of Main Board firms have paid attention to Star Market firms with similar innovation information to that of the Main Board firms they track. Second, the analysts of Main Board firms use the incremental innovation information provided by these Star Market firms to enhance their ability to produce forecasts for Main Board firms. To test the first link in the above transmission path, we construct the following model:

$$AnalyStar_{it} = \beta_0 + \beta_1 Treat_i + \beta_C Control_{it} + \varepsilon_{it} \tag{6}$$

where $AnalyStar_{it}$ indicates whether the analysts of Main Board firm i choose to follow Star Market firms in year t; the definitions of the other variables are the same as in model (1). The sample period for model (6) is 2019–2021 because analysts have had the possibility of choosing whether to track Star Market firms only since the establishment of that market. If the first link in the above transmission path holds, the coefficient of *Treat* is expected to be positive and significant.

To test the second link in the possible transmission path, we construct the firm-level variable *DumFollow*. If the analysts of a Main Board firm choose to follow Star Market firms, then *DumFollow* is assigned a value of 1 during the entire sample period of this Main Board firm; otherwise, it is assigned a value of 0. On this basis, the full sample is divided into two sub-samples comprising analysts who choose and choose not to follow Star Market firms (''Follow'' and ''Not Follow,'' respectively). If the second link in the possible transmission path holds, the regression results of model (1) should be stronger for the ''Follow'' sample and weaker or non-existent for the ''Not Follow'' sample.

Table 6
Transmission path analysis.

	(1)	(2)	(3)
	AnalySTAR	Follow *Accuracy*	Not Follow *Accuracy*
Treat	**0.6081*** **		
	(6.56)		
Post × Treat		**0.0547*** **	**0.0489**
		(5.13)	**(1.20)**
Control	Yes	Yes	Yes
Constant	–1.3962***	–0.2828***	0.2208
	(–5.62)	(–3.51)	(1.47)
Observations	3,513	6,114	912
R-squared	0.289	0.345	0.442
Industry	Yes	Yes	Yes
Year	Yes	Yes	Yes

Note: Asterisks denote the level of statistical significance: ***, $p < 0.01$; **, $p < 0.05$; *, $p < 0.1$. The t values are in parentheses.

The results of testing the first link are shown in column 1 of Table 6. The coefficient of *Treat* is positive and significant at the 1% level, which is in line with expectations. The results of testing the second link are shown in columns 2 and 3 of Table 6. The coefficient of *Post* × *Treat* is positive and significant only for the "Follow" sample, which is also in line with expectations.

7. Conclusions

Drawing on the establishment of China's Star Market, this paper studies whether the innovation information provided by a specific listing board can spill over to another list board. The main conclusions are as follows. (1) After the establishment of the Star Market, the accuracy of analysts' forecasts for Main Board firms with higher (but not lower) information similarity to the Star Market firms significantly improved. (2) This effect is stronger in samples with greater reductions in listing thresholds, more innovation characteristics and greater innovation information needs. (3) Since the establishment of the Star Market, analysts have tended to follow Star Market firms that have similar information to the Main Board firms they follow, which also enhances the baseline effect.

The above conclusions have three implications. First, the number of listed firms can have a positive effect on the information environment through analysts, an information intermediary that is crucial to the efficiency of the capital market. The results also show that information sources outside the tracked firm are potentially important factors affecting analysts' forecasts. Second, innovation information has both professional thresholds and confidentiality requirements; consequently, corporate innovation disclosure faces agency problems and proprietary costs, forming the so-called "innovation disclosure dilemma." Potentially, further improving the corporate listing system could fill the gap in innovative listed firms and alleviate the innovation disclosure dilemma via the overall innovation information supply of the capital market. Third, the institutional arrangement of the listing threshold for innovation companies has important economic consequences and should be treated with caution.

This paper has certain limitations. First, it mainly examines the impact of the Star Market on analysts' forecasts. However, financial forecasting is only one aspect of analyst behavior. The increase in innovation information may also affect other analyst behaviors, such as tracking target selection, field research and stock ratings. Future research may consider an expanded scope to explore these aspects. Second, this paper mainly provides evidence from the level of Main Board firms regarding how analysts' forecasts of these firms are affected by the Star Market, but does not provide analyst-level evidence. Future research may consider mining the text data of analyst research reports to explore how Main Board analysts use the increase in innovation information due to the Star Market to provide more intuitive empirical evidence.

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Is corporate digital transformation counter-cyclical?

Shuai Wang [a], Xi Chen [b], Qinggang Wang [a,*]

[a] School of Accounting, Zhongnan University of Economics and Law, China
[b] School of Management, Wuhan Institute of Technology, China

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ABSTRACT

In this paper, we assess listed companies in China to empirically examine the relationship between economic cycles and corporate digital transformation. We find that enterprises undergo a higher level of digital transformation during business contraction, and digital transformation exerts a counter-cyclical effect, which is significantly stronger in non-state-owned enterprises and enterprises with a high proportion of low-skilled labor and a high growth level, but significantly weaker in enterprises in financial distress. Digital transformation during periods of contraction can enhance financing accessibility, optimize labor structures and improve corporate governance over the subsequent one to three years. This can alleviate the pressure of economic contraction. Our study contributes to the literature on economic cycles and digital transformation and provides insights enabling governments and enterprises to better understand macroeconomic trends, advance digital transformation and promote high-quality economic development.

1. Introduction

Digital transformation has become a focal issue for both academics and policymakers and a key aspect of corporate strategic decision-making worldwide (Pellegrini et al., 2020; Bianchini et al., 2023). However, research into the impact of external policies and environments on corporate digital transformation remains scarce. Some studies explore the impact of intellectual property protection (Ilvonen et al., 2018) and government innovation subsidies (Chanias et al., 2019) on digital transformation, but the lack of research into the effects of corporate digital transformation decisions in response to changes driven by macroeconomic cycles represents a notable gap in the literature. Therefore, the theoretical framework of this study considers the

* Corresponding author.
E-mail addresses: ahthws0825@163.com (S. Wang), catiechencc@163.com (X. Chen), kjxywqg1125@zuel.edu.cn (Q. Wang).

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impact of the economic cycle on strategic decision-making, and we analyze the relationship between economic cycles and digital transformation decisions. We examine whether, during economic contraction periods, firms take a conservative approach by reducing their level of digital transformation to enhance financial flexibility and mitigate risks, or take an aggressive stance by actively increasing their digital transformation to leverage its advantages and alleviate the adverse effects of economic contraction.

Economic contractions often lead to reduced sales profits and increased operational risk, with numerous small businesses facing bankruptcy and large corporations making layoffs, due to factors such as broken financial chains, disordered labor structures and outdated governance practices. Thus, economic contraction can reduce corporate funds, harm technological development and growth and deplete resources, prompting firms to adopt a conservative stance and apply defensive strategies, which then reduces their level of digital transformation. This suggests that digital transformation will have a pro-cyclical effect. However, digital transformation has unique advantages over other micro-level initiatives, such as improving the information environment (Demoulin and Coussement, 2020), enhancing corporate governance capabilities, reducing transaction costs and cost stickiness (Goldfarb and Tucker, 2019), promoting resource integration and optimizing labor structures (Ye et al., 2022). These advantages can change a firm's motivation for digital transformation during periods of economic contraction. Value maximization should be the goal of corporate investment decisions. If the benefits of digital transformation appear to outweigh the risks and the advantages gained can help optimize production processes, reduce operating costs and improve competitiveness to ease the pressures of economic contraction, firms may proactively pursue such a strategy and digital transformation will exhibit a counter-cyclical effect. Therefore, the relationship between economic cycles and corporate digital transformation should be explored and the unique advantages of digital technologies considered. Understanding the response of corporate digital transformation to macroeconomic cycle changes will clarify the motivations and goals for embarking on digital transformation from a macroeconomic perspective, which can help to further develop the digital economy.

China is the largest developing country in the world, and its unique development model and economic structure provide a distinctive perspective and rich data sources for the study of the relationship between economic cycles and corporate digital transformation. The challenges China encounters in its rapid economic development are broadly reflective of global trends, and its digital economy, which involves big data, cloud computing, artificial intelligence and the Internet of Things, is steadily increasing and gradually permeating various sectors.[1] This transformation is leading to changes in corporate production methods and business models. Such changes can further inform issues related to economic cycles and corporate digital transformation. Thus, by drawing on data from China we can gain a broader understanding of the relationship between economic cycles and corporate digital transformation and provide valuable insights and references for other countries.

In this paper, we empirically examine the relationship between economic cycles and corporate digital transformation using A-share listed companies in the Chinese capital market from 2009 to 2021. We further analyze the contextual effects of factors such as ownership nature, labor skill level, growth capability and financial distress and the motivations and economic consequences of corporate digital transformation. Our study makes three main contributions to the literature.

First, economic and corporate finance theories suggest that whether companies are conservative or aggressive in their decision-making during economic contractions depends on which approach can best provide them with competitive advantages, benefit their current development and mitigate the adverse effects of the contractions in the economy. While existing research mainly examines companies' reactions to economic contractions from the perspectives of investment, capital structure adjustment, social responsibility performance and tax avoidance, we consider the unique advantages of digital technologies and the counter-cyclical response of digital transformation to economic contraction. This extends the theoretical framework and the literature concerning economic cycles and corporate micro-decision-making and can inform the further effective development of the digital economy.

[1] According to the Digital China Development Report (2021), China's digital economy grew from 27.2 trillion yuan in 2017 to 45.5 trillion yuan in 2021, increasing its share of GDP from 32.9 % to 39.8 %.

Second, we provide an enterprise-level perspective and empirical evidence regarding the growth of China's digital economy. Enterprises must succeed if the national economy is to effectively develop, and promoting corporate digital transformation can contribute to the development of the digital economy. We find that firms are more inclined to pursue digital transformation during economic downturns so they can realign their market positioning and secure competitive advantages, which partially explains the counter-cyclical stability in the growth of the digital economy.

Third, by analyzing contextual factors such as the nature of ownership, labor skill level, growth capability, financial distress and the economic consequences of corporate digital transformation during economic contractions, our study furthers the understanding of issues related to the macroeconomic cycle across different contextual characteristics. It can also inform the government about the motivations for corporate digital transformation, thus leading to the further development of the digital economy.

2. Literature review, theoretical analysis and research hypotheses

2.1. Literature review

The cyclical fluctuations of the economy affect the external operating environment of businesses, necessitating that strategic decisions be adjusted by firms in response to macroeconomic changes and their own circumstances (Collins, 2017; David, 2011). During periods of economic contraction, whether firms are conservative or aggressive in their strategic approach depends on the balance between the potential benefits and risks of their decision. Some studies suggest that firms that face economic contraction may adopt conservative strategies, such as reducing capital investments (Begenau and Salomao, 2019) and capital structure adjustments (Lian et al., 2020) and increasing cash holdings, to enhance financial flexibility and mitigate potential risks and crises. Conversely, they may instead adopt aggressive strategies, such as engaging in less tax avoidance (Chen et al., 2016) and attempting to enhance social responsibility performance (Wang et al., 2023). By strategically adjusting their market positioning, enhancing competitiveness and seizing opportunities in the uncertain environment, they can adapt to evolving market demands and mitigate the adverse effects of economic contractions. However, few studies explore how such contractions influence digital transformation, which is subject to micro-level decisions.

Digital transformation, like other investment decisions such as tax avoidance and corporate social responsibility initiatives, has specific economic outcomes, including shifts in market positioning and competitive advantages such as improved access to financing and increased government support (Fan et al., 2024; Zhou and Li, 2023). However, unlike other investment decisions, leveraging digital technology to change production methods and business models can help enterprises improve the information environment (Demoulin and Coussement, 2020), optimize labor structures (Ye et al., 2022) and reduce transaction costs and cost stickiness (Goldfarb and Tucker, 2019), thereby contributing to improved corporate performance in capital markets and efficient value creation (Zhang et al., 2021). Due to its current importance, scholars have extensively researched the factors influencing corporate digital transformation. Providing a favorable environment for digital transformation is found to lower costs and thus further motivate firms. This can be achieved through initiatives such as intellectual property protection (Ilvonen et al., 2018) and government subsidies for innovation (Chanias et al., 2019). An adverse external environment, such as one involving local economic growth targets, can reduce this motivation (Yang et al., 2021). Digital transformation is often implemented through top-level organizational decisions (Sun et al., 2020), and Zhang and Huang (2024) draw on upper echelon theory to assess the attitudes and inclinations of top management teams toward digital transformation.

In summary, the literature on corporate digital transformation is relatively extensive, but few in-depth explorations have been conducted into how macroeconomic cyclical fluctuations can lead to changes in the status and the development environment of enterprises, and consequently affect decisions regarding digital transformation. Therefore, we examine the relationship between economic cycles and corporate digital transformation, with consideration of the unique advantages of digital technology. Specifically, in the face of an economic contraction, will firms adopt conservative strategies to preserve cash flow, thereby reducing the extent of digital transformation and demonstrating a pro-cyclical effect? Or will they adopt aggressive strategies to leverage the unique advantages of digital transformation to enhance competitiveness, mitigate risks and

embark on further digitization, thus exhibiting a counter-cyclical effect? This investigation not only extends the research into economic cycles and corporate digital transformation but can also help governments gain a deeper understanding of macroeconomic dynamics and encourage corporate digital transformation, thus advancing the high-quality development of the digital economy.

2.2. Theoretical analysis and research hypotheses

Since the 2008 financial crisis, economies worldwide have faced various negative shocks, prompting both domestic and international investigations into the effects of macroeconomic factors on micro-level corporate behavior. ''Economic cycles'' refers to the phenomenon of alternating economic expansion and contraction. During economic contractions, market development is sluggish, channels for resource acquisition diminish and firms face greater financing pressure (Begenau and Salomao, 2019). The external support environment also deteriorates, further affecting business operations. These adverse effects disrupt the processes of managerial decision-making and strategic choices. The motivations underlying corporate decisions such as dynamic adjustments in capital structure, investment and financing strategies and social responsibility performance may need to evolve, to adapt to the environment and mitigate the pressure of economic contraction (Lian et al., 2020; Wang et al., 2023). Digital transformation, as the subject of micro-level decisions, may also be influenced by external economic fluctuations, and firms may adopt either conservative or aggressive strategies towards digital transformation to cope with downward economic pressure. Thus, digital transformation may exhibit either pro-cyclical or counter-cyclical effects.

Digital transformation is a resource-intensive activity in terms of technology, and a conducive environment for growth. Enterprises lacking funds or technology or facing unfavorable external environments may have less motivation for digital transformation. During periods of economic contraction, channels for resource acquisition diminish and the external support environment deteriorates. Consequently, firms may then adopt conservative digital transformation strategies and allocate funds toward enhancing financial flexibility and strengthening their abilities to defend against operational uncertainties. Specifically, during economic contractions, the level of digital transformation in enterprises is lower, exhibiting a pro-cyclical effect in digital transformation. The specific reasons are as follows.

First, during economic contractions, enterprises lack sufficient funding to support digital transformation. The sluggish market during such periodss negatively impacts the core businesses of enterprises, leading to reduced earnings and cash flow (Qian and Hu, 2015). Economic cycles and financial market indicators such as loan interest rates are also closely related. During periods of economic contraction, monetary policies become more restrictive and adversely affect financing options such as bank loans and trade credit (Zhou and Li, 2023), and thus the funds firms have access to are reduced. These limited funds prompt firms to adopt conservative strategies, which affects the digital transformation process.

Second, enterprises are less likely to receive sufficient technological support for digital transformation during periods of economic contraction, as they will lack a supportive external environment. The increase in fiscal pressure can lead firms to prioritize short-term performance goals so they can avoid fiscal deficits or gain a competitive edge across regions (Yang et al., 2021), rather than pursuing long-term sustainable development. Long-term and innovative fiscal technology expenditure will thus be reduced accordingly. Such expenditure is essential for long-term and risky digital transformation projects, as it can reduce risk and costs and encourage further digital transformation (Wu et al., 2021). A lack of funds for such expenditure means a conducive external environment for corporate digital transformation cannot be established. Thus, conservative digital transformation strategies may then be more appropriate.

Enterprises therefore appear likely to adopt a conservative approach toward digital transformation in times of economic contraction. They may preserve funds and increase cash flow to ensure financial flexibility, thereby coping with the uncertainties they face and enhancing their defensive capabilities. Consequently, the level of digital transformation decreases, and the effect is pro-cyclical. We therefore propose the following hypothesis.

H1a: Digital transformation in enterprises exhibits a pro-cyclical effect, this means that during periods of economic contraction, enterprises are less likely to engage in digital transformation.

However, an opposite—i.e., counter-cyclical—effect may be observed in terms of digital transformation during times of economic contraction. The literature indicates that digital transformation has unique advantages over other investment decisions. It can help improve information environments (Demoulin and Coussement, 2020), enhance financing capabilities (Zhou and Li, 2023), optimize labor structures (Ye et al., 2022) and reduce transaction costs and fee stickiness (Goldfarb and Tucker, 2019), thereby improving capital market performance and the efficiency of value creation (Zhang et al., 2021). Therefore, during periods of economic contraction, enterprises may adopt aggressive strategies due to the unique advantages brought about by digital transformation and actively engage in it, to alleviate the operational challenges they face.

Three main factors may prompt enterprises to actively engage in digital transformation. First, undertaking such actions can facilitate access to financing, which is essential for a company's survival and development. Enterprises with stronger financing capabilities have lower liquidity cash needs and fewer working capital requirements than other firms (Huberman, 1984), and are more resilient to risk. However, the market is sluggish during periods of economic contraction, and the core operations of enterprises can be negatively affected, thus reducing profits. Credit policies will simultaneously tighten and external financing channels become more constrained (Begenau and Salomao, 2019), exacerbating the capital shortage problem. In such adverse market conditions, ensuring capital turnover becomes a major concern for enterprises. Digital transformation can help enterprises compete with peers and secure financing opportunities. Through digital technology, they can alleviate information asymmetry, ensure risk assessments by external financing institutions are accurate, improve corporate credit ratings and increase external financing institutions' willingness to extend credit (Zhou and Li, 2023). Therefore, enterprises may actively pursue digital transformation during periods of economic contraction to obtain financing and alleviate any negative effects.

Second, digital transformation can help to optimize enterprises' labor structures. Human capital is a form of strategic asset, and its expansion can promote growth and development. However, it can also lead to a chaotic labor structure and potentially redundancy. If a company fails to identify and address such issues, labor costs can increase and productivity decrease (Erosa et al., 2010). During economic contractions, unfavorable market conditions further expose labor redundancy issues, raising labor costs and reducing productivity, which constrains cash flow and may even lead to a financial crisis. Digital transformation can help companies identify and alleviate labor issues, thus saving on costs. By leveraging digital information technologies, companies can enhance transparency, collect and utilize operational data and achieve improved management and production (Qi and Xiao, 2020). This can free up a significant proportion of the workforce, especially from roles related to information searching and those involving repetitive tasks, for example by establishing unmanned production lines and re-organizing the labor structure (Li et al., 2024). Therefore, during periods of economic contraction, companies may proactively undertake digital transformation to optimize their labor structures, address redundancy issues and reduce labor costs.

Third, digital transformation can also enhance internal controls. Effective internal control mechanisms are crucial for enterprise operation and development, as they improve the ability to respond to negative events. Core business operations can be negatively affected during periods of economic contraction, and companies with weaker governance capabilities may lack flexibility and struggle to overcome adversity in a sluggish market. Digital transformation not only makes internal communication more efficient but also enhances the intelligence of control activities and the accuracy of risk assessments. Thus, internal control mechanisms will become more effective (Zhao et al., 2023). Consequently, enterprises may pursue digital transformation to optimize internal control, enhance their governance capabilities and cope with the uncertainties brought about by economic contractions.

Based on the above analysis, we argue that because enterprises will gain advantages from digital transformation, such as facilitating financing, optimizing labor structure and improving internal control quality, they are likely to adopt an aggressive strategy during periods of economic contraction, and to actively engage in digital transformation. Therefore, this paper proposes the following hypothesis.

H1b: Digital transformation in enterprises has a counter-cyclical effect, this means that during periods of economic contraction, enterprises are more likely to engage in digital transformation.

3. Model specification and sample selection

3.1. Model specification

To examine the relationship between economic contraction cycles and corporate digital transformation, we construct an OLS regression model (1).

$$DT_{i,t} = \beta_0 + \beta_1 GAP(CYCLE)_{i,t-1} + \beta_2 SIZE_{i,t-1} + \beta_3 LEV_{i,t-1} + \beta_4 TOP1_{i,t-1} + \beta_5 ROA_{i,t-1} + \beta_6 GROW_{i,t-1} + \beta_7 BOARD_{i,t-1} + \beta_8 INDEP_{i,t-1} + \beta_9 SALA_{i,t-1} + \beta_{10} HOLD_{i,t-1} + \beta_{11} LISTY_{i,t-1} + \beta_{12} HBZC_{i,t-1} + \beta_{13} DEVE_{i,t-1} + IND\ US + AREA + \varepsilon \quad (1)$$

Model (1) is used to examine the relationship between economic contraction cycles and corporate digital transformation. As enterprises often refer to previously published economic indicators when making decisions, we lag the explanatory variables by one period to mitigate potential endogeneity issues in the model. $GAP_{i,t\text{-}1}$ represents the economic contraction cycle variable for period $t-1$. Following Wang et al. (2023), we use the macroeconomic HP filtering method to measure the variables $GAP_{i,t\text{-}1}$ and $CYCLE_{i,t\text{-}1}$, where $GAP\_{i,t\text{-}1}$ represents the negative value of the actual growth rate gap. We apply the HP filtering method to GDP growth rate data of China from 2008 to 2020 to remove long-term trends, obtaining the actual GDP growth rate gap (GAPS) to measure economic cycles in the lagged period from 2009 to 2021. For the ease of interpretation of the regression results, we negate the indicators, generating $GAP_{i,t\text{-}1}$ as equal to −GAPS. $CYCLE\_{i,t\text{-}1}$ indicates whether the economy is in a contraction cycle. If $GAP_{i,t\text{-}1}$ is greater than 0, $CYCLE_{i,t\text{-}1}$ is assigned a value of 1. If $GAP_{i,t\text{-}1}$ is less than 0, $CYCLE_{i,t\text{-}1}$ is assigned a value of 0. The actual years of economic contraction during the 2008–2020 period are 2009, 2012–2016 and 2020, while the years of economic expansion are 2008, 2010, 2011 and 2017–2019, which are broadly consistent with those summarized by Ding and Yan (2019) and Wang et al. (2023), indicating a certain level of rationality in the indicators.

$DT_{i,t}$ represents the level of corporate digital transformation. Both digital and intelligent technologies are involved in digital transformation, so big data and artificial intelligence can be applied in decision-making and business development. The frequency of the use of terms related to digital technologies in an enterprise's annual reports reflects its digitalization strategy, thus embodying its business philosophy and development path. Therefore, following Wu et al. (2021), we apply text analysis and use the frequency of terms related to digitalization, such as "artificial intelligence," "big data," "cloud computing," "blockchain" and "digital technology applications," in annual reports as a proxy indicator for corporate digital transformation. $DT_{i,t}$ is calculated as the natural logarithm of the total word frequency plus one.

We also control for various factors that can potentially influence the digital transformation of enterprises. These include firm size ($SIZE_{i,t\text{-}1}$), calculated as the natural logarithm of total assets at the end of the period; financial leverage ($LEV_{i,t\text{-}1}$), calculated as the ratio of total liabilities to total assets at the end of the period; ownership concentration ($TOP1_{i,t\text{-}1}$), which is the percentage of shares held by the largest shareholder; profitability ($ROA_{i,t\text{-}1}$), which is the ratio of net profit to average total assets; growth capability ($GROW_{i,t\text{-}1}$), which is the growth rate of main business income; board characteristics ($BOARD_{i,t\text{-}1}$) is measured by the natural logarithm of the total number of board members; the independent director ratio ($INDEP_{i,t\text{-}1}$), which is the ratio of independent directors to total board members; executive compensation ($SALA_{i,t\text{-}1}$), which is the natural logarithm of the total compensation of the top three executives; executive shareholding ($HOLD_{i,t\text{-}1}$), which is the ratio of shares held by executives to total shares; industry dummy variables (*INDUS*, based on the China Securities Regulatory Commission industry classification standard and involving 16 dummy variables); and regional dummy variables (*AREA*, involving 31 dummy variables for 32 provinces).

As the economic cycle variables in this study are time series data, directly controlling for annual fixed effects could lead to multicollinearity. Controlling for macroeconomic variables can to some extent substitute for annual fixed effects in capturing macroeconomic time factors (Zhang and Liu, 2018). Therefore, we further control for monetary policy ($HBZC_{i,t\text{-}1}$) and capital market development ($DEVE_{i,t\text{-}1}$), which represent the growth rate of money supply (M1) and the annual turnover rate of stocks, respectively. According to our theoretical expectations, the coefficients β_1 of $GAP_{i,t\text{-}1}$ and $CYCLE_{i,t\text{-}1}$ in Model (1) should be significantly greater than 0.

The detailed definitions of the variables are provided in the Appendix.

3.2. Sample selection

The study sample consists of A-share listed companies on the Chinese stock market from 2009 to 2021. To reduce any adverse effects due to abnormal samples, the relevant data are filtered as follows. First, 1,516 observations are excluded due to abnormal trading statuses such as ST and PT. A total of 1,033 observations in the financial and insurance industries are then removed, and 5,187 with missing data are excluded. After filtering, 32,094 observations remain. All continuous variables are winsorized at the 1st and 99th percentiles. The macroeconomic data in this study are sourced from the National Bureau of Statistics, while the internal control quality data are obtained from the DIB Internal Control and Risk Management Database. Other relevant data are sourced from the China Stock Market and Accounting Research (CSMAR) Database. The analysis is conducted using Stata 15.0 software.

4. Empirical results analysis and discussion

4.1. Descriptive statistics and correlation analysis

Table 1 presents the descriptive statistics of the main research variables. The mean and standard deviation of $DT_{i,t}$ are 1.3867 and 1.4354, respectively, with a maximum value of 5.1180 and a minimum value of 0, indicating significant variations in the digitalization levels among the listed companies. The maximum and minimum values of $GAP_{i,t-1}$ are 6.2436 and –4.7191, respectively, with a standard deviation of 2.6698, indicating cyclical fluctuations in the Chinese economy. The average value of $TOP1_{i,t-1}$ is 0.3451, suggesting that the average ownership stake of the largest shareholder in the sample companies is 34.51 %. The mean value of $INDEP_{i,t-1}$ is 0.3742, indicating that on average 37.42 % of the directors on each company's board are independent, which meets the requirement of a minimum of one-third of independent directors on the board, as set by the China Securities Regulatory Commission. The mean and maximum values of $HOLD_{i,t-1}$ are 0.0731 and 0.6153, respectively, indicating that the average ownership stake of executives in listed companies is not high, but some companies have relatively large executive ownership stakes.

Fig. 1 depicts the trend in the average level of corporate digital transformation from 2009 to 2021. The digitalization level of Chinese enterprises has been increasing year by year. However, the growth rate increased during the period of economic contraction from 2012 to 2015. After 2016, the digitalization growth rate slowed down, providing preliminary support for research hypothesis H1b, which suggests that corporate digital transformation exhibits a counter-cyclical effect. However, a multivariate regression analysis is required to confirm this.

Table 1
Descriptive statistics.

Variables	Obs.	Mean	Std.Dev.	Min.	25 %	50 %	75 %	Max.
$DT_{i,t}$	32,094	1.3867	1.4354	0.0000	0.0000	1.0986	2.3979	5.1180
$GAP_{i,t-1}$	32,094	–0.0651	2.6698	–4.7191	–2.6134	0.6578	1.9735	6.2436
$CYCLE_{i,t-1}$	32,094	0.5375	0.4986	0.0000	0.0000	1.0000	1.0000	1.0000
$SIZE_{i,t-1}$	32,094	22.0526	1.2821	19.2642	21.1270	21.8745	22.7829	26.0536
$LEV_{i,t-1}$	32,094	0.4228	0.2078	0.0669	0.2536	0.4154	0.5819	0.8574
$TOPI_{i,t-1}$	32,094	0.3451	0.1482	0.0881	0.2289	0.3234	0.4464	0.7482
$ROA_{i,t-1}$	32,094	0.0371	0.0643	–0.2899	0.0144	0.0381	0.0678	0.2066
$GROW_{i,t-1}$	32,094	0.3512	0.7970	–0.5640	–0.0310	0.1349	0.4283	4.1596
$BOARD_{i,t-1}$	32,094	2.1332	0.1994	1.6094	1.9459	2.1972	2.1972	2.7081
$INDEP_{i,t-1}$	32,094	0.3742	0.0533	0.3125	0.3333	0.3333	0.4286	0.5714
$SALA_{i,t-1}$	32,094	14.2965	0.7370	12.4175	13.8263	14.2912	14.7461	16.2838
$HOLD_{i,t-1}$	32,094	0.0731	0.1413	0.0000	0.0000	0.0007	0.0668	0.6153
$LISTY_{i,t-1}$	32,094	17.4809	7.7324	3.0000	12.0000	16.0000	25.0000	31.0000
$HBZC_{i,t-1}$	32,094	10.5912	7.6310	1.5000	4.4000	8.6000	15.2000	33.2000
$DEVE_{i,t-1}$	32,094	3.8916	2.7275	0.2772	1.8891	3.1836	5.1625	13.5064

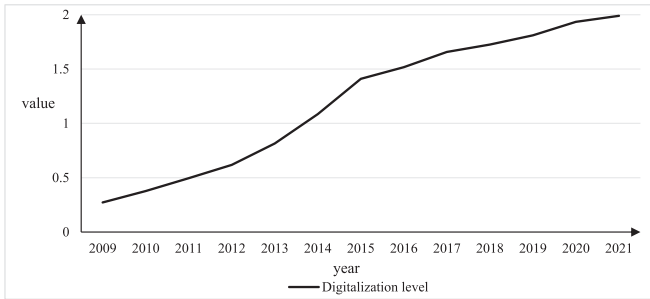

Fig. 1. Trend of digital transformation over time.

4.2. Economic contraction cycles and corporate digital transformation

The results of the multiple regression analysis on the relationship between economic contraction cycles and corporate digital transformation are presented in Table 2. The explanatory variables correspond to the eco-

Table 2
Economic contraction cycles and corporate digital transformation (H1).

Dep. Var.	$DT_{i,t}$	
	(1)	(2)
$GAP_{i,t-1}$	0.0204***	
	(4.8876)	
$CYCLE_{i,t-1}$		0.0531***
		(4.9967)
$SIZE_{i,t-1}$	0.2182***	0.2187***
	(10.1432)	(10.2629)
$LEV_{i,t-1}$	–0.3614***	–0.3578***
	(–6.8137)	(–6.7755)
$TOP1_{i,t-1}$	–0.4626***	–0.4591***
	(–6.4509)	(–6.2833)
$ROA_{i,t-1}$	–0.9406***	–0.9600***
	(–4.7425)	(–4.9156)
$GROW_{i,t-1}$	0.1101	0.1093
	(1.3850)	(1.3701)
$BOARD_{i,t-1}$	–0.3666***	–0.3688***
	(–5.8899)	(–5.9303)
$INDEP_{i,t-1}$	0.4689**	0.4682**
	(2.6529)	(2.6283)
$SALA_{i,t-1}$	0.2462***	0.2499***
	(12.4700)	(12.7301)
$HOLD_{i,t-1}$	0.3370***	0.3306***
	(3.8721)	(3.8842)
$LISTY_{i,t-1}$	–0.0283***	–0.0286***
	(–13.1430)	(–13.3372)
$HBZC_{i,t-1}$	–0.0182***	–0.0176***
	(–13.6918)	(–12.5626)
$DEVE_{i,t-1}$	0.0391***	0.0407***
	(9.0387)	(9.4631)
Constant	–5.7984***	–5.9157***
	(–14.1715)	(–14.5626)
Fixed Effect	YES	YES
Adjusted R^2	0.3585	0.3582
Obs.	32,094	32,094

Note: ***, **, and * represent the 1 %, 5 % and 10 % levels of significance, respectively, for a two-tailed test.

nomic contraction cycles variables $GAP_{i,t-1}$ and $CYCLE_{i,t-1}$, and all reported T-values are clustered at the industry level (as below). Table 2 shows that the coefficient between $GAP_{i,t-1}$ and $DT_{i,t}$ is 0.0204, and significant at the 1 % level. Similarly, the coefficient between $CYCLE_{i,t-1}$ and $DT_{i,t}$ is 0.0531, significant at the 1 % level. These results together indicate that the level of corporate digital transformation is higher during economic contraction cycles, thus supporting research hypothesis H1b. Enterprises adopt aggressive strategies in each cycle when market development is sluggish, to alleviate the operational issues caused by economic contraction. They also actively engage in digital transformation to better obtain financing, optimize the labor structure and enhance the level of governance. This indicates that digital transformation has a countercyclical effect.

In terms of control variables, as Column (1) in Table 2 shows, the coefficient of $SIZE_{i,t-1}$ is positive and significant, indicating that enterprises with larger asset scales have higher levels of digital transformation; the coefficient of $LEV_{i,t-1}$ is negative and significant, suggesting that higher leverage levels are associated with lower levels of digital transformation; the coefficient of $TOP1_{i,t-1}$ is negative and significant, indicating that concentrated equity ownership is detrimental to corporate digital transformation; the coefficient of $BOARD\_{i,t-1}$ is negative and significant, suggesting that larger board sizes are associated with lower levels of enterprise digitalization; the coefficient of $SALA_{i,t-1}$ is positive and significant, indicating that higher executive compensation is associated with higher levels of digital transformation; and the coefficient of $LISTY_{i,t-1}$ is negative and significant, indicating that longer listing periods are associated with lower levels of digitalization.

4.3. Sensitivity test

To increase the robustness of our research conclusions, we conduct a series of sensitivity tests, and the findings remain largely unchanged. This indicates that the results of the tests are relatively stable.

4.3.1. Changing the variable measurement methods

In the previous section, we use the frequency of digital-related terms in annual reports to measure corporate digital transformation. In this section, we change the measurement method and use the proportion of investment in substantive digital-related intangible assets to total intangible assets to measure corporate digital transformation. This generates the variable $DT1_{i,t}$. We then measure digital transformation $DT2_{i,t}$ using the natural logarithm of the frequency of digital-related terms discussed and analyzed by the management. The results are shown in Table 3. The coefficients of $GAP_{i,t-1}$ and $CYCLE_{i,t-1}$ are both positive and significant. These results are consistent with our empirical analysis in the previous study, indicating that our findings are robust.

Table 3
Robustness test: Changing the variable methods.

Dep. Var.	$DT1_{i,t}$		$DT2_{i,t}$	
	(1)	(2)	(3)	(4)
$GAP_{i,t-1}$	0.0015***		0.0372***	
	(2.5988)		(6.5133)	
$CYCLE_{i,t-1}$		0.0134**		0.2255***
		(2.3431)		(5.4077)
Constant	0.3211***	0.3183***	–3.9147***	–4.0777***
	(4.4103)	(4.3826)	(–10.3370)	(–10.7177)
Controls	YES	YES	YES	YES
Fixed Effect	YES	YES	YES	YES
Adjusted R^2	0.2396	0.2396	0.3503	0.3521
Obs.	30,835	30,835	30,447	30,447

Note: ***, **, and * represent the 1 %, 5 % and 10 % levels of significance, respectively, for a two-tailed test.

Table 4
Robustness test: Changing the sample time interval.

Dep. Var.	$DT_{i,t}$			
	2011–2021		2014–2021	
$GAP_{i,t-1}$	0.0108**		0.0052**	
	(2.8221)		(2.7482)	
$CYCLE_{i,t-1}$		0.0484*		0.0312**
		(1.9663)		(2.7555)
Constant	–4.9530***	–5.7099***	–4.0411***	–4.4929***
	(–14.9332)	(–16.3727)	(–12.7805)	(–12.5065)
Controls	YES	YES	YES	YES
Fixed Effect	YES	YES	YES	YES
Adjusted R^2	0.3340	0.3386	0.3122	0.3134
Obs.	29,336	29,336	23,353	23,353

Note: ***, **, and * represent the 1 %, 5 % and 10 % levels of significance, respectively, for a two-tailed test.

4.3.2. Changing the sample time interval

The sample period in the previous section is 2009 to 2021. We find that the density of digital-related terms changes over time, as fewer are identified in the early period of the sample and more in the later period. To enhance the robustness of the research results, we change the sample time intervals to 2011–2021 and 2014–2021, and re-conduct the empirical test of Model (1). The results are shown in Table 4. The coefficients of $GAP_{i,t-1}$ and $CYCLE_{i,t-1}$ are both positive and significant. These results are consistent with the empirical analysis in the previous study, indicating that our findings are robust.

4.3.3. Instrumental variable method

To reduce interference from the noise of endogenous explanatory variables, we reexamine the above model using the instrumental variable method. Following Wang et al. (2023), we select the lagged one-period growth rate of per capita oil consumption ($SYZZ_{i,t-1}$) as the instrumental variable, which is a continuous variable with a standard deviation of 2.7178, indicating significant differences in variable values. We select this instrumental variable for two reasons. First, the consumption of material energy such as oil significantly promotes economic growth and represents improvements in people's livelihoods, (He et al., 2018). The growth of per capita oil consumption reflects the speed of economic expansion, which has a positive effect on the economic cycle variable (the actual GDP growth rate gap). The higher the growth of per capita oil consumption, the larger the actual GDP growth rate gap, and thus it meets the correlation assumption of the instrumental variables. Second, per capita oil consumption is unlikely to directly influence corporate digital transformation in the short term, and its correlation with the level of enterprise digitalization is not significant, thus satisfying the exogeneity assumption of instrumental variables.

The results after this reexamination are given in Table 5. In the first stage, the coefficient between $SYZZ_{i,t-1}$ and $GAP_{i,t-1}$, $CYCLE_{i,t-1}$ is negative and significant, indicating a significant negative correlation between the growth of per capita oil consumption and the economic contraction cycle, which is in line with the correlation assumption of the instrumental variables. In the second stage, the coefficients between $GAP_{i,t-1}$, $CYCLE_{i,t-}$ and $DT_{i,t}$ do not change substantially. Thus, the research results remain robust after controlling for endogeneity issues. We also find from the instrumental variable test that the partial F-statistic in Table 5 is significant, indicating that under-identification is not a problem. These combined results suggest that endogeneity is not a major issue in this study.

5. Heterogeneity analysis and economic consequences of the counter-cyclical effect of digital transformation

5.1. Heterogeneity analysis

During economic contraction cycles, companies actively engage in digital transformation to facilitate financing, optimize their labor structures and enhance internal governance. Their engagement may be influenced by factors such as property rights, labor skills, growth prospects and financial constraints.

Table 5
Robustness test: Instrumental variable method.

Dep. Var.	First-Stage		Second-Stage	
	$GAP_{i,t-1}$	$CYCLE_{i,t-1}$	$DT_{i,t}$	
$SYZZ_{i,t-1}$	–0.3123***	–0.2274***		
	(–44.3413)	(–43.1222)		
$GAP_{i,t-1}$			0.0847***	
			(12.1144)	
$CYCLE_{i,t-1}$				0.7239***
				(12.2496)
Constant	–8.0377***	–4.8026***	–5.1773***	–5.4338***
	(–29.7175)	(–22.7083)	(–25.6208)	(–27.1672)
Controls	YES	YES	YES	YES
Fixed Effect	YES	YES	YES	YES
Adjusted R^2	0.2227	0.1366	0.3420	0.3157
Obs.	32,094	32,094	32,094	32,094

Note: ***, **, and * represent the 1 %, 5 % and 10 % levels of significance, respectively, for a two-tailed test.

In terms of property rights, state-owned enterprises are under government control and have various differences from non-state-owned enterprises. First, their objectives differ. While private companies aim to maximize their shareholders' interests, the state owns the capital and shares of state-owned enterprises. In addition to pursuing profits, they also have political and social responsibilities, and engage in activities such as strategic security, emergency response, rural revitalization, public services and charitable work. Thus, they support national welfare and serve as key pillars and "stabilizers" of society. Second, their channels for resource acquisition differ. State-owned enterprises possess inherent property rights advantages, making it easier for them to establish close relationships with the government or financial institutions and acquire resources that are readily available. Non-state-owned enterprises, however, can only obtain financing through rent-seeking or enhancing competitiveness (Kornai et al., 2003). Hence, during economic contraction cycles, these differences in property rights can determine the motivations for digital transformation. Compared with non-state-owned enterprises, state-owned enterprises enjoy natural resource advantages but also bear responsibilities such as regional employment. Consequently, the motivations of financing and optimal labor structures for digital transformation may be weaker. Economic contraction may therefore motivate non-state-owned enterprises to engage more in digital transformation, leading to a stronger counter-cyclical effect.

Unlike in traditional operations, through digital transformation companies can leverage emerging technologies to efficiently capture production data and provide timely feedback, thus enhancing production management (Qi and Xiao, 2020). The production models derived from this transformation, such as unmanned workshops and production lines, can rapidly reduce low-skill labor costs by eliminating tasks like information searching and other basic repetitive work, thereby enhancing the labor structure (Li et al., 2024). These cost-saving advantages can provide strong incentives to companies with a high proportion of low-skilled labor to pursue digital transformation during economic contraction periods. This suggests that the counter-cyclical effect of digital transformation will be greater in such companies.

High growth levels indicate that a company is in a stage of rapid development and that its governance methods and management models are more open, making it more receptive to digital transformation and to using digital information technology to reform business processes and management models. Therefore, companies with higher growth levels may be more motivated to optimize their labor structure and internal control systems through digital transformation, which can enhance their resource integration and corporate governance capabilities and lead to a stronger counter-cyclical effect from digital transformation.

Financial distress refers to a business state in which a company cannot repay debts or cover daily expenses. Such companies typically adopt conservative strategies to preserve cash flow by reducing investments and saving costs. This can prevent any potential bankruptcy or liquidation. During economic contraction cycles, the external environment is likely to further deteriorate, and thus the operating conditions of companies will worsen. The lagged effects of digital transformation and the resources required mean that aggressive digital

transformation strategies to alleviate downward economic pressure for companies in financial distress may not be appropriate, as the companies' financial chain may be at risk and bankruptcy may follow. Therefore, during economic contraction cycles, companies in financial distress are more inclined to adopt conservative strategies, and their motivation for digital transformation may be weaker, resulting in a weaker counter-cyclical effect.

Based on the above analysis, we propose that the counter-cyclical effect of corporate digital transformation is significantly stronger in non-state-owned enterprises, enterprises with a higher proportion of low-skilled labor and those with higher growth levels, while it is significantly weaker in financially distressed enterprises. We thus construct Model (2) based on Model (1).

$$DT_{i,t} = \beta_0 + \beta_1 GAP(CYCLE)_{i,t-1} + \beta_2 GAP(CYCLE)_{i,t-1} \times ADJUST_{i,t-1} + \beta_3 ADJUST_{i,t-1} + \beta_4 CONTROL_{i,t-1} + INDUS + AREA + \varepsilon_{i,t-1} \quad (2)$$

where $ADJUST_{i,t-1}$ represents the lagged contextual moderating variables, including ownership nature $SOE_{i,t-1}$, assigned a value of 1 if the enterprise is non-state-owned, and otherwise 0. Low-skilled labor enterprise, $LOW_{i,t-1}$, is assigned a value of 1 if the proportion of employees with degrees or below is less than the median, indicating a higher proportion of low-skilled labor in the enterprise, and otherwise 0. High-growth-level enterprise, $DGROW_{i,t-1}$, is assigned a value of 1 if the main business revenue growth rate is higher than the median, indicating a higher growth capability of the enterprise, and otherwise 0. Altman's Z-score index, where a higher Z-score indicates a better financial condition, has been proposed for enterprise financial distress, $ZSCO_{i,t-1}$, but its defined gray area [1.8, 2.675] is applicable to U.S. manufacturing companies and may not be suitable for the Chinese market. Therefore, we regard it as a dummy variable and assign a value of 1 if the Z-score index is less than the median, indicating the enterprise is in financial distress, and otherwise 0.

The regression results are shown in Table 6, where Columns (1)–(4) represent the heterogeneity analysis related to ownership nature, labor skill level, growth level and financial distress ($SOE_{i,t-1}$, $LOW_{i,t-1}$, $DGROW_{i,t-1}$, $ZSCO_{i,t-1}$). In Columns (1) to (3), the coefficients of $GAP_{i,t-1} \times ADJUST_{i,t-1}$ and $CYCLE_{i,t-1} \times ADJUST_{i,t-1}$ are all positive and significant, indicating that the counter-cyclical effect of digital transformation is significantly stronger in non-state-owned enterprises, those with lower-skilled labor and high-growth-level enterprises. In Column (4), the coefficients of $GAP_{i,t-1} \times ADJUST_{i,t-1}$ and $CYCLE_{i,t-1} \times ADJUST_{i,t-1}$ are negative and significant, indicating that the counter-cyclical effect of digital transformation is significantly weaker for financially distressed enterprises.

Table 6
Heterogeneity analysis.

Dep. Var.	$DT_{i,t}$							
	(1)$SOE_{i,t-1}$		(2)$LOW_{i,t-1}$		(3)$DGROW_{i,t-1}$		(4)$ZSCO_{i,t-1}$	
$GAP_{i,t-1}$	0.0090*		0.0080		–0.0066		0.0216***	
	(1.8764)		(1.5225)		(–1.5511)		(7.0308)	
$CYCLE_{i,t-1}$		0.0362		0.0367		–0.0545*		0.1367***
		(0.8453)		(1.1117)		(–1.8729)		(5.9689)
$GAP_{i,t-1} \times ADJUST_{i,t-1}$	0.0119***		0.0155***		0.0380***		–0.0126**	
	(4.2967)		(5.0670)		(14.8965)		(–2.7279)	
$CYCLE_{i,t-1} \times ADJUST_{i,t-1}$		0.0776***		0.1054***		0.2460***		–0.1109***
		(3.4613)		(6.4205)		(14.3592)		(–3.4446)
$ADJUST_{i,t-1}$	0.2134***	0.1692***	–0.3185***	–0.3765***	–0.0167	–0.1539***	–0.2134***	–0.1512***
	(6.5240)	(4.5159)	(–4.9872)	(–5.8721)	(–0.8612)	(–7.7633)	(–7.2920)	(–3.9687)
Constant	–6.4031***	–6.4682***	–5.1669***	–5.2186***	–5.7957***	–5.7585***	–5.9526***	–6.0729***
	(–15.6979)	(–15.8869)	(–12.0954)	(–12.2847)	(–14.3957)	(–14.2566)	(–14.7069)	(–15.0931)
Controls	YES	YES	YES	YES	YES	YES	YES	YES
Fixed Effect	YES	YES	YES	YES	YES	YES	YES	YES
Adjusted R^2	0.3614	0.3613	0.3700	0.3700	0.3597	0.3599	0.3617	0.3618
Obs.	32,094	32,094	32,094	32,094	32,094	32,094	32,094	32,094

Note: ***, **, and * represent the 1 %, 5 % and 10 % levels of significance, respectively, for a two-tailed test.

5.2. Economic consequences of the counter-cyclical effect of digital transformation

The previous discussion indicates that during economic contraction cycles, companies may actively pursue digital transformation to facilitate financing, optimize labor structures and improve internal governance levels to alleviate their difficulties. But do companies achieve these goals? We analyze the relationship between economic cycles, digital transformation and companies' financing convenience, labor structure and internal governance levels over the next year and the next three years to test this theoretical expectation. Based on Model (1), we establish Model (3).

$$FC(EMPLOY, IC)_{i,t+1(t+3)} = \beta_0 + \beta_3 DT_{i,t} + \beta_4 CONTROL_{i,t-1} + YEAR + INDUS + AREA + \varepsilon_{i,t-1} \quad (3)$$

where FC represents the degree of corporate financing constraints, referring to Gu et al. (2020). FC ranges from 0 to 1, where a higher value indicates a higher degree of corporate financing constraints, with a mean value of 0.4287. The labor structure of enterprises is proxied by the excess employee rate $EMPLOY$, which is a negative indicator with a mean value of –0.02153. The larger the excess employee rate, the more imperfect the labor structure of the enterprise. We measure this based on the correlation between industry average income and average employee scale, with the calculation formula as follows.

$$\mathrm{EMPLOY_i} = \frac{\mathrm{Emp_i} - \mathrm{Sales_i} * \frac{\mathrm{Emp_{ind}}}{\mathrm{Sales_{ind}}}}{\mathrm{Emp_i}}$$

$EMPLOY_i$ represents the excess employee rate of company i; Emp_i is the total number of employees of company i; $Sales_i$ is the total sales of company i; Emp_{ind} is the average number of employees in the industry; and $Sales_{ind}$ is the average sales in the industry. IC represents the quality of internal control, equal to the natural logarithm of the DIB Enterprise Internal Control Index, with a mean value of 6.0558. The higher the quality of internal control, the higher the level of corporate governance.

The regression results are shown in Tables 7 and 8. In Column (1), the coefficients of the economic contraction cycle sample $DT_{i,t}$ with $FC_{i,t+1}$ and $FC_{i,t+3}$ are both negative and significant, while those of the economic expansion cycle sample $DT_{i,t}$ with $FC_{i,t+1}$ and $FC_{i,t+3}$ are either not significant or small compared with those in the contraction cycle. This indicates that digital transformation during economic contraction cycles is more conducive to obtaining financing convenience in the next year and the next three years. In Column (2), the coefficients of the economic contraction cycle sample $DT_{i,t}$ with $EMPLOY_{i,t+1}$ and $EMPLOY_{i,t+3}$ are both negative and significant, whereas those of the economic expansion cycle sample $DT_{i,t}$ with $EMPLOY_{i,t+1}$ and $EMPLOY_{i,t+3}$ are not significant. This suggests that digital transformation during economic contraction cycles is more effective in reducing the excess employee rate in the next year and the next three years, thus optimizing the labor structure. In Column (3), the coefficients of the economic contraction cycle sample $DT_{i,t}$ with $IC_{i,t+1}$ and $IC_{i,t+3}$ are both positive and significant, while those of the economic expansion cycle

Table 7
Economic cycle, digital transformation and financing convenience (labor structure, internal governance level) for the next year.

Dep. Var.	(1) $FC_{i,t+1}$		(2) $EMPLOY_{i,t+1}$		(3) $IC_{i,t+1}$	
	CYCLE = 1	*CYCLE = 0*	*CYCLE = 1*	*CYCLE = 0*	*CYCLE = 1*	*CYCLE = 0*
$DT_{i,t}$	–0.0130***	–0.0021	–0.0295*	–0.0227	0.0464***	0.0233
	(–10.0603)	(–1.3351)	(–1.8137)	(–0.8902)	(5.1514)	(1.4194)
Constant	3.2176***	3.7243***	2.2197***	2.3954***	–1.2327*	0.2995
	(14.5808)	(29.4631)	(3.1361)	(3.3504)	(–1.8354)	(0.6915)
Controls	YES	YES	YES	YES	YES	YES
Fixed Effect	YES	YES	YES	YES	YES	YES
Adjusted R^2	0.5898	0.6978	0.1656	0.1707	0.1306	0.1561
Obs.	17,251	14,843	17,251	14,843	17,251	14,843

Note: ***, **, and * represent the 1 %, 5 % and 10 % levels of significance, respectively, for a two-tailed test.

Table 8
Economic cycle, digital transformation and financing convenience (labor structure, internal governance level) for the next three years.

Dep. Var.	(1) $FC_{i,t+3}$		(2) $EMPLOY_{i,t+3}$		(3) $IC_{i,t+3}$	
	CYCLE = 1	*CYCLE = 0*	*CYCLE = 1*	*CYCLE = 0*	*CYCLE = 1*	*CYCLE = 0*
$DT_{i,t}$	–0.0128***	–0.0049***	–0.0474**	–0.0034	0.0270**	–0.0089
	(–5.9363)	(–3.2790)	(–2.5318)	(–0.1515)	(2.1525)	(–0.5718)
Constant	3.2656***	3.1582***	1.2948*	2.5089***	4.5548***	1.0726
	(18.4459)	(19.7699)	(1.8278)	(3.5339)	(11.3464)	(0.9183)
Controls	YES	YES	YES	YES	YES	YES
Fixed Effect	YES	YES	YES	YES	YES	YES
Adjusted R^2	0.5415	0.5518	0.1249	0.1456	0.0626	0.0449
Obs.	12,895	10,734	12,895	10,734	12,895	10,734

Note: ***, **, and * represent the 1 %, 5 % and 10 % levels of significance, respectively, for a two-tailed test.

sample $DT_{i,t}$ with $IC_{i,t+1}$ and $IC_{i,t+3}$ are not significant. This indicates that digital transformation during economic contraction cycles is more conducive to improving the quality of internal control in the next year and the next three years, thus enhancing the level of internal governance.

These conclusions support our research hypotheses, revealing that the digital transformation activities of enterprises during economic contraction cycles have a positive impact on long-term financing convenience, labor structure and internal governance levels. This further supports the previous finding that a counter-cyclical effect occurs in the digital transformation of enterprises.

6. Conclusions

In this study, we empirically examine the relationship between economic cycles and corporate digital transformation using data on Chinese listed companies. We find that companies exhibit a higher level of digital transformation during economic contractions, thus clearly demonstrating counter-cyclicality. This effect is more pronounced in non-state-owned enterprises, those with a higher proportion of low-skilled labor and those with higher levels of growth, while it is significantly weaker in financially distressed companies. Further research reveals that compared with periods of economic expansion, engaging in digital transformation during periods of economic contraction can help companies in the following year and three years access financing more easily, optimize their labor structure and improve internal governance, thereby alleviating the pressure and challenges brought about by economic contraction.

This study not only extends the research in the fields of economic cycles and corporate digital transformation, but also contributes to the government's and companies' understanding of macroeconomic development laws, so they can encourage digital transformation and high-quality economic development. Thus, we propose the following policy suggestions.

First, the government should consider changes in the motives for corporate digital transformation under economic cycles to ensure such transformation is effective, and to promote digital economic development. The advantages of digital technology motivate companies to actively engage in digital transformation during times of economic contraction, so they can facilitate financing, optimize their labor structures and enhance internal control quality. This presents a counter-cyclical effect of digital transformation. The government should consider the motivations behind enterprise digital transformation in conjunction with changes in the macroeconomic cycle, to promote corporate digital transformation and the high-quality development of the digital economy in an orderly and efficient manner.

Second, the government should formulate and implement counter-cyclical policies and regulations based on the counter-cyclical effect of digital transformation. In the current period of slowing macroeconomic growth and structural transformation, the government and relevant regulatory authorities should strengthen their policy guidance regarding digital transformation during economic cycles, fully consider the motives for corporate digital transformation during economic contractions, and offer support to promote corporate digital development and the balanced growth of the digital economy.

Third, contextual factors such as the nature of property rights, labor skill levels, growth levels and financial distress should be considered by companies and governments. The counter-cyclical effect of corporate digital transformation is more pronounced in non-state-owned enterprises, those with a higher proportion of low-skilled labor and those with higher growth levels, while it is significantly weaker in financially distressed companies. Therefore, when conducting self-resource adjustments or offering guidance, companies and governments should fully consider the impact of these factors, accurately promote and assess the intensity and flexibility of digital transformation and ensure the digital economy develops effectively and efficiently.

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	Data Source
$DT_{i,t}$	The natural logarithm of 1 plus the total word frequency related to corporate digital transformation in the annual report.	CSMAR
$GAP_{i,t-1}$	Defined as −GAPS, i.e., the negative of GAPS, the actual GDP growth rate gap calculated by the macroeconomic HP filtering method.	National Bureau of Statistics
$CYCLE_{i,t-1}$	Binary variable: if $GAP_{i,t-1}$ is greater than 0, assign a value of 1; if $GAP_{i,t-1}$ is less than 0, assign a value of 0.	National Bureau of Statistics
$SIZE_{i,t-1}$	The natural logarithm of total assets at the end of the period for the company.	CSMAR
$LEV_{i,t-1}$	The ratio of total liabilities to total assets at the end of the period.	CSMAR
$TOP1_{i,t-1}$	The ratio of shares held by the largest shareholder to total shares outstanding.	CSMAR
$ROA_{i,t-1}$	Enterprise asset return rate, equal to net profit divided by average total assets.	CSMAR
$GROW_{i,t-1}$	The ratio of the difference between main operating revenue and the previous year's main operating revenue to the previous year's main operating revenue.	CSMAR
$BOARD_{i,t-1}$	The natural logarithm of the total number of board members.	CSMAR
$INDEP_{i,t-1}$	The ratio of independent directors to the total number of board members.	CSMAR
$SALA_{i,t-1}$	The natural logarithm of the total compensation of the top three executives	CSMAR
$HOLD_{i,t-1}$	The ratio of shares held by executives to total shares outstanding.	CSMAR
$LISTY_{i,t-1}$	The difference between the current year and the year of listing.	CSMAR
$HBZC_{i,t-1}$	The growth rate of monetary supply (M1).	National Bureau of Statistics
$DEVE_{i,t-1}$	The stock turnover rate of the capital market.	CSMAR
$YEAR$	Involving 32 provinces, with 31 dummy variables set.	CSMAR

(*continued on next page*)

Appendix (*continued*)

Variable	Definition	Data Source
INDUS	Based on the industry classification standard of the China Securities Regulatory Commission (2012), involving 17 industries, with 16 dummy variables set.	CSMAR
$SOE_{i,t-1}$	If the enterprise is a non-state-owned enterprise, assign a value of 1; otherwise, assign a value of 0.	CSMAR
$LOW_{i,t-1}$	If the proportion of employees with education below undergraduate level is less than the median, assign a value of 1; otherwise, assign a value of 0.	CSMAR
$DGROW_{i,t-1}$	If the growth rate of the main business income of the enterprise is greater than the median, assign a value of 1; otherwise, assign a value of 0.	CSMAR
$ZSCO_{i,t-1}$	Using the Z-score index proposed by Altman, if the Z-score index is less than the median, assign a value of 1; otherwise, assign a value of 0.	CSMAR
$FC_{i,t+1}$	Following the method proposed by Gu et al. (2020), calculate the probability of occurrence of corporate financing constraints (ranging from 0 to 1), where a higher value indicates a higher degree of corporate financing constraints.	CSMAR
$EMPLOY_{i,t+1}$	Calculated according to the association between industry average income and average employee size.	CSMAR
$IC_{i,t+1}$	Equals the natural logarithm of the Enterprise Internal Control Index from the Internal Control and Risk Management Database.	DIB database

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Labor outsourcing and corporate innovation

Wenbin Yang [a], Jiaqi Mou [b], Li Ji [c,*]

[a] School of Business China West Normal University, 1# Shida Road, Shunqing District, Nanchong City, Sichuan 637001, PR China
[b] School of Management Xihua University, 999# Tuqiao Jinzhou Road, Jinniu District, Chengdu City, Sichuan 610039, PR China
[c] School of Accounting Southwestern University of Finance and Economics, 555# Liutai Avenue, Wenjiang District, Chengdu City, Sichuan 611130, PR China

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ABSTRACT

This study investigates the impact of labor outsourcing on innovation, using manually collected data from Chinese A-share listed companies from 2012 to 2022. The results indicate that labor outsourcing significantly enhances firms' innovation level. This relationship is primarily driven by improvements in financial flexibility and operational flexibility. Furthermore, we find that this positive relationship is more pronounced for firms facing high financial constraints and economic policy uncertainty, and firms located in regions with low population aging. The findings also suggest that labor outsourcing encourages enterprises to prioritize innovations with low rather than high originality.

1. Introduction

Innovation plays a crucial role in driving industrial transformation and upgrading. Unlike regular production and operational activities, innovation demands significant funding and involves higher risks and uncertain returns (Amoroso et al., 2017). Enterprises need substantial financial backing for research and development (R&D) investments. They often use financial leverage to access the required funds, ensuring the sustainability of their innovation. However, excessive leverage can increase debt servicing pressures,

* Corresponding author.
E-mail address: jili@swufe.edu.cn (L. Ji).

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ultimately diminishing financial flexibility and hindering corporate innovation (Chen, 2016; Wang et al., 2019). Given the generally high leverage ratios in society, it is essential to reduce the leverage of enterprises. However, if not managed carefully, this can result in funding shortages that hinder innovation. A major challenge for Chinese firms lies in balancing the use of leverage to fuel innovation with the minimization of financial risks. Enhancing corporate flexibility is key to resolving this tension, as it allows firms to navigate uncertainties and capitalize on investment opportunities (Gamba and Triantis, 2008). Scholars have highlighted the critical role of flexibility in corporate innovation, particularly concerning working capital (Ju et al., 2013) and operating leverage (Zhu et al., 2021).

Labor outsourcing offers firms increased flexibility. In China, listed companies typically pay lower hourly wages for outsourced labor than for regular employees. Most outsourced tasks are low-tech and repetitive and do not directly contribute to innovations (Yang et al., 2023a). The literature indicates that outsourcing's real option feature provides firms with financial flexibility and operational flexibility. First, outsourcing can increase firms' cash holdings. By allowing firms to swiftly adjust their cost structures in response to market fluctuations, outsourcing reduces risks in volatile environments, boosts creditors' confidence and increases the likelihood of securing external financing (Gamba and Triantis, 2008; Marchica and Mura, 2010). Outsourced tasks are performed by contractors using their own resources, which also mitigates cash outflows associated with building new facilities or hiring regular employees (Alexander and Young, 1996; Chod and Zhou, 2014). Second, in terms of operational flexibility, outsourcing contracts are often based on actual service volume or output, enabling firms to convert fixed costs into variable costs. This reduces operating leverage and allows firms to quickly adjust the scale and nature of outsourcing in response to market demand and specific project requirements (He and Liu, 2011; Sedatole et al., 2012; Holzhacker et al., 2015).

In summary, labor outsourcing enhances cash holdings and reduces operating leverage, granting firms greater flexibility. This flexibility enables firms to swiftly invest in new opportunities or projects as needed, offering robust support for long-term investments such as R&D. This increased freedom not only improves companies' ability to navigate market volatility and uncertainty but also strengthens their capacity for long-term growth and innovation.

In China, labor outsourcing has emerged as a popular strategy for reducing costs and improving efficiency. Using data from China from 2012 to 2022, we investigate the relationship between corporate labor outsourcing and innovation. Our analysis begins in 2012, when the China Securities Regulatory Commission (CSRC) first required listed firms to disclose contractor remuneration. As shown in Fig. 1, there has been a considerable increase in the adoption of labor outsourcing strategies by Chinese A-share listed companies. This trend underscores the growing importance of labor outsourcing in the contemporary business landscape and emphasizes the need for further research into its impact on innovation.

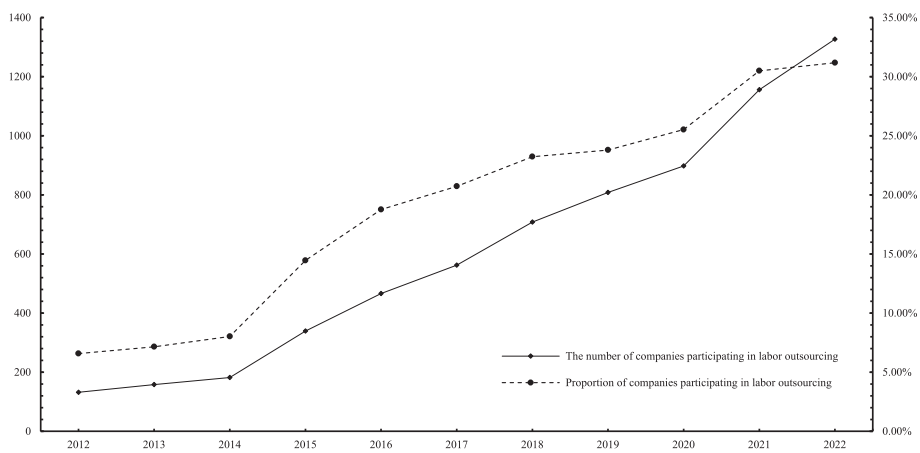

Fig. 1. Tendency chart of labor outsourcing.

Our empirical results show that the labor outsourcing behavior of enterprises significantly promotes firm innovation, and the results remain robust after conducting a series of robustness tests. One possible mechanism driving this finding is that labor outsourcing boosts flexibility, enabling firms to secure sufficient funds for innovation and swiftly reallocate internal resources to drive innovation endeavors. We use financial flexibility and operational flexibility to investigate the mechanism between labor outsourcing and innovation. Our empirical results align with expectations, indicating that the improved flexibility resulting from labor outsourcing may be a key factor driving the increase in firm innovation. Furthermore, we divide our sample firms into two groups based on financial constraints, economic policy uncertainty and degree of population aging. Our findings reveal a stronger positive association between labor outsourcing and innovation for firms facing high financial constraints and economic policy uncertainty, and firms operating in areas with a low degree of population aging. Finally, we find that labor outsourcing encourages enterprises to focus on low-originality innovation rather than high-originality innovation.

The contributions of this paper are as follows. First, our research expands the literature on the economic consequences of outsourcing. Although resource-based theory suggests that outsourcing can facilitate the transfer of external knowledge to firms' internal capabilities, thereby enhancing innovation (Gilley et al., 2004), few scholars have explored the impact of outsourcing on innovation from the perspective of flexibility. Our findings indicate that labor outsourcing effectively enhances corporate financial flexibility and operational flexibility, thus ultimately promoting innovation. In this way, we enrich the outsourcing-related literature.

Second, this research extends the understanding of the value of flexibility. The literature on capital structure reveals that firms often adopt conservative debt policies, even when the expected distress costs are low. This phenomenon is attributed to firms aiming to maintain flexibility (Marchica and Mura, 2010), which can bring about significant benefits. Relevant studies indicate that seizing investment opportunities and mitigating underinvestment costs are crucial reasons for firms to maintain flexibility. Outsourcing can enhance the proportion of variable costs for companies (Holzhacker et al., 2015), thereby increasing their flexibility (Choi et al., 2021; Yang et al., 2023b); however, there has been no empirical exploration of the value of this flexibility in relation to long-term investments such as R&D investment. This paper provides empirical evidence of the positive effects of labor outsourcing on both financial and operational flexibility, adding to the literature related to flexibility.

Finally, this study enriches the literature on the factors influencing corporate innovation. Previous studies examine the effects of various financial metrics on innovation, including firm size, working capital (Ju, 2013), financial leverage (Chen, 2016; Wang et al., 2019) and operational leverage (Zhu et al., 2021). Labor outsourcing, as a form of operational employment, has a more complex impact on innovation activities. On the one hand, it increases the proportion of variable costs (Holzhacker et al., 2015), enabling firms to swiftly adjust their internally generated funds and ultimately promoting innovation. On the other hand, labor outsourcing typically involves low-end, repetitive tasks aimed at cost savings rather than acquiring specialized knowledge. Therefore, the positive impact of labor outsourcing on corporate innovation tends to be more pronounced for low-originality innovations. Our results connect firms' employment decisions with their innovation behaviors, representing a valuable contribution to the literature on innovation.

2. Literature review and hypothesis development

2.1. Innovation

Innovation is characterized by high risk, high failure rates and unpredictability, with huge upfront investments often becoming sunk costs. It typically takes a long time for innovations to yield business benefits. As a result, innovation activities necessitate considerable capital for long-term investment (Hottenrott and Peters, 2012). The literature has examined the factors influencing firms' innovation activities from both external and internal financing perspectives.

There are two main challenges in obtaining the funds necessary for innovation through external financing. First, the high degree of uncertainty associated with innovation activity creates significant financing constraints for firms, making it difficult for them to obtain external financing or resulting in high costs for financing (Ju et al., 2013). Second, in China's current financing model, increasing R&D investment requires financial

leverage. However, excessive leverage places significant pressure on firms for debt servicing, and the high fixed interest payments complicate the adjustment of internal cash flow across periods, thereby reducing financial flexibility and ultimately restricting corporate innovation.

Supporting enterprise innovation through internal financing presents two challenges. First, if firms' internal finances are unstable, innovation activities may be halted due to disruptions in the financial chain (Zhu et al., 2021). Second, innovation activities often incur high adjustment costs, leading to significant losses during sudden interruptions (Hall, 2002; Ju, 2013). Firms with strong risk tolerance tend to have more stable internal funds, which are essential for sustaining innovation efforts. For example, the buffering capacity of a firm's working capital can help absorb financial shocks, smoothing the volatility of innovation investments. Spain's labor market reforms have lowered dismissal costs, which in turn reduces adjustment costs and supports innovation (Garcia-Vega et al., 2021). Conversely, higher adjustment costs can prevent firms from quickly reducing operating expenses, resulting in increased volatility in internal cash flows and negatively impacting the sustainability of innovative activities. For example, labor protection policies can raise the adjustment costs associated with human resources, leading to insufficient innovation activity (Griffith and Macartney, 2014). Excessive operating leverage can decrease a firm's risk tolerance, making it more challenging to adjust cash flows over time and ultimately inhibiting innovation (Zhu et al., 2021).

In short, within China's current financing environment, enterprises often rely on financial leverage to boost their R&D investments. However, excessive financial leverage can heighten the pressure of repaying debts and interest, thereby constraining R&D investment (Wang et al., 2019). A key challenge for Chinese firms is finding the right balance between using financial leverage to promote innovation and lowering financial leverage to mitigate financial risks.

Enhancing the flexibility of financial resource allocation can enable enterprises to increase R&D investments without raising financial leverage, thus facilitating long-term innovative development. The literature indicates that greater flexibility not only improves a company's adaptability to uncertain market conditions but also aids in seizing valuable investment opportunities, thus minimizing potential losses from underinvestment (Marchica and Mura, 2010). For example, Ju et al. (2013) demonstrate that the buffering capacity of working capital against financial shocks can smooth fluctuations in innovation investments, while Zhu et al. (2021) argue that reducing operational leverage enhances a company's ability to manage internal cash flows over time, thereby fostering corporate innovation.

2.2. Labor outsourcing and innovation

Labor outsourcing can increase both the financial and operational flexibility of firms. First, outsourcing allows companies to access specialized and complementary resources or capabilities from external providers (Barney, 1991; Holcomb and Hitt, 2007). For example, outsourcing can raise the proportion of skilled workers and enhance labor productivity (Chongvilaivan and Hur, 2011). This increased efficiency in resource allocation leads to more reliable and secure future returns. As a result, firms experience reduced risk in volatile market environments while gaining increased trust from creditors (Gamba and Triantis, 2008; Marchica and Mura, 2010), ultimately improving their financial flexibility. Second, outsourcing can convert some of a firm's fixed costs into variable costs, thereby reducing operating leverage and increasing operational flexibility. For example, by outsourcing functions such as aircraft maintenance and medical services to third parties, airlines and hospitals can transform part of their fixed costs into variable costs. This allows enterprises to swiftly adjust the scale and nature of outsourcing in response to fluctuations in market demand and the specific requirements of a project, thereby improving their operational flexibility (He and Liu, 2011; Sedatole et al., 2012; Holzhacker et al., 2015).

In short, labor outsourcing can reduce the uncertainty faced by firms and enhance their ability to secure and use external funds. It also lowers operational leverage, giving firms greater freedom in decision-making. Both factors improve managerial flexibility, reduce short-term financial pressure and create a favorable environment for long-term investments such as R&D, which can yield significant long-term benefits. Based on this, we propose the following research hypothesis:

H1: Labor outsourcing is positively related to the level of innovation.

3. Data and research design

3.1. Data and sample selection

We begin with 31,262 labor outsourcing observations from 2012 to 2022, as A-share listed companies have been required to disclose their total labor outsourcing compensation since 2012, in accordance with CSRC regulations. Then, we exclude financial firms and those under "Special Treatment" (ST and *ST firms). After excluding observations with missing values, 26,288 observations remain. Table 1 shows the detailed sample selection procedure. Among these observations, 6,129 implement labor outsourcing strategies, while 20,159 do not.

We obtain financial and governance data from the China Stock Market & Accounting Research database, while labor outsourcing information is manually collected from the annual reports of A-share listed companies. To mitigate the impact of extreme values, all data are winsorized at the top and bottom 1 %.

3.2. Measures

3.2.1. Innovation

Corporate innovation is typically measured from two perspectives: inputs and outputs. Inputs refer to R&D investments, whereas outputs are reflected in the number of patents. However, the number of patents registered is influenced by various external factors, which reduces its comparability as a measure of innovative output and makes it less suitable as an explanatory variable (David et al., 2000). In contrast, innovation inputs, primarily determined by enterprise managers, better reflect their decision-making behaviors. Therefore, we measure innovation as the ratio of R&D expenses to the book value of total assets, multiplied by 100 (*RDTA*) (Hirshleifer et al., 2012). In addition, we use the number of patents as an alternative measure in our robustness tests (He and Tian, 2013).

3.2.2. Labor outsourcing and control variables

The independent variable, labor outsourcing (*OTSC*), is measured as the remuneration paid to contractors by A-share listed companies, scaled by the firm's sales revenue.

According to previous studies (Zhu et al., 2021; Liang, 2022), firms' innovation input is an essential factor, thus we control for prior R&D expenses (*INNOVATION*). Additionally, we control for several firm financial variables that may influence a firm's innovation strategy, including firm size (*SIZE*), leverage (*LEV*), profitability (*ROE*), net cash generated from operating activities (*CFO*), fixed assets (*PPETA*) and the market value to book value (*TOBINQ*) to capture firm and financial characteristics. We also control for governance variables, including the shareholding of institutional investors (*INS*), management shareholding (*MHOLD*) and the top shareholder (*TOP1*). We also include firms' analyst following (*AF*) and media coverage (*MEDIA*) to reflect the level of external monitoring. Table 2 presents detailed variable definitions.

3.3. Regression model

We estimate the following model to test the impact of labor outsourcing on firms' innovation:

$$RDTA = \alpha_0 + \alpha_1 \times OTSC + \alpha_j \times Controls + \Sigma Incode + \Sigma year + \varepsilon \quad (1)$$

Table 1
Sample selection procedure.

Criteria	Number of Observations
Total Chinese A-share listed companies disclosed earnings forecast with December 31st FYE for 2012 ~ 2020	31,262
(−) Firms in the financial industry	(645)
(−) Distressed firms, such as ST and *ST	(266)
(−) Firms without data necessary to estimate control variables	(4,063)
Final Sample	26,288

Table 2
Variable definitions.

Variable	Definition
OTSC	Labor outsourcing cost/Revenue (in thousands)
RDTA	R&D investment/Total assets
INNOVATION	*RDTA* lagged by one period
SIZE	The natural logarithm of total assets
LEV	The natural logarithm of the ratio of debt to total assets
ROE	Net profit/Equity
CFO	Net cash flow from operations/Total assets
PPETA	Fixed assets/Total assets
TOBINQ	The market value of a company divided by its book value
INS	The quantity of shares held by institutional investors/The total number of shares
MHOLD	The quantity of shares held by management/The total number of shares
TOP1	The quantity of shares held by the largest shareholder/The total number of shares
AF	ln(1 + the number of analysts following a firm)
MEDIA	ln(1 + the number of news reports about a firm)

where *RDTA* is firms' innovation level and *OTSC* is the core independent variable representing firms' labor outsourcing. *Controls* are the control variables. $\sum Incode$ represents industry fixed effects and $\sum year$ represents year fixed effects. If α_1 is significant and positive in Model (1), it will indicate that firms' labor outsourcing behavior can promote innovation.

4. Empirical results

4.1. Descriptive statistics

Table 3 presents the descriptive statistics for all variables in the regression analysis. The average value of *RDTA* is 2.399, with a minimum value of 0 and a maximum of 12.262, indicating significant variations in innovation across firms. The average value of *OTSC* is 0.026, with a maximum value of 0.656. This suggests that on average, the scale of labor outsourcing for firms is not substantial, although there is considerable variation among companies. The average *ROE* of our sample is 2.8 %, with an average *SIZE* of 22.319 and an average *LEV* of 43.0 %. Overall, the descriptive statistics of our control variables fall within a reasonable range.

Table 3
Descriptive statistics.

Variable	N	mean	sd	p25	p50	p75	min	max
OTSC	26,288	0.026	0.092	0.000	0.000	0.000	0.000	0.656
RDTA	26,288	2.399	2.162	0.000	0.887	1.974	3.223	12.262
INNOVATION	26,288	2.187	1.995	0.000	0.733	1.841	2.996	10.694
SIZE	26,288	22.319	1.282	20.001	21.399	22.114	23.008	26.352
LEV	26,288	0.430	0.202	0.065	0.271	0.420	0.574	0.938
ROE	26,288	0.028	0.073	−0.340	0.010	0.032	0.062	0.195
CFO	26,288	0.048	0.066	−0.144	0.009	0.046	0.086	0.241
PPETA	26,288	0.210	0.144	0.009	0.097	0.182	0.293	0.648
TOBINQ	26,288	2.068	1.320	0.839	1.249	1.643	2.373	8.464
INS	26,288	0.425	0.248	0.003	0.216	0.436	0.625	0.913
MHOLD	26,288	0.137	0.189	0.000	0.000	0.015	0.256	0.671
TOP1	26,288	0.329	0.144	0.083	0.217	0.305	0.422	0.721
AF	26,288	1.682	1.505	0.000	0.000	1.609	2.996	4.727
MEDIA	26,288	3.788	1.705	0.000	3.258	4.220	4.949	6.538

4.2. Correlation analyses

Table 4 shows the correlation coefficients for each pair of independent variables. We observe a positive correlation between *OTSC* and *RDTA*, aligning with H1, indicating that labor outsourcing may promote innovation. The correlation coefficients among other variables are relatively low, suggesting that multicollinearity among the control variables is not a significant issue.

4.3. Regression analysis

Table 5 presents our main results from estimating Model (1). Column (1) reports the results including only industry fixed effects and year fixed effects. We find that the coefficient of *OTSC* is 0.774 and is statistically significant at the 1 % level. Column (2) includes the additional control variables, revealing a coefficient of *OTSC* of 0.699, which remains significant at the 1 % level. Across all our estimates in Table 5, we find positive and significant coefficients of *OTSC* and *RDTA*, thus supporting H1, indicating that labor outsourcing has a positive effect on firms' innovation.

4.4. Robustness tests

4.4.1. Alternative measures of innovation

According to Liang (2022), we construct alternative innovation variables as follows: the number of patents obtained by the company in the current year (*PAT0*), and the number of patents expected to be obtained in the next year (*PAT1*) and the following two years (*PAT2*). We run a tobit model using *PAT0*, *PAT1* and *PAT2* as substitute variables.[1] As shown in Columns (1)–(3) of Table 6, these results are consistent with our main results.

4.4.2. Regional and firm fixed effects

Given that regional economic development and labor force dynamics may affect firms' outsourcing decisions and innovative activities, we conduct the regression by controlling for regional fixed effects and firm fixed effects. Columns (4)–(5) of Table 6 show that the coefficient of *OTSC* is positive and significant at the 1 % level, which is consistent with our main results.

4.4.3. Sample selection bias and endogenous solution

To mitigate sample selection bias, we use the propensity score matching (PSM) method. The treatment group comprises firms that implemented labor outsourcing strategies, while the control group consists of firms that did not pursue labor outsourcing strategies. We estimate a probit model using the full sample to identify the propensity score matched control sample. The dependent variable is whether a firm uses a labor outsourcing strategy (*TOTSC*), and the independent variables include *SIZE*, *LEV*, *ROA, CFO*, *PPETA*, *TOBINQ*, *INS*, *MHOLD*, *TOP1*, *AF* and *MEDIA*. We obtain a propensity score for each firm based on the results. We match one control firm with the closest propensity score in the same year for each treatment firm, and thus get the propensity score matched control sample. We also conduct a mean test to assess whether the means of the variables differ between the matched samples, ensuring satisfactory matching.

Table 7 presents the mean test before and after PSM. As shown in Panel A, most of the variables exhibit significant differences between the treatment and control groups. Panel B illustrates the results of covariate balance checks between the control and treatment groups. The results indicate that the control sample after PSM aligns closely with the treatment firms across nearly all dimensions.

We estimate Model (1) using the matched sample and the results are shown in Column (1) of Table 8. The results are again consistent with our main results.

To further address endogeneity issues, we use the Heckman two-stage model (Heckman, 1979). In the first stage, the mean value of *OTSC* of other companies in the same year and region is added as a control variable

[1] Referring to Zhu et al. (2021), the explanatory variables are continuous using the natural logarithm of the number of patents plus 1.

Table 4
Correlation matrix.

	RDTA	*OTSC*	*INNOVATION*	*SIZE*	*LEV*	*ROE*	*CFO*	*PPETA*	*TOBINQ*	*INS*	*MHOLD*	*TOP1*	*AF*	*MEDIA*
RDTA	1													
OTSC	0.038***	1												
INNOVATION	0.825***	−0.002	1											
SIZE	−0.172***	0.051***	−0.210***	1										
LEV	−0.174***	0.058***	−0.215***	0.473***	1									
ROE	0.083***	−0.025***	0.112***	0.047***	−0.372***	1								
CFO	0.054***	−0.013**	0.058***	0.077***	−0.179***	0.403***	1							
PPETA	−0.167***	−0.022***	−0.191***	0.075***	0.072***	−0.037***	0.201***	1						
TOBINQ	0.229***	−0.024***	0.252***	−0.368***	−0.255***	0.142***	0.106***	−0.101***	1					
INS	−0.116***	0.021***	−0.162***	0.442***	0.177***	0.124***	0.125***	0.126***	−0.013**	1				
MHOLD	0.167***	0.002	0.205***	−0.329***	−0.286***	0.140***	0.019***	−0.137***	0.033***	−0.633***	1			
TOP1	−0.101***	0.020***	−0.129***	0.184***	0.023***	0.146***	0.111***	0.107***	−0.088***	0.496***	−0.068***	1		
AF	0.105***	−0.033***	0.111***	0.384***	−0.034***	0.375***	0.227***	−0.029***	0.138***	0.259***	0.060***	0.089***	1	
MEDIA	−0.052***	−0.064***	−0.056***	0.093***	0.048***	0.066***	0.029***	0.046***	0.131***	0.066***	−0.014**	0.031***	0.252***	1

Note: The bottom left corner reports the Pearson correlation coefficients. *OTSC* is positively correlated with *RDTA*. The definitions of the variables are shown in Table 2. *, ** and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively.

Table 5
Regression results.

Dependent variable: *RDTA*	Hypothesis 1	
	(1)	(2)
OTSC	0.774***	0.699***
	(2.95)	(2.91)
INNOVATION		0.409***
		(25.33)
SIZE		−0.162***
		(−4.75)
LEV		0.024
		(0.21)
ROE		−0.465***
		(−2.63)
CFO		0.557***
		(3.47)
PPETA		0.267*
		(1.66)
TOBINQ		0.059***
		(4.76)
INS		−0.157
		(−1.36)
MOHLD		−0.083
		(−0.61)
TOP1		−0.188
		(−0.91)
AF		0.034***
		(3.11)
MEDIA		−0.006
		(−0.37)
Constant	1.996***	5.119***
	(8.47)	(6.69)
Year	Yes	Yes
Industry	Yes	Yes
Observations	26,288	26,288
Adjusted R^2	0.225	0.779

Note: This table reports the results of Model (1), controlling for year and industry fixed effects. The variables are defined in Table 2. Column (1) presents the regression results of Model (1) without the control variables, and Column (2) presents the regression results of Model (1) with the control variables. *Year* and *Industry* denote the control variables for year and industry effects, respectively. The *t*-values are presented in parentheses below the coefficients. *, ** and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively.

in the probit regression to calculate the inverse Mills ratio (*IMR*). In the second stage, we incorporate *IMR* into the model to control for self-selection bias. As shown in Column (2) of Table 8, the results align with our main results.

To tackle potential endogeneity concerns, we use the difference-in-differences (DID) method. Specifically, we designate the control group as firms that did not engage in labor outsourcing throughout the entire research period (indicated by a *Treat* value of 0). The treatment group comprises firms that did not engage in labor outsourcing during the first half of the period but started to do so in the remaining time (represented by a *Treat* value of 1), with the *Post* variable indicating the changing point. For the treatment group, *Post* takes a value of 0 before the transition period when labor outsourcing had not yet been initiated and 1 thereafter. In contrast, *Post* is consistently 0 for the control group. The DID regression results in Column (3) of Table 8 support our primary findings while effectively controlling for endogeneity concerns.

Table 6
Alternative measures of the independent variable with fixed effects added.

Dependent variable: *RDTA*	Alternative variable			Regional-level control variables added	Firm fixed effects
	PAT0	*PAT1*	*PAT2*	*RDTA*	*RDTA*
	(1)	(2)	(3)	(4)	(5)
OTSC	2.416***	2.488***	2.118***	1.019***	0.707***
	(6.54)	(5.70)	(4.16)	(4.84)	(2.90)
INNOVATION	0.358***	0.354***	0.328***	0.699***	0.411***
	(17.35)	(14.70)	(12.18)	(61.40)	(25.29)
SIZE	0.372***	0.379***	0.416***	−0.059***	−0.150***
	(8.06)	(7.18)	(7.12)	(−3.67)	(−3.93)
LEV	−1.111***	−1.108***	−1.055***	−0.034	0.011
	(−4.69)	(−4.07)	(−3.51)	(−0.44)	(0.10)
ROE	1.918***	1.753**	2.722***	−0.744***	−0.513***
	(2.87)	(2.27)	(3.08)	(−4.36)	(−2.89)
CFO	−1.455**	−1.431**	−1.401*	0.505***	0.562***
	(−2.32)	(−1.99)	(−1.77)	(3.34)	(3.53)
PPETA	−0.292	−0.253	0.032	0.006	0.227
	(−1.00)	(−0.77)	(0.09)	(0.06)	(1.35)
TOBINQ	−0.168***	−0.190***	−0.153***	0.073***	0.060***
	(−4.90)	(−4.83)	(−3.41)	(7.08)	(4.77)
INS	0.819***	0.579**	0.131	0.152**	−0.147
	(3.27)	(2.03)	(0.41)	(2.02)	(−1.26)
MOHLD	1.383***	1.101***	0.739**	0.188**	−0.072
	(4.91)	(3.43)	(2.09)	(2.33)	(−0.53)
TOP1	0.095	0.259	0.650*	−0.064	−0.173
	(0.31)	(0.74)	(1.69)	(−0.59)	(−0.85)
AF	0.027	0.027	0.025	0.033***	0.033***
	(0.82)	(0.73)	(0.63)	(3.46)	(2.93)
MEDIA	0.056	0.046	−0.010	−0.014	−0.006
	(1.44)	(1.05)	(−0.21)	(−1.10)	(−0.41)
Constant	−13.510***	−13.066***	−13.690***	2.038***	4.892***
	(−13.16)	(−11.20)	(−10.62)	(5.85)	(5.87)
Year	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes	No
Regional	No	No	No	Yes	No
Firm	No	No	No	No	Yes
Observations	26,288	21,209	17,745	26,288	26,288
Pseudo (Adjusted) R^2	0.028	0.025	0.022	0.149	0.155

Note: This table reports the results of robustness tests using the alternative measure of *RDTA* and controlling for firm fixed effects. The independent variable is *OTSC*. The definitions of the variables are shown in Table 2. *PAT0*, *PAT1* and *PAT2* are the number of patents obtained by the company in the current year, in the next year and the following two years, respectively. Columns (1)–(3) show the regression results using different measurements of innovation. Column (4) shows the regression results while controlling for regional fixed effects. Column (5) presents the regression results while controlling for firm fixed effects. *Year*, *Industry* and *Regional* denote the control variables for year, industry and regional effects, respectively. The *t*-values are presented in parentheses below the coefficients. *, ** and ***

4.5. Mechanism analysis: Flexibility

Flexibility offers numerous advantages for firms. A higher ratio of variable costs can enhance a firm's risk tolerance, simplify the adjustment of endogenous cash flows across periods and facilitate effective responses to competition and technological changes (Zhu et al., 2021). Additionally, adequate cash reserves and robust financing capabilities enable firms to quickly identify and capitalize on new opportunities (Barry et al., 2022).

Innovation is a complex, capital-intensive process that necessitates long-term investment and is inherently fraught with uncertainty and significant capital demands. When firms possess strong risk tolerance, their inter-

nal capital tends to be more stable, fostering the sustainability of their innovation efforts. For example, the buffering capacity of a firm's working capital against financial shocks can smooth the volatility of its investment in innovation (Ju et al., 2013). Conversely, high adjustment costs can hinder firms from rapidly reducing their operating expenses, potentially leading to increased volatility in internal cash flows and negatively impacting the sustainability of their innovative activities. Furthermore, excessive operating leverage diminishes a firm's risk tolerance and complicates the adjustment of cash flows over time, ultimately inhibiting innovation (Zhu et al., 2021).

We argue that labor outsourcing enhances both the financial and operational flexibility of firms. This increased flexibility alleviates concerns over short-term financial pressures, bolsters firms' capacity to embrace the risks associated with innovation projects and ultimately fosters innovation within the organization.

4.5.1. Financial flexibility

Outsourcing may enhance corporate financial flexibility. Choi et al. (2021) identify financial flexibility as a significant motive for companies engaging in outsourcing. We follow Barry et al. (2022) and use the ratio of

Table 7
Mean tests.

Panel A: Mean tests before PSM

	Mean		*t*-statistic
	Treatment group (N = 6,129)	Control group (N = 20,159)	
SIZE	22.578	22.240	−18.191***
LEV	0.458	0.422	−12.250***
ROE	0.030	0.028	−2.241**
CFO	0.050	0.047	−3.067***
PPETA	0.205	0.211	2.534**
TOBINQ	1.920	2.112	9.993***
INS	0.459	0.415	−12.266***
MHOLD	0.128	0.140	4.434***
TOP1	0.338	0.326	−5.975***
AF	1.627	1.699	3.316***
MEDIA	3.426	3.897	19.086***

Panel B: Mean Tests After PSM

	Mean		*t*-statistic
	Treatment group (N = 6,098)	Control group (N = 6,098)	
SIZE	22.567	22.579	0.457
LEV	0.456	0.458	0.553
ROE	0.030	0.029	−0.933
CFO	0.050	0.051	0.967
PPETA	0.206	0.206	0.043
TOBINQ	1.924	1.944	0.901
INS	0.458	0.460	0.463
MHOLD	0.128	0.126	−0.368
TOP1	0.338	0.337	−0.561
AF	1.622	1.640	0.660
MEDIA	3.438	3.449	0.343

Note: This table reports the results of mean tests before and after propensity score matching (PSM). The definitions of the variables are shown in Table 2. The control group contains firms that pursued labor outsourcing strategies and the treatment group contains firms that did not. Panel A reports the mean difference between the control and treatment groups before PSM. Panel B reports the mean difference after PSM and shows that there are no significant differences in the means of any covariates. *, ** and *** indicate significance at the 10%, 5% and 1% levels, respectively.

Table 8
Sample selection bias and endogenous solution.

Dependent variable: *RDTA*	Sample selection bias		Endogenous solution
	PSM	Heckman two-stage estimate	DID
	(1)	(2)	(3)
OTSC (Treat × Post)	1.044***	0.639***	0.128**
	(4.42)	(2.64)	(2.05)
INNOVATION	0.828***	0.410***	0.431***
	(56.54)	(25.36)	(20.13)
SIZE	−0.038*	−0.157***	−0.070*
	(−1.73)	(−4.54)	(−1.69)
LEV	−0.015	−0.090	−0.020
	(−0.14)	(−0.70)	(−0.15)
ROE	−0.683**	−0.753***	−0.662***
	(−2.45)	(−3.16)	(−3.58)
CFO	0.276	0.523***	0.226
	(1.07)	(3.22)	(1.14)
PPETA	0.077	0.176	0.479***
	(0.58)	(1.06)	(2.77)
TOBINQ	0.053***	0.070***	0.019
	(3.44)	(5.01)	(1.08)
INS	0.256**	−0.331**	−0.532***
	(2.27)	(−2.27)	(−3.46)
MOHLD	0.465***	−0.211	−0.289
	(3.92)	(−1.35)	(−1.58)
TOP1	0.060	−0.142	0.106
	(0.40)	(−0.69)	(0.46)
AF	0.030*	0.039***	0.054***
	(1.88)	(3.53)	(3.86)
MEDIA	−0.004	0.005	0.007
	(−0.22)	(0.29)	(0.54)
IMR		−0.206*	
		(−1.91)	
Constant	1.780***	5.742***	3.020***
	(3.54)	(7.02)	(3.19)
Year	Yes	Yes	Yes
Industry	Yes	Yes	Yes
Observations	12,196	26,284	21,541
Adjusted R^2	0.788	0.777	0.864

Note: This table reports the results of sample selection bias and endogenous solution. The dependent variable is *RDTA*. The definitions of the variables are shown in Table 2. Column (1) presents the regression results after PSM. Column (2) presents the regression results using the Heckman two-stage method. Column (3) shows the DID regression results. *Year* and *Industry* denote the control variables for year and industry effects, respectively. The *t*-values are presented in parentheses below the coefficients. *, ** and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively.

cash and cash equivalents in year $t-1$ to total assets in year t (*FF*) as a measure of corporate financial flexibility. In Table 9, Column (1), the dependent variable is financial flexibility. We observe a coefficient of 0.213 for *OTSC*, which is significant at the 5 % level. This result indicates that labor outsourcing significantly enhances corporate financial flexibility, confirming the flexibility channel.

4.5.2. Operational flexibility

Operational flexibility refers to a firm's ability to adjust its production methods by balancing fixed and variable costs. Outsourcing allows firms to delegate operational tasks to contractors based on external conditions, facilitating the conversion of fixed into variable costs and thereby enhancing operational flexibility (Holzhacker et al., 2015; Choi et al., 2021).

According to Aboody et al. (2018), we estimate firms' operating leverage by regressing the coefficient of sales revenue against operating costs. First, using an 8-year window, we regress the natural logarithm of operating costs (*LNOC*) against the natural logarithm of sales revenue (*LNREV*) to obtain the regression coefficient λ_1 of *LNREV*. The regression model is as follows:

$$LNOC = \lambda_0 + \lambda_1 \times LNREV + \varepsilon \tag{2}$$

where *LNOC* represents the natural logarithm of a company's operating costs, which includes operating costs, management expenses and sales expenses. To avoid a mechanical relationship between the estimated operating leverage and R&D investment, we remove the amount of amortization of intangible assets and R&D investments that are expensed in the current period when calculating operating costs. *LNREV* represents the natural logarithm of a company's sales revenue.

Second, the measure of operating leverage (*OL*) is calculated as 1-λ_1. The reason for this is that previous studies show that the regression coefficient λ_1 of the natural logarithm of operating costs against the natural logarithm of sales revenue can reflect the proportion of variable costs to average costs in a company. Therefore, 1-λ_1 measures the proportion of fixed costs to variable costs in a company, reflecting its operating leverage (Lev, 1974; Aboody et al., 2018).

Finally, following Choi et al. (2021), we use 1-(1-λ_1) = λ_1 as the indicator of operational flexibility (*OF*), reflecting the proportion of variable costs. The larger the value of *OF*, the higher the operational flexibility of the firm.

We conduct a regression using *OF* as the dependent variable and *OTSC* as the independent variable. The results presented in Table 9, Column (2), show that the coefficient of *OTSC* is 0.116, which is significant at the 5 % level. This indicates that labor outsourcing significantly improves firms' operational flexibility.

5. Further discussion

5.1. Financial constraints

Enterprises facing higher financing constraints often struggle to cope with the negative impacts of market fluctuations due to insufficient capital, which limits their ability to quickly adjust their operations (Ju et al., 2013; Choi et al., 2021). Outsourcing offers these firms the flexibility to adapt to uncertain market environments. When firms encounter high financing constraints, outsourcing becomes even more critical in maintaining business flexibility and thus has a more pronounced effect on promoting innovation.

Using the SA index (*SA*) to measure financing constraints (Ju et al., 2013), we divide the sample into two groups based on the median of *SA* and conduct regressions for each group. As shown in Columns (1) and (2) of Table 10, the coefficient of *OTSC* is positive and significant at the 1 % level for firms with high financial constraints. However, for the low financial constraints group (Column (2)), the coefficient of *OTSC* is not significant. This result aligns with our expectations, indicating that the flexibility introduced by labor outsourcing is more beneficial for firms facing higher financial constraints.

5.2. Economic policy uncertainty

We further examine the impact of uncertainty. Previous studies find that uncertainty significantly increases information asymmetry between firms and external fund providers (Nagar et al., 2019), leading to higher external financing costs (Li et al., 2021) and potentially causing underinvestment problems (Drobetz et al., 2018; Yang et al., 2023a). In contrast, during periods of low uncertainty, firms experience lower financing costs and reduced investment inefficiencies. This reduces the necessity for labor outsourcing-induced flexibility in capturing investment opportunities. Thus, we expect the impact of labor outsourcing on innovation to be more pronounced when firms face higher uncertainty.

We refer to Nie et al. (2020) and conduct a textual analysis of the *Management Discussion and Analysis* section of firms' annual reports. Then, we construct a firm-year uncertainty index to capture the uncertainty levels of each company in each year. Column (3) in Table 10 shows the results for the high firm-level uncertainty group. The coefficient of *OTSC* is 1.581 and is significant at the 1 % level. Column (4) presents

Table 9
Regression results of mechanism analysis.

Dependent variable:	Flexibility	
	Financial flexibility (*FF*)	Operational flexibility (*OF*)
	(1)	(2)
OTSC	0.213**	0.116**
	(2.04)	(2.10)
INNOVATION	−0.004	0.012***
	(−1.31)	(4.56)
SIZE	−0.012	0.033***
	(−1.49)	(5.28)
LEV	−0.135***	−0.035
	(−4.63)	(−1.45)
ROE	−0.029	−0.077**
	(−0.54)	(−2.37)
CFO	−0.052	−0.067**
	(−1.01)	(−2.02)
PPETA	−0.158***	0.100**
	(−2.74)	(2.54)
TOBINQ	0.005	−0.005
	(1.50)	(−1.60)
INS	0.002	−0.038
	(0.06)	(−1.55)
MOHLD	0.028	0.132***
	(0.71)	(3.34)
TOP1	0.017	0.104***
	(0.29)	(2.67)
AF	−0.006*	−0.003
	(−1.78)	(−1.30)
MEDIA	0.005	−0.002
	(1.25)	(−0.77)
Constant	0.460**	0.361**
	(2.26)	(2.44)
Year	Yes	Yes
Industry	Yes	Yes
Observations	26,288	26,003
Adjusted R^2	0.026	0.004

Note: This table reports the results of the mechanism analysis controlling for industry and year fixed effects. The definitions of the variables are shown in Table 2. *Year* and *Industry* denote the control variables for year and industry effects, respectively. The *t*-values are presented in parentheses below the coefficients. *, ** and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively.

the findings for the low firm-level uncertainty group, where the coefficient of *OTSC* is not statistically significant. Overall, our findings suggest that labor outsourcing is more beneficial in enhancing innovation for companies facing higher levels of macro- and firm-level uncertainty.

5.3. Degree of population aging

The effect of labor outsourcing on promoting innovation may be influenced by the degree of population aging in the region where the firm operates. First, regions with a younger population tend to have more dynamic labor markets, greater labor mobility and a wider range of skills. In such areas, firms can tap into a more diverse and skilled labor pool through outsourcing. Conversely, regions with older populations may

face more stagnant labor markets with a lack of fresh skills and knowledge, which can limit the effectiveness and innovativeness of labor outsourcing. Second, firms in regions with lower levels of population aging often have a higher proportion of younger workers in their core workforce. This can facilitate learning new skills and knowledge from contractors, and these firms may use labor outsourcing not only to cut costs but also to enhance their internal team's expertise. In short, regions with less aging populations provide a more favorable environment for innovation, making labor outsourcing more effective in promoting innovation.

Using the proportion of the population over 65 years old to the total population in each region to measure the degree of aging (*OLD*) in each region, we divide the sample into two groups according to the median of *OLD* and conduct the regression for each group. As shown in Columns (5) and (6) of Table 10, the coefficient

Table 10
Regression results of further discussion.

	Financial constraints (*SA*)		Economic policy uncertainty (*EPU*)		Degree of population aging (*OLD*)	
Dependent variable: *RDTA*	High	Low	High	Low	Low	High
	(1)	(2)	(3)	(4)	(5)	(6)
OTSC	1.811***	−0.382	1.581***	−0.057	1.298***	0.235
	(4.60)	(−1.34)	(3.83)	(−0.20)	(3.24)	(0.82)
INNOVATION	0.322***	0.354***	0.375***	0.394***	0.337***	0.345***
	(13.11)	(17.08)	(16.02)	(18.09)	(13.93)	(14.69)
SIZE	−0.227***	−0.208***	−0.190***	−0.188***	−0.209***	−0.190***
	(−4.04)	(−4.71)	(−3.73)	(−4.38)	(−3.41)	(−3.65)
LEV	0.084	−0.346**	−0.023	0.017	0.308	−0.253
	(0.43)	(−2.01)	(−0.15)	(0.10)	(1.62)	(−1.43)
ROE	−0.374	−0.577***	−0.303	−0.741***	−0.058	−0.648***
	(−1.31)	(−2.62)	(−1.38)	(−2.76)	(−0.24)	(−2.70)
CFO	0.581**	0.412**	0.674***	0.501**	0.911***	0.248
	(2.07)	(2.29)	(3.20)	(2.17)	(3.90)	(1.27)
PPETA	0.441*	0.128	0.140	0.594***	0.176	0.369
	(1.71)	(0.58)	(0.57)	(2.66)	(0.74)	(1.53)
TOBINQ	0.073***	0.051***	0.019	0.078***	0.048***	0.068***
	(4.01)	(3.10)	(1.02)	(4.59)	(2.71)	(3.43)
INS	−0.058	−0.188	−0.011	−0.105	−0.012	−0.122
	(−0.34)	(−1.12)	(−0.07)	(−0.68)	(−0.08)	(−0.65)
MOHLD	0.198	−0.318	−0.005	0.099	−0.208	0.127
	(0.95)	(−1.26)	(−0.02)	(0.57)	(−0.88)	(0.65)
TOP1	0.106	−0.571*	−0.255	−0.614**	−0.553*	0.311
	(0.34)	(−1.93)	(−0.89)	(−2.27)	(−1.72)	(0.86)
AF	0.031*	0.052***	0.030*	0.028*	0.015	0.028*
	(1.68)	(3.74)	(1.90)	(1.81)	(0.91)	(1.85)
MEDIA	−0.000	0.006	0.025	−0.026	−0.036*	0.035
	(−0.01)	(0.44)	(1.11)	(−1.47)	(−1.95)	(1.47)
Constant	6.773***	6.427***	5.659***	5.883***	6.471***	5.161***
	(5.28)	(6.61)	(5.13)	(6.45)	(4.84)	(4.65)
Year	Yes	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes	Yes	Yes
Observations	13,144	13,144	13,150	13,138	13,258	13,030
Adjusted R^2	0.610	0.808	0.657	0.767	0.685	0.705

Note: This table reports the results of the further discussion controlling for industry and year fixed effects. The definitions of the variables are shown in Table 2. Columns (1) and (2) present the regression results with the sample divided into two groups according to financial constraints. Columns (3) and (4) present the regression results with the sample divided into two groups according to economic policy uncertainty. Columns (5) and (6) present the regression results with the sample divided into two groups according to the degree of population aging. *Year* and *Industry* denote the control variables for year and industry effects, respectively. The *t*-values are presented in parentheses below the coefficients. *, ** and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively.

Table 11
Regression results of further discussion: Different types of innovation.

Dependent variable: *RDTA*	PAT_D_{t+1}	PAT_U_{t+1}	PAT_I_{t+1}
	(1)	(2)	(3)
OTSC	1.704***	1.268	0.438
	(2.58)	(1.35)	(0.71)
ROE	0.175***	0.145***	0.251***
	(4.83)	(3.19)	(8.41)
SIZE	−0.315***	−0.582***	0.069
	(−3.25)	(−5.49)	(1.00)
LEV	−0.514	−0.348	−1.116***
	(−1.22)	(−0.71)	(−3.51)
CFO	−0.196	1.146	1.335*
	(−0.23)	(1.11)	(1.94)
PPETA	0.603	0.240	−0.893
	(0.72)	(0.26)	(−1.43)
TOBINQ	−2.576***	−0.289	−0.364
	(−4.84)	(−0.46)	(−0.88)
INNOVATION	−0.126**	−0.253***	−0.191***
	(−2.19)	(−3.90)	(−4.72)
AF	0.329	−0.233	0.432
	(0.71)	(−0.45)	(1.35)
MEDIA	1.612***	1.608***	0.372
	(3.21)	(2.83)	(1.03)
INS	−0.048	0.013	−0.015
	(−0.08)	(0.02)	(−0.03)
MHOLD	0.080	0.136**	0.083**
	(1.41)	(2.14)	(1.99)
TOP1	0.056	0.078	0.047
	(0.79)	(1.01)	(0.95)
AGE	0.643	5.633***	−4.511***
	(0.35)	(2.84)	(−3.44)
Constant	1.742	6.377***	−4.711***
	(0.83)	(2.78)	(−3.11)
Year	Yes	Yes	Yes
Industry	Yes	Yes	Yes
Observations	21,209	21,209	21,209
Pseudo R^2	0.047	0.028	0.028

Note: This table reports the results of the further discussion using the tobit model. The definitions of the variables are shown in Table 2. Columns (1)–(3) present the regression results using PAT_D_{t+1}, PAT_U_{t+1} and PAT_I_{t+1} as the dependent variables, respectively. As the degree of innovation for these three types of patents increases successively, so does the level of innovation risk. *Year* and *Industry* denote the control variables for year and industry effects, respectively. The *t*-values are presented in parentheses below the coefficients. *, ** and *** indicate statistical significance at the 10 %, 5 % and 1 % levels, respectively.

of *OTSC* is positive and significant at the 1 % level for firms located in regions with a low degree of population aging. However, for the high aging group (Column (6)), the coefficient of *OTSC* is not significant. This result aligns with our expectations, indicating that the effect of labor outsourcing on promoting corporate innovation is more pronounced in companies operating in regions with a younger population.

5.4. Different types of innovation

The previous results suggest that labor outsourcing improves firms' financial and operational flexibility, which in turn promotes firm innovation. Additionally, a strand of literature rooted in resource-based theory

argues that one reason outsourcing promotes innovation is that firms can combine contractors' resources with their own, enhancing resource complementarity. This allows firms to bring in resources that complement their existing technology, knowledge and managerial experience (Strange and Humphrey, 2019). It is worth noting that the labor outsourcing discussed in this paper primarily involves low-end, repetitive tasks, and firms often outsource these activities mainly to reduce costs rather than to acquire specialized expertise. Therefore, the impact of labor outsourcing may differ across various types of innovation activities.

To address this question, we use the tobit model to examine the influence of labor outsourcing on the natural logarithm of the number of design patents (PAT_D_{t+1}), utility model patents (PAT_U_{t+1}) and invention patents (PAT_I_{t+1}) for the next year separately. The rationale behind this approach lies in the understanding that the degree of innovation increases sequentially from design patents to utility model patents and finally to invention patents, with a corresponding rise in innovation risk. Table 11 presents the results. The coefficient of $OTSC$ on PAT_D_{t+1} is significant and positive, whereas the coefficients of $OTSC$ on PAT_U_{t+1} and PAT_I_{t+1} are not significant. This implies that labor outsourcing promotes enterprises to engage more in low-originality innovation rather than high-originality innovation.

6. Conclusion

The literature indicates that firms primarily adopt outsourcing strategies to leverage contractors' comparative advantages and reduce costs. However, few studies have focused on the flexibility that results from outsourcing. This aspect is crucial, as a substantial body of research suggests that a firm's flexibility is a key factor influencing financial decision-making. Consequently, we explore the impact of labor outsourcing on innovation by examining insights related to organizational adjustments.

The findings demonstrate that labor outsourcing has a significant positive effect on firms' innovation levels. We use financial flexibility and operational flexibility to uncover the underlying mechanism driving this relationship. The results indicate that the impact of labor outsourcing on innovation is primarily achieved by increasing flexibility. In the further discussion, we divide the sample into two groups according to the firms' financial constraints, economic policy uncertainty and degree of population aging. Our results indicate that labor outsourcing can significantly promote innovation behaviors for firms facing high financial constraints and economic policy uncertainty, and for firms operating in areas with a low degree of population aging. These findings highlight the importance of considering flexibility when evaluating labor outsourcing decisions for optimal resource allocation and financial performance. Furthermore, the effect of labor outsourcing may vary across different types of innovation activities. Specifically, the results suggest that labor outsourcing encourages enterprises to engage more in low-originality innovation rather than high-originality innovation.

We acknowledge several limitations of our study. Specifically, the disclosed information is limited to the total amount of labor outsourcing. There is a lack of data regarding the specific businesses outsourced by firms and the characteristics of the contractors, which makes it difficult to classify firms based on their labor outsourcing characteristics and to conduct a more in-depth analysis of the impact of labor outsourcing on enterprise efficiency. In future research, scholars would benefit from obtaining detailed data on labor outsourcing to analyze how corporate performance is influenced by the types of outsourced businesses and the characteristics of the contractors.

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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How do managers use MD&A disclosures to respond to negative news?

Lingbing Liu, Huixin Geng*, Yutong Wang

School of Accounting, Dongbei University of Finance and Economics, China

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ABSTRACT

This study investigates whether and how managers respond to major negative news by increasing the information content of their MD&A disclosures. We predict that major negative news influences managers' disclosure decisions by increasing legitimacy pressures and reducing opportunities to obscure information. Based on textual similarity data of financial news, we adopt a new measure to identify explosive negative news and find that managers increase the information content of their MD&A disclosures after major negative news. The relationship between major negative news and MD&A information content is stronger for firms held by the Social Security Fund, in industries with more penalties and for firms with higher analyst coverage. After considering endogeneity, particularly omitted variable bias and self-selection bias, and using different measures of the variables, our conclusions remain robust.

1. Introduction

As the media plays an important role in capital markets, we explore how corporate managers respond to legitimacy pressures from major negative news. The integration of the Internet and big data has significantly reduced the cost of reprinting in digital media, leading to a substantial increase in the number of reprints and, consequently, an improvement in the speed and breadth of information dissemination. For example, in 2022, the news "Haitian Flavouring & Food Co. Ltd response to soy sauce additive controversy" reached the fourth position on the Real-Time Hot Search List (HSL) of Sina Weibo, China's largest microblogging website, lasting 543 min and leading to an 8.9 % drop in stock prices. Do managers use the information content of disclosures to respond to major negative news? What part of such disclosures do they use? We explore these questions in the present study.

* Corresponding author.
E-mail addresses: liulingbing@dufe.edu.cn (L. Liu), huixingeng@foxmail.com (H. Geng), Ellenytw@gmail.com (Y. Wang).

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Although some parts of negative news get "drowned" in the data deluge, other articles become major negative news stories through widespread republication, with lasting effects. Corporate governance research shows that original reports provide new information to the market (Miller, 2006). These findings are primarily motivated by the idea that repetition of known information should not affect returns in an efficient market. Therefore, simply rebroadcasting information already available through other sources cannot provide new insights to the market. However, the repeated presentation of negative news by various media outlets, even without any new information, and the sentiment conveyed in such coverage can influence investors, leading to large movements in stock prices (Huberman and Regev, 2001; Tetlock, 2011). Repeated exposure to news, regardless of its sentiment, can enhance the public's belief in its veracity (Dechêne et al., 2010). Some characteristics of major negative news, particularly those associated with investor confidence, predict a positive relationship between major negative news and the information content of Management Discussion and Analysis (MD&A) sections. For example, Chan (2003) finds that news headlines cause stock prices to drift over 12-month periods, with the impact on company performance diminishing to 0 by the fourth year. Additionally, pre-initial public offering (IPO) media coverage is negatively related to a stock's expected return up to 3 years after its IPO (Liu et al., 2014). Dealing with major negative news with long-term effects is an important challenge for managers.

Major negative news leads stakeholders to view firms with skepticism. Legitimacy is widely seen as arising from societal evaluation of objectives, reflecting the public's perception of the appropriateness and acceptability of corporate conduct. Legitimacy management examines how companies use signaling to attract investors and enhance their societal acceptability by demonstrating their capabilities. It is undoubtedly essential for all organizations to know how to transform inputs into outputs to meet their stakeholders' needs and desires (Zimmerman and Zeitz, 2002). However, negative news, especially major negative news, leads to a deterioration in a company's market reputation and raises doubts among investors about its production capacity. The literature argues that information disclosure is an effective tool to respond to legitimacy pressure caused by major negative news (Cho and Patten, 2007; Aerts and Cormier, 2009). We focus on MD&A disclosures, which is an important way for managers to communicate their views to investors.

Investors can extract useful information from MD&A sections, assess firms' short-term prospects (Bryan, 1997) and predict their ability to continue as a going concern (Mayew et al., 2015). As a crucial tool for managing a firm's external image, this section of the annual report receives considerable attention from investors (Clarkson et al., 1999). However, more information does not necessarily lead to a greater reduction in legitimacy pressure. Pope et al. (2023) identify a practice called "strategic fluffing," which implies that while managers inflate the "volume" of information disclosed, they do not increase the overall "weight" or seriousness of their disclosures. To assess the availability of useful information to investors, we use an indicator of information content, representing the proportion of firm-specific information that cannot be explained by other firms in the same industry or market. More informative content leads to reduced information asymmetry and agency problems (Biddle et al., 2009), which informs the public about a firm's performance and behavior, changes external stakeholders' perceptions, guides stakeholders' attention and adjusts investors' expectations. Therefore, in response to major negative news, managers may intentionally increase the information content of their MD&A disclosures. In contrast, media coverage is linked to capital market pressure. It intensifies managerial myopia across the market, leading managers to sacrifice long-term interests for short-term profits (Stein, 1988; Graham et al., 2005; Malmendier and Tate, 2009; Dai et al., 2021). Excessive pressure prevents managers from undertaking long-term projects, leading to suboptimal business decisions. Faced with major negative news, managers may stabilize stock prices by limiting the information content of their MD&A disclosures. Examining these opposing arguments can shed light on how managers respond to major negative news with significant reputational consequences.

Most studies measure media coverage using the number of articles about a company (Fang and Peress, 2009; Hillert et al., 2014; Kim et al., 2016; An et al., 2020; Gao et al., 2021). Although this method provides comprehensive measures of media coverage and legitimacy pressure, it does not distinguish between major negative news and general negative news, making it difficult to highlight its role in previous empirical studies. This may stem from the fact that it is difficult to distinguish major negative news from general negative news. Although negative news with substantial reprints can be recognized as major negative news, data on reprints are equally difficult to obtain. In this paper, we identify reprints by analyzing news textual similarity data. Our

empirical results show a significant increase in MD&A information content after companies experience major negative news. These findings remain robust to instrument variable (IV) tests, controlling for self-selection bias, using alternative variables and adding several additional control variables. Furthermore, the findings are more significant in firms held by the Social Security Fund (SSF), in industries with more penalties and in firms with higher analyst coverage than in their respective counterparts. We also find that the information content of forward-looking statements (FLSs) is more significant, indicating that managers primarily increase their inclusion of FLS information rather than non-FLS information in MD&A disclosures. Finally, after experiencing major negative news, higher information content helps to mitigate its effect on stock prices.

Overall, this paper supports the argument that managers respond to legitimacy pressures from major negative news by increasing the information content of their MD&A disclosures, rather than by obfuscating information, which contributes to the literature in the following ways. (1) Studies mainly explore the role of major negative news, aggregated from reprints, in corporate governance. However, with the development of digital media, attention to major negative news has not increased accordingly. As the first academic attempt to fill this gap, this paper verifies that major negative news, aside from original reporting, is an effective form of media participation in corporate governance. In the relationship between media exposure and corporate reputation, stakeholders express their expectations through the media. In extreme cases, managers have two choices: either try to meet all stakeholder expectations or ignore stakeholders and "fight the fires" as they develop in the media (Wartick, 1992). Through theoretical analysis and empirical testing, we find that managers prioritize stakeholder demands after major negative news. They provide firm-specific information as a direct means of managing legitimacy and protecting their company's image from negative impacts. (2) We also provide new evidence for a legitimacy management strategy as the market moves closer to an "efficient market." Research based on the incomplete revelation hypothesis (IRH) shows that when prices underreact to earnings changes, managers have the incentive to obfuscate information through low-quality disclosure (Li, 2008; Laksmana et al., 2012). However, major negative news significantly reduces information processing costs (Belnap, 2023). Therefore, managers shift from obfuscating information to disclosing it, actively increasing the information content of their MD&A disclosures. As a result, increased firm-specific information in MD&A sections produces content that is distinctive from standard information and informative for financial statement readers. (3) We introduce a new measure of major negative news. Most studies measure media coverage using the number of news articles written about companies (Fang and Peress, 2009; Hillert et al., 2014; An et al., 2020). However, this approach neglects the various types of news affecting investors' sentiment and truth judgment, treating the impact of different news as the same, which makes it difficult to distinguish between the effects of major negative news and general negative news. In contrast, we measure reprints based on the textual similarity of news articles, which allows us to differentiate between major negative news and general negative news.

2. Literature review

2.1. Media legitimacy and corporate information disclosure

Rooted in political economy, legitimacy theory has developed in the fields of corporate and organizational studies. Suchman's (1995) definition of organizational legitimacy has become widely accepted, stating that legitimacy is "a general perception or assumption that the actions of an entity are appropriate within some socially constructed system of norms, values, beliefs, and definitions." Media coverage disseminates organizational information and assesses its outcomes (Grund, 1996). The media increases investors' exposure to corporate information and shapes this information, either positively or negatively, to construct a public image of firms (Pollock and Rindova, 2003). Hence, by shaping public perceptions and judgments on critical issues (Pollock and Rindova, 2003; Nikolaeva and Bicho, 2011; Bednar et al., 2013), the impact of the media strongly suggests an agenda-setting function (McCombs and Shaw, 1972).

The emphasis on the role of the media as a gatekeeper of the capital market has led many researchers to examine and compare the effects of different types of information disclosures on legitimacy management. From a media legitimacy perspective, managers can proactively restore their legitimacy through information disclosure (Elsbach and Sutton, 1992), through three main strategies. (1) Directly explaining negative events.

Companies can reduce the unsystematic stock market risk associated with environmentally illegitimate actions by expressing their commitment to the natural environment (Bansal and Clelland, 2004). They can also reduce legitimacy pressures linked to corporate climate issues by providing voluntary climate change-related information (Dawkins and Fraas, 2011). (2) Using irrelevant factors to attract attention. Companies may actively and intensively engage in targeted poverty alleviation in the face of negative media coverage, even though such action may be unrelated to the content exposed (Yang et al., 2023). They can also adjust the direction of quarterly financial reporting decisions based on the extent of media coverage (Bowen et al., 2005). (3) Offsetting the negative impact of scandals by providing explanations with positive information (Rudkin et al., 2018). In summary, companies can manage their legitimacy through various methods. Pfarrer et al. (2010), using data from 291 firms over 15 years, find that firms with high reputation or celebrity status are more likely than others to receive larger market rewards for positive surprises and smaller market penalties for negative surprises. Given the advantages provided by strong legitimacy to firms, it is not surprising that firms invest considerable effort in managing their legitimacy under the influence of media coverage.

In this paper, we directly test whether managers are more proactive in disclosing firm-specific information in response to major negative news, based on news similarity data from China. Studies mainly focus on how media coverage of corporate environmental performance triggers environmental information disclosure (Bansal and Clelland, 2004; Cho and Patten, 2007; Aerts and Cormier, 2009; Pfarrer et al., 2010; Pope et al., 2023). In contrast, we do not limit the content of news in our sample, with the aim of exploring the differential impact of major negative news on the information content of MD&A disclosures.

2.2. MD&A information content

The MD&A section is an important part of a firm's annual report that includes firm-specific information (Clarkson et al., 1999; Muslu et al., 2015). It helps reduce information asymmetry and agency conflicts between a firm's managers and external stakeholders (Davis and Tama-Sweet, 2012), deepens investors' understanding of operational activities and provides information that helps investors predict future firm performance (Muslu et al., 2015). However, due to managerial opportunism, the manipulation of information, particularly of the readability and tone of MD&A sections, has become a widespread phenomenon. For example, Li (2008) analyzes the readability of annual reports and finds that reduced readability increases the cost of processing adverse information, causing such information to be either not reflected in stock prices or to be reflected with a delay. Lin et al. (2022) suggest that an overly optimistic tone in MD&A sections is the result of management manipulation rather than the provision of incremental information and is closely associated with future risks. Similarly, earnings manipulation leads to greater similarity in MD&A sections, resulting in less useful information (Wang et al., 2023). All of these empirical studies are in line with the expectations of the IRH, which predicts that managers mitigate the impact of negative news by obfuscating information because prices underreact to information with high processing costs (Bloomfield, 2002).

As an information intermediary in the capital market, the media collects information, thereby significantly reducing its processing costs. For example, Miller (2006) analyzes published press articles and finds that the media ensured early public dissemination of an accounting issue. The reporter's investigation sparked a strong market response, fully reflecting the role of the press as a "watchdog." Furthermore, 14 % of fraud cases are revealed by the media, which is significantly higher than the 6 % exposed by the Securities and Exchange Commission (SEC) (Dyck et al., 2010). In summary, the information role of the media in the capital market decreases the likelihood that managers will hide negative news (An et al., 2020). We focus on firms' information disclosure strategies after major negative news, which is an important addition to the literature.

3. Theoretical analysis and research hypotheses

To investigate the information disclosure strategies used by firms after major negative news, we focus on legitimacy theory and the managerial obfuscation hypothesis. Major negative news leads to a significant decrease in investor confidence, thereby increasing legitimacy pressures. Such news significantly reduces the information asymmetry between a firm's managers and external stakeholders, thereby reducing the opportunities for companies to obfuscate information. Stronger legitimacy pressures and fewer opportunities for

obfuscation prompt managers to enhance the information content of their MD&A disclosures. However, major negative news may also exert market pressure. First, such pressure leads managers to make myopic decisions. Second, it encourages managers to actively avoid the risks associated with disclosing information. Consequently, increased market pressure may also prompt managers to reduce the information content of their MD&A disclosures.

3.1. Legitimacy management

Major negative news leads organizations to be subject to greater scrutiny and questioning about whether they are beneficial to stakeholders, increasing pressure on their legitimacy. Managers must convey the message that their company's strategy and structure align with business norms, a prerequisite for favorable performance. Listed companies are more sensitive to legitimacy constraints than other companies, as violations lead to stock price fluctuations. If managers fail to preserve their firm's reputation, the loss will be associated with a significant drop in share price (Matejek and Gössling, 2014). This may lead managers to disclose firm-specific information to regain legitimacy and trust from stakeholders (Shivaani and Agarwal, 2020). Studies even suggest that legitimacy management is a form of information disclosure (Deegan et al., 2000). Lindblom (1994) proposes a set of less biased legitimation strategies: communicating organizational changes; attempting to change stakeholder perceptions; associating with symbols with strong legitimacy; and adjusting societal expectations regarding strategic disclosure (Hahn and Lülfs, 2014). Prior studies focus primarily on environmental information disclosure as a tool for corporate legitimacy management (Bansal and Clelland, 2004; Bansal and Kistruck, 2006; Cho and Patten, 2007; Aerts and Cormier, 2009; Chen et al., 2013; Matejek and Gössling, 2014; Shivaani and Agarwal, 2020). Recent research highlights that firms use executive compensation information, risk information and innovation information for the same purpose (Rao et al., 2008; Oliveira et al., 2011; Laksmana et al., 2012; Shivaani and Agarwal, 2020; Zhou et al., 2021). As one of the most important voluntary disclosures in annual reports, the predictive ability of MD&A disclosures provides incremental value to investors (Mayew et al., 2015), helping them make more effective decisions.

Major negative news has more lasting negative effects on corporate legitimacy than general negative news. Consequently, managers may increase the information content of their MD&A disclosures to maintain the legitimacy of their firm and defend against legitimacy attacks, preserve their firm's image and enhance market recognition. The specific mechanisms are as follows.

(1) MD&A disclosures with high information content inform the public about a firm's performance and changes in behavior. One of the objectives of the SEC's mandate for MD&A disclosure is to disclose information about future events and trends that may affect a firm's operations (Li, 2010a). In the context of ongoing regulation, forward-looking information provides useful incremental information to capital markets (Lang and Lundholm, 1996; Gelb and Zarowin, 2002; Lundholm and Myers, 2002). For example, Muslu et al. (2015) find that more forward-looking statements help to incorporate more information about a company's future earnings into its stock price, which mitigates the low information efficiency of stock prices and enhances the company's information environment.

(2) MD&A disclosures with high information content change the perceptions of external stakeholders. MD&A disclosures with high information content help alleviate information asymmetry between managers and external capital providers and reduce adverse selection issues, leading to more effective corporate investments (Biddle et al., 2009). Due to the spillover effect of MD&A disclosures, firm-specific information provided in MD&A sections also changes competitors' investment decisions by altering the overall industry perception of their future development (Cho and Muslu, 2021).

(3) MD&A disclosures with high information content serve to guide stakeholders' attention. Investors' perceptions can be manipulated by associating a company with symbols of high legitimacy (Lindblom, 1994). For example, Cho (2009) suggests that legitimacy management can be accomplished directly by diverting public attention. In an information-overloaded stock market, given their limited attention and high information processing costs, investors are unable to process all available information (Barber and Odean, 2008; Dellavigna and Pollet, 2009; Hirshleifer et al., 2009). Positive signals, such as low awareness costs and acquisition costs associated with high levels of information content (Blankespoor et al., 2020), can easily mislead investors into engaging in irrational behavior in their investment decisions (Daniel et al., 1998; Daniel and Hirshleifer, 2015;

Cho and Muslu, 2021). Abnormal positive tone, as a form of MD&A information content, induces investor optimism and herd behavior (Huang et al., 2014; Guldiken et al., 2017). Hence, increasing the information content of MD&A disclosures encourages investors to focus on company-specific information released by the company, thereby offsetting, to some extent, the adverse impact of major negative news on investor attention.

(4) MD&A disclosures with high information content adjust investors' expectations. Although most companies provide accurate descriptions of historical events, few provide useful and precise forecasts in their MD&A disclosures because such forecasts are used as internal data (Pava and Epstein, 1993; Liu et al., 2015, 2018). The increase in forward-looking information in MD&A disclosures enriches their informativeness and plays an important role in conveying competitive advantages and future development prospects. Such positive signals in FLSs positively influence investors' expectations (Li, 2010a). Additionally, investors typically have high expectations of companies engaged in digital transformation. By disclosing information about their digital endeavors, companies can effectively capture the attention of investors.

In summary, MD&A disclosures with high information content can achieve legitimacy management by informing, changing perceptions, guiding attention and raising expectations. After major negative news, managers may actively disclosure more informative information in their MD&A sections to build investor confidence and mitigate negative effects such as stock price volatility.

3.2. Management confusion

The IRH asserts that when extracting statistics from public data becomes too costly, the stock market may underreact to such data. Managers have an incentive to obfuscate information with complicated disclosures to delay the market's reaction, especially when their firm's performance is poor (Bloomfield, 2002; Li, 2008). Consistent with the management obfuscation hypothesis, previous research indicates that managers tend to disclose information more strategically when their firms are performing well (Schrand and Walther, 2000).

(1) Major negative news prevents managers from hiding information. Media coverage helps investors reduce information processing costs and information asymmetry by analyzing and rebroadcasting information from other intermediaries (Miller, 2006). The widespread dissemination of negative news significantly reduces acquisition costs for public investors, making it difficult for listed companies to conceal negative news (An et al., 2020). After major negative news, managers are unable to obfuscate their company's information or reduce required information disclosure. Instead, they disclose more firm-specific information to promote a positive corporate image.

(2) MD&A disclosures with high information content reduce the cost of processing good news. Boilerplate disclosure, redundant texts and information that remains unchanged over time make it difficult to distinguish between relevant and irrelevant information, leading to increased costs for users when processing annual reports (Blankespoor et al., 2020). MD&A disclosures with higher information content attract more attention from investors because they can identify useful information more effectively (Meng et al., 2017).

In summary, following major negative news, managers are motivated to increase the information content of their MD&A disclosures. By providing more high-quality information to the capital market, they decrease the cost of processing MD&A disclosures, thereby reducing adverse effects such as stock price volatility.

Based on the above discussion, we propose the following hypothesis:

H1a: Managers of firms facing major negative news increase the information content of their MD&A disclosures.

3.3. Capital market pressure

The publication of major negative news, by exposing the company's negative news to a wider audience, places excessive pressure on managers, leading to a decrease in the information content of their MD&A disclosures. Negative news leads to lower expected stock returns. In addition, low media coverage tends to generate higher returns than stocks with high media coverage (Fang and Peress, 2009). Specifically, the persistent negative impact of media coverage leads to a strong drift that can last up to 12 months (Chan, 2003). Investors in Chinese capital markets are less professional than those in other markets and are therefore more likely to

rely on media opinions (Kling and Gao, 2008; Zhu et al., 2017). Their investment activities also tend to exhibit gambling and speculative behavior (Yao et al., 2014; Hsieh et al., 2020; Liu and Zhao, 2023), which increases managers' sensitivity to market pressures due to stock price volatility triggered by major negative news. As Vega's (2006) empirical research reveals, public news generates excessive buying or selling pressure. Similar to the suboptimal decisions made by managers under high media pressure, such as reducing their innovation investments and engaging in negative news hoarding (Chen et al., 2018; Dai et al., 2021), managers proactively reduce their disclosure of firm-specific information to pursue short-term profits. A firm's dependence on its existing resources limits the extent of change that can be achieved in the short term. Substantial expansion of a firm's capabilities often requires the acquisition of new resources (Morrow et al., 2007). This may lead firm managers to decide to reduce their disclosure of firm-specific information under market pressure to avoid further stock price fluctuations caused by media attention. For example, Zhou et al. (2024) find that media coverage leads to stronger positive sentiment in disclosures, but reduces their readability. Furthermore, prior research indicates that clarifying negative news is often futile. The optimal strategy for managers is to disclose information cautiously and discreetly, strictly guarding against any potential "triggers" that might give the media an opportunity to exploit it. One such potential trigger is the information disclosed in MD&A sections, which provide a qualitative description of the firm from the perspective of its managers. Following this logic, we expect that when firms face major negative news, managers, under market pressure, will choose to reduce the disclosure of firm-specific information to avoid additional media coverage and the resulting stock price volatility.

In summary, following major negative news, managers are motivated to decrease the information content of their MD&A disclosures. Under market pressure, they disclose less firm-specific information to obscure negative news and mitigate potential risks.

Based on the above discussion, we propose the following hypothesis:

H1b: Managers of firms facing major negative news decrease the information content of their MD&A disclosures.

4. Research design

4.1. Sample selection and data source

In this paper, we use the textual similarity of news articles to identify reprints and classify negative news into two types: major negative news and general negative news. For this classification, we obtain basic online financial news data and similarity data for Chinese A-share listed firms from the Chinese Research Data Services (CNRDS) database. In 2007, the implementation of new Accounting Standards for Business Enterprises coincided with the development of MD&A disclosure requirements. Additionally, this year marked an important milestone in the convergence of Chinese accounting standards with international standards. We use data from 2007 to 2022 as the sample for this paper. Financial data of Chinese A-share listed companies are obtained from the China Stock Market and Accounting Research (CSMAR) database. In terms of MD&A data, we use Python scripts to retrieve firms' annual reports from the CNINF website and convert them into ".txt" files. After excluding observations with missing variables, special treatment (i.e., ST or *ST) companies and companies in the financial industry, our final sample consists of 29,296 observations.

4.2. Variable definitions

4.2.1. Major negative news

Reprints reflect not only the extent of news dissemination but also the persistence of news, which is an important manifestation of the influence of news coverage. Previous research uses the sum of reports identified by keyword searches throughout the year to measure media coverage, resulting in a mix of impacts from both major negative news and general negative news. Using this method means that news with various influences is equally important and can be directly aggregated. However, media reprints impact both the emotional response and the truth judgment of investors (Huberman and Regev, 2001; Dechêne et al., 2010; Tetlock, 2011). From a subjective perspective, investors on social media selectively expose themselves to confirmatory

information and follow users who share a bullish view on the same stock, leading to the "echo chamber effect"[1] that reinforces their own judgments (Cookson et al., 2023). To accurately measure the impact of major negative news, we measure reprints based on news textual similarity data.

The procedure for identifying firms facing major negative news is as follows. First, we obtain news content similarity data from the CNRDS database. Referring to the literature (Li, 2010a, 2010b), each news article is represented as an n-dimensional vector based on the vector space model. Over a 15-day calculation period, the textual similarity of two articles is measured by the angle between the two vectors representing the articles, with a smaller angle indicating greater similarity. Second, we select 98 % as a threshold to identify reprints. If the similarity between two news articles is at least 98 %, one of the articles is considered a reprint of the other and the total number of reprints is incremented by 1. Third, we rank all news articles from a given year based on the total number of reprints. We define news articles ranked in the top 5 % of negative news as major negative news, while other news articles are considered general negative news. Finally, we construct a dummy variable, *Boom*, which is equal to 1 if a firm experienced at least one major negative news during the year and 0 otherwise.

4.2.2. MD&A information content

Firm-specific information is essential to mitigate information asymmetry between a firm's managers and external stakeholders (Muslu et al., 2015; Cho and Muslu, 2021). However, MD&A disclosures are not required to be audited (Hüfner, 2007; Brown and Tucker, 2011) and contain substantial boilerplate disclaimers, invalid and unnecessary information and generic language (Li, 2010a), leading to empty content and template issues. We evaluate the information content of MD&A disclosures across industry and market dimensions based on the level of specific information disclosed. Referring to the literature (Hanley and Hoberg, 2010; Meng et al., 2017), we decompose the information in the MD&A sections into standard and informative components. Specifically, we define firm-specific information in MD&A sections as content that differentiates a firm from other listed companies in the same industry and market. Conversely, standard information refers to content in MD&A sections that is duplicated or similar to that of other listed companies in the same industry and market.

The procedure for measuring the information content of MD&A disclosures is as follows. First, MD&A sections are extracted from annual reports using regular expressions. After adding accounting-specific terminology, using a stop word list and removing punctuation and stop words, these MD&A paragraphs are segmented into individual words using the Python package *Jieba*. Second, we represent each MD&A text as a vector and normalize these vectors by dividing them by the total number of words in the MD&A sections to ensure comparability. Third, we calculate the industry standardized vector, $Norm_{I,t}$, as the average of the standardized vectors of all companies in the same industry. Similarly, the market standardized vector, $Norm_{M,t}$, is calculated as the average of the standardized vectors of all companies outside the focal company's industry. The industry and market normalized vectors for a given company are calculated using Model (1) and Model (2), where I represent the number of companies in the industry and Q represents the number of companies in the market. Then, we use Model (3) to decompose the firm-specific normalized vector.

$$Norm_{I,t} = \frac{1}{P-1} \sum_{j=1, j \neq i}^{P} Norm_{j,t} \tag{1}$$

$$Norm_{M,t} = \frac{1}{Q-P} \sum_{j=1, j \neq i}^{Q-P} Norm_{j,t} \tag{2}$$

$$Norm_{i,t} = \alpha_0 + \alpha_1 \times Norm_{I,t} + \alpha_2 \times Norm_{M,t} + \mu_{i,t} \tag{3}$$

[1] The echo chamber effect is a phenomenon whereby investors deliberately choose to consume information that aligns with their prior views (Cookson et al., 2023).

In Model (3), a higher value of α_1 indicates that more parts of the MD&A text can be explained by other companies in the same industry. Similarly, a higher value of α_2 indicates that more parts of the MD&A text can be explained by companies outside the focal company's industry in the same market. The residual $\mu_{i,t}$ indicates the portion of the text that cannot be explained by other companies in the industry or market. Finally, we define $\alpha_1 + \alpha_2$ as standard information in MD&A sections ($Stdmda_{i,t}$, $Stdmda_{i,t} = a_1 + a_2$). To avoid complete collinearity between standard information and information content, the sum of the absolute values of the residual vector dimensions is defined as the information content of MD&A disclosures ($Infmda_{i,t}$, $Infmda_{i,t} = \sum |\mu_{i,t}|$).

4.3. Empirical model

To test H1, we establish the following research model:

$$Infmda_{i,t} = \beta_0 + \beta_1 \times Boom_{i,t} + \beta \times Control_{i,t} + \sum Year + \sum Province + \sum Ind + \sum Province \times Year + \varepsilon_{i,t} \quad (4)$$

where the dependent variable is the information content of MD&A disclosures, which we estimate using Models (1) to (3). *Boom* is the core explanatory variable in this paper, which takes a value of 1 throughout the year if a firm has experienced at least one major negative news and 0 otherwise. Referring to the literature (Dyck et al., 2008; Zhang and Su, 2015; An et al., 2022; Liu and Zhao, 2023), we include the following control variables in Eq. (4) that may affect corporate disclosure: company size (*Size*), standard information in MD&A (*Stdmda*), return on total assets (*ROA*), book-to-market ratio (*BM*), debt ratio (*Lev*), operating income growth rate (*Growth*), state-owned enterprises (*SOE*), proportion of independent directors (*Indep*), percentage of shareholding of the largest shareholder (*Top1*), CEO duality (*Dual*), management shareholding ratio (*Mshare*), board size (*Board*) and discretionary accruals (*DA*). Detailed descriptions of the variables can be found in Table 1. Considering the uneven development of the media industry in different regions of China (Zhang and Su, 2015), we control for province, year and industry fixed effects. Furthermore, we control for province-year interaction fixed effects to eliminate omitted variable bias. All regressions are clustered at the firm level to calculate standard errors.

5. Empirical results and analysis

5.1. Descriptive statistics

Table 2 presents the descriptive statistics of the main variables in this paper. We winsorize all continuous variables at the top and bottom 1 % to prevent the influence of outliers. We first extract and define major negative news from companies' financial news, resulting in 5,650 firm-year observations with major negative news, accounting for 19.286 % of the full sample, and 23,646 firm-year observations without such news. The mean value of reprints of major negative news (12.407) is 8.79 times higher than the average number for all news (1.411). There is variance in *Infmda*, which ensures the variability of the full sample and provides a basis for subsequent analyses. The results of the remaining variables are consistent with the real situation of the firms.

5.2. Multivariate regression results of major negative news and MD&A information content

Table 3 presents the multiple regression results of Eq. (4). We control for *Size* in column (1) for two main reasons. First, large firms are more likely than small firms to become the focus of media coverage, which increases their likelihood of facing major negative news; additionally, firm size is an important explanatory factor in corporate information disclosure. Second, *Size* is unlikely to be influenced by major negative news in the same year, as it is calculated based on the natural logarithm of total assets. *Size* is not only a pretreatment variable but also affects both the likelihood that a firm will face major negative news and the information content of its MD&A disclosures. In summary, *Size* is a good control variable for exploring the causal rela-

Table 1
Main variable definitions.

	Variable	Definition
Dependent variables	*Infmda*	The absolute value of the residual ($\mu_{i,t}$) from Model (3).
Explanatory variables	*Boom*	If a company faces major negative news during the year, *Boom* takes a value of 1 and otherwise 0.
Control variables	*Size*	The natural logarithm of total assets.
	Stdmda	The sum of a_1 and a_2 from Model (3).
	ROA	Profits divided by total assets.
	BM	The ratio of shareholders' equity to the market value of the company.
	Lev	The ratio of total liabilities to total assets.
	Growth	The growth rate of operating income.
	SOE	A state-owned enterprise takes a value of 1 and otherwise 0.
	Indep	The proportion of independent directors on the board.
	Top1	The ratio of the number of shares held by the largest shareholder to the total number of shares outstanding.
	Dual	Takes a value of 1 if the CEO and chair of the board are the same person and otherwise 0.
	Mshare	The ratio of the number of shared held by management to the total number of shares outstanding.
	Board	The natural logarithm of the number of board members.
	DA	Discretionary accruals are measured using the modified Jones model.

Table 2
Descriptive statistics.

Variable	Observations	Mean	Standard deviation	Min	Median	Max
Infmda	29,296	1.465	0.153	1.120	1.462	1.911
Boom	29,296	0.193	0.395	0	0	1
Size	29,296	22.319	1.262	20.013	22.137	26.237
Stdmda	29,296	0.996	0.224	0.567	0.972	1.755
ROA	29,296	0.038	0.064	–0.218	0.036	0.224
BM	29,296	0.624	0.252	0.123	0.618	1.188
Lev	29,296	0.445	0.199	0.065	0.442	0.886
Growth	29,296	0.162	0.388	–0.552	0.103	2.354
SOE	29,296	0.400	0.490	0	0	1
Indep	29,296	0.375	0.053	0.333	0.357	0.571
Top1	29,296	0.337	0.148	0.084	0.313	0.740
Dual	29,296	0.256	0.436	0	0	1
Mshare	29,296	0.109	0.176	0	0.002	0.656
Board	29,296	2.132	0.200	1.609	2.197	2.708
DA	29,296	0.005	0.094	–0.315	0.007	0.292

tionship between major negative news and the information content of MD&A disclosures. Failure to control for this variable could lead to serious omitted variable bias. The coefficient of *Boom* in column (1) is 0.006 and is positive and significant at the 5 % level, indicating that firms facing major negative news tend to increase the information content of their MD&A disclosures. We also control for year, province, industry and province-year fixed effects in column (2). The regression coefficient of *Boom* is positive and significant at the 1 % level. Finally, we add the other control variables in column (3), and the coefficients are still significant. In summary, the regression results in Table 2 confirm our research hypothesis that firms facing major negative news show a significant increase in the information content of their MD&A disclosures. The regression coefficient of *Boom* in column (3) is 0.008, indicating an average increase of 0.008 in MD&A information content for firms facing major negative news, thus verifying H1.

Diverging from the argument that managers strategically reduce the readability of their annual reports to make firms reporting negative news more difficult to read (Li, 2008), we find that major negative news prompts a substantial change in disclosure strategy. Firms facing major negative news disclose more firm-specific information, which is of great theoretical importance. Additionally, considering the high proprietary cost of disclosing firm-specific information (Ellis et al., 2012; Li et al., 2018), our regression results show the trade-off between the benefits of maintaining legitimacy and the advantage gained by competitors by obtaining propri-

Table 3
Main results.

Variable	(1) *Infmda*	(2) *Infmda*	(3) *Infmda*
Boom	0.006**	0.009***	0.008***
	(2.445)	(3.184)	(2.837)
Size	–0.024***	–0.023***	–0.027***
	(–32.461)	(–13.270)	(–12.306)
Stdmda			0.054***
			(6.721)
ROA			0.058**
			(2.154)
BM			–0.031***
			(–3.552)
Lev			0.026**
			(2.340)
Growth			–0.012***
			(–4.960)
SOE			0.021***
			(4.419)
Indep			0.041
			(1.231)
Top1			–0.008
			(–0.629)
Dual			–0.002
			(–0.643)
Mshare			–0.101***
			(–9.195)
Board			–0.013
			(–1.195)
DA			–0.053***
			(–4.763)
Constant	2.008***	1.973***	2.029***
	(120.756)	(51.615)	(41.575)
Control	NO	NO	YES
Year FE	NO	YES	YES
Province FE	NO	YES	YES
Ind FE	NO	YES	YES
*Province*Year FE*	NO	YES	YES
Observations	29,296	29,296	29,296
Adjusted R-squared	0.039	0.183	0.211

Notes: *, ** and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively; the t-statistics, reported in parentheses, are computed based on standard errors adjusted for firm-level clustering.

etary information. The significant positive regression coefficient indicates that the benefits of maintaining legitimacy outweigh the costs of aiding competitors, which implies that managers ultimately choose to sacrifice some of their firm's proprietary information to gain legitimacy with market investors. In summary, our results highlight the important role of major negative news in encouraging the disclosure of firm-specific information.

5.3. Robustness tests

To ensure the reliability of our conclusions, we perform the following robustness tests and present the results in Tables 4 to 8.

5.3.1. IV approach

Many factors influence the occurrence of major negative news, such as a company facing financing constraints or the presence of a successor CEO (Miller, 2006; Core et al., 2008). To estimate the effect of major

negative news on MD&A information content, we use the two-stage least squares model for panel data to address endogeneity concerns.

One of the methods we adopt to address omitted variable bias is the difference in preferences in traditional Chinese culture regarding the numbers 8 and 4. Referring to the literature (An et al., 2022), we construct the variable *LuckyNum* using the frequency of use of the number 8 minus the frequency of use of the number 4 in the sample's stock symbols, for two main reasons: (1) Chinese culture has a strong preference for the number 8, considering it a symbol of good luck, while avoiding the number 4, which is considered inauspicious (Brown and Mitchell, 2008). To cater to public preferences, the media might pay more attention to listed companies whose ticker symbols contain the number 8 (Soroka, 2006; An et al., 2022). (2) *LuckyNum*, as a random characteristic of listed companies, meets the IV exogeneity condition. Although *LuckyNum* is not correlated with MD&A information content, it does attract greater investor attention. Analysts, as another important intermediary in the stock market, also pay more attention to companies with lucky numbers based on investors' preferences. This implies that our IV affects the information content of MD&A disclosures in ways other than simply major negative news. To better satisfy the IV exclusion restriction, we include investor attention and analyst coverage as control variables. Following Da et al. (2011), we measure investor attention using the Search Volume Index (*SVI*) and analyst coverage using the number of analysts following a firm (*AnaAttention*).

Another method we adopt is to use the exogenous shock of media reporting during the COVID-19 pandemic from 2020 to 2022. We construct the variable *LowCoverage*, which takes a value of 1 for observations from 2020 to 2022 and 0 otherwise, for two main reasons. (1) During the COVID-19 pandemic, Chinese media actively reported positive responses to the outbreak (Fox, 2021; Wirz et al., 2022). Consequently, financial news coverage decreased significantly, lowering the probability of companies facing major negative news. (2) The COVID-19 pandemic (2020–2022) serves as an exogenous shock, fulfilling the IV exogeneity condition. However, the COVID-19 pandemic affected MD&A content not only through major negative news but also through three additional channels. First, COVID-19 had an indirect impact on MD&A disclosure among companies in specific industries such as healthcare. Second, concentrated provincial outbreaks of COVID-19 had an indirect impact on MD&A content. Third, management may have made targeted MD&A disclosures due to trade restrictions on imports and exports during the COVID-19 pandemic. In addition to controlling for year, industry, province and province-year fixed effects, we include overseas trade (*OverseasTrade*) as a control variable to better satisfy the IV exclusion restriction. We measure the intensity of trade restrictions on overseas imports and exports by counting a firm's overseas subsidiaries. A higher number of overseas subsidiaries suggests that a greater portion of operations were affected by the COVID-19 pandemic, increasing firms' targeted disclosures in their MD&A sections. Specifically, if a company establishes subsidiaries abroad and the names or business scope of these subsidiaries include words related to trade, imports, exports, sales or operations, then the company is considered to have overseas subsidiaries related to trade, excluding subsidiaries registered in "tax havens."

In summary, we construct two instruments, *LuckyNum* and *LowCoverage*, for our explanatory variable *Boom*. We also account for other pathways through which these IVs can influence the information content of MD&A disclosures. However, as *LuckyNum* is based on cross-sectional data and remains constant across firms, it cannot generate variations across firms and over time. Therefore, following Angrist and Krueger (1991) and An et al. (2022), we construct the IV *LuckyNum*LowCoverage* by interacting *LuckyNum* with *LowCoverage*. Additionally, we use the mean of firms facing major negative news within the industry and year (*BoomMean*) as an IV to address endogeneity concerns, for two main reasons. (1) The density of major negative news in the industry is significantly correlated with the probability of a company facing major negative news. (2) Individual firms have little influence on the density of major negative news within the entire industry, which satisfies the IV exogeneity restriction.

The results are reported in Table 4. From the first-stage regression results in column (1), using *LuckyNum*LowCoverage* and *BoomMean* as IVs, we find that the signs of the estimated coefficients are consistent with our hypothesis. During the COVID-19 pandemic, companies whose stock symbols contained a higher proportion of the number 8 were more likely to face major negative news. From the second-stage regression results in column (2), we note that the findings in Table 3 still hold. That is, managers actively increase the information content of their MD&A disclosures after major negative news by 0.008, according

Table 4
IV method.

	First (1) *Boom*	Second (2) *Infmda*
*LuckyNum*LowCoverage*	0.020***	
	(3.869)	
BoomMean	0.937***	
	(28.820)	
Boom		0.029**
		(2.536)
SVI	0.003***	0.001
	(2.736)	(1.291)
AnaAttention	–0.014**	–0.029***
	(–2.286)	(–8.067)
OverseasTrade	0.000	0.000
	(0.029)	(1.027)
Size	0.114***	–0.021***
	(22.542)	(–7.252)
Stdmda	–0.028**	0.055***
	(–2.547)	(6.853)
ROA	–0.091*	0.115***
	(–1.733)	(4.391)
BM	–0.224***	–0.048***
	(–12.776)	(–4.908)
Lev	–0.025	0.021*
	(–1.296)	(1.874)
Growth	–0.013**	–0.011***
	(–2.128)	(–4.688)
SOE	–0.023***	0.019***
	(–2.799)	(3.937)
Indep	0.264***	0.032
	(4.056)	(0.960)
Top1	–0.018	–0.007
	(–0.791)	(–0.573)
Dual	–0.001	–0.001
	(–0.094)	(–0.349)
Mshare	0.001	–0.087***
	(0.041)	(–7.869)
Board	0.025	–0.011
	(1.307)	(–1.000)
DA	–0.045	–0.052***
	(–1.571)	(–4.664)
Constant	–2.499***	
	(–23.464)	
First-Stage F-statistic	423.766	
Hansen's J-statistic (overidentification test)	[p = 0.147]	
Control	YES	YES
Year FE	YES	YES
Province FE	YES	YES
Ind FE	YES	YES
*Province*Year FE*	YES	YES
Observations	29,296	29,296
R-squared	0.228	0.068

Notes: *, ** and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively; the t-statistics, reported in parentheses, are computed based on standard errors adjusted for firm-level clustering. The table presents the Kleibergen–Paap rk Wald F statistic test for weak instruments (First-Stage F-statistic).

to the results in column (3) of Table 3, and by 0.029 according to the results in column (2) of Table 4. Regarding the validity of our instruments, the F-statistic for the weak instrument variable test is 423.766, which significantly exceeds the critical value of 19.93 at the 10 % level, as indicated by Stock and Yogo (2005). As the number of instruments exceeds the number of endogenous regressors, we report the results of Hansen's J-statistic, an overidentification test, and our instruments pass Hansen's overidentification test.

5.3.2. Self-selection bias

In this paper, the underlying assumption of our regression is that companies randomly experience major negative news, which requires an equal probability that companies experience major negative news. However, companies with potential accounting fraud and abnormal executive compensation are more likely than others to experience major negative news (Miller, 2006; Core et al., 2008). To control for this self-selection bias, we perform a treatment effects model analysis using the two-stage regression method proposed by Heckman (1979). In the first stage, we use a probit regression to identify the experience of major negative news. In the second stage, we estimate Eq. (4) by including the inverse Mills ratio (IMR) as an additional control, estimated from the first-stage probit regression. Consistent with the IV regression, we also control for investor attention (*SVI*), analyst attention (*AnaAttention*) and overseas trade (*OverseasTrade*) to ensure that our IVs (*LuckyNum*LowCoverage* and *BoomMean*) only indirectly influence MD&A information content through IMR. However, there are two problems with the two-step method. First, using the two-step method to compute IMR may further amplify errors during the second-stage estimation. Second, adjusting clustering using the two-step method is difficult. Therefore, for robustness, we use the maximum likelihood estimation method to estimate the treatment effects model to ensure the reliability of our conclusions.

To select control firms with similar characteristics to the treatment firms, we use the propensity score matching (PSM) method to mitigate self-selection bias caused by observed variables. For each year from 2007 to 2022, we run a probit regression where the dependent variable is whether a firm experienced major negative news during the year (*Boom*) and include *LuckyNum*LowCoverage* and the control variables in Eq. (4) as explanatory variables. The propensity score is calculated using the estimated coefficients and the realization of the corresponding independent variables. Each firm that experienced major negative news is matched with a firm that did not experience major negative news, using the closest propensity score within a caliper range of 0.01. We ultimately obtain a matched sample of 8,056 firm-year observations. The results, presented in columns (2), (4) and (5), indicate that even after controlling for self-selection bias, our results remain positive and significant at the 1 % confidence level.

5.3.3. Changing the threshold for identifying major negative news

According to the above results, our conclusions remain robust when we use a 98 % similarity threshold to identify news reprinting and a 5 % threshold to identify major negative news. However, it must be acknowledged that the choice of this threshold is subjective. We adopt a 95 % threshold to identify similar news and use the top 1 % of reprints to identify major negative news, to ensure the reliability of our main results. We estimate Eq. (4) and use *Boom_95_5*, *Boom_95_1* and *Boom_98_1* as alternative independent variables. *Boom_95_5* (*Boom_95_1*) uses the 95 % similarity threshold to identify reprints and the 5 % (1 %) threshold to identify major negative news. *Boom_98_1* uses the 98 % similarity threshold to identify reprints and the 1 % threshold to identify major negative news. The results are reported in columns (1) to (3) of Table 6, where we continue to find a positive association between major negative news and MD&A information content.

5.3.4. Identifying major negative news by industry

Although we control for industry fixed effects, there is a significant difference in media coverage across industries. For example, companies in highly polluting industries receive more media coverage than those in other industries (Deegan and Gordon, 1996). Therefore, we sort reprints by industry and year to identify major negative news. Consistent with the above measure, we adopt 95 % and 98 % thresholds to identify similar news and 1 % and 5 % thresholds to identify major negative news. We re-estimate Eq. (4) using *Boom_95_5_Ind*, *Boom_95_1_Ind*, *Boom_98_5_Ind* and *Boom_98_1_Ind* as alternative independent variables. *Boom_95_5_Ind* (*Boom_95_1_Ind*) uses the 95 % similarity threshold to identify reprints and the 5 % (1 %) threshold to identify major bad news. *Boom_98_5_Ind* (*Boom_98_1_Ind*) uses the 98 % similarity threshold

Table 5
Relationship between major negative news and MD&A information content after controlling for self-selection bias.

Variable	Heckman's two-step method		Heckman's maximum likelihood method		PSM
	(1) First *Boom*	(2) Second *Infmda*	(3) First *Boom*	(4) Second *Infmda*	(5) *Infmda*
*LuckyNum*LowCoverage*	0.113***		0.105***		
	(5.304)		(3.875)		
BoomMean	3.481***		3.429***		
	(25.315)		(24.302)		
Boom		0.044***		0.055***	0.009**
		(5.096)		(3.918)	(2.540)
SVI	0.032***	0.001*	0.030***	0.001	
	(4.837)	(1.920)	(3.312)	(1.217)	
AnaAttention	–0.028	–0.028***	–0.024	–0.028***	
	(–1.112)	(–14.061)	(–0.807)	(–8.024)	
OverseasTrade	–0.000	0.000***	–0.000	0.000	
	(–0.098)	(2.649)	(–0.169)	(1.048)	
Size	0.451***	–0.023***	0.450***	–0.024***	–0.026***
	(29.560)	(–14.065)	(22.417)	(–8.045)	(–8.645)
Stdmda	–0.105**	0.055***	–0.106*	0.055***	0.049***
	(–2.307)	(15.267)	(–1.848)	(6.987)	(4.323)
ROA	–0.388*	0.117***	–0.338	0.118***	0.137***
	(–1.835)	(6.771)	(–1.375)	(4.520)	(3.378)
BM	–0.878***	–0.045***	–0.873***	–0.042***	–0.033***
	(–14.362)	(–8.189)	(–11.460)	(–4.305)	(–2.614)
Lev	–0.075	0.021***	–0.070	0.021*	0.045***
	(–1.105)	(3.823)	(–0.783)	(1.937)	(2.994)
Growth	–0.045	–0.011***	–0.047*	–0.011***	–0.020***
	(–1.642)	(–4.999)	(–1.652)	(–4.574)	(–4.366)
SOE	–0.100***	0.019***	–0.101***	0.019***	0.019***
	(–3.887)	(8.821)	(–2.884)	(4.092)	(2.962)
Indep	0.907***	0.028	0.915***	0.025	0.065
	(4.287)	(1.566)	(3.413)	(0.750)	(1.512)
Top1	–0.121*	–0.007	–0.127	–0.007	–0.007
	(–1.722)	(–1.237)	(–1.337)	(–0.545)	(–0.425)
Dual	–0.003	–0.001	–0.003	–0.001	–0.006
	(–0.133)	(–0.650)	(–0.101)	(–0.363)	(–1.117)
Mshare	–0.078	–0.087***	–0.096	–0.087***	–0.118***
	(–1.065)	(–15.476)	(–1.033)	(–7.939)	(–7.604)
Board	0.041	–0.011**	0.045	–0.011	–0.008
	(0.671)	(–2.138)	(0.561)	(–1.079)	(–0.577)
DA	–0.121	–0.051***	–0.136	–0.051***	–0.065***
	(–1.023)	(–5.230)	(–1.044)	(–4.569)	(–3.286)
Constant	–11.536***	1.896***	–11.519***	1.923***	1.981***
	(–29.598)	(51.236)	(–23.866)	(29.444)	(30.616)
Control	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
Province FE	YES	YES	YES	YES	YES
Ind FE	YES	YES	YES	YES	YES
*Province*Year FE*	YES	YES	YES	YES	YES
Observations	29,296	29,296	29,296	29,296	8,056

Notes: *, ** and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively; the t-statistics, reported in parentheses, are computed based on standard errors adjusted for firm-level clustering. Due to the difficulty of conducting enterprise-level clustering in the two-step method, the results in columns (1) and (2) lack cluster adjustment.

to identify reprints and the 5 % (1 %) threshold to identify major negative news. The results are reported in columns (4) to (7) of Table 6, where we continue to find a positive association between major negative news and MD&A information content.

5.3.5. Using Weibo hot searches as major negative news

Reprint-based metrics are used as proxies for major negative news in our above analysis, but even if we change the threshold for major negative news, subjective bias remains an issue. In this section, we consider whether negative news about listed companies appears on Weibo's HSL as a criterion for identifying major negative news, thereby eliminating potential subjective bias. Weibo is recognized as one of the most influential social media platforms in China, and Weibo's HSL reflects the dynamics of public attention (Cui and Kertész, 2021). The ratio of Weibo reposts related to events on Sina Weibo is much higher than that of trending topics on Twitter, which indicates that our metric based on Weibo's HSL effectively reflects public interest (Guan et al., 2014).

The procedure for determining whether negative news about listed companies appears on Weibo's HSL is as follows. First, we use a web crawling program to build separate data repositories for news related to listed companies that appears on Weibo's HSL.[2] As the searchable data start from December 2019, our data cover the period from 2020 to 2022. Second, we manually identify each hot topic that includes the name of a listed company and only keep those related to negative news. We estimate Eq. (4) using *Boom_Weibo* as an alternative independent variable. *Boom_Weibo* indicates whether a listed company has negative topics appearing on Weibo's HSL during the year. The results are reported in column (8) of Table 6, where we continue to find a positive association between major negative news and MD&A information content.

5.3.6. Alternative measures of MD&A information content

We also use textual similarity data from the WinGo database as an alternative measure of MD&A information content, with higher values indicating greater similarity to the MD&A sections of other firms in the same industry. We estimate Eq. (4) using *SimilarityWingo_Mean*, *SimilarityWingo_Median*, *SimilarityLDA_Mean* and *SimilarityLDA_Median* as alternative dependent variables. *SimilarityWingo_Mean* (*SimilarityWingo_Median*) and *SimilarityLDA_Mean* (*SimilarityLDA_Median*) are defined as the industry average (median) similarity for MD&A sections calculated using the WinGo and LDA methods, respectively. The regression results are shown in Table 6. The coefficients of these alternative dependent variables are positive and significant at the 1 % level.

5.3.7. Adding control variables for corporate media connection

Prior research shows that the effect of media governance is influenced by the links between firms and the media. Listed companies with media connections have approximately 18 % more news coverage than those without such connections, and about 10 % more of this coverage consists of positive reports (Yulei et al., 2016). They also tend to engage in more extensive earnings management under the cover provided by their connected media (Yan et al., 2023). Given the crucial role of the media in guiding investor decisions by creating an interpretive context, media-connected firms are more likely than others to collude with the media to influence the dissemination of major negative news. We therefore add media-connected variables as control variables, namely whether firms have a media-connected subsidiary (*SubCompanyMedia*), a manager with media-related work experience (*ResumeMedia*) and a manager with a media-connected major (*MajorMedia*). The regression results are shown in column (1) of Table 8. The coefficient of *Boom* is still positive and significant at the 1 % level.

5.3.8. Adding control variables for readability

In this paper, the definition of MD&A information content refers to firm-specific information that cannot be explained by other companies in the same industry or market. However, complex or specialized words in MD&A sections do not increase their information content, but rather demonstrate managers' intention to obscure the information by reducing its readability. Therefore, we add a control variable for readability to rule out the alternative explanation that managers intentionally obscure information by lowering its readability. Additionally, we use the proportion of professional words (*ProfessionRatio*) as an indicator of readability. The regression results are shown in columns (2) and (3) of Table 8. The coefficients of *Boom* are still positive and significant at the 1 % level.

[2] Weibo HSL news is collected from the Hot Search Engine, https://Weibo.zhaoyizhe.com.

Table 6
Alternative measure of the explanatory variable.

Variable	Different thresholds							Weibo
	(1) *Infmda*	(2) *Infmda*	(3) *Infmda*	(4) *Infmda*	(5) *Infmda*	(6) *Infmda*	(7) *Infmda*	(8) *Infmda*
Boom_95_5	0.007**							
	(2.368)							
Boom_95_1		0.008*						
		(1.731)						
Boom_98_1			0.015***					
			(3.067)					
Boom_95_5_Ind				0.008***				
				(2.855)				
Boom_95_1_Ind					0.011**			
					(2.558)			
Boom_98_5_Ind						0.007***		
						(2.680)		
Boom_98_1_Ind							0.014***	
							(3.357)	
Boom_Weibo								0.028**
								(2.073)
Size	–0.026***	–0.026***	–0.026***	–0.027***	–0.026***	–0.027***	–0.026***	–0.023***
	(–12.166)	(–11.974)	(–12.088)	(–12.288)	(–12.050)	(–12.268)	(–12.147)	(–9.418)
Stdmda	0.054***	0.054***	0.054***	0.054***	0.054***	0.054***	0.054***	0.037***
	(6.722)	(6.712)	(6.728)	(6.728)	(6.726)	(6.716)	(6.726)	(3.640)
ROA	0.058**	0.058**	0.058**	0.058**	0.057**	0.058**	0.058**	0.010
	(2.158)	(2.149)	(2.171)	(2.162)	(2.139)	(2.153)	(2.168)	(0.285)
BM	–0.031***	–0.032***	–0.032***	–0.031***	–0.032***	–0.031***	–0.032***	–0.015
	(–3.574)	(–3.676)	(–3.613)	(–3.517)	(–3.625)	(–3.538)	(–3.591)	(–1.446)
Lev	0.026**	0.026**	0.026**	0.026**	0.026**	0.026**	0.026**	–0.014
	(2.336)	(2.350)	(2.361)	(2.338)	(2.354)	(2.348)	(2.352)	(–0.987)
Growth	–0.012***	–0.012***	–0.012***	–0.012***	–0.012***	–0.012***	–0.012***	–0.007
	(–4.967)	(–4.986)	(–4.973)	(–4.976)	(–4.966)	(–4.977)	(–4.967)	(–1.622)
SOE	0.021***	0.021***	0.021***	0.021***	0.021***	0.021***	0.021***	0.019***
	(4.400)	(4.385)	(4.405)	(4.414)	(4.396)	(4.409)	(4.415)	(3.264)
Indep	0.041	0.042	0.042	0.041	0.041	0.041	0.041	0.036
	(1.235)	(1.267)	(1.253)	(1.234)	(1.243)	(1.237)	(1.235)	(0.816)
Top1	–0.008	–0.008	–0.008	–0.008	–0.008	–0.008	–0.008	–0.001
	(–0.638)	(–0.647)	(–0.649)	(–0.626)	(–0.644)	(–0.619)	(–0.643)	(–0.033)
Dual	–0.002	–0.002	–0.002	–0.002	–0.002	–0.002	–0.002	–0.003
	(–0.643)	(–0.649)	(–0.651)	(–0.663)	(–0.645)	(–0.651)	(–0.660)	(–0.606)
Mshare	–0.101***	–0.102***	–0.101***	–0.101***	–0.101***	–0.101***	–0.101***	–0.068***
	(–9.199)	(–9.213)	(–9.208)	(–9.207)	(–9.207)	(–9.205)	(–9.206)	(–5.088)
Board	–0.013	–0.013	–0.013	–0.013	–0.013	–0.013	–0.013	–0.011
	(–1.193)	(–1.185)	(–1.193)	(–1.187)	(–1.188)	(–1.185)	(–1.202)	(–0.742)
DA	–0.054***	–0.054***	–0.054***	–0.053***	–0.053***	–0.053***	–0.054***	–0.037*
	(–4.786)	(–4.792)	(–4.802)	(–4.784)	(–4.767)	(–4.775)	(–4.796)	(–1.654)
Constant	2.026***	2.018***	2.023***	2.030***	2.022***	2.029***	2.025***	1.980***
	(41.372)	(41.186)	(41.378)	(41.553)	(41.342)	(41.505)	(41.486)	(33.482)
Control	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES
Province FE	YES	YES	YES	YES	YES	YES	YES	YES
Ind FE	YES	YES	YES	YES	YES	YES	YES	YES
*Province*Year FE*	YES	YES	YES	YES	YES	YES	YES	YES
Observations	29,296	29,296	29,296	29,296	29,296	29,296	29,296	9,516
Adjusted R-squared	0.211	0.210	0.211	0.211	0.210	0.211	0.211	0.256

Notes: *, ** and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively; the t-statistics, reported in parentheses, are computed based on standard errors adjusted for firm-level clustering. The reduced sample size in column (8) is due to limited data availability for *Boom_Weibo* from 2020 to 2022.

Table 7
Using MD&A similarity as an alternative measure of MD&A information content.

Variable	*SimilarityWingo*		*SimilarityLDA*	
	(1) *SimilarityWingo Mean*	(2) *SimilarityWingo Median*	(3) *SimilarityLDA Mean*	(4) *SimilarityLDA Median*
Boom	–0.008***	–0.009***	–0.005***	–0.007***
	(–3.018)	(–3.240)	(–2.685)	(–3.237)
Size	–0.009***	–0.009***	–0.009***	–0.009***
	(–4.676)	(–4.543)	(–6.011)	(–5.499)
Stdmda	0.007	0.004	–0.003	–0.001
	(1.416)	(0.747)	(–0.767)	(–0.145)
ROA	0.085***	0.089***	0.049***	0.038*
	(4.033)	(3.911)	(2.846)	(1.914)
BM	0.027***	0.027***	0.028***	0.030***
	(3.953)	(3.696)	(5.072)	(4.571)
Lev	0.019**	0.021**	0.018**	0.022***
	(2.202)	(2.224)	(2.551)	(2.721)
Growth	–0.002	–0.002	0.001	0.003*
	(–1.132)	(–0.991)	(0.814)	(1.670)
SOE	–0.008**	–0.009**	–0.004	–0.006*
	(–2.169)	(–2.128)	(–1.274)	(–1.701)
Indep	–0.045*	–0.046	–0.060***	–0.067***
	(–1.725)	(–1.630)	(–2.718)	(–2.636)
Top1	0.007	0.006	–0.001	–0.005
	(0.708)	(0.563)	(–0.175)	(–0.469)
Dual	0.000	0.000	0.001	0.001
	(0.164)	(0.156)	(0.459)	(0.541)
Mshare	0.035***	0.038***	0.037***	0.046***
	(4.311)	(4.390)	(5.797)	(6.152)
Board	0.001	0.001	–0.006	–0.010
	(0.116)	(0.063)	(–0.872)	(–1.150)
DA	–0.005	–0.003	0.005	0.014
	(–0.455)	(–0.309)	(0.574)	(1.436)
Constant	0.719***	0.749***	0.622***	0.635***
	(17.280)	(16.685)	(17.742)	(15.656)
Control	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Province FE	YES	YES	YES	YES
Ind FE	YES	YES	YES	YES
*Province*Year FE*	YES	YES	YES	YES
Observations	29,296	29,296	29,296	29,296
Adjusted R-squared	0.158	0.151	0.364	0.372

Notes: *, ** and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively; the t-statistics, reported in parentheses, are computed based on standard errors adjusted for firm-level clustering.

6. Additional tests

The above results indicate that managers, in response to legitimacy pressure caused by major negative news, will increase the information content of their MD&A disclosures. To further support the theoretical logic of our paper, we provide additional empirical evidence from three perspectives. First, we investigate how major negative news influences the information content of MD&A sections across firms. These additional cross-sectional tests aim to deepen our understanding of managers' disclosure behavior. Second, we differentiate the content of MD&A sections to provide further evidence on how managers increase the information content of their MD&A disclosures. Third, following Meng et al. (2017), we empirically test the effectiveness of higher MD&A information content in the sample of firms affected by major negative news, indicating the feasibility of using MD&A information content for legitimacy management.

Table 8
Adding additional control variables.

Variable	(1) *Infmda*	(2) *Infmda*	(3) *Infmda*
Boom	0.008***	0.009***	0.008***
	(2.786)	(3.152)	(3.110)
SubCompanyMedia	–0.026		
	(–1.033)		
ResumeMedia	–0.003		
	(–0.584)		
MajorMedia	0.079		
	(0.822)		
ReadabilityAnnualReport		0.010***	
		(14.712)	
ProfessionRatio			1.560***
			(30.634)
Size	–0.027***	–0.021***	–0.016***
	(–12.344)	(–9.538)	(–7.807)
Stdmda	0.053***	0.047***	0.042***
	(6.716)	(6.022)	(5.677)
ROA	0.058**	0.038	0.064***
	(2.174)	(1.455)	(2.640)
BM	–0.031***	–0.037***	–0.041***
	(–3.525)	(–4.371)	(–5.169)
Lev	0.026**	0.025**	0.027***
	(2.310)	(2.290)	(2.690)
Growth	–0.012***	–0.008***	–0.009***
	(–4.957)	(–3.477)	(–3.971)
SOE	0.021***	0.017***	0.015***
	(4.421)	(3.784)	(3.488)
Indep	0.042	0.037	0.027
	(1.266)	(1.129)	(0.912)
Top1	–0.008	–0.015	–0.007
	(–0.617)	(–1.174)	(–0.620)
Dual	–0.002	–0.002	–0.001
	(–0.627)	(–0.484)	(–0.161)
Mshare	–0.102***	–0.099***	–0.065***
	(–9.240)	(–9.378)	(–6.695)
Board	–0.012	–0.013	0.004
	(–1.166)	(–1.200)	(0.402)
DA	–0.054***	–0.049***	–0.049***
	(–4.801)	(–4.515)	(–4.750)
Constant	2.027***	2.102***	0.987***
	(41.659)	(43.282)	(17.541)
Control	YES	YES	YES
Year FE	YES	YES	YES
Province FE	YES	YES	YES
Ind FE	YES	YES	YES
*Province*Year FE*	YES	YES	YES
Observations	29,296	29,296	29,296
Adjusted R-squared	0.211	0.239	0.322

Notes: *, ** and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively; the t-statistics, reported in parentheses, are computed based on standard errors adjusted for firm-level clustering.

6.1. Cross-sectional tests

A simple logical extension of our theoretical analysis is that firms subject to higher legitimacy pressure are more affected by major negative news than their counterparts. Specifically, we examine the underlying mechanism through three factors: SSF holdings, industry regulatory penalties and analyst attention.

6.1.1. Impact of the SSF

Since the SSF entered the Chinese stock market in 2003, its investment choices have followed the three principles of safety, profitability and liquidity. However, the high volatility of the Chinese stock market does not align with the SSF's requirement for security, forcing it to prioritize investment risk when selecting stock investments. Major negative news leads to a significant decrease in investor confidence and an increase in investment risk. To promote a positive image, the managers of firms whose shares are held by the SSF are likely to actively increase the information content of their MD&A disclosures. We therefore investigate the effect of SSF shareholding on managers' actions. We split the sample based on whether a company is owned by the SSF. We then estimate Eq. (4) using the two subsamples separately. Our results are reported in columns (1) and (2) of Table 9. The coefficient of *Boom* in column (1) (firms owned by the SSF) is greater than that in column (2) (firms not owned by the SSF). Additionally, the coefficient of the interaction term *Boom*SSF* is positive and significant at the 1 % level in column (3). Thus, these results suggest that managers of companies owned by the SSF actively increase the information content of their MD&A disclosures when faced with major negative news.

6.1.2. Impact of industry penalties

Due to limited investor attention, penalties, which are major events in an industry, attract investor attention. Due to similar operating environments and significant overlap in business operations of companies in the same industry, penalties against individual companies are often perceived by investors as industry risks rather than firm-specific risks (Donelson et al., 2022). According to signaling theory, one party may undertake actions to signal its underlying quality to the other party (Connelly et al., 2011) to reduce the information asymmetry between the two parties (Spence, 2002). For example, CEOs convey the intrinsic quality of their companies to potential investors through the perceptible quality of their financial statements (Zhang and Wiersema, 2009). In summary, managers generally convey signals that can be picked up by investors and that are difficult for underperforming companies to imitate to distinguish themselves from other companies in the industry. The information content of MD&A disclosures is not only a form of voluntary disclosure but is also difficult to imitate, which helps to reduce legitimacy pressure. We therefore investigate the effect of industry penalties on managers' actions. We split the sample based on the total number of penalties in a company's industry. We then estimate Eq. (4) in the two subsamples separately. Our results are reported in columns (4) and (5) of Table 9. The coefficient of *Boom* in column (4) (high penalty) is higher than that in column (5) (low penalty). Additionally, the coefficient of the interaction term *Boom*PenaltyIndDum* is positive and significant at the 10 % level in column (6). Thus, these results suggest that managers of companies in an industry with more penalties actively increase the information content of their MD&A disclosures when faced with major negative news.

6.1.3. Impact of analyst coverage

The media fulfills its "watchdog" role not only by conducting original investigations and analyses but also by rebroadcasting information from other information intermediaries (Miller, 2006). In this section, we focus on the synergy effect between media coverage and analyst coverage. Specifically, Guest and Kim (2023) provide evidence of the important role of analysts in media information sources. They find that a loss of analyst coverage leads to higher expenses in providing financial media coverage, indicating a symbiotic relationship between analysts and the media. In terms of analyst coverage, meeting or beating analyst forecasts can result in favorable market outcomes, while failing to meet targets often leads to adverse stock returns and puts executive compensation and job security at risk (Bartov et al., 2002; Kothari et al., 2016). Therefore, firms with higher analyst coverage experience greater scrutiny and face increased pressure from both analysts and investors (Roychowdhury, 2006; Gentry and Shen, 2013), as major negative news causes greater legitimacy pressure, forcing firm managers to proactively manage their legitimacy by increasing the information content of their MD&A disclosures. We therefore investigate the effect of analyst attention on managers' actions. We split the sample based on whether the number of analysts following a company is above the industry average. We then estimate Eq. (4) in the two subsamples separately. The coefficient of *Boom* in column (7) (high analyst coverage) is higher than that in column (8) (low analyst coverage). Additionally, the coefficient of the interaction term *Boom*AnalystCoverageDum* is positive and significant at the 1 % level in column (9). Thus, these results suggest that managers of companies with higher analyst coverage actively increase the information content of their MD&A disclosures when faced with major negative news.

Table 9
Impact of the SSF, industry penalties and analyst coverage.

Variable	*SSF*			*PenaltyNumberIndDum*			*AnalystCoverageDum*		
	SSF	non-SSF		High	Low		High	Low	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Infmda	*Infmda*	*Infmda*	*Infmda*	*Infmda*	*Infmda*	*Infmda*	*Infmda*	*Infmda*
Boom	0.015**	0.005	0.005	0.012***	0.003	0.004	0.011***	–0.000	–0.002
	(2.520)	(1.626)	(1.507)	(3.258)	(0.838)	(1.040)	(2.876)	(–0.025)	(–0.516)
SSF			–0.011***						
			(–3.540)						
*Boom*SSF*			0.015***						
			(2.616)						
PenaltyIndDum						–0.006***			
						(–3.212)			
*Boom*PenaltyIndDum*						0.008*			
						(1.773)			
AnalystCoverageDum									–0.023***
									(–7.072)
*Boom*AnalystCoverageDum*									0.017***
									(3.425)
Size	–0.017***	–0.028***	–0.026***	–0.024***	–0.029***	–0.027***	–0.017***	–0.030***	–0.022***
	(–4.488)	(–11.996)	(–11.811)	(–9.833)	(–11.446)	(–12.290)	(–5.914)	(–8.990)	(–9.334)
Stdmda	0.052***	0.054***	0.054***	0.043***	0.067***	0.054***	0.072***	0.039***	0.054***
	(3.475)	(6.560)	(6.720)	(4.445)	(7.074)	(6.729)	(6.549)	(4.106)	(6.792)
ROA	0.236***	0.039	0.063**	0.040	0.081**	0.056**	0.322***	–0.056*	0.090***
	(3.754)	(1.425)	(2.372)	(1.291)	(2.257)	(2.084)	(8.109)	(–1.883)	(3.408)
BM	–0.035**	–0.030***	–0.033***	–0.038***	–0.020*	–0.031***	–0.017	–0.033**	–0.043***
	(–2.236)	(–3.206)	(–3.804)	(–3.751)	(–1.828)	(–3.563)	(–1.483)	(–2.572)	(–4.789)
Lev	0.029	0.024**	0.025**	0.023*	0.031**	0.026**	0.032**	0.019	0.023**
	(1.361)	(2.108)	(2.280)	(1.790)	(2.372)	(2.331)	(1.977)	(1.443)	(2.091)
Growth	–0.022***	–0.011***	–0.012***	–0.010***	–0.013***	–0.012***	–0.020***	–0.005*	–0.012***
	(–3.374)	(–4.165)	(–5.018)	(–3.238)	(–3.775)	(–4.952)	(–5.356)	(–1.674)	(–5.028)
SOE	0.017*	0.023***	0.021***	0.024***	0.017***	0.021***	0.028***	0.013**	0.019***
	(1.949)	(4.721)	(4.466)	(4.423)	(3.114)	(4.418)	(4.095)	(2.345)	(4.051)
Indep	0.043	0.039	0.039	0.045	0.052	0.041	0.005	0.058	0.040
	(0.716)	(1.117)	(1.161)	(1.146)	(1.328)	(1.235)	(0.124)	(1.372)	(1.189)
Top1	–0.009	–0.007	–0.008	–0.006	–0.007	–0.008	0.010	–0.023	–0.010
	(–0.403)	(–0.489)	(–0.597)	(–0.381)	(–0.502)	(–0.620)	(0.562)	(–1.415)	(–0.745)
Dual	–0.004	–0.002	–0.002	–0.001	–0.003	–0.002	–0.001	–0.002	–0.002
	(–0.630)	(–0.457)	(–0.605)	(–0.302)	(–0.618)	(–0.625)	(–0.256)	(–0.456)	(–0.501)
Mshare	–0.056***	–0.109***	–0.101***	–0.088***	–0.113***	–0.101***	–0.058***	–0.122***	–0.094***
	(–2.761)	(–9.557)	(–9.143)	(–6.826)	(–8.917)	(–9.201)	(–3.950)	(–8.851)	(–8.543)
Board	0.009	–0.015	–0.013	–0.019	–0.002	–0.013	–0.003	–0.016	–0.012
	(0.471)	(–1.372)	(–1.215)	(–1.535)	(–0.147)	(–1.191)	(–0.189)	(–1.263)	(–1.133)

(*continued on next page*)

Table 9 (*continued*)

Variable	*SSF*			*PenaltyNumberIndDum*			*AnalystCoverageDum*		
	SSF	non-SSF		High	Low		High	Low	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Infmda	*Infmda*	*Infmda*	*Infmda*	*Infmda*	*Infmda*	*Infmda*	*Infmda*	*Infmda*
DA	–0.066***	–0.049***	–0.054***	–0.061***	–0.049***	–0.053***	–0.089***	–0.009	–0.053***
	(–2.596)	(–4.050)	(–4.852)	(–4.259)	(–3.132)	(–4.735)	(–5.520)	(–0.606)	(–4.780)
Constant	1.735***	2.069***	2.017***	1.997***	2.042***	2.031***	1.746***	2.144***	1.937***
	(19.656)	(40.411)	(41.025)	(35.854)	(36.011)	(41.640)	(24.946)	(30.572)	(37.647)
Control	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Province FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Ind FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
*Province*Year FE*	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	5,424	23,816	29,296	15,948	13,339	29,296	14,006	15,271	29,296
Adjusted R-squared	0.208	0.212	0.211	0.214	0.211	0.211	0.198	0.219	0.214

Notes: *, ** and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively; the t-statistics, reported in parentheses, are computed based on standard errors adjusted for firm-level clustering.

6.2. Characteristics of MD&A information content

In this section, we analyze the characteristics of MD&A information content, particularly FLS information content, and provide evidence on how managers increase the information content of their MD&A disclosures. Investors demand more forward-looking information (Muslu et al., 2015; Liu et al., 2022) because it improves their ability to anticipate future earnings (Hussainey et al., 2003; Hussainey and Walker, 2009). However, even within FLSs, there are significant differences in the effects of different types. In their study of UK annual reports, Hussainey et al. (2003) find that earnings-related FLSs, but not broader FLSs, can better help investors accurately predict future changes in earnings. Using regular expressions, we decompose the sentences in the MD&A sections into future outlook sections and historical review sections, classifying all future outlook sections as FLSs, while all historical review sections are classified as non-FLSs. We use the same method as that used for MD&A information content to measure the information content of FLSs (*InfmdaFLS*) and non-FLSs (*InfmdaNonFLS*). We then estimate Eq. (4) using *InfmdaFLS* and *InfmdaNonFLS* as alternative dependent variables. The results are presented in Table 10, showing that managers actively increase the information

Table 10
Difference between FLS information content and non-FLS information content.

Variable	(1) *InfmdaFLS*	(2) *InfmdaNonFLS*
Boom	0.016***	0.004
	(3.973)	(0.930)
Size	–0.018***	–0.026***
	(–6.463)	(–7.221)
Stdmda	0.098***	0.095***
	(10.845)	(7.103)
ROA	–0.024	0.054
	(–0.676)	(1.015)
BM	–0.020*	–0.015
	(–1.735)	(–0.833)
Lev	–0.003	0.041*
	(–0.191)	(1.894)
Growth	–0.002	–0.012**
	(–0.684)	(–2.216)
SOE	0.011*	0.012*
	(1.887)	(1.659)
Indep	0.096**	–0.036
	(2.170)	(–0.586)
Top1	–0.054***	–0.032*
	(–3.242)	(–1.652)
Dual	0.006	0.004
	(1.285)	(0.612)
Mshare	–0.033**	–0.083***
	(–2.406)	(–5.253)
Board	0.001	–0.020
	(0.102)	(–1.259)
DA	–0.045***	–0.029
	(–2.851)	(–1.183)
Constant	1.874***	2.148***
	(30.119)	(24.999)
Control	YES	YES
Year FE	YES	YES
Province FE	YES	YES
Ind FE	YES	YES
*Province*Year FE*	YES	YES
Observations	25,118	29,296
Adjusted R-squared	0.079	0.024

Notes: *, ** and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively; the t-statistics, reported in parentheses, are computed based on standard errors adjusted for firm-level clustering. The reduced sample size in column (1) is due to the absence of the outlook section in some MD&A sections.

content of their FLSs after experiencing major negative news, while there is no significant change in the information content of non-FLSs. Our results are consistent with the idea that firms provide FLSs with higher information content to maintain investor confidence (El-Gazzar, 1998).

6.3. Effectiveness of the information content of MD&A disclosures

For listed companies, legitimacy is a prerequisite for achieving favorable performance. Reduced legitimacy increases stock price volatility, thereby intensifying firms' willingness to maintain their legitimacy (Matejek and Gössling, 2014). Major negative news, owing to its widespread and lasting effects, has a significant and long-term influence on corporate legitimacy, which in turn increases the risk of stock price volatility in the following year. Based on legitimacy theory, we suggest that companies are likely to increase the information content of their MD&A disclosures to maintain their legitimacy, thereby mitigating future stock price volatility caused by reduced legitimacy. Although the literature indicates that higher MD&A information content reduces stock price crash risk in the following year (Meng et al., 2017), major negative news has a significantly greater impact on corporate legitimacy than general negative news. Therefore, even if managers increase the information content of their MD&A disclosures, it may still be difficult for them to reduce threats to their legitimacy. Restricting our sample to firms that experienced major negative news during the year, we run regressions using next year's stock price crash risk as the dependent variable and MD&A information content as the independent variable to examine whether higher MD&A information content can reduce next year's stock price crash risk for these firms. If the coefficient of MD&A information content is still significant and negative, it will indicate that managers' disclosure behavior is effective, supporting the above theoretical analysis and hypotheses. We establish the following research model:

$$VAR\_ADJ_{i,t+1} = \beta_0 + \beta_1 \times Infmda_{i,t} + \beta \times Control_{i,t} + \sum Year + \sum Province + \sum Ind + \sum Province \times Year + \varepsilon_{i,t} \quad (5)$$

$$NCSKEW_{i,t+1} = \beta_0 + \beta_1 \times Infmda_{i,t} + \beta \times Control_{i,t} + \sum Year + \sum Province + \sum Ind + \sum Province \times Year + \varepsilon_{i,t} \quad (6)$$

$$DUVOL_{i,t+1} = \beta_0 + \beta_1 \times Infmda_{i,t} + \beta \times Control_{i,t} + \sum Year + \sum Province + \sum Ind + \sum Province \times Year + \varepsilon_{i,t} \quad (7)$$

where the subscripts i and t represent the firm and the year, respectively. VAR_ADJ denotes stock price volatility, which is measured using the variance of stock returns over the year. Referring to the literature (Kim et al., 2011a, 2011b), $DUVOL$ denotes down-to-up volatility and $NCSKEW$ is negative conditional return skewness. We include the following control variables in Model (6) that may affect stock price volatility: stock return after market adjustments (*Ret*), *Size*, *Lev*, *BM*, ratio of net cash flow from operating activities to total assets (*Cashflow*), variance of *Cashflow* over the past 5 years (*VCashflow*), *Ret* squared (*RetSQ*) and an indicator of whether a company cross-lists B-shares or H-shares (*ABH*). In Models (7) and (8), the following variables are included as control variables for stock price crash risk: *Ret*, *Size*, *Lev*, *BM*, *Stdmda*, abnormal turnover (*Dturn*), stock return volatility (*Sigma*), *ROA* and *DA*. The coefficient of *Infmda* in Table 11 is statistically negative at the 5 % level, which indicates that MD&A disclosures with higher information content reduce stock price crash risk in the following year, even if firms have experienced major negative news.

7. Conclusion

Information content, as an important characteristic of textual disclosure, refers to the proportion and difficulty of useful information that investors can obtain from MD&A disclosures. It also reflects managers' proactive approach to disclosing firm-specific information. Hence, the information content of MD&A disclosures has important implications for improving the information disclosure system of listed companies in China. Our results show that the information content of MD&A disclosures by listed firms increases significantly when they experience major negative news during the year. This improvement is more pronounced for firms with SSF shareholders, for firms in industries facing more penalties and for firms benefiting from greater

Table 11
Impact of MD&A disclosures on the stock prices of firms experiencing major negative news.

Variable	(1) *VAR_ADJ* $t+1$	(2) *DUVOL* $t+1$	(3) *NCSKEW* $t+1$
Infmda	–0.002**	–0.112**	–0.184**
	(–2.345)	(–2.124)	(–2.390)
Ret	0.007***	0.030*	0.035
	(23.182)	(1.857)	(1.515)
Size	–0.002***	0.005	0.023*
	(–19.182)	(0.674)	(1.878)
Lev	0.006***	0.025	0.025
	(8.855)	(0.473)	(0.321)
BM	–0.002***	–0.220***	–0.405***
	(–3.426)	(–4.795)	(–5.704)
Cashflow	–0.009***		
	(–5.799)		
VCashflow	0.006*		
	(1.717)		
RetSQ	0.001***		
	(6.613)		
ABH	0.000		
	(1.136)		
Stdmda		–0.003	0.015
		(–0.094)	(0.281)
Dturn		0.004	–0.006
		(0.322)	(–0.380)
Sigma		–2.739	–4.866
		(–1.145)	(–1.363)
ROA		0.103	0.249
		(0.708)	(1.103)
DA		0.037	0.024
		(0.430)	(0.195)
Constant	0.067***	–0.062	–0.373
	(25.660)	(–0.320)	(–1.282)
Control	YES	YES	YES
Year FE	YES	YES	YES
Province FE	YES	YES	YES
Ind FE	YES	YES	YES
*Province*Year FE*	YES	YES	YES
Observations	4,482	4,482	4,482
Adjusted R-squared	0.790	0.070	0.067

Notes: *, ** and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively; the t-statistics, reported in parentheses, are computed based on standard errors adjusted for firm-level clustering.

analyst coverage. Moreover, we find that managers increase the information content of their MD&A disclosures by increasing the information content of their FLSs.

Our results enrich research on the factors that affect voluntary disclosure and distinguish the roles of major negative news and general negative news in corporate governance. This paper also has important practical implications. First, our results show that major negative news significantly improves the quality of MD&A sections, emphasizing the role of reprints as an important approach for the media. Most studies pay attention to original news, which is considered to provide new information to markets, while reproduced articles from other intermediaries fail to do so (Miller, 2006). However, we show that in the Internet age, with reprints being virtually free, they can also have an impact on corporate governance. Our findings provide a reference for media outlets in terms of their information role, encouraging them to actively reprint negative news to expand

their influence. Second, our findings on MD&A information content suggest a shift in managers' disclosure behavior from "obscuring information" to "disclosing information" due to major negative news. Managers have an incentive to obscure information that they do not want investors to discover (Bloomfield, 2002). However, when major negative news is publicly released, managers must increase disclosure of firm-specific information to maintain legitimacy. Hence, more emphasis should be placed on the role of the media in corporate governance, as it can dissuade managers from withholding negative news, which is consistent with the finding of An et al. (2020), even if it only reprints information from other intermediaries.

Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Differentiated governance of executive compensation in Chinese state-owned enterprises

Yuanyuan Liu, Guojian Zheng, Guilong Cai

School of Business, Sun Yat-sen University, 135 Xingangxi Road, Haizhu District, Guangzhou, China

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ABSTRACT

In the context of differentiated governance and the deepening market-oriented reform of compensation in China, we divide state-owned enterprises (SOEs) into four categories according to their equity structure, namely absolute holding firms, relative holding firms, major impact firms and equity participation firms, to examine the current situation and effectiveness of differentiated governance for executive compensation. We report four main findings. First, executive compensation levels, compensation gaps and equity incentives increase as government control decreases, indicating the emergence of differentiated governance of executive compensation in SOEs. Second, the driving force behind differentiated compensation is the government's willingness to intervene in SOEs. The government's ability to intervene in SOEs is not diminished by reduced equity control, and the government may even compensate for such a reduction by appointing excess executives. Third, differentiated governance of compensation is more prominent in local and competitive SOEs, while equity incentives lag significantly behind salary levels and salary gap incentives. Fourth, differentiated governance of compensation levels and gaps are effective in reducing agency problems and enhancing innovation in SOEs; however, the impact of equity incentives is limited. These findings enrich the literature on the differentiated governance of SOEs and facilitate a more comprehensive understanding of executive incentive and compensation contracts in Chinese SOEs.

E-mail address: caiglong@mail2.sysu.edu.cn (G. Cai)

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1. Introduction

State-owned enterprises (SOEs) play a unique role in the Chinese economy and have always been strictly controlled by the government. Undoubtably, such government control has greatly contributed to China's economic growth. However, it has also caused SOEs to fall into governance dilemmas concerning government intervention and the absence of owners, making it difficult for them to adapt to fierce market competition. The Chinese government has consistently encouraged SOEs to participate in mixed-ownership reforms to enhance their core competitiveness through property rights transfer. SOEs have made remarkable achievements in the ownership reforms. Fig. 1 shows the distribution of the largest shareholder ratio in SOEs. On average, the stake held by the largest shareholder declined from 47 % in 2003 to 38 % in 2021. Fig. 2 divides SOEs into four categories according to the largest shareholder ratio. The proportion of listed SOEs whose largest shareholder owns more than 50 % of the shares decreased from 46.85 % in 2003 to 23.25 % in 2021. Conversely, whereas in 2003 only 4.8 % of the largest shareholders of SOEs held less than 20 % of the shares, this surged to 10 % in 2021. The middle ground, namely the percentage of listed SOEs in which the largest shareholder owns 20–30 % and 30–50 % of the shares, has remained relatively stable.

While the mixed-ownership reform of SOEs has made significant progress in optimizing equity structures, governance mechanisms still need further improvement. The challenge stems from applying the same governance model to mixed-ownership enterprises as is used for wholly state-owned companies, which hinders the realization of the institutional advantages of mixed-ownership enterprises.[1] In 2020, the Chinese government issued the *Opinions on Accelerating the Improvement of the Socialist Market Economy System in the New Era*, which explicitly emphasizes the necessity for mixed-ownership enterprises to develop a governance model different from that of wholly state-owned companies. Accordingly, in 2021, the State-Owned Assets Supervision and Administration Commission of Shandong Province released the *Guiding Opinions on Differentiated Control of Provincial State-Owned Relatively Controlled Mixed-Ownership Enterprises*, which aims to establish a regulatory framework that emphasizes capital management, while clearly defining the boundaries of rights and responsibilities between provincial enterprises and relatively controlled enterprises. It is thus evident that establishing a differentiated governance system according to the equity structure of SOEs is one of the major challenges in mixed-ownership reform.

Effective compensation incentive contracts are crucial for mitigating conflicts between executives and shareholders (Jensen and Meckling, 1976; Jensen and Murphy, 1990). However, due to the inherent drawbacks of government intervention and the state-owned asset management system, government shareholders tend to adopt the traditional administrative salary system, which may reduce the compensation incentives for executives, causing them to seek alternative compensation mechanisms such as political promotion, on-the-job consumption and rent-seeking (Chen et al., 2005; Xu et al., 2014; Cao et al., 2019). Consequently, the development of a market-oriented salary distribution system has consistently remained central to SOE reform. Accordingly, the central government has repeatedly emphasized the importance of deepening the market-oriented reform of salaries for SOEs, not least in *Guiding Opinions on Deepening the Reform of State-Owned Enterprises*, issued in 2015, and *Notice on Carrying out the Special Action for the Three System Reform of Central Enterprises*, issued in 2019. Theoretically, executive compensation in SOEs changes as government shareholding decreases. On the one hand, government ownership, which constitutes the cornerstone of state governance, reflects the government's capacity and willingness to intervene in SOEs. As government ownership decreases, its willingness and ability to intervene in SOEs diminish simultaneously, resulting in less non-operational noise in SOE performance. Thus, SOEs with lower levels of government ownership are more likely to adopt market-oriented compensation contracts. On the other hand, given the rigidity of the government's control over SOEs, its discourse power in relation to SOEs depends on its willingness to exert control rather than on the shareholding ratio. Furthermore, path dependence makes it challenging for SOEs to adjust the compensation system in the short term. As a result, whether the government will implement a differentiated compensation governance contract according to the equity structure of SOEs remains an empirical question.

[1] https://gongyi.sohu.com/a/541167794_120157024.

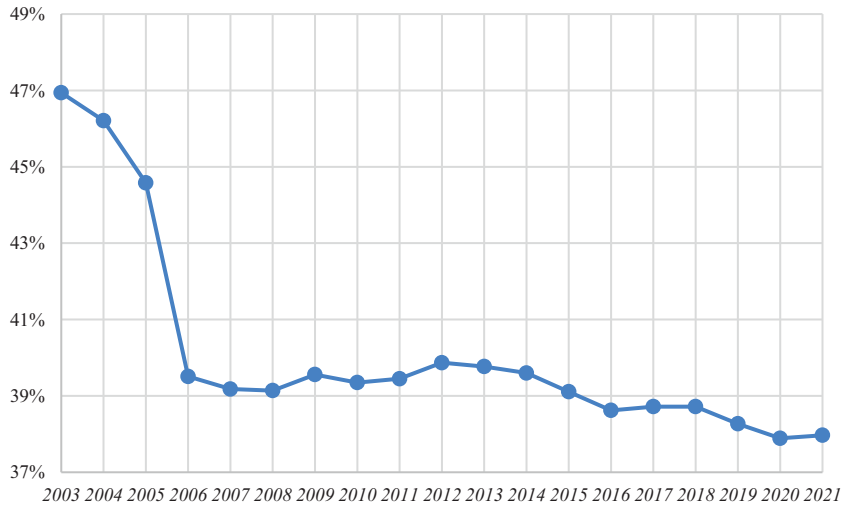

Fig. 1. Distribution of the largest shareholder ratio in SOEs.

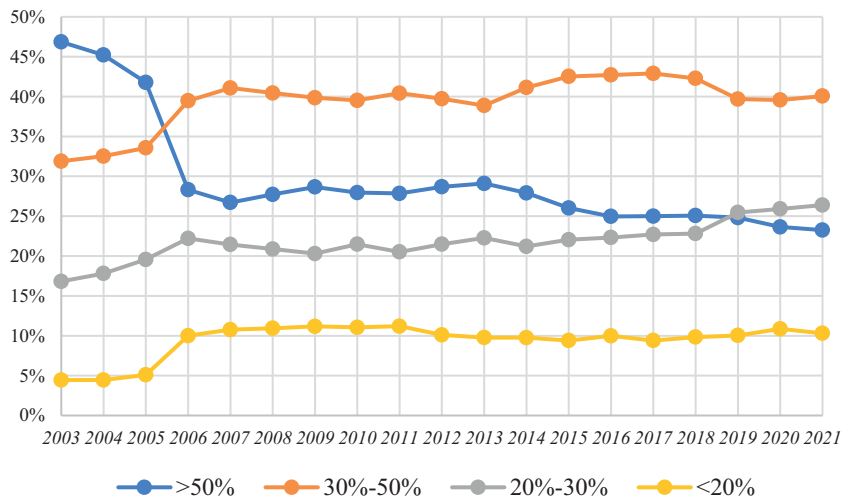

Fig. 2. Proportion of listed SOEs divided by the shareholding of the largest shareholder.

In the context of exploring differentiated governance of mixed-ownership enterprises and the deepening market-oriented reform of compensation in China, we take Chinese-listed SOEs from 2008 to 2021 as initial study sample. We begin by dividing the SOEs into four categories according to the proportion of shares held by the largest shareholder: state-owned absolute holding firms (*AbFm*), relative holding firms (*ReFm*), major influence firms (*MjFm*) and state-owned participation firms (*PtFm*). This categorization facilitates our examination of the current situation and evaluation of the effectiveness of differentiated compensation governance in SOEs. We make four main findings. First, SOEs have developed a differentiated governance model for executive compensation, characterized by increases in executive compensation, a widening compensation gap and enhanced equity incentives as the proportion of state-owned shareholders decreases. Second, the government's willingness to intervene is the main driving force behind the differentiated governance of executive compensation. The government's ability to intervene in SOEs does not diminish as its shareholding ratio declines. In fact, the government may even appoint additional executives to compensate for the diminished discourse power that results from its reduced shareholding. Third, the differential governance of SOEs' executive

compensation is more effectively implemented in local and competitive SOEs. Unlike compensation levels and the compensation gap, the differentiated governance of equity incentives requires improvement. Fourth, the differentiated governance of compensation levels and the compensation gap has a positive effect on the mitigation of agency problems and the promotion of innovation in SOEs, while the effectiveness of equity incentives remains limited.

In this study, we investigate the current situation of differentiated governance of executive compensation, evaluate its efficacy and offer a valuable reference for advancing the differentiated governance of SOEs. We make three main contributions to the literature. Firstly, we enrich the literature on equity structure. Previous studies focus on the performance of enterprises with different equity properties (Dewenter and Malatesta, 2001; Chen et al., 2009a). For instance, Chen et al. (2009a) categorizes China's listed SOEs into four groups: (1) those controlled by state asset management bureaus (SAMBs), (2) those affiliated with the central government, (3) those affiliated with the local government and (4) private investors. They compare the operating efficiency of Chinese-listed companies across different types of controlling shareholders. They find that firms controlled by the central government perform best and that SAMBs and privately controlled firms perform worst, while firms controlled by the local government in the middle. More recent research focuses on how equity structure arrangements affect the operational efficiency of SOEs (Gan et al., 2018; Zhang et al., 2020; Wang et al., 2022). By placing SOEs at the bottom of the pyramid hierarchy (Fan et al., 2013; Wang et al., 2022) and introducing non-state shareholders (Zhang et al., 2020; Li et al., 2023; Yu et al., 2023) and privatization (Gan et al., 2018), government intervention can be reduced effectively, thereby enhancing the operational efficiency of SOEs. In contrast to such research, our study does not involve changes to equity structure or property rights. Instead, we investigate whether government shareholders will adopt various compensation governance models according to equity structure without changes to equity structure. Furthermore, we reveal the micro mechanism by which equity structure affects the efficiency of SOEs from the perspective of executive compensation incentives. Our study thus not only enriches the literature on equity structure but also has significant practical implications for advancing differentiated governance and deepening the reform of SOEs.

Secondly, we contribute to research on the classified governance of SOEs. The dual attributes of SOEs make it difficult for them to resolve mission conflicts solely through the reform of property rights or pyramid decentralization. Therefore, promoting SOEs reform according to hierarchy and category constitutes a breakthrough in the new round of reform. Most studies classify SOEs into commercial and public welfare categories based on industry attributes (Yang, 1998; Huang and Yu, 2013; Huang, 2022). However, it is meaningless to regulate SOEs according to industry attributes, as the majority of listed SOEs belong to competitive industries. It is particularly urgent to establish suitable classification standards for the promotion of differentiated governance in SOEs. We are the first to present the concept of differentiated governance from an equity perspective. In doing so, we not only enrich the literature on classified governance but also provide important guidance for the coordinated promotion of classified governance reform.

Thirdly, we make a significant contribution to the literature on executive compensation. Most studies on compensation treats enterprises as homogeneous individuals and examines how compensation contracts are affected by the institutional environment (Bryan et al., 2005; Xin and Tan, 2009), market structure (Liu et al., 2007) and internal governance mechanisms (Quan et al., 2010; Cai et al., 2018a). However, such studies ignore whether these agreements align with the specific characteristics of enterprises, which may limit the effectiveness of compensation incentives. We propose differentiated compensation governance for SOEs from the perspective of equity structure. Furthermore, we suggest that compensation contracts be tailored to firms' characteristics, which not only contributes to the literature on compensation incentives but also provides insights into corporate compensation contract design.

The remainder of this paper is organized as follows. Section 2 describes the institutional background and develops the hypotheses. Section 3 presents the model design. Section 4 reports and discusses the empirical findings and conducts additional tests. Finally, Section 5 concludes.

2. Institutional background and hypothesis development

2.1. Institutional background

Due to the inherent drawbacks of the state-owned asset management system and government intervention, effective implementation of performance-based compensation arrangements in SOEs can be challenging (Chen et al., 2005). Given the large number of SOEs, it is difficult for the government to obtain sufficient information to monitor operational performance at an appropriately low cost, which in turn makes it more difficult to sign effective incentive contracts with executives (Laffont and Tirole, 1993; Shleifer and Vishny, 1994; Lin et al., 2004). Consequently, a one-size-fits-all compensation management system has become the optimal choice for government shareholders. However, the failure of monetary incentives has prompted executives to seek alternative compensation mechanisms such as political promotion, on-the-job consumption and rent-seeking (Chen et al., 2005), none of which are conducive to improving the economic efficiency of SOEs (Xin et al., 2007; Xu and Zhang, 2018).

To break the rigid salary system, SOEs salary reforms have consistently been in compliance with market-oriented principles. It is widely acknowledged that the social burdens embedded in the socio-economic system and government intervention associated with state ownership have prevented SOEs from operating in a market-oriented manner (Laffont and Tirole, 1993). Consequently, the reform of property rights and government decentralization measures, which aims to reduce government intervention, has become the focus of SOEs compensation reform. In terms of property rights, a decline in state-owned equity leads to less government interference, a reduction in non-operational noise in performance and a purification of operating goals (Gan et al., 2018; Zhang et al., 2020; Li et al., 2023; Yu et al., 2023), making performance-based compensation contracts become more effective. Simultaneously, the profit-oriented nature of non-state-owned capital enhances the incentive to oversee managers, consequently reducing the probability of managers engaging in opportunistic behavior (Cai et al., 2018a). Existing literature generally indicates that non-state-owned shareholders can enhance the effectiveness of executive compensation contracts within SOEs (Cai et al., 2018a; Chen and Yu, 2022).

In terms of government decentralization, the complex pyramid structure increases the cost to the government of obtaining timely information to intervene in the daily operations of SOEs, and thus it serves as an institutional arrangement for government decentralization (Fan et al., 2013; Wang et al., 2022). As profit orientation is emphasized in company objectives along with government decentralization, market-oriented pay is employed to incentivize managers (Jiang, 2016). In addition, the market environment, as the cornerstone of business operations, plays an important role in promoting the market-oriented compensation reform of SOEs. For instance, Xin and Tan (2009) conclude that the sensitivity between executive compensation and SOEs performance increases as market-oriented reforms progress, and the competition arising from this reform is the main driver force behind the transformation of executive compensation contracts in SOEs. As market-oriented reforms progress, market-oriented manager compensation contracts may replace the on-the-job consumption compensation system.

In summary, the majority of studies on SOEs compensation reform treat companies as homogeneous individuals, highlighting how property rights, government decentralization and the external market environment affect compensation marketization reforms. However, such studies ignore the characteristics of equity diversification under mixed-ownership reforms, and research on differentiated compensation governance in SOEs remains limited.

2.2. Hypothesis development

State-owned equity, which is the basis of the governance of SOEs, reflects the intensity of administrative governance brought about by government control. Consequently, government shareholding reflects the government's desire and capacity to impose compensation regulation on SOEs. In theory, the government can implement differentiated compensation governance according to SOEs' equity structure. Lower government ownership implies that the government places more emphasis on economic goals than on public goals, suggesting its strong willingness to delegate. Therefore, the government tends to implement market-oriented compen-

sation to enhance the economic efficacy of SOEs (Chen et al., 2009b). The core of classified mixed-ownership reform lies in adjusting government's equity holding over SOEs according to their functional positioning. For SOEs operating in competitive industries, it is necessary to gradually reduce the dominance of state-owned capital while leveraging the operational advantages of non-state-owned capital to achieve the preservation and appreciation of state-owned assets.[2] Research also suggests that governments have an incentive to decentralize through the introduction of non-state shareholder governance for competitive industries (Cai et al., 2018b), as well as to enhance SOE corporate governance through widening the pay gap and pay–performance sensitivity (Cai et al., 2018a,b). Consequently, in SOEs with a lower proportion of government ownership, the government is less inclined to impose salary regulations and more likely to adopt market-oriented salary distribution mechanisms, which aims to enhance the economic efficiency of SOEs and mitigate the agency problems that arise from the separation of ownership and control (Jensen and Meckling, 1976). Furthermore, as the government's equity control over SOE declines, its ability to shift policy burdens to SOEs also reduces. As a result, there is a reduction in non-operational noise in performance, making performance-based pay contracts more effective. As the largest shareholder in SOEs, the government has the authority to appoint and dismiss executives. In general, the government intends to incorporate public goals into the evaluation of executives to transfer public policy goals to SOEs (Bai and Xu, 2005; Chang and Wong, 2009; Liao et al., 2009; Chen et al., 2021). With less government ownership, the government's ability to appoint executives is expected to diminish, and simultaneously firms will bear less of the policy burden. Thus, as the performance of SOEs better reflects the level of effort of executives, more market-oriented salary incentives should be applied (Holmstrom and Milgrom, 1994; Bai and Xu, 2005; Bai et al., 2006). It follows that the government should enforce differentiated compensation covenants according to firms' equity structure, and that SOEs with lower government ownership are more likely to apply market-oriented compensation covenants.

However, a differentiated compensation governance model can be difficult to adopt in SOEs because of the administrative nature and rigidity of government shareholder control over the long term. The control exercised by government shareholders over SOEs can be flexible, given their authority to allocate resources (Shen and Yang, 2019). As a result, the government's influence over SOEs is determined by its desire to control rather than by its shareholding ratio (Shen and Yang, 2019), and a reduction in state ownership may not necessarily alleviate the dominant influence of state logic over SOEs (Fisman and Wang, 2010). Additionally, although the central goal of SOE reform has consistently been the transition from administrative to economic governance, both the weakening of administrative governance and the improvement in economic governance require time, because the influence of path dependence makes it difficult to change SOEs' traditional compensation management systems in the short term. Besides, the lack of precise operational guidelines regarding differentiated governance in mixed-ownership enterprises further exacerbates the difficulty of applying differentiated governance in SOEs. On the basis of these considerations, we propose the following competing hypotheses:

H1a: The government may implement differentiated compensation governance according to SOEs' shareholding structures, indicating that enterprises with a lower level of government ownership are more inclined to adopt a market-oriented compensation system.
H1b: The government may not implement differentiated compensation governance according to SOEs' shareholding structures.

3. Research design

3.1. Sample selection and data sources

Our sample consisted of state-owned A-share listed firms in China from 2008 to 2021. We selected 2008 as the starting year because the split-share structure reform was not completed until 2007. Before that reform, the

[2] https://www.gov.cn/zhengce/2015-09/13/content_2930440.htm. https://finance.stockstar.com/SS2015092400002725.shtml.

government typically held a concentrated share in state-owned listed companies, making differentiated governance unnecessary. We excluded listed firms in the financial industry, firms with missing or abnormal data, special treatment firms and firms that had experienced particular transfer. All continuous variables were winsorized at 1 % and 99 %. We manually collected data for directors, supervisors and senior executives appointed by shareholders from the directors' resumes disclosed in annual reports, while data on the regional legal environment were sourced from the China Marketization Index series reports by Wang et al. (2021). All company-level data were obtained from the China Stock Market and Accounting Research (CSMAR) database.

3.2. Variable definitions

3.2.1. SOE equity classification

In line with previous studies (Li and Li, 2006; Xu et al., 2006), we classified China's listed SOEs into four major types based on the shareholding of the largest shareholder. Companies whose largest shareholder holds more than 50 % of shares were defined as absolute holding firms (*AbFm*); those whose largest shareholder holds a stake of 30–50 % were categorized as state-owned relative holding firms (*ReFm*); those whose largest shareholder holds 20–30 % of the shareholdings were named major impact firms (*MjFm*); and those whose largest shareholder holds less than 20 % were classified as state-owned equity participation firms (*PtFm*). We chose the four-category method instead of the traditional three-category method for three reasons. First, the firms whose largest shareholder holds less than 20 % of the shares account for 10 % of listed SOEs (see Fig. 2). Second, the SOEs in the *PtFm* category have largely served as pioneers in the mixed-ownership reform, characterized by a diversity of shareholders, their need for differentiated governance is intensified. Ultimately, because 20 % is the critical level for determining whether an investor has significant influence over an investee, setting 20 % as a threshold is appropriate for the purpose of this study. Specially, when SOEs are classified as *AbFm*, *ReFm*, *MjFm* or *PtFm*, *Type50_100*, *Type30_50*, *Type20_30* and *Type0_20*, respectively, equal 1; otherwise, they equal 0.

3.2.2. Executive compensation

Executive compensation packages contain both monetary and non-monetary components, with the monetary component including salary levels and salary structure, while the non-monetary component consists primarily of equity incentives. Accordingly, we used compensation level (*Pay*), the compensation gap (*BWT*) and equity incentives (*Equity*) to reflect executive compensation contracts. Higher values of these variables indicate a higher degree of marketization in executive compensation. In line with previous studies (Cai and Zheng, 2016), we proxied compensation level (*Pay*) by the natural logarithm of the aggregate compensation of the top three executives. We used the top three executives rather than a particular executive, such as the CEO, to evaluate executive compensation is based on the following considerations: (1) Certain executives may serve for less than 1 year. Retaining these executives within the sample would lead to incomparability between executives with less than 1 year of tenure and those who serve for the entire year; excluding them from the sample is likely to result in sample selection bias, given that executive turnover is typically sensitive to performance. (2) Furthermore, the compensation of the top three executives is more closely indicative of the compensation level of the management team. As for the compensation gap (*BWT*), the measure used in this study is the difference between the average compensation of the top three executives and the average employee compensation (Zhou and Zhu, 2010). We took the natural logarithm transformation of *BWT* to normalize its distribution. Adopting the same approach as previous studies (Xie and Chen, 2010; Xiao et al., 2013), we assessed equity incentives (*Equity*)[3] in terms of the proportion of the equity awarded to executives to the total share capital of the company in the current year.

[3] The data come from the detailed list of equity incentive grants in the CSMAR database.

3.3. Model design

To examinze whether government shareholders implement a differentiated compensation incentive contract based on the equity structure of SOEs, we designed the following model:

$$Salary_{it} = \alpha + \beta 1 * type30\_50_{it} + type20\_30_{it} + \beta 3 * type0\_20_{it} + \gamma Control_{it} + Ind + Year + \varepsilon \quad (1)$$

where *Salary* represents the compensation incentive contract variables discussed in Section 3.2.2, namely compensation level (*Pay*), the compensation gap (*BWT*) and equity incentives (*Equity*). *Type30_50* is a dummy variable that equals 1 for firms whose biggest shareholder possesses 30–50 % of the shareholdings, *Type20_30* equals 1 for firms whose largest shareholder owns 20–30 % of the shares and *Type0_20* equals 1 for firms whose largest shareholder holds less than 20 % of the shares. SOEs in which the largest shareholder holds more than 50 % of the shares form the benchmark. By comparing compensation in various equity structures with compensation in the benchmark group, we can infer whether SOEs implement differential compensation governance.

Control represents a series of control variables. Consistent with prior research (Ma et al., 2013; Bu et al., 2017), we controlled for firm size (*Size*), profitability (*Roa*), the leverage ratio (*Lev*), firm growth (*Growth*), board size (*Board*), the proportion of independent directors (*Inde*) and CEO duality (*Dual*). We also included year and industry fixed effects in the model. Table 1 summarizes the definitions of the variables.

4. Empirical results and discussion

4.1. Descriptive statistics

Table 2 presents the summary statistics for the main variables. The mean value of *Shd1th* is 0.407, which indicates that on average the largest shareholder holds 40.7 % of shares. By categorizing SOEs according to ownership structure, we can observe that the proportions of SOEs that are absolute holding firms (*AbFm*), relative holding firms (*ReFm*), major impact firms (*MjFm*) and state-owned equity participation firms (*PtFm*) are 30.1 %, 40.9 %, 20.3 % and 8.7 %, respectively. The government's control over SOEs is mainly characterized as relative holding, and there is a considerable disparity in the shareholding ratios of the largest shareholders. As for executive compensation, the average total compensation of the top three executives, without logarithmic transformation, is RMB2.42441 million. There is considerable variation across SOEs, with the highest being RMB46.8733 million and the lowest being RMB0.0381 million. The mean of *BWT*

Table 1
Variable definitions.

Variable	Definition
Pay	The logarithm of the sum of the top three managers' compensation
BWT	The logarithm of the difference between executive compensation and employee compensation
Equity	The percentage of incentives granted to executives to the total shares of the company
Shd1th	The percentage of shares held by the largest shareholder
Type50_100	Equal to 1 if a company's largest shareholder holds more than 50 % of its shares
Type30_50	Equal to 1 if a company's largest shareholder holds more than 30 % but less than 50 % of its shares
Type20_30	Equal to 1 if a company's largest shareholder holds more than 20 % but less than 30 % of its shares
Type0_20	Equal to 1 if a company's largest shareholder holds less than 20 % of its shares
Size	The logarithm of total assets at the end of the year
Roa	Net income to total assets
Lev	Total debt to total assets
Growth	The annual change ratio of a firm's total sales
Board	The logarithm of board numbers
Inde	The percentage of independent directors on the board
Dual	A dummy variable that equals 1 if the chairman and CEO are the same person, and 0 otherwise
Firm	A firm dummy variable
Industry	An industry dummy variable based on the classifications of the China Securities Regulatory Commission
Year	A year dummy variable

Table 2
Descriptive statistics.

Variable	N	Mean	Min.	P50	Max.	SD
Shd1th	13,771	0.407	0.036	0.402	1.000	0.158
Type50_100	13,771	0.301	0.000	0.000	1.000	0.459
Type30_50	13,771	0.409	0.000	0.000	1.000	0.492
Type20_30	13,771	0.203	0.000	0.000	1.000	0.402
Type0_20	13,771	0.087	0.000	0.000	1.000	0.281
Pay[1]	13,771	242.441	3.810	177.760	4,687.330	260.013
Pay	13,771	14.391	12.545	14.391	16.479	0.747
BWT	13,526	13.027	7.153	13.059	15.339	0.916
Equity	13,771	0.002	0.000	0.000	0.141	0.012
Roa	13,771	0.029	–0.329	0.029	0.212	0.061
Size	13,771	22.646	19.403	22.502	26.088	1.413
Lev	13,771	0.510	0.050	0.518	0.979	0.206
Growth	13,771	0.157	–0.615	0.090	3.099	0.451
Board	13,771	2.206	1.609	2.197	2.708	0.192
Inde	13,771	0.369	0.308	0.333	0.571	0.053
Dual	13,771	0.099	0.000	0.000	1.000	0.299

[1] Pay without logarithmic transformation.

is 13.027. In contrast, equity incentives are not widespread among SOEs; more than half of SOEs have not implemented them, a situation that reflects the regulatory constraints.

4.2. Baseline regression results

Table 3 presents the results of model (1). Regardless of whether the dependent variable is *Pay*, *BWT* or *Equity*, the coefficients of *Type30_50*, *Type20_30* and *Type0_20* are significantly positive and increase sequentially. This suggests that *ReFm*, *MjFm* and *PtFm* companies have higher levels of market-oriented compensation than *AbFm* companies, manifested as higher pay levels, wider compensation gaps and more equity incentives. However, the relative marketization of compensation in *ReFm*, *MjFm* and *PtFm* companies remains unknown. We therefore conducted pairwise difference tests on the coefficients of *Type30_50*, *Type20_30* and *Type0_20*. The results demonstrate that the level of compensation marketization increases sequentially across *ReFm*, *MjFm* and *PtFm* companies, with significant differences among them. This indicates that a differentiated governance model for compensation in SOEs has gradually emerged. Thus, hypothesis 1a is supported.

4.3. Mechanism testing

The results reported in Table 3 indicate that a differentiated governance model for executive compensation in SOEs has emerged. However, the reasons for this differentiation in compensation governance remain unclear. As the basis of governance of enterprises, government shareholding reflects the government's capacity and desire to impose compensation regulation on SOEs. From the perspective of regulatory inclination, as the government's shareholding decreases, its willingness to intervene in SOEs diminishes. Consequently, the government tends to apply more market-oriented compensation policies to delegate authority. In terms of regulatory capacity, the government's authority to appoint executives diminishes with its shareholding, thereby reducing its ability to transfer public objectives to SOEs. Consequently, there is less non-operational noise in the performance of SOEs, which allows performance to reflect managerial efforts more accurately. More market-oriented contracts should therefore be implemented (Holmstrom and Milgrom, 1994; Bai and Xu, 2005; Bai et al., 2006). An important question remains unanswered: Is the differentiated governance of executive compensation in SOEs driven by government decentralization or by diminished government capacity for intervention? If the results in Table 3 are attributable to the government's ability to intervene, there should be a noticeable difference in the proportion of government-appointed executives across companies with varying

Table 3
Equity classification and differentiated governance of executive compensation.

	(1) *Pay*	(2) *BWT*	(3) *Equity*
Type30_50	0.0951***	0.1504***	0.0008**
	(3.5414)	(4.2923)	(2.5014)
Type20_30	0.1766***	0.2710***	0.0015***
	(5.0663)	(6.1626)	(3.3743)
Type0_20	0.3162***	0.4403***	0.0043***
	(6.7601)	(7.7545)	(3.8270)
Roa	2.4834***	3.2288***	0.0131***
	(15.0402)	(15.2672)	(4.7248)
Size	0.2421***	0.2813***	0.0006***
	(20.6186)	(19.3499)	(3.4176)
Lev	–0.3957***	–0.4350***	0.0010
	(–6.0361)	(–5.1284)	(1.0140)
Growth	–0.0320**	–0.0362*	0.0001
	(–2.5425)	(–1.7976)	(0.4443)
Board	0.0975	0.1037	0.0003
	(1.4224)	(1.2294)	(0.3066)
Inde	–0.3340	–0.4630*	0.0030
	(–1.6117)	(–1.8119)	(0.8763)
Dual	0.0265	0.0343	0.0005
	(0.8397)	(0.8389)	(0.8179)
Constant	8.0313***	5.6598***	–0.0165***
	(27.7527)	(15.5856)	(–3.7930)
Industry	Yes	Yes	Yes
Year	Yes	Yes	Yes
(20 30)–(30 50)	0.0815***	0.1206***	0.0007*
(0 20)–(30 50)	0.2211***	0.2899***	0.0035***
(0 20)–(20 30)	0.1396***	0.1693***	0.0028***
N	13,771	13,526	13,771
Adj. R^2	0.46	0.39	0.06

Note: t-statistics are reported in parentheses, and robust standard errors are clustered at the firm level. (20 30)–(30 50) represents the coefficient differences between *Type20_30* and *Type30_50*; (0 20)–(30 50) represents the coefficient differences between *Type0_20* and *Type30_50*; and (0 20)–(20 30) represents the coefficient differences between *Type0_20* and *Type20_30*. The value of the difference test is the difference between different coefficients. ***, ** and * indicate statistical significance at the 0.01, 0.05 and 0.10 levels, respectively.

ownership structures. Column (1) of Table 4 suggests that although the coefficients of *Type20_30* and *Type0_20* are negative and significant, they do not pass the pairwise coefficient difference test.

However, the results in column (1) of Table 4 do not definitively indicate a reduction in government control over SOEs. Studies find that when the government's equity control is weak, it tends to sustain authority by strengthening personnel control (Zheng et al., 2023). For instance, Chen et al. (2013) and Zheng et al. (2023) find that substantial control over a company is achieved by appointing an excess number of directors. To exclude the possibility of declining government intervention capacity, we analyzed how the largest shareholder's holding ratio affects the appointment of excess executives. Following the approach adopted in previous studies (Zheng et al., 2023), we measured executive over-delegation (*Excess_Exe*) by calculating the difference between the proportion of executives appointed and the shareholding ratio. Column (2) of Table 4 reveals that the coefficients of *Type30_50*, *Type20_30* and *Type0_20* are positive and significant and increase sequentially in magnitude. The difference test also indicates that there are significant differences between each pair of coefficients. These results suggest that the government may compensate for the loss of control due to decreased shareholding by strengthening personnel control. Thus, the differentiated governance of executive compensation in SOEs is more likely driven by government decentralization.

Table 4
Equity classification and executive appointment.

	(1) *Executive*	(2) *Excess_Exe*
Type30_50	–0.0057	0.1821***
	(–1.6354)	(35.8898)
Type20_30	–0.0088**	0.3199***
	(–1.9865)	(61.4083)
Type0_20	–0.0090*	0.4111***
	(–1.7078)	(74.5915)
Control	Yes	Yes
Industry	Yes	Yes
Year	Yes	Yes
(20 30)–(30 50)	–0.0031	0.1378***
(0 20)–(30 50)	–0.0033	0.229***
(0 20)–(20 30)	–0.0002	0.0912***
N	12,991	12,991
Adj. R^2	0.08	0.62

Note: t-statistics are reported in parentheses, and robust standard errors are clustered at the firm level. (20 30)–(30 50) represents the coefficient differences between *Type20_30* and *Type30_50*; (0 20)–(30 50) represents the coefficient differences between *Type0_20* and *Type30_50*; and (0 20)–(20 30) represents the coefficient differences between *Type0_20* and *Type20_30*. The value of the difference test is the difference between different coefficients. ***, ** and * indicate statistical significance at the 0.01, 0.05 and 0.10 levels, respectively.

4.4. Robustness testing

4.4.1. Difference-in-differences model

Taking the change in the shareholding ratio of the largest shareholders in SOEs as the research scenario, we developed the following model for causal inference:

$$Salary_{it} = \alpha + \beta 1 * Treat_{it} * Post_{it} + firm_i + Year + \gamma' Control_{it} + \varepsilon \quad (2)$$

where *Treat* is a dummy variable that equals 1 if the government's control over SOEs diminishes significantly (e.g., a change from *AbFm* to *ReFm*), and *Post* equals 1 in the current and subsequent year when the government's control over SOEs decreases. We also added firm fixed effects and the same series of control variables as in model (1). Table 5 shows that the coefficient of *Treat*Post* is positive and significant regardless of whether the dependent variable is *Pay*, *BWT* or *Equity*, which is consistent with our main results.

Table 5
Equity classification and differentiated governance of executive compensation: DID model.

	(1) *Pay*	(2) *BWT*	(3) *Equity*
*Treat*Post*	0.0575*	0.1048**	0.0020*
	(1.7295)	(2.2687)	(1.8783)
Control	Yes	Yes	Yes
Industry	Yes	Yes	Yes
Year	Yes	Yes	Yes
Firm	Yes	Yes	Yes
N	7,873	7,740	7,873
Adj. R^2	0.48	0.34	0.04

Note: t-statistics are reported in parentheses, and robust standard errors are clustered at the firm level. (20 30)–(30 50) represents the coefficient differences between *Type20_30* and *Type30_50*; (0 20)–(30 50) represents the coefficient differences between *Type0_20* and *Type30_50*; and (0 20)–(20 30) represents the coefficient differences between *Type0_20* and *Type20_30*. The value of the difference test is the difference between different coefficients. ***, ** and * indicate statistical significance at the 0.01, 0.05 and 0.10 levels, respectively.

4.4.2. Addressing endogeneity

The endogeneity of the ownership structure may affect our findings in three ways. First, as La Porta et al. (1997, 1998, 2000, 2002) find, an enterprise's ownership structure is largely determined by the legal environment, and a higher concentration of ownership is associated with weaker investor protection. Second, industry characteristics may contribute to the endogeneity of ownership structures. According to *Guiding Opinions on Deepening the Reform of State-Owned Enterprises* released in 2015, SOEs should be classified and managed according to industry attributes. The document encourages state capital to participate in the daily operations of competitive commercial SOEs through equity participation, whereas public welfare SOEs can be controlled through sole ownership by the state. Thus, the ownership structure of SOEs is partially determined by industry characteristics. Third, studies suggest that the ownership structure of SOEs is also influenced by the regional market environment (Cai et al., 2018b). Therefore, to mitigate the influence of ownership structure endogeneity, we added regional legal environment (*Law*), industry attributes (*HHI*) and *Province*Year* fixed effects to model (1). As Table 6 shows, our conclusions hold after controlling for these variables.

4.4.3. Ruling out alternative explanations

Our findings may also be influenced by the presence of non-state shareholder governance. Non-state shareholders are inclined to enhance incentive and supervision mechanisms to mitigate opportunistic behavior by managers (Cai et al., 2018a). Therefore, the differentiated compensation management in SOEs that we identify in this study may result from non-state shareholders' governance. To rule out this alternative explanation, we incorporated non-state shareholder ownership (*Nonsoe*) into model (1). As Table 7 shows, our conclusions remain valid.

Our conclusions are also likely to be influenced by the professional managerial compensation system. The *Guiding Opinions on Deepening the Reform of State-Owned Enterprises* issued by China in 2015 highlighted the adoption of a professional manager system within SOEs. Consequently, the adoption of market-based compensation in companies with less government ownership may be attributed to the increase in the number of professional managers. To exclude this alternative explanation, we regressed model (1) using data from 2008 to 2014. If our findings are truly driven by the professional manager system, the differentiated compensation governance model should not exist before 2015. Table 8 reports the regression results, which are consistent with our main results.[4]

4.5. Cross-sectional testing

4.5.1. Effect of administrative hierarchy

Theoretically, the influence of the administrative hierarchy of SOEs on the differentiated governance of executive compensation is uncertain. As pioneers of SOE reform, central enterprises play a leading role in advancing the classified governance of SOEs.[5] For example, the large central enterprise COFCO Group divides its member enterprises into three categories according to their equity structure and applies differentiated management strategies for each type of subsidiary. However, central enterprises also tend to be positioned in sectors that are vital for the national economy and are therefore subject to many policy burdens. The government tends to hold large equity stakes in central SOEs, which makes those SOEs less likely to adopt market-driven compensation contracts.

As Table 9 shows, local SOEs exhibit an evident differentiated governance model in terms of compensation level (*Pay*), the compensation gap (*BWT*) and equity incentives (*Equity*). In contrast, central SOEs show an initial differentiated governance model only in terms of compensation level (*Pay*) and the compensation gap (*BWT*). In terms of equity incentives (*Equity*), although the equity incentive intensities of *ReFm*, *MjFm*

[4] It is challenging to rule out the influence of professional managers on the conclusion as it is difficult to obtain information on whether SOE executives hire professional managers and how much they are paid for their services. Scholars are encouraged to further explore the basis of obtaining data on professional SOE managers.

[5] In recent years, central SOEs, such as China State Construction Engineering Corporation, China Resources Group, State Development & Investment Corporation and China Southern Power Grid, have often served as benchmarks for differentiated management control in the SOE sector.

Table 6
Robustness tests: Addressing endogeneity.

Panel A: Control legal environment

	(1) *Pay*	(2) *BWT*	(3) *Equity*
Type30_50	0.1039***	0.1585***	0.0008**
	(4.0267)	(4.6351)	(2.5260)
Type20_30	0.1991***	0.2926***	0.0015***
	(5.9655)	(6.8484)	(3.4268)
Type0_20	0.3401***	0.4647***	0.0043***
	(7.3927)	(8.3217)	(3.8602)
Law	0.0263***	0.0272***	0.0000
	(11.3237)	(9.2775)	(0.8078)
Control	Yes	Yes	Yes
Industry	Yes	Yes	Yes
Year	Yes	Yes	Yes
(20 30)–(30 50)	0.0952***	0.1341***	0.0007*
(0 20)–(30 50)	0.2362***	0.3062***	0.0035***
(0 20)–(20 30)	0.141***	0.1721***	0.0028***
N	13,769	13,524	13,769
Adj. R^2	0.50	0.41	0.06

Panel B: Control industry characteristics

	(1) *Pay*	(2) *BWT*	(3) *Equity*
Type30_50	0.0955***	0.1508***	0.0008**
	(3.5543)	(4.3026)	(2.5072)
Type20_30	0.1768***	0.2714***	0.0015***
	(5.0701)	(6.1661)	(3.3744)
Type0_20	0.3174***	0.4419***	0.0043***
	(6.7830)	(7.7775)	(3.8514)
HHI	0.2752	0.2987	–0.0019
	(1.5108)	(1.2849)	(–0.3049)
Control	Yes	Yes	Yes
Industry	Yes	Yes	Yes
Year	Yes	Yes	Yes
(20 30)–(30 50)	0.0813***	0.1206***	0.0007*
(0 20)–(30 50)	0.2219***	0.2911***	0.0035***
(0 20)–(20 30)	0.1406***	0.1705***	0.0028***
N	13,763	13,518	13,763
Adj. R^2	0.46	0.39	0.06

Panel C: Control *Province*Year* fixed effects

	(1) *Pay*	(2) *BWT*	(3) *Equity*
Type30_50	0.1051***	0.1589***	0.0008**
	(4.2977)	(4.8418)	(2.3961)
Type20_30	0.1768***	0.2640***	0.0014***
	(5.6429)	(6.5116)	(3.0855)
Type0_20	0.2963***	0.4094***	0.0041***
	(6.7320)	(7.6097)	(3.6576)
Control	Yes	Yes	Yes
Industry	Yes	Yes	Yes
*Province*Year*	Yes	Yes	Yes
(20 30)–(30 50)	0.0717***	0.1051***	0.0006*
(0 20)–(30 50)	0.1912***	0.2505***	0.0033***

(*continued on next page*)

Table 6 (*continued*)

Panel C: Control *Province*Year* fixed effects			
	(1) *Pay*	(2) *BWT*	(3) *Equity*
(0 20)–(20 30)	0.1195***	0.1454***	0.0027***
N	13,767	13,523	13,767
Adj. R^2	0.54	0.46	0.06

Note: t-statistics are reported in parentheses and robust standard errors are clustered at the firm level. (20 30)–(30 50) represents the coefficient differences between *Type20_30* and *Type30_50*; (0 20)–(30 50) represents the coefficient differences between *Type0_20* and *Type30_50*; and (0 20)–(20 30) represents the coefficient differences between *Type0_20* and *Type20_30*. The value of the difference test is the difference between different coefficients. ***, ** and * indicate statistical significance at the 0.01, 0.05 and 0.10 levels, respectively.

Table 7
Robustness test: Control non-state shareholder ownership.

	(1) *Pay*	(2) *BWT*	(3) *Equity*
Type30_50	0.0756***	0.1257***	0.0007**
	(2.8203)	(3.6068)	(2.1132)
Type20_30	0.1266***	0.2056***	0.0012***
	(3.6259)	(4.6941)	(2.7150)
Type0_20	0.2589***	0.3657***	0.0040***
	(5.5060)	(6.4496)	(3.4833)
Nonsoe	0.7277***	0.9438***	0.0042***
	(7.3212)	(8.6873)	(2.8408)
Control	Yes	Yes	Yes
Industry	Yes	Yes	Yes
Year	Yes	Yes	Yes
(20 30)–(30 50)	0.0510**	0.0799**	0.0005***
(0 20)–(30 50)	0.1833***	0.2400***	0.0033***
(0 20)–(20 30)	0.1323***	0.1601***	0.0028***
N	13,771	13,526	13,771
Adj. R^2	0.48	0.41	0.06

Note: t-statistics are reported in parentheses, and robust standard errors are clustered at the firm level. (20 30)–(30 50) represents the coefficient differences between *Type20_30* and *Type30_50*; (0 20)–(30 50) represents the coefficient differences between *Type0_20* and *Type30_50*; and (0 20)–(20 30) represents the coefficient differences between *Type0_20* and *Type20_30*. The value of the difference test is the difference between different coefficients. ***, ** and * indicate statistical significance at the 0.01, 0.05 and 0.10 levels, respectively.

and *PtFm* companies are significantly higher than those of *AbFm* companies, they do not pass the difference test, which implies that there is a long way to go in differentiated governance for central SOEs. Table 9 also reveals deficiencies in the differentiated compensation governance of SOEs. Although the government can implement differentiated compensation governance according to SOEs' equity structure, there are boundary ambiguities in the governance of *AbFm* and *ReFm* enterprises (e.g., the results for *Type 30_50* in columns (1) and (6) are not significant). In terms of incentive strategies, SOEs lag behind in long-term incentives represented by equity incentives.

4.5.2. Effect of industry attributes

Crucial factors in designing compensation contracts include the verifiability of performance and the correlation between performance and management effort (Jensen and Murphy, 1990). A highly competitive market environment can mitigate information asymmetry between shareholders and managers, providing shareholders with more information for evaluating performance and thereby improving the effectiveness of executive

Table 8
Robustness test: Excluding the impact of the professional manager system.

	(1) *Pay*	(2) *BWT*	(3) *Equity*
Type30_50	0.0853**	0.1361***	0.0003
	(2.4200)	(2.8678)	(1.6007)
Type20_30	0.0872**	0.1682***	0.0010**
	(1.9672)	(2.9151)	(2.0959)
Type0_20	0.2748***	0.4027***	0.0027**
	(4.6692)	(5.6824)	(2.3419)
Control	Yes	Yes	Yes
Industry	Yes	Yes	Yes
Year	Yes	Yes	Yes
(20 30)–(30 50)	0.0019	0.0321*	0.0007**
(0 20)–(30 50)	0.1895***	0.2666***	0.0024***
(0 20)–(20 30)	0.1876***	0.2345***	0.0017*
N	6,485	6,285	6,485
Adj. R^2	0.42	0.36	0.05

Note: t-statistics are reported in parentheses, and robust standard errors are clustered at the firm level. (20 30)–(30 50) represents the coefficient differences between *Type20_30* and *Type30_50*; (0 20)–(30 50) represents the coefficient differences between *Type0_20* and *Type30_50*; and (0 20)–(20 30) represents the coefficient differences between *Type0_20* and *Type20_30*. The value of the difference test is the difference between different coefficients. ***, ** and * indicate statistical significance at the 0.01, 0.05 and 0.10 levels, respectively.

Table 9
Cross-sectional test: Effect of administrative hierarchy.

Variable	(1)	(2)	(3)	(4)	(5)	(6)
	Pay		*BWT*		*Equity*	
	Central	*Local*	*Central*	*Local*	*Central*	*Local*
Type30_50	0.0499	0.1407***	0.0884*	0.2105***	0.0022***	0.0001
	(1.2734)	(4.2554)	(1.8693)	(4.7290)	(3.3314)	(0.3699)
Type20_30	0.1498***	0.1992***	0.2200***	0.3088***	0.0017**	0.0016***
	(2.9839)	(4.4960)	(3.5325)	(5.4103)	(2.4904)	(2.7149)
Type0_20	0.2623***	0.3522***	0.3803***	0.4814***	0.0054**	0.0038***
	(3.6169)	(6.1741)	(4.3185)	(6.8908)	(2.0593)	(3.5261)
Control	Yes	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
(30 50)–(20 30)	0.0999**	0.0585*	0.1316**	0.0983**	–0.0005	0.0015***
(30 50)–(0 20)	0.2124***	0.2115***	0.2919***	0.2709***	0.0032	0.0037***
(20 30)–(0 20)	0.1125**	0.153***	0.1603**	0.1726***	0.0037*	0.0022**
N	4,981	8,790	4,920	8,606	4,981	8,790
Adj. R^2	0.52	0.45	0.44	0.37	0.08	0.06

Note: t-statistics are reported in parentheses, and robust standard errors are clustered at the firm level. (20 30)–(30 50) represents the coefficient differences between *Type20_30* and *Type30_50*; (0 20)–(30 50) represents the coefficient differences between *Type0_20* and *Type30_50*; and (0 20)–(20 30) represents the coefficient differences between *Type0_20* and *Type20_30*. The value of the difference test is the difference between different coefficients. ***, ** and * indicate statistical significance at the 0.01, 0.05 and 0.10 levels, respectively.

compensation incentive contracts. In addition, competitive companies cannot achieve high profits through monopolistic positions, which ties performance closely to management effort and improves the effectiveness of performance-based compensation contracts. Therefore, we divided the sample into competitive and monop-

Table 10
Cross-sectional test: Effect of industry attribute.

Variable	(1)	(2)	(3)	(4)	(5)	(6)
	Pay		*BWT*		*Equity*	
	Monopolistic	*Competitive*	*Monopolistic*	*Competitive*	*Monopolistic*	*Competitive*
Type30_50	0.0955*	0.0941***	0.1300*	0.1512***	0.0003	0.0010***
	(1.7963)	(3.1606)	(1.7881)	(3.8930)	(0.5138)	(2.5872)
Type20_30	0.1604**	0.1755***	0.2851***	0.2659***	–0.0005	0.0017***
	(2.2830)	(4.6594)	(2.8553)	(5.5994)	(–0.8812)	(3.5156)
Type0_20	0.1382*	0.3212***	0.2778**	0.4419***	–0.0007	0.0048***
	(1.8300)	(6.3298)	(2.4542)	(7.1795)	(–1.2492)	(3.9474)
Control	Yes	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
(20 30)–(30 50)	0.0649	0.0814***	0.1551**	0.1147*	–	0.0007***
(0 20)–(30 50)	0.0427	0.2271***	0.1478**	0.2907***	–	0.0038***
(0 20)–(20 30)	–0.0222	0.1457***	–0.0073	0.176***	–	0.0031***
N	1,590	12,181	1,555	11,971	1,590	12,181
Adj. R^2	0.48	0.47	0.35	0.40	0.03	0.07

Note: t-statistics are reported in parentheses, and robust standard errors are clustered at the firm level. (20 30)–(30 50) represents the coefficient differences between *Type20_30* and *Type30_50*; (0 20)–(30 50) represents the coefficient differences between *Type0_20* and *Type30_50*; and (0 20)–(20 30) represents the coefficient differences between *Type0_20* and *Type20_30*. The value of the difference test is the difference between different coefficients. ***, ** and * indicate statistical significance at the 0.01, 0.05 and 0.10 levels, respectively.

olistic[6] SOEs and conducted a regression analysis on each subsample. As Table 10 shows, differentiated compensation governance is more effectively implemented in competitive SOEs than in monopolistic SOEs.

4.6. Further analysis

The aim of differentiated governance in SOEs is to optimize corporate governance structures and spur firms' vitality. In this section, we aim to evaluate whether differentiated compensation governance in SOEs successfully meets these objectives.

4.6.1. Differentiated compensation governance and agency costs

Effective executive compensation contracts are regarded as beneficial in mitigating conflicts between managers and shareholders (Jensen and Murphy, 1990). With the implementation of differentiated compensation, the government implements more market-oriented compensation contracts for SOEs with lower equity control. This raises the question of whether differentiated compensation governance does indeed reduce agency costs. We used the administrative expense ratio (*Agency*) as a proxy of agency costs between shareholders and managers to examine how interactions between compensation contracts (including compensation level, compensation gap as well as equity incentives) and equity category variables influence agency costs. In Table 11, *Mediation* represents the executive compensation contract, which includes compensation level (*Pay*), the compensation gap (*BWT*) and equity incentives (*Equity*). In columns (1)–(2), the coefficient of the interaction term is negative and significant, which suggests that both compensation level (*Pay*) and the compensation gap (*BWT*) have a positive role in mitigating agency problems, whereas the effect of equity incentives (*Equity*) is limited. Since 2006, the China Securities Regulatory Commission has permitted listed companies to implement equity incentives. However, a number of restrictions may hinder SOEs from doing so, leaving considerable room for improvement of SOEs' long-term incentive structures.

[6] In reference to previous literature (Cai et al., 2018a), we classify enterprises in the following industries as monopolistic: (1) oil and natural gas exploitation; (2) tobacco manufacturing; (3) petroleum processing, coking and nuclear fuel processing; (4) railway transportation; (5) waterway transport; (6) air transport; (7) postal services; (8) telecommunications, radio and television and satellite transmission services; and (9) electric power, heat, gas and water production and supply.

Table 11
Equity classification, executive compensation contracts and agency costs.

	(1)	(2)	(3)
	Dependent variable = *Agency*		
Interaction variable	*Pay*	*BWT*	*Equity*
*Type30_50*Mediation*	–0.0054*	–0.0046*	0.0378
	(–1.7329)	(–1.7660)	(0.2513)
*Type20_30*Mediation*	–0.0122***	–0.0094***	–0.0800
	(–2.8632)	(–2.6360)	(–0.5071)
*Type0_20*Mediation*	–0.0146***	–0.0136***	0.1475
	(–2.6024)	(–2.6488)	(0.6980)
Control	Yes	Yes	Yes
Industry	Yes	Yes	Yes
Year	Yes	Yes	Yes
(20 30)–(30 50)	–0.0068**	–0.0048*	–
(0 20)–(30 50)	–0.0092**	–0.0090**	–
(0 20)–(20 30)	–0.0024	–0.0042	–
N	13,771	13,526	13,771
Adj. R^2	0.28	0.28	0.28

Note: t-statistics are reported in parentheses, and robust standard errors are clustered at the firm level. (20 30)–(30 50) represents the coefficient differences between *Type20_30* and *Type30_50*; (0 20)–(30 50) represents the coefficient differences between *Type0_20* and *Type30_50*; and (0 20)–(20 30) represents the coefficient differences between *Type0_20* and *Type20_30*. The value of the difference test is the difference between different coefficients. ***, ** and * indicate statistical significance at the 0.01, 0.05 and 0.10 levels, respectively.

4.6.2. Differentiated compensation governance and innovation

Due to regulations on compensation, executive compensation in SOEs does not adequately reflect managerial effort, leading to lower innovation investment in SOEs (Xin et al., 2007; Wu, 2014). The implementation of differentiated compensation governance raises the question of whether market-oriented compensation contracts for SOEs motivate executives to invest actively in innovation. Using the share of research and development expenditures to total operating revenues (*R&D*) as an indicator of corporate innovation investments, we analyzed how the interaction term between compensation contracts (including compensation level, compensation gap as well as equity incentives) and equity classification influences innovation investment. As Table 12 suggests, both compensation level (*Pay*) and the compensation gap (*BWT*) have a positive effect on innovation investments, whereas the impact of equity incentives is limited. This finding highlights the constraints faced by SOEs in implementing equity incentives. Furthermore, the coefficients of *Type30_50*Pay* and *Type30_50*BWT* are not statistically significant, indicating that the government's differentiated governance boundaries for *AbFm* and *ReFm* enterprises are not well-defined.

5. Conclusions

In the context of exploring the differentiated governance of mixed-ownership enterprises and the deepening market-oriented reform of compensation in China, we examine the current situation and effectiveness of differentiated governance of executive compensation in SOEs. By dividing SOEs into four categories according to the proportion of shares held by their largest shareholder, we find that a differentiated compensation governance model has emerged within SOEs from the perspective of equity and that market-oriented executive compensation increases noticeably as the extent of equity control diminishes. Channel testing reveals that the differentiated governance model in SOEs is driven by the government's willingness to intervene. The gov-

Table 12
Equity classification, executive compensation contracts and innovation.

	(1)	(2)	(3)
	Dependent variable = *R&D*		
Interaction variable	*Pay*	*BWT*	*Equity*
*Type30_50*Mediation*	0.0008	0.0003	0.1589
	(0.6598)	(0.2868)	(1.2707)
*Type20_30*Mediation*	0.0040***	0.0031***	–0.0265
	(2.7623)	(2.7196)	(–0.2341)
*Type0_20*Mediation*	0.0101***	0.0062*	0.8655**
	(2.7633)	(1.9014)	(2.0358)
Type30_50	–0.0129	–0.0045	–0.0006
	(–0.7217)	(–0.3510)	(–0.6042)
Type20_30	–0.0551***	–0.0375**	0.0033**
	(–2.6664)	(–2.5614)	(2.0593)
Type0_20	–0.1367***	–0.0713*	0.0067**
	(–2.7222)	(–1.7296)	(2.4773)
Control	Yes	Yes	Yes
Industry	Yes	Yes	Yes
Year	Yes	Yes	Yes
(20 30)–(30 50)	0.0032**	0.0028**	–
(0 20)–(30 50)	0.0093***	0.0059**	0.7066*
(0 20)–(20 30)	0.0061**	0.0031	0.892**
N	13,771	13,526	13,771
Adj. R^2	0.25	0.25	0.26

Note: t-statistics are reported in parentheses, and robust standard errors are clustered at the firm level. (20 30)–(30 50) represents the coefficient differences between *Type20_30* and *Type30_50*; (0 20)–(30 50) represents the coefficient differences between *Type0_20* and *Type30_50*; and (0 20)–(20 30) represents the coefficient differences between *Type0_20* and *Type20_30*. The value of the difference test is the difference between different coefficients. ***, ** and * indicate statistical significance at the 0.01, 0.05 and 0.10 levels, respectively.

ernment's ability to intervene in SOEs does not decline with a reduction in its shareholding percentage. Instead, the government may compensate for the loss of control due to reduced equity stakes by appointing excess executives. Cross-sectional tests indicate that differentiated compensation governance is particularly significant in local and competitive SOEs. Compared with compensation level and compensation gap incentives, equity incentives lag behind in terms of differentiated governance, and there is a lack of a well-defined governance model for absolute and relative holding companies. The economic results suggest that differentiated governance for compensation levels and compensation gaps can effectively reduce agency problems and enhance innovation in SOEs, whereas the impact of differentiated governance for equity incentives is limited.

Our conclusions have important practical significance and policy guidance implications. First, it is essential to establish clear equity classification standards for mixed-ownership enterprises and to define the governance boundaries for each category of SOEs. Operationally, the precise definition of SOEs according to their equity structure is a prerequisite for differentiated governance. Official documents offer guidelines for categorizing SOEs, typically using 50 % shareholding as a critical threshold. However, this division is too crude and does not align with the reality of equity dispersion in SOEs in the context of mixed-ownership reforms. Consequently, to facilitate differentiated governance reform, the government should release official documents that provide definitive classification standards for equity in SOEs.

Second, the government should persist in advancing differentiated governance reforms for SOEs. The differentiated governance of mixed-ownership SOEs is currently in early stages. Although an initial model of differentiated governance of executive compensation based on equity perspectives has been established, it remains insufficiently effective in central and monopolistic SOEs. This lack of effectiveness is attributable

not only to the inherent attributes of central and monopolistic SOEs but also to the absence of guidance documents. Hence, the central government should actively explore this area and issue corresponding guidelines to provide detailed instructions for implementing differentiated governance in SOEs.

Third, it is essential to eliminate institutional barriers and reinforce long-term incentive mechanisms. As an effective means of harmonizing shareholder and executive interests, equity incentives play an important role in encouraging executives to engage in long-term value-creation activities. However, SOEs may encounter various institutional challenges in implementing equity incentives due to regulatory restrictions. Thus, the government should steadily deregulate, encouraging SOEs to implement equity incentives and make active use of other long-term incentive tools.

Finally, our findings indicate the importance of deepening government decentralization reforms and protecting the rights of non-state shareholders. We find that the government's control over SOEs is not solely tied to its shareholding percentage, as the government may compensate for the decline in its equity control by appointing an excess number of executives. This practice not only impairs the rights of non-state shareholders but also conflicts with the policy goal of facilitating reform through mixed ownership. It is evident that there is much progress to be made in terms of improving corporate governance mechanisms in mixed-ownership SOEs.

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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