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Stakeholder responses to mandating environmental, social and governance reporting in Hong Kong



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ABSTRACT

We examine stakeholders' comment letters regarding the Hong Kong Exchange's (HKEX) 2015 Consultation Paper, which proposed mandating ESG reporting in Hong Kong. We test for significant differences in responses between stakeholder groups and whether the HKEX's decision was consistent with stakeholders' preferences in the consultation process. Examining comment letters submitted by six lobbying groups—preparers, investors, the accounting profession, NGOs, other institutions and individuals—we analyze survey responses using textual analysis software and statistical tests. We find that users and the accounting profession participated more than preparers. We also find that preparers and users took different positions on mandating ESG reporting when lobbying the HKEX, whereas preparers and the accounting profession advocated similar positions. Moreover, we find a significant association between stakeholder groups' preferences and the HKEX's decision on most proposed changes.

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1. Introduction

Environmental, social and governance (ESG¹) reporting has traditionally been a voluntary practice in many countries, but there is a global trend of mandating ESG reporting through legislation² (for example, the EU Directive on Non-Financial Reporting) and stock exchange rules³ (for example, the Listing Rules of the Hong Kong Exchange (HKEX)). In response to ESG concerns at global and local levels, Hong Kong was the first stock market in Asia to impose mandatory⁴ ESG reporting requirements on all listed companies (Liu et al., 2019). At the stock exchange level, there was no local ESG guide before 2012. After launching the first public consultation proposing an ESG Reporting Guide in December 2011, the HKEX issued the first voluntary Hong Kong ESG Reporting Guide ("the 2012 Guide") in August 2012. Then, a second Consultation Paper ("the 2015 Consultation Paper") was published in July 2015 to seek views on upgrading the 2012 Guide from voluntary to a "comply or explain" basis. As a result, an upgraded ESG reporting guide ("the 2015 Guide") was issued in December 2015 and was appended to the Listing Rules (Appendix 27 to the Main Board Listing Rules). The 2015 Guide requires all listed firms to comply with General Disclosures (GDs) from 2016 onward and environmental key performance indicators (KPIs) from 2017 onward. Notably, the disclosure of social KPIs remained a "recommended practice." Issuers that did not comply with this ESG reporting requirement had to provide reasons why items were not disclosed. Few years after launching the 2015 Guide, the HKEX produced another Consultation Paper in December 2019, in which it reviewed the 2015 Guide, and subsequently published the upgraded 2019 Guide, which is the version currently in effect. Although the 2019 Guide took effect on 1 July 2020, the 2015 Guide (which was subsequently incorporated into the current guide) was effective between 2016 and 2019. The 2019 Guide emphasizes the board's leadership role and accountability in firms' ESG reporting. In view of the global demand for disclosure of climate change-related information, in April 2023 the HKEX issued another Consultation Paper, "Enhancement of Climate-related Disclosures," under the ESG Framework. Table 1 shows the changes in requirements between the 2012 and 2015 Guides, and Fig. 1 shows the timeline of the development of ESG reporting requirements in Hong Kong since 2011.

This study focuses on the 2015 consultation, which led to the change from voluntary to mandatory ESG reporting in Hong Kong from 2016. Specifically, this study investigates whether there were significant differences in responses between stakeholder groups and whether the HKEX's decision was consistent with the respondents' preferences during the development of mandatory ESG reporting. Hong Kong is selected for the investigation of lobbying on ESG reporting for two main reasons. First, the HKEX became the first Asian stock exchange to mandate ESG reporting via its Listing Rules following a public consultation in 2015. The Consultation Paper attracted a considerable response from global, mainland Chinese and local stakeholders in the form of comment letters, which form the foundation for this lobbying study. Second, the literature on stakeholder lobbying around the mandating of Hong Kong ESG reporting is scant. The only research on ESG reporting in the Hong Kong setting is a legal study by Lu (2016), who conducts discourse analysis of comment letters to manually identify key issues, followed by an event study.

This study examines the comment letters submitted by lobbying groups in response to the HKEX's 2015 Consultation Paper, which proposed upgrading the voluntary 2012 Guide to the mandatory 2015 Guide (published as an appendix to the Listing Rules). We analyze the responses to open-ended survey questions using textual analysis software and the responses to closed-ended survey responses using statistical tests. The responses to the 2015 Consultation Paper were submitted initially by 203 respondents representing both institutions and individuals, profit-making companies and not-for-profit organizations, and preparers and users of

¹ The term "ESG" has been officially adopted by the Hong Kong Exchange (HKEX) and is used throughout this study. Although the HKEX uses the term "ESG," its ESG Reporting Guides cover only the environmental (E) and social (S) areas. Notably, however, the environmental and social disclosures include laws and regulations, for example, environmental laws and labor laws, that are part of governance (G). The governance area is also separately dealt with by the Corporate Governance Code of Hong Kong Listing Rules (Appendix 14).

² The Reporting Exchange. Available from:https://www.reportingexchange.com/mapsearch. [23 April 2019].

³ Sustainable Stock Exchange Initiatives. Available from:https://www.sseinitiative.org/data. [23 April 2019].

⁴ The HKEX mandates ESG reporting on a "comply or explain" basis, a form of soft law that is a more effective alternative to outright mandates (Ho, 2017). Listed firms that do not comply with this requirement have to explain why items are not disclosed. Note that Krueger et al. (2021) consider "comply or explain" regulation as mandatory ESG disclosure in their study.

	2012 Guide	2015 Guide		2019 Guide
Areas of ESG Reporting Guide	Voluntary Practice	Comply or Explain	Voluntary Practice	Comply or Explain
1. General Disclosures				
Environmental				
Social				
2. KPIs				
Environmental				
Social				

Table 1				
The levels of ESG disclosure	obligations in	the 2011. 20	015 and 2019	Consultations.

Note: The purpose of the 2015 Guide (the focus of this study) was to upgrade General Disclosures and environmental KPIs to "comply or explain," while the objective of the 2019 Guide was to upgrade social KPIs to "comply or explain."



Fig. 1. Timeline of ESG reporting development in Hong Kong.

ESG reports. We find that users and the accounting profession participated more than preparers in the consultation. The evidence also shows that preparers and users took different positions on mandating ESG reporting when lobbying the HKEX, whereas preparers and the accounting profession advocated similar positions. Moreover, the results suggest that the HKEX's decision was consistent with stakeholder groups' preferences during the development of mandatory ESG reporting via the publication of the 2015 Guide.

This study contributes to the scant accounting literature on lobbying around the mandating of ESG reporting in Hong Kong, and provides a suitable lens for understanding the HKEX's consultation process and its role in the development of Hong Kong's ESG reporting regime at the stock exchange level. To the best of our knowledge, this is the first accounting study in the Hong Kong context to investigate stakeholder lobbying around the mandating of ESG reporting. The extant lobbying literature focuses mostly on accounting standard setting (e.g. Georgiou and Roberts, 2004; Georgiou, 2010; Bamber and McMeeking, 2016). Numerous studies examine the influence of stakeholder groups on the independence of accounting standard setters, and investigate whether and how accounting standard setters are influenced by different respondent groups through submissions of comment letters (Hewa et al., 2018). However, the literature on lobbying around the mandating of non-financial (especially ESG) reporting requirements is limited. The current study fills this gap by revealing the independent role of standard setters in the process of developing mandatory disclosure of corporate ESG information.

Moreover, the findings have practical implications for relevant stakeholders, including preparers, practitioners and investors, concerning the due process of setting international sustainability standards in the near future. This study examines lobbying in response to the HKEX consultation, whose recommendations eventually mandated ESG reporting through the Listing Rules. Furthermore, the results of this study can inform other stock exchanges seeking to develop mandatory ESG reporting requirements at the stock exchange level.

The next section outlines the existing literature and the development of the study's hypotheses. Section 3 describes the sample and method. Section 4 presents the empirical results. Section 5 discusses and concludes the study with limitations and suggestions for future research.

2. Literature review and hypothesis development

Various corporate social responsibility theories, especially legitimacy theory and agency theory, are relevant to this lobbying study from preparers', users' and the accounting profession's perspectives. Here, "preparers" refers to listed firms (represented via managers), "users" refers to investors and/or shareholders and "the accounting profession" refers to independent accountants or auditors nominated by listed firms.

First, legitimacy theory is widely used to interpret corporate actions and activities, particularly relating to environmental and social issues. Legitimacy theory (Perrow, 1970) purports that business organizations are expected to act in accordance with societal norms. For example, a firm should take steps to minimize its environmental and social impacts and improve its relations with regulators (Haniffa and Cooke, 2005; Taylor and Shan, 2007; Branco and Rodrigues, 2008; Reverte, 2009). Moreover, legitimacy theory explains the positive association between firm size and a firm's intention to disclose voluntary information, because larger firms do not want to breach social contracts due to public pressure (Baldini et al., 2018). Therefore, legitimacy theory argues that larger firms are more motivated to engage in lobbying than smaller firms. For example, Hewa et al. (2018) use legitimacy theory to explain how the International Accounting Standards Board (IASB) was influenced by respondent groups during the development of the expected credit loss model for IFRS 9 Financial Instruments. Bamber and McMeeking (2016) draw on legitimacy theory to examine the international accounting standard-setting due process of IFRS 7. Reuter and Messner (2015) suggest that large firms tend to have a greater demand for legitimacy and hence have stronger motivation to influence the development of integrated reporting.

In contrast, agency theory (Jensen and Meckling, 1976) is used to understand principal–agent relationships. For example, managers (the agents) are expected to act in the best interests of shareholders (the principals). However, agency theory argues that agency problems arise where there is a separation of ownership and control of a firm. To ensure that professional managers (agents for preparers) can maximize the interests of their firms' shareholders (principals/users), information disclosure is likely to be greater in widely held firms (Berle, 1932; Jensen and Meckling, 1976; Fama and Jensen, 1983). Additionally, the accounting profession will act in the interest of its clients (i.e. principals/preparers) when lobbying for standards (Reuter and Messner, 2015). Furthermore, corporations (i.e. preparers) often expect their auditors to represent their interests before standard setters (Jorissen et al., 2010).

Empirically, lobbying studies focus mostly on standard setting for financial reporting. Sutton (1984), in a lobbying study on accounting standard-setting bodies in the UK and US, defines the differences between lobbying and voting, characteristics of lobbyists, timing of lobbying and methods of lobbying. Numerous studies examine the influence of interest groups on the independence of accounting standard setters (e.g. Georgiou and Roberts, 2004; Larson, 2007; Georgiou, 2010; Jorissen et al., 2010; Stenka and Taylor, 2010). Furthermore, many researchers study lobbying in the context of the setting of specific accounting standards (e.g. ED49 by Tutticci, 1994; IAS 14 by Kwok and Sharp, 2005; IFRS 6 by Cortese et al., 2010; ED8 by Katselas and Birt, 2011; IFRS 2 by Giner and Arce, 2012; IFRS 7 by Bamber and McMeeking, 2016; IFRS 9 by Hewa et al., 2018).

However, lobbying studies on sustainability issues and non-financial reporting are limited. Mobus (2011) evaluates comment letters in response to SOP 96–1 "Environmental Remediation Liabilities" using content analysis. Lodhia and Martin (2012a) examine the responses to the National Greenhouse and Energy Reporting Act submitted by corporations and other stakeholders using the content analysis software Leximancer. Lodhia and Martin (2012b) also use Leximancer to analyze submissions made by firms in emissions-intensive trade-exposed industries to the Garnaut Climate Change Review. Reuter and Messner's (2015) lobbying study is the first on integrated reporting, in which the comment letters in response to the 2011 discussion paper on the International Integrated Reporting Council's (IIRC) standard setting are analyzed. Arikan et al. (2017) analyze the Securities and Exchange Commission's consultation process and legislation related to the provenance of conflict minerals.

To further examine the characteristics of lobby groups and the influence of interest groups on the independence of accounting standard setters, many studies investigate whether and how the standard setters are influenced by different stakeholder groups during the development of accounting standards through the submission of comment letters (Hewa et al., 2018). For example, Sutton (1984) argues that the preparers of reports lobby because the potential economic benefits of securing their favored proposal are expected to be greater than the benefits to the users of reports. Kwok and Sharp (2005) demonstrate that the users of financial reports are interested in more extensive disclosure of information, whereas preparers have the opposite preference due to the extra cost of disclosure. Surrounding the due process of setting standards and regulations, Larson (2007) investigates constituent participation in the International Financial Reporting Interpretations Committee (IFRIC), a significant part of the IASB; it is found that professional accountancy bodies and accounting standard setters were two important stakeholder groups that contributed 58 % of the responses, while preparers and users did not regularly write comment letters to the IFRIC. Stenka and Taylor (2010) empirically analyze lobbying activities around the concept of control within the UK accounting standard setting process. Corporate stakeholders are found to have paid more attention to issues around the specific applicability of the concept of control, while non-corporate respondents were more concerned with issues around the general applicability of this concept. Oher studies find that preparers constitute the most active lobbying groups (Jorissen, 2010; Giner and Arce, 2012), whereas users undertake the least amount of lobbying activity due to the cost of lobbying (Georgiou, 2010). Furthermore, Beaumont et al. (2018) examine lobbying strategies over the two stages of the 2009 Productivity Commission Inquiry into executive remuneration in Australia and find that industry groups, professional bodies and representative bodies were more likely to vote against the change during the first stage. They also find that the Commission's final recommendations were more aligned with the views expressed by representative bodies than with those expressed by professional bodies.

In terms of classification of stakeholder groups, Tutticci et al. (1994) classify respondents into six groups industry, individuals, representative bodies, professional bodies, academics and government—and argue that the incentives of these groups to lobby will differ. Kwok and Sharp (2005) reveal the influences of preparers, users, accountants and regulators. Beaumont et al. (2018) describe the characteristics of groups: for example, "industry" refers to companies (i.e. preparers in the present study) conducting business with the intention of making a profit, while "professional bodies" (i.e. the accounting profession in this study) refers to organizations that are representatives of accountants or lawyers. In terms of frequency, research shows that preparers of financial reports issue comment letters more frequently than users of financial reports (e.g. Sutton, 1984; Jorissen et al., 2010; Giner and Arce, 2012). Furthermore, the accounting profession is the second most active issuer of comment letters (Jorissen et al., 2012). Therefore, following Reuter and Messner (2015), the first set of hypotheses of this study relate to whether there were significant differences among stakeholders' responses in terms of frequency of comments:

H1a. Preparers participated more or less in the HKEX consultation than investors (i.e. users in the narrower sense).

H1b. Preparers participated more or less in the HKEX consultation than users in the broader sense.

H1c. Preparers participated more or less in the HKEX consultation than the accounting profession.

Studies show that the potential economic benefits of securing preparers' favored proposal tend to be greater than the benefits to the user of reports (Sutton, 1984). Meanwhile, agency theory (Jensen and Meckling, 1976) predicts that the accounting profession will act in the interest of its clients (i.e. the preparers of reports). Therefore, following Reuter and Messner (2015), the second set of hypotheses of this study relate to whether there were significant differences among stakeholders' responses in terms of the positions expressed by comments:

H2a. Preparers and investors took different positions on the mandating of ESG reporting when lobbying the HKEX.

H2b. Preparers and users (in the broader sense) took different positions on the mandating of ESG reporting when lobbying the HKEX.

H2c. Preparers and the accounting profession took similar positions on the mandating of ESG reporting when lobbying the HKEX.

Finally, achieving legitimacy is one of the major objectives of standard setters when asking for public comments. Although the users of reports are the target beneficiaries of accounting standard setting, the preparers have significant influence inasmuch as the changes made to the accounting standard setting are consistent with the preparers' preferences. Following Hewa et al. (2018), we test whether the HKEX's decision was consistent with respondent groups' preferences in accordance with expectations of fairness in the process based on legitimacy theory (Bamber and McMeeking, 2016). Therefore, the last hypothesis is as follows:

H3. The HKEX's decision was consistent with stakeholder groups' preferences.

3. Data and method

3.1. Data

The data used in this study consist of the responses (comment letters) submitted by respondents to the 2015 consultation.⁵ A total of 203 submissions to the consultation process were initially received by the HKEX, all of which are publicly available in PDF format on the HKEX website.⁶ The response form for the 2015 Consultation Paper contained two parts. Part A provided the general information of the respondent, i.e. their name, company/entity type (or position in the case of individuals) and contact information. The HKEX used this information to categorize the types of respondents, which it then reported in the separate document titled "Consultation Conclusion". Respondents could choose not to disclose their identity to the public. Part B contained a total of 15 questions (shown in Appendix A), each followed by Yes/No tick boxes (for closed-ended questions) or a box for respondents to explain the reasons for their views (for open-ended questions or written responses). For closed-ended questions, a third possible option was no response (leaving the boxes blank). Of the 15 questions, we identified nine that were relevant to this study, namely Q1–3, Q9 and Q11–Q15. Q1 asked whether listed firms should be required to disclose whether they complied with the "comply or explain" provisions in the ESG Guide. Q2 asked whether listed firms should publish an annual ESG report in the same period covered by their annual report. O3 asked whether ESG information should be presented in a firm's annual report or in a standalone report published within three months of the annual report. Q9 concerned the proposal of mandating GDs, while Q11–Q14 asked whether the respondents agreed with the proposal of mandating environmental KPIs. Finally, Q15 concerned the proposal of incorporating gender disclosure

⁵ Hong Kong Exchanges and Clearing Limited 2015, *Consultation Conclusions on Environmental, Social and Governance Reporting Guide.* Available from:https://www.hkex.com.hk/-/media/HKEX-Market/News/Market-Consultations/2011-to-2015/July-2015-Consultation-Pape/Conclusions/cp201507cc.PDF. [15 November 2018].

⁶ Hong Kong Exchanges and Clearing Limited 2015, Responses to Consultation Paper on Review of the Environmental, Social and Governance Reporting Guide. Available from:https://www.hkex.com.hk/news/market-consultations/2011-to2015/responses_december_2015?sc_lang=en. [10 January 2019].

Table 2 The frequency of submissions by stakeholders.

Stakeholders	Initial number of responses	Number of identical submissions		Number (%) of responses (after excluding identical submissions)	Number of submissions in Chinese	Final number (%) of responses (after excluding submissions in Chinese)
Listed companies (preparers)	37	:	5	32 (17 %)	2	30 (19 %)
Investors (users in narrower sense)	41		2	39 (21 %)	0	39 (24 %)
Accounting profession	6	(0	6 (3 %)	0	6 (4 %)
NGOs	18	(0	18 (10 %)	1	17 (11 %)
Other institutions	29	(0	29 (16 %)	2	27 (17 %)
Individuals	72	10	0	62 (33 %)	20	42 (26 %)
Total	203	1'	7	186 (100 %)	25	161 (100 %)

Note: HKEX initially received a total of 203 submissions from six respondent groups. Percentages of responses may not add up to 100% due to rounding errors.

as part of voluntary social disclosure, in line with international practice. The remaining questions (Q4–8 and Q10) concerned changes to the heading and the proposed wording, and are not relevant to this study.

Among the 203 initial submissions, 17 are found to be identical to other responses, so these are excluded from the sample. Moreover, 25 responses⁷ were submitted in Chinese, and hence not applicable to Leximancer. Therefore, the final number of responses for both content and statistical analysis is 161. Notably, the HKEX's classification of respondent groups was somewhat misleading. For example, the HKEX grouped accounting professional bodies and other professional bodies into the same category. However, accountants, lawyers and bankers all have different roles in the domain of financial and non-financial reporting and disclosure. Therefore, in this study, we re-categorize the stakeholder groups following previous studies, e.g. Reuter and Messner (2015). As mentioned in Section 1, as the HKEX is one of the largest global financial centers, its market consultation attracted considerable attention from a wide range of respondents. Appendix B lists all 161 respondents. Table 2 shows the frequency of submissions by stakeholders.

As shown in Table 2, the 161 respondents consisted of 119 institutions and 42 individuals. It is unsurprising that institutions were more proactive in responding to the Consultation Paper than individuals. There are five groups of institutions. The first group is listed companies, which is the only group representing the preparers. The multinational companies listed in Hong Kong responding to the 2015 consultation included AIA Group, Cathay Pacific, HSBC, Manulife, Standard Chartered Bank and Swire Pacific. The second group is investors or analysts, who are defined as the users of ESG reports in a narrower sense (e.g. Giner and Arce, 2012; Reuter and Messner, 2015). These respondents included global fund managers such as Investee Asset Management, Hermes Investment Management, Fidelity Worldwide Investment and BlackRock. The third group is the accounting profession, such as the Association of Chartered Certified Accountants and the Hong Kong Institute of Certified Public Accountants, which are global and local accounting professional bodies, respectively. Notably, all Big 4 accounting firms responded to the consultation. The fourth category is non-governmental organizations (NGOs); the most important respondent in this group is the Global Reporting Initiative (GRI). The GRI is the most widely used international framework for ESG reporting (KPMG, 2017⁸), and its guide-

⁷ Among the 25 submissions in Chinese, 20 were from individuals and five were from institutions.

⁸ The KPMG Survey of Corporate Responsibility Reporting 2017. Available from:https://assets.kpmg/content/dam/kpmg/xx/pdf/2017/ 10/kpmg-survey-of-corporate-responsibility-reporting-2017.pdf. [5 July 2019].

lines became standards in 2018. The last group of institutions is denoted "Other Institutions" and includes respondents such as the British Council, FTSE Russell and the University of Hong Kong. The remaining respondents are classified as individuals.

Among the groups of institutional stakeholders, investors or analysts (users in the narrower sense) and listed firms (preparers) were the most represented (in terms of number of submissions) in responses to the proposal of upgrading ESG reporting from a "recommended" to a "comply or explain" provision. This finding is partially consistent with Jorissen et al. (2010) and Giner and Arce (2012), who show that preparers are the most represented respondent group.

3.2. Method

Both content analysis and statistical tests are applied. First, we use Leximancer (Smith and Humphreys, 2006) to analyze and compare different stakeholder groups' responses to the nine relevant open-ended questions (written responses) to address the first and second set of hypotheses (H1 and H2). Leximancer⁹ is an Australian-developed software program that autonomously analyses the content of textual documents such as comment letters and generates visual and other outputs. Among the most important visual outputs are a concept map, which identifies the main themes, and a ranked concept list. The software also enables the user to explore the relationship between themes and concepts, to perform a search of the documents and to explore examples of concepts linked to the original text. One advantage of Leximancer is the ability to conduct both conceptual analysis and relational analysis. This enables Leximancer to quantify and display the conceptual structure of text for further interpretation and analysis. For example, Chen and Bouvan (2009) utilize Leximancer to explore national differences in corporate responsibility reporting in the US, UK, Australia and Germany. Leximancer is an objective and reliable research method for analyzing the content of sustainability reports (Chen and Bouvain, 2009; Lodhia and Martin, 2012a; Lodhia and Martin, 2012b).

There are four processing stages of running the Leximancer system. The first stage involves selecting documents. In this study, the documents are the submissions to the 2015 Consultation Paper in PDF format. As the PDF copies of each document contain the same 15 questions with yes/no tick boxes, which are not the focus of our content analysis via Leximancer, the questions and yes/no tick boxes are removed from each document before uploading into Leximancer. Therefore, only written responses are analyzed. The second stage is to generate concept seeds, and the third stage is to generate a thesaurus. All settings in these stages are set as default except Concept Seeds Editor. First, the remove button is used to remove any unwanted automatic concept seeds. In this study, irrelevant words like "guide," "view" and "applicable" are removed. Second, same or similar concepts are merged. For example, "companies" and "company," "disclosure" and "disclosures," "issuer" and "issuers," "proposal" and "proposed" and "report," "reporting" and "reports" are merged. The fourth and final stage is to generate a concept map, which is the first important Leximancer output, to address the second set of hypotheses (H2a and H2b).

In addition to using concept maps, Leximancer software can generate a list of the most important concepts. In Leximancer, a concept is a group of related words or terms that occur together in the text. As this study aims to examine whether there were significant differences among stakeholder group' responses, we compare the frequency of all identified concepts and particularly, the concept "agree" expressed by stakeholder groups. We use ANOVA (see Chen and Bouvain, 2009) to investigate whether there are any significant differences in the frequencies of concepts detected in the comment letters to test the first set of hypotheses (H1a, H1b and H1c).

Second, the responses to closed-ended questions are classified as categorical variables. With respect to data input, the responses to closed-ended questions are coded as "+1" for Yes, "-1" for No and "0" for No response. To analyze categorical variables, we use the Mann–Whitney test and Fisher's exact test. Initially, a total of six groups of stakeholders are examined. To test the second set of hypotheses (H2a, H2b and H2c), we use the Mann–Whitney test to examine whether there are significant differences between the positions of preparers and users or between those of preparers and the accounting profession (see Reuter and Messner,

⁹ Leximancer User Guide Release 4.5.

2015). Last, to address the third hypothesis (H3), we use Fisher's exact test to investigate whether the HKEX's decision was associated with stakeholders' preferences during the development of mandatory ESG reporting requirements (Kwok and Sharp, 2005; Giner and Arce, 2012; Hewa et al., 2018).

4. Empirical results

4.1. Analysis of responses to open-ended questions

We compare the comment letters submitted by different stakeholder groups. In the first step, we use Leximancer to generate a concept map and identify the major themes with associated concepts for each stakeholder group. Additionally, Leximancer can separately produce a list of the most important concepts, which are the small gray nodes shown on a concept map. Figs. 2–7 show the themes on the concept map for each stakeholder group. We identify themes that commonly appeared in the comment letters: "ESG," "reporting/disclosure," "companies," "HKEX/Hong Kong" and "international." As the Consultation Paper concerned the review of the ESG Reporting Guide, it is not surprising to detect the above common themes, which means that ESG reporting or disclosure made by companies listed on HKEX or in Hong Kong is in line with the international practice.

However, we also detect another common theme, "gender," which is only found in the comment letters submitted by users¹⁰ (broader sense), including investors (users in the narrower sense), NGOs, other institutions and individuals. As gender disclosure (being part of social disclosure) is important but was still voluntary in the 2015 consultation, users suggested that the HKEX encourage preparers to disclose gender diversity. Below are some example comments:

More work should be done to enhance the awareness of the imbalance situation. Hong Kong employers should have access to the widest possible talent pool not limited by gender but the individual competency.

Based on the principle of gender equality, we are concerned that the percentage of women.....

We believe that gender diversity is not only for business, but it is critical to Hong Kong's competitive advantage.

Additionally, one purpose of this study is to investigate whether there was any difference among stakeholder group' responses, particularly between listed firms (preparers) and investors (users in the narrower sense). Therefore, we focus on the themes representing similarities or differences in the views of each stakeholder group. In listed firms' comment letters, we detect both "proposal" and "objection" themes. While the theme "proposal" is strongly associated with the concept "agree," the theme "objection" is linked to the theme "proposal" on the concept map in Fig. 2. Hence, listed firms had mixed views in relation to the proposal of mandating ESG reporting. For example, some text hits for the themes "proposal" and "objection," respectively, were as follows:

We agree with the proposal to include a note under Rule 13.91 to clarify the disclosure manner and timing of the publication of ESG report.

Some industries are more environmentally sensitive but some are non-sensitive sectors and low polluters. For those non-sensitive sectors, it would incur cost but would yield no additional benefit and would be very burdensome.

In investor comment letters, we likewise detect the theme "proposal." However, we also identify the theme "support" but not "objection." Again, the theme "proposal" is strongly associated with the concept "agree," and the theme "support" is linked to the theme "guide" (which is, in turn, related to the theme "proposal") on the concept map in Fig. 3. Being users of ESG reports, investors mainly supported the proposal of mandating ESG reporting. Example text hits for the theme "proposal" and "support," respectively, were as follows:

¹⁰ Members of the accounting profession, which consists of professional bodies and accounting firms, are not defined as users of ESG reports (Reuter and Messner, 2015).



Fig. 2. Concept map of the consultation responses to review of ESG Reporting Guide in Hong Kong submitted by Listed Companies (Preparers). (Visible Concepts 33%, Theme Size 33%, Rotation θ^{θ}). Notes: The concepts are clustered into higher-level "themes" when the map is generated. Concepts that appear together often in the same pieces of text attract one another strongly, and so tend to settle near one another in the map space. The themes aid interpretation by grouping the clusters of concepts, and are shown as colored circles on the map. Each theme takes its name from the most connected concept within that circle. A cluster of conceptually related concepts is grouped by the theme "pipework." The themes are heat-mapped to indicate importance. This means that the "hottest" or most important theme appears in red, the next hottest in orange, and so on according to the color wheel. The Concept Map contains the names of the main concepts that occur within the text. These are shown as gray labels on the map. The size of a concept's dot reflects its connectivity in the concept map. In other words, the larger the concept dot, the more often the concept is coded in the text along with the other concepts in the map.

We agree with the proposed new ESG Reporting Guide.

We support for the comments, recommendations and responses presented in their submission (as attached).

In accounting profession submissions, we detect the theme "agree," as shown in Fig. 4, which is also associated with the concept "HKEX." The accounting profession includes both accounting bodies and accounting firms, both of which generally agreed with the proposal. A relevant text hit was as follows:

We agree with the proposal and the rationale put forward by the HKEX.

In NGO comment letters, we detect the theme "GRI," as shown in Fig. 5, which is related to the theme "proposed." As some NGOs are international organizations, they suggested that the HKEX guide should be consistent with the GRI standards. A relevant text hit was as follows:

G4 reporting as automatic compliance with the HKEX Guide.....



Fig. 3. Concept map of the consultation responses to review of ESG Reporting Guide in Hong Kong submitted by Investors (Users in narrower sense). (Visible Concepts 33%, Theme Size 33%, Rotation 0^{0}). Notes: The concepts are clustered into higher-level "themes" when the map is generated. Concepts that appear together often in the same pieces of text attract one another strongly, and so tend to settle near one another in the map space. The themes aid interpretation by grouping the clusters of concepts, and are shown as colored circles on the map. Each theme takes its name from the most connected concept within that circle. A cluster of conceptually related concepts is grouped by the theme "pipework." The themes are heat-mapped to indicate importance. This means that the "hottest" or most important theme appears in red, the next hottest in orange, and so on according to the color wheel. The Concept Map contains the names of the main concepts that occur within the text. These are shown as gray labels on the map. The size of a concept's dot reflects its connectivity in the concept map. In other words, the larger the concept dot, the more often the concept is coded in the text along with the other concepts in the map.

In submissions from the "Other Institutions" group, we again identify the theme "proposed," as shown in Fig. 6, which is associated with the concept "disclosure." Stakeholders in this group generally supported the proposal of upgrading the guide to mandatory. A relevant text hit was as follows:

.....supports the proposal of disclosure of ESG reporting by.....

In individuals' comment letters, we detect the theme "comply," as shown in Fig. 7, which is linked to the theme "gender" and associated with the concept "HKEX." Individuals generally supported the HKEX proposal and gender disclosure. A relevant text hit was as follows:



Fig. 4. Concept map of the consultation responses to review of ESG Reporting Guide in Hong Kong submitted by Accounting profession. (Visible Concepts 33%, Theme Size 33%, Rotation 0^{θ}). Notes: The concepts are clustered into higher-level "themes" when the map is generated. Concepts that appear together often in the same pieces of text attract one another strongly, and so tend to settle near one another in the map space. The themes aid interpretation by grouping the clusters of concepts, and are shown as colored circles on the map. Each theme takes its name from the most connected concept within that circle. A cluster of conceptually related concepts is grouped by the theme "pipework." The themes are heat-mapped to indicate importance. This means that the "hottest" or most important theme appears in red, the next hottest in orange, and so on according to the color wheel. The Concept Map contains the names of the main concepts that occur within the text. These are shown as gray labels on the map. The size of a concept's dot reflects its connectivity in the concept map. In other words, the larger the concept dot, the more often the concept is coded in the text along with the other concepts in the map.

.....comply with the HKEX guidelines.....

In the second step, to address H1a, H1b and H1c, we compare the relative importance of concepts, measured by their frequency of occurrence based on concept mapping and word frequency, in each of the stakeholder groups' submissions. Overall, we find a statistically significant difference between stakeholder groups in



Fig. 5. Details of the concept "proposal" on the map. Concept map of the consultation responses to review of ESG Reporting Guide in Hong Kong submitted by NGOs. (Visible Concepts 33%, Theme Size 33%, Rotation θ^0). Notes: The concepts are clustered into higher-level "themes" when the map is generated. Concepts that appear together often in the same pieces of text attract one another strongly, and so tend to settle near one another in the map space. The themes aid interpretation by grouping the clusters of concepts, and are shown as colored circles on the map. Each theme takes its name from the most connected concept within that circle. A cluster of conceptually related concepts is grouped by the theme "pipework." The themes are heat-mapped to indicate importance. This means that the "hottest" or most important theme appears in red, the next hottest in orange, and so on according to the color wheel. The Concept Map contains the names of the main concepts that occur within the text. These are shown as gray labels on the map. The size of a concept's dot reflects its connectivity in the concept map. In other words, the larger the concept dot, the more often the concept is coded in the text along with the other concepts in the map.

the mention of important concepts. A Tukey post hoc test demonstrates that preparers' (listed companies') submissions mention the concepts less frequently than those of investors (users in narrower sense) as well as the accounting profession, NGOs and other institutions. Additionally, listed firms have a lower frequency than investors and the accounting profession in the mentioning of "agree." Therefore, preparers lobbied less frequently in the submission of written responses than users did. Table 3 shows the frequency of all identified concepts and the particular concept "agree." Tables 4a and 4b respectively compare the frequency of all identified concepts and the concept "agree" by stakeholder groups. The responses to the closed-ended survey questions are further analyzed in Section 4.2.



Fig. 6. Concept map of the consultation responses to review of ESG Reporting Guide in Hong Kong submitted by Other institutions. (Visible Concepts 33%, Theme Size 33%, Rotation θ^{θ}). Notes: The concepts are clustered into higher-level "themes" when the map is generated. Concepts that appear together often in the same pieces of text attract one another strongly, and so tend to settle near one another in the map space. The themes aid interpretation by grouping the clusters of concepts, and are shown as colored circles on the map. Each theme takes its name from the most connected concept within that circle. A cluster of conceptually related concepts is grouped by the theme "pipework." The themes are heat-mapped to indicate importance. This means that the "hottest" or most important theme appears in red, the next hottest in orange, and so on according to the color wheel. The Concept Map contains the names of the main concepts that occur within the text. These are shown as gray labels on the map. The size of a concept's dot reflects its connectivity in the concept map. In other words, the larger the concept dot, the more often the concept is coded in the text along with the other concepts in the map.

4.2. Analysis of responses to closed-ended questions

The primary responses by the 161 respondents to all 15 closed-ended questions are summarized in Appendix B, among which a total of 55 respondents requested that the HKEX not disclose their company names. As



Fig. 7. Concept map of the consultation responses to review of ESG Reporting Guide in Hong Kong submitted by Individuals. (Visible Concepts 33%, Theme Size 33%, Rotation 0^{θ}). Notes: The concepts are clustered into higher-level "themes" when the map is generated. Concepts that appear together often in the same pieces of text attract one another strongly, and so tend to settle near one another in the map space. The themes aid interpretation by grouping the clusters of concepts, and are shown as colored circles on the map. Each theme takes its name from the most connected concept within that circle. A cluster of conceptually related concepts is grouped by the theme "pipework." The themes are heat-mapped to indicate importance. This means that the "hottest" or most important theme appears in red, the next hottest in orange, and so on according to the color wheel. The Concept Map contains the names of the main concepts that occur within the text. These are shown as gray labels on the map. The size of a concept's dot reflects its connectivity in the concept map. In other words, the larger the concept dot, the more often the concept is coded in the text along with the other concepts in the map.

explained above, the responses (i.e. +1, 0 and -1) to nine specific consultation questions (Q1, Q2, Q3, Q9, and Q11–Q15) are the focus in this analysis. The key changes between the 2012 Guide and the proposed 2015 Guide are highlighted in Appendix C.

In relation to the respondents' attitudes toward HKEX's proposal of mandating ESG reporting in Hong Kong, Table 5 shows that both preparers and investors generally agreed with the HKEX proposals mentioned in Q1 (disclosure of "comply or explain" provisions), Q2 (annual ESG reporting), Q9 (mandatory GDs) and Q15 (gender disclosure), but there were differences between the positions of preparers and investors regarding Q3 (location and time of ESG reports) and Q11–Q14 (mandatory environmental KPIs). Therefore, to address H2, we use a Mann–Whitney test to investigate whether there were significant differences between the positions of lobbying groups regarding the latter set of questions. We find significant differences between preparers and investors regarding Q3 (p = 0.002) and Q11–Q14 (p between 0.002 and 0.010) at the 5 % significance level (H2a). As noted above, users can alternatively be defined broadly to include investors, NGOs, other institutions and individuals. Table 6 demonstrates that preparers and users in the broader sense also tended to take different positions on some of the HKEX's proposals. We find significant differences in the positions between

Table 3				
Comparison of frequency	of identified	concepts l	by stakeholder	group.

		•					
	Ν	Total frequency of concepts	Average frequency of concepts	Total frequency of the concept "agree"		Average frequency of the concept "agree"	
Listed companies	30	1,158	38.6		37		1.23
Investors	39	3,473	89.05		81		2.08
Accounting profession	6	448	74.67		35		5.83
NGOs	17	1,397	82.18	Not detected		Not detected	
Other institutions	27	1,859	68.85		19		0.70
Individuals	42 161	1,365	32.5		52		1.24

Note: the concepts were automatically identified by Leximancer.

preparers and users on Q2 (p = 0.046), Q3 (p = 0.007), Q11 (p = 0.033) and Q12 (p = 0.042) at the 5 % significance level (H2b).

Regarding whether there was any difference in positions between preparers and the accounting profession, Table 7 shows that there is no evidence to reject the null hypothesis for all of the questions that are the focus in this study (Q1, Q2, Q3, Q9 and Q11–15). All *p*-values are non-significant (H2c).

To test the association between stakeholder groups and the HKEX's decision (H3), we use Fisher's exact test, following Kwok and Sharp (2005), Giner and Arce (2012) and Hewa et al. (2018). Table 8 summarizes the numbers of respondents who expressed the three types of opinion (i.e. agreement "+1", no comment "0" and disagreement "-1") for the nine relevant consultation questions. As shown in the "Agreement" column of Table 8, overall, positive opinions were the respondents' most common responses to the HKEX consultation questions. All Fisher's exact test scores except that for Q15 are significant at the 5% level (i.e. *p*-values between 0.000 and 0.033), showing that the HKEX's decision was consistent with the respondent groups' preferences on most of the proposed changes.

5. Discussion and conclusion

The lobbying literature focuses mostly on standard setting for financial reporting by examining the influence of stakeholder groups on the independence of accounting standard setters through submissions of comment letters (e.g. Kwok and Sharp, 2005; Cortese et al., 2010; Giner and Arce, 2012; Beaumont et al., 2018; Hewa et al., 2018). This study, which is based on two conflicting theories, i.e. agency theory and legitimacy theory, extends the lobbying literature to non-financial (specifically ESG) disclosures within accounting research in the Hong Kong context using a novel method that combines Leximancer software and statistical tests.

In the first stage, we use the textual analysis software Leximancer to generate a concept map for each respondent group and identify the differences between preparers and users. The theme "gender" is only found in the comment letters submitted by users (in the broader sense). Hence, users generally supported the proposal of incorporating gender disclosure (albeit voluntarily) as part of social disclosure, whereas some preparers did not agree. The preparers' mixed view on gender disclosure is further tested by Fisher's exact test. Additionally, we detect both the "proposal" and "objection" themes only in the preparers' comment letters. Again, some Hong Kong listed firms did not agree with the proposal of mandating the ESG reporting requirement. Therefore, H2a and H2b are supported by qualitative analysis.

We then use ANOVA to compare the relative importance (measured by frequency) of the word concepts produced by Leximancer. We find significant differences between preparers and users and between preparers and the accounting profession. In terms of the relative frequency of all identified concepts, preparers participated less than all other stakeholder groups except individuals. Regarding the relative frequency of the con-

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cept "agree," preparers agreed with the HKEX proposal less frequently than investors, the accounting profession and individuals, which is in contrast to previous research such as Jorissen et al. (2010), Giner and Arce (2012) and Reuter and Messner (2015) showing that preparers were the most active respondent group and to Kwok and Sharp (2005) showing that the preparer group had a significant influence on IAS 14. Therefore, H1a, H1b and H1c are supported.

In the second stage, we use statistical tests to further compare and analyze the responses to closed-ended questions. In view of the Mann–Whitney test results, we first compare the positions of preparers and investors. Regarding the location and publishing time of ESG reports (Q3), preparers of reports agreed more than investors with issuing ESG reports three months after the publication of financial reports (either as standalone reports or part of the annual report). Hence, preparers advocated more positively than users. However, in view of mandating environmental KPIs (Q11–14), we find the inverse results, that is, investors agreed with the proposal more than preparers. In terms of mandating environmental KPIs, users advocated more positively than preparers. Therefore, H2a is supported by the quantitative analysis. Similar results are found when the users are defined in a broader sense. In addition to the location and time of ESG reports, preparers advocated more positively than users in relation to annual ESG reporting. In contrast, in relation to mandating environmental KPIs, users advocated more positively than preparers advocated more positively than preparers advocated more positively than preparers advocated more positively than users in relation to annual ESG reporting. In contrast, in relation to mandating environmental KPIs, users advocated more positively than preparers regarding Q11 and Q12. Hence, H2b is supported by the quantitative analysis. Comparing the positions of preparers and accountants, we find that both groups tended to advocate similar positions toward the HKEX's proposal in all respects (Q1, Q2, Q3, Q9 and Q11–15 are the focus). All *p*-values are non-significant. Hence, H2c is supported by the quantitative analysis. This result is consistent with agency theory and previous studies such as Reuter and Messner (2015).

Table 4a

	(A) Stakeholder	(B) Stakeholder	Mean difference (A – B)
Tukey HSD	Listed firms	Investors	-50.45***
•		Accounting profession	-36.07***
		NGOs	-43.58***
		Other institutions	-30.25***
		Individuals	6.10***
	Investors	Listed firms	50.45***
		Accounting profession	14.38***
		NGOs	6.87***
		Other institutions	20.20***
		Individuals	56.55***
	Accounting profession	Listed firms	36.07***
		Investors	-14.38***
		NGOs	-7.51***
		Other institutions	5.82***
		Individuals	42.17***
	NGOs	Listed firms	43.58***
		Investors	-6.87***
		Accounting	7.51***
		Other institutions	13.33***
		Individuals	49.68***
	Other institutions	Listed firms	30.25***
		Investors	-20.20***
		Accounting profession	-5.82***
		NGOs	-13.33***
		Individuals	36.35***
	Individuals	Listed firms	-6.1***
		Investors	-56.55***
		Accounting	-42.17***
		NGOs	-49.68***
		Other institutions	_36 35***

Comparison of frequency of all identified concepts by stakeholder groups.

Note: ANOVA test: *** The mean difference is significant at the 0.01 level.

	(A) Stakeholder	(B) Stakeholder	Mean difference (A – B)
Tukey HSD	Listed firms	Investors	-0.85***
•		Accounting profession	-4.60***
		Other institutions	0.53***
		Individuals	-0.01^{***}
	Investors	Listed firms	0.85***
		Accounting profession	-3.75***
		Other institutions	1.38***
		Individuals	0.84***
	Accounting profession	Listed firms	4.60***
		Investors	3.75***
		Other institutions	5.13***
		Individuals	4.59***
	Other institutions	Listed firms	-0.53***
		Investors	-1.38***
		Accounting profession	-5.13***
		Individuals	-0.54***
	Individuals	Listed firms	0.01***
		Investors	-0.84^{***}
		Accounting	-4.59***
		Other institutions	0.54***

Table 4b Comparison of frequency of the concept "agree" by stakeholder group.

Note: ANOVA: *** The mean difference is significant at the 0.01 level.

Table 5 Average positions of listed companies (preparers) and investors (users).

	Q1	Q2	Q3	Q9	Q11	Q12	Q13	Q14	Q15
Preparers	0.70	0.80	0.67	0.63	0.10	0.10	0.17	0.17	0.80
Users	0.72	0.82	0.05	0.79	0.74	0.77	0.74	0.74	0.85
p-value	0.949	0.745	0.002***	0.563	0.004***	0.002***	0.010***	0.007***	0.834

Note: Mann–Whitney test: *** The mean difference is significant at the 0.01 level. "+1" = agree; "0" = no response/neutral; "-1" = disagree.

In view of the decision made by the HKEX during the consultation process, we find a significant association between the large proportion of positive responses (agreement) and the HKEX's decisions on Q1, Q2, Q3, Q9 and Q11–Q14, which is consistent with Giner and Arce (2012) and Hewa et al. (2018). Therefore, H3 is supported. Table 9 summarizes the 2015 Consultation Conclusions on the proposed ESG Guide in 2015, in conjunction with the statistical test results found in this study.

This study makes several contributions. First, it contributes to the literature by addressing the lack of research into stakeholder groups' responses during the development of mandatory ESG reporting in the East Asian context. Previous lobbying studies focus mostly on the financial reporting context. As the literature on lobbying around ESG reporting in the Hong Kong context is scant, our findings provide an interesting case of a change from voluntary to mandatory ESG reporting, adding to the stream of East Asian-based ESG report-

Table 6 Average positions of listed companies (preparers) and users (broader sense).

01										
	Q1	Q2	Q3	Q9	Q11	Q12	Q13	Q14	Q15	
Preparers	0.70	0.80	0.67	0.63	0.10	0.10	0.17	0.17	0.80	
Users	0.64	0.648	0.304	0.624	0.536	0.528	0.512	0.536	0.712	
p-value	0.229	0.046**	0.007***	0.470	0.033**	0.042**	0.111	0.092	0.232	

Note: Mann–Whitney test: *** The mean difference is significant at the 0.01 level. ** The mean difference is significant at the 0.05 level. "+1" = agree; "0" = no response/neutral; "-1" = disagree.

Table 7	
Average positions of listed companies (preparers) an	d the accounting profession.

	Q1	Q2	Q3	Q9	Q11	Q12	Q13	Q14	Q15
Preparers	0.70	0.80	0.67	0.63	0.10	0.10	0.17	0.17	0.80
Accounting profession	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83
<i>p</i> -value	0.817	1.000	0.849	0.798	0.098	0.098	0.140	0.140	1.000

Note: Mann-Whitney test. "+1" = agree; "0" = no response/neutral; "-1" = disagree.

ing research in one of the largest international financial centers. To the best of our knowledge, this is the first accounting study to analyze different stakeholder groups' responses to the HKEX's proposal of mandating ESG reporting in Hong Kong. Second, this study extends the ESG and lobbying literature methodologically by using mixed methods including textual analysis software, Leximancer, to analyze open-ended survey responses qualitatively and statistical tests to analyze closed-ended survey responses quantitatively. Third, the results show that the HKEX remained independent during the development of ESG reporting, and its decision was not influenced by those preparers who opposed (selected "No" to) the consultation questions, but was consistent with stakeholders' preferences overall. Theoretically, the fairly unbiased standard-setting process can be explained by legitimacy theory. Last, the findings show that users were the leading stakeholder group in submitting responses (both in terms of the number of submissions and the frequency of concepts identified in this study) to the HKEX on mandating ESG (non-financial) reporting, in contrast with research on the mandating of financial reporting showing that preparers submitted the majority of comment letters or had a significant influence (Cortese et al., 2010; Hewa et al., 2018). Furthermore, the present study finds that preparers and users took different positions, whereas preparers and the accounting profession took similar positions on the mandating of ESG reporting when lobbying the HKEX. This evidence is consistent with agency theory.

Furthermore, this study provides practical implications for relevant stakeholders including regulators, preparers (via managers), users, the accounting profession and regulators of other stock exchanges. For example, by mandating ESG reporting, the HKEX—being the frontline regulator—sends a clear signal to the financial market that there will be a large demand for professional ESG experts, thus attracting potential workers who are considering a career in ESG. Additionally, this study finds that the HKEX attracted not only large but also medium and small-sized listed firms (preparers) to participate in the consultation process, as ESG reporting is equally applicable to small and medium-sized firms, in contrast with previous research demonstrating that mainly large firms participated in the public consultation process (Sutton, 1984). Moreover, listed firms, being the preparers, will consider both the future benefits and costs of preparing ESG reports when they lobby the HKEX. From the users' perspective, investors prefer that preparers provide more relevant information (i.e. ESG information in this study) to aid their investment decision-making when they look for socially responsible stocks. Furthermore, the accounting profession plays a key role in the standard-setting process for ESG reporting. However, previous studies show that preparers and the accounting profession adopt similar positions in their comment letters (Reuter and Messner, 2015). To safeguard the integrity of the financial markets in the context of ESG reporting and disclosures, accountants' professionalism and independence must not be influenced by other parties. This study also provides policy implications for other stock exchanges that plan to incorporate mandatory ESG reporting requirements into their Listing Rules. From the regulators' perspectives, standard setters' independence should not be compromised during the due process of mandating nonfinancial disclosures. Additionally, listed firms (preparers) that have conflicts of interest with investors (users) will tend to lobby against any proposal to mandate non-financial reporting requirements. Therefore, the consultation process should be vigorous and transparent in terms of involving multiple means of communication and stages of consultation.

However, this study has several limitations. The first is our sample size, which is restricted to a limited number of respondents and excludes submissions in Chinese. Second, the analysis is restricted to comment letters voluntarily submitted by respondents. Therefore, this study's reliance on comment letters to draw inferences about the influence of lobbying may have introduced bias (Camfferman and Zeff, 2018). Future research could explore other means of responses to a Consultation Paper to gain a comprehensive picture of stakeholder

Table 8	
Fisher's exact test for the significance of stakeholder	r groups' responses to closed-ended questions by question.

Question	Total	Agreement "+1"	No comment "0"	Disagreement "-1"	Expected N	Residual	Significance
1. Disclosure of "comply	or expla	in" provisions					
Preparers	30	24	3	3	20.90	3.10	0.033**
Investors	39	30	7	2	27.10	2.90	
Accounting Profession	6	5	1	0	4.20	0.80	
NGOs	17	11	6	0	11.80	-0.80	
Other Institutions	27	13	14	0	18.80	-5.80	
Individuals	42	29	12	1	29.2	-0.2	
Total	161	112	43	6			
2. Annual ESG reporting	ţ						
Preparers	30	26	2	2	21.20	4.80	0.023**
Investors	39	32	7	0	27.60	4.40	
Accounting Profession	6	5	1	0	4.20	0.80	
NGOs	17	11	6	0	12.00	-1.00	
Other Institutions	27	14	13	0	19.10	-5.10	
Individuals	42	26	14	2	29.70	-3.70	
Total	161	114	43	4			
3. Location and time of 1	ESG repo	orts					
Preparers	30	23	4	3	16.00	7.00	0.001***
Investors	39	15	11	13	20.80	-5.80	
Accounting Profession	6	5	1	0	3.20	1.80	
NGOs	17	8	6	3	9.10	-1.10	
Other Institutions	27	11	15	1	14.40	-3.40	
Individuals	42	24	15	3	22.40	1.60	
Total	161	86	52	23			
9. Mandatory General D	isclosure						
Preparers	30	23	3	4	20.30	2.70	0.008***
Investors	39	31	8	0	26.40	4.60	
Accounting Profession	6	5	1	0	4.10	0.90	
NGOs	17	11	6	0	11.50	-0.50	
Other Institutions	27	13	14	0	18.30	-5.30	
Individuals	42	26	13	3	28.40	-2.4	
Total	161	109	45	7			
11. Mandatory Environm	iental KP	Is					
Preparers	30	15	3	12	17.00	-2.00	0.000***
Investors	39	29	10	0	22.00	7.00	
Accounting Profession	6	5	1	0	3.40	1.60	
NGOs	17	11	6	0	9.60	1.40	
Other Institutions	27	10	16	1	15.30	-5.30	
Individuals	42	21	18	3	23.70	-2.70	
Total	161	91	54	16			
12. Mandatory Environm	iental KP	Is					
Preparers	30	15	3	12	17.00	-2.00	0.000***
Investors	39	30	9	0	22.00	8.00	
Accounting Profession	6	5	1	0	3.40	1.60	
NGOs	17	11	6	0	9.60	1.40	
Other Institutions	27	10	16	1	15.30	-5.30	
Individuals	42	20	18	4	23.70	-3.70	
Total	161	91	53	17			
13. Mandatory Environm	iental KP	Is					
Preparers	30	16	3	11	16.80	-0.80	0.000***
Investors	39	29	10	0	21.80	7.20	

Question	Total	Agreement "+1"	No comment "0"	Disagreement "-1"	Expected N	Residual	Significance
Accounting Profession	6	5	1	0	3.40	1.60	
NGOs	17	11	6	0	9.50	1.50	
Other Institutions	27	9	17	1	15.10	-6.10	
Individuals	42	20	18	4	23.50	-3.50	
Total	161	90	55	16			
14. Mandatory Environm	ental KP	PIs					
Preparers	30	16	3	11	17.30	-1.30	0.000***
Investors	39	30	8	1	22.50	7.50	
Accounting Profession	6	5	1	0	3.50	1.50	
NGOs	17	11	6	0	9.80	1.20	
Other Institutions	27	9	17	1	15.60	-6.60	
Individuals	42	22	17	3	24.30	-2.30	
Total	161	93	52	16			
15. Gender disclosure							
Preparers	30	26	2	2	23.30	2.70	0.468
Investors	39	34	4	1	30.30	3.70	
Accounting Profession	6	5	1	0	4.70	0.30	
NGOs	17	11	5	1	13.20	-2.20	
Other Institutions	27	18	8	1	21.00	-3.00	
Individuals	42	31	9	2	32.60	-1.60	
Total	161	125	29	7			

Table 8 (continued)

Note: Fisher's exact test. *** **p < 0.01**, ****p < 0.05**.

groups' influence in development of ESG (non-financial) reporting requirements. Moreover, future studies could consider more than one event when investigating other proposed changes to Listing Rules. In addition, comparative studies between Hong Kong and other countries that have mandated ESG reporting at the stock exchange level could be conducted. Finally, future research could investigate stakeholders' lobbying activities around the mandating of the global sustainability reporting standards proposed by the International Sustainability Standards Board.

Conflict of interest

Ricky C.K. Chung declares that he has no conflict of interest. Lyndie Bayne declares that she has no conflict of interest. Jacqueline Birt declares that she has no conflict of interest.

Acknowledgment

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Appendix A. 2015 HKEX Consultation Questions¹¹

1. Do you agree with our proposal to amend Rule 13.91 to require issuers to disclose in their annual reports or ESG reports whether they have complied with the "comply or explain" provisions in the ESG Guide and if they have not, they must give considered reasons in the ESG reports?

¹¹ Hong Kong Exchanges and Clearing Limited 2015, *Consultation Paper on Environmental, Social and Governance Reporting Guide*. Available from:https://www.hkex.com.hk/-/media/HKEX-Market/Listing/Rules-and-Guidance/Other-Resources/Environmental-Social-and-Governance/Exchange-Publications-on-ESG/cp201507.pdf?la=en [11 February 2019].

Table 9						
Lobbying and	Consultation	Conclusions	on the	proposed	2015	Guide.

Consultation questions	2015 Guide (proposed)	HKEX decision	Interpretation of test results
1. Disclosure of "comply or explain" provisions	This Guide comprises two levels of disclosure obligations: (a) "comply or explain" provisions; and (b) recommended disclosures. An issuer must report on the "comply or explain" provisions of this Guide. If the issuer does not report on one or more of these provisions, it must provide reasons in its ESG report.	Adopted (effective from 2016)	Fisher's exact test (significant): HKEX was associated with stakeholder groups.
2. Annual ESG reporting	An issuer must disclose ESG information on an annual basis and regarding the same period covered in its annual report.	Adopted (effective from 2016)	Fisher's exact test (significant): HKEX was associated with stakeholder groups.
3. Location and time of ESG reports	An ESG report may be presented as information in the issuer's annual report, in a separate report, or on the issuer's website. Whichever format is adopted, the ESG report should be published on the Exchange's website and the issuer's website. Where not presented in the issuer's annual report, the issuer should publish this information as close as possible to, and in any event no later than three months after, the publication of the issuer's annual report.	Adopted (effective from 2016)	Fisher's exact test (significant): HKEX was associated with stakeholder groups.
9. Mandatory General Disclosures	"Comply or explain"	Adopted (effective from 2016)	Fisher's exact test (significant): HKEX was associated with
11–14. Mandatory Environmental KPIs	"Comply or explain"	Adopted but the implementation date was postponed by one year (i.e. commencing on or after 1 January 2017)	Fisher's exact test (significant): HKEX was associated with stakeholder groups.
15. Gender disclosure	All Recommended Disclosures	Adopted (incorporated the wording of "gender")	Fisher's exact test (not significant): HKEX was not associated with
	Total workforce by gender, employment type, age group and geographical region.	May upgrade the Social KPIs to "comply or explain" in due course	stakeholder groups.
	Employee turnover rate by gender, age group and geographical region.		

- 2. Do you agree with our proposal to amend Rule 13.91 to require the issuer to report on ESG annually and regarding the same period covered in its annual report?
- 3. Do you agree with our proposal to include a Note under Rule 13.91 to clarify that:
 - (i) an ESG report may be presented as information in its annual report, in a separate report, or on the issuer's website; and
 - (ii) the issuer should publish the ESG report as close as possible to, and in any event no later than three months after, the publication of the issuer's annual report?

- 4. Do you agree with our proposal to revise the introductory section of the Guide into four areas (i.e. "The Guide", "Overall Approach", "Reporting Principles" and "Complementing ESG Discussions in the Business Review Section of the Directors' Report"), and with the wording set out in Appendix II to the Consultation Paper?
- 5. Do you agree with the proposed wording of the Reporting Principles (i.e. "Materiality", "Quantitative", "Balance" and "Consistency") in the introductory section of the Guide, as set out in Appendix II to the Consultation Paper?
- 6. Do you agree with the proposed wording in the Guide linking it to Appendix 16 to the Main Board Listing Rules (in relation to the requirement for ESG discussions in the business review section of the directors' report), as set out in Appendix II to the Consultation Paper?
- 7. Do you agree with the proposal to re-arrange the Guide into two Subject Areas (A. Environmental and B. Social) and re-categorise "Workplace Quality", "Operating Practices" and "Community Involvement" under Subject Area B?
- 8. Do you agree with the proposal to change the heading "Workplace Quality" to "Employment and Labour Standards"?
- 9. Do you agree with our proposal to upgrade the General Disclosures for each Aspect of the ESG Guide to "comply or explain"?
- 10. Do you agree with our proposal to amend the wording of paragraph (b) under current Aspects A1, A2, A4, B1, C2 and C3, re-numbered Aspects A1, B1, B2, B4, B6 and B7, to "compliance with relevant laws and regulations that have a significant impact on the issuer..." in order to align it with the language of the relevant provisions of the Companies Ordinance?
- 11. Do you agree with our proposal to revise proposed Aspect A1 ("Emissions") by upgrading to "comply or explain" the current KPIs B1.1, B1.2, B1.4 and B1.5, re-numbered KPIs A1.1, A1.2, A1.4 and A1.5, concerning disclosure of emissions and non-hazardous waste?
- 12. Do you agree with our proposal to upgrade to "comply or explain" the current KPIs B1.3 and B1.6, renumbered KPIs A1.3 and A1.6, concerning disclosure of hazardous waste?
- 13. Do you agree with our proposal to upgrade to "comply or explain" the KPIs under the current Aspect B2, re-numbered Aspect A2, "Use of Resources"?
- 14. Do you agree with our proposal to upgrade to "comply or explain" the current KPI B3.1, re-numbered KPI A3.1, concerning disclosure of the significant impacts of activities on the environment and natural resources?
- 15. Do you agree with our proposal to incorporate gender disclosure in proposed Subject Area B. Social, under the sub-heading "Employment and Labour Standards"?

Appendix B. Summary of overall responses to the 2015 consultation paper

("1" = agree; "0" = no response; "-1" = disagree).

No. Constituents	Respondents	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15
1 Preparers	AAC Technologies	1	1	-1	1	1	1	-1	-1	1	1	1	1	1	1	1
	Holdings															
2 Preparers	AIA Group Ltd	1	1	1	1	-1	1	1	1	1	1	1	1	1	1	1
3 Preparers	Cathay Pacific Airways Ltd	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
4 Preparers	China CITIC Bank Co Ltd	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5 Preparers	CLP Holdings Ltd	1	1	-1	0	-1	1	1	1	1	1	1	1	1	1	1
6 Preparers	Henderson Land	1	1	1	1	1	1	1	1	-1	1	-1	-1	-1	-1	1
7 Preparers	Hong Kong Ferry Holdings	1	1	1	1	1	1	1	1	-1	1	-1	-1	-1	-1	1
8 Preparers	HSBC Holdings pls	1	1	1	1	1	-1	1	1	1	1	1	1	1	1	1
9 Preparers	Manulife International Ltd	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
10 Preparers	MTR Corporation Ltd	1	1	1	1	1	1	1	1	1	1	1	-1	1	1	1
11 Preparers	New World Development	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

No.	Constituents	Respondents	Q1 (Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15
12	Preparers	Pacific Andes International	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	Preparers	Sa Sa International	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
		Holdings															
14	Preparers	Standard Chartered pls	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
15	Preparers	The Hong Kong and	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
		Shanghai Hotels															
16	Preparers	Listed Company 1	-1	1	1	1	1	-1	1	1	-1	1	-1	-1	-1	-1	1
17	Preparers	Listed Company 2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
18	Preparers	Listed Company 3	1	1	0	1	1	1	1	1	1	1	-1	-1	-1	-1	-1
19	Preparers	Listed Company 4	1	1	1	1	1	1	1	1	1	1	-1	-1	-1	-1	1
20	Preparers	Listed Company 5	1	1	1	1	1	1	1	1	1	1	-1	-1	-1	-1	1
21	Preparers	Listed Company 7	1	1	1	1	1	1	1	1	1	1	-1	-1	-1	-1	1
22	Preparers	Listed Company 8	1	1	1	1	1	1	-1	1	1	1	1	1	1	1	1
23	Preparers	Listed Company 9	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
24	Preparers	Listed Company 10	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
25	Preparers	Listed Company 11	1	1	1	1	1	1	1	1	1	1	-1	-1	-1	-1	-1
26	Preparers	Listed Company 13	-1	1	1	-1	-1	1	1	1	1	1	-1	-1	-1	-1	1
27	Preparers	Listed Company 14	-1	-1	1	1	-1	-1	1	1	-1	1	-1	-1	-1	-1	1
28	Preparers	Listed Company 15	1	-1	-1	-1	1	-1	1	1	1	1	-1	1	1	1	1
29	Preparers	Listed Company 16	1	1	1	1	1	1	1	1	1	1	-1	-1	-1	-1	1
30	Preparers	Listed Company 17	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
31	Other	Asia Capital Markets	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	institutions	Institute															
32	Other	Asian Corporate	1	1	-1	1	1	1	1	1	1	1	1	1	1	1	1
	institutions	Governance Association															
33	Accounting	ACCA	1	1	1	1	-1	-1	-1	1	1	1	1	1	1	1	1
	profession																
34	Other	Association of Executive	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	institutions	Search and Leadership															
		Consultants															
35	Other	Hong Kong Association of	1	1	1	1	1	1	1	1	1	1	1	1	1	1	-1
	institutions	Banks	_	_	_	-	-	_	_	-		-	_	_	_	_	_
36	Accounting	Hong Kong Institute of	1	1	1	1	-1	1	1	1	1	1	1	1	1	1	1
	profession	Certified Public															
	F	Accountants															
37	Other	Hong Kong Institute of	1	0	1	1	1	1	0	0	0	0	0	0	0	0	0
2,	institutions	Directors	-	Ū	-			-	0	0	Ū	0	U	Ŭ	U	0	0
38	Other	Hong Kong Institute of	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
20	institutions	Qualified Environmental		-	-	1	1	1	1	1	-	1	-		-	1	
	motivations	Professionals Ltd															
39	Other	Out Leadership	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
57	institutions	out Leudership	Ū	v	v	0	0	0	0	0	U	0	v	v	v	v	•
40	Other	Principles for Responsible	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	institutions	Investment	v	0	v	0	0	0	0	v	v	0	0	v	v	v	0
41	Other	The British Chamber of	1	1	1	1	1	1	_1	_1	1	1	1	1	1	1	1
71	institutions	Commerce in Hong Kong			1	1	1	1	1	1	1	1	1	Ŧ	1	1	1
42	Other	The Canadian Chamber of	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	institutions	Commerce in Hong Kong	•	•	•						•			•	•	•	1

Appendix B (continued)

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No.	Constituents	Respondents	Q1 (Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14 (Q15
43	Other	The Chamber of Hong	1	1	1	1	1	1	1	1	1	1	-1	-1	-1	-1	1
	institutions	Kong Listed Companies															
44	Other	The Hong Kong Institute of	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0
	institutions	Chartered Secretaries															
45	Other	The Hong Kong Society of	0	1	0	1	1	0	0	0	0	1	0	0	0	0	1
	institutions	Financial Analysts															
46	Other	The Law Society of Hong	1	1	1	0	0	0	1	1	1	0	0	0	0	0	0
	institutions	Kong															
47		Allied Environmental	1	1	1	1	-1	1	1	1	1	1	1	1	1	1	1
		Consultants Ltd															
48	Investors/	APG Investments Asia Ltd	1	1	-1	1	1	1	1	1	1	1	1	1	1	1	1
	Analysts																
49	Investors/	Baillie Gifford & Co	1	1	-1	1	1	1	1	1	1	1	1	1	1	1	1
	Analysts			-	-	1	1	1	1	1	-	1		-		-	
50	Investors/	BlackBock	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
50	Analysts	Dideki(Oek	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
51	Investors/	BMO Global Asset	1	1	_1	1	1	1	1	1	1	_1	1	1	1	1	1
51	Analysts	Management EMEA	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
52	Investors/	British Columbia	1	1	_1	1	1	1	1	1	1	_1	1	1	1	1	1
52	Applyets	Investment Management	1	1	-1	1	1	1	1	1	1	-1	1	1	1	1	1
	Analysis	Corporation															
52	Investors	Colifornia Public	0	Δ	0	Δ	0	0	0	0	0	0	0	0	0	0	0
33	A malwata	California Public	U	U	U	0	0	0	0	0	U	0	U	U	U	U	U
	Analysis	Sustem															
51	Investors	System,	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
54	Investors/	Carbon Care Asia	1	1	1	-1	1	1	I	1	1	1	1	1	1	1	1
	Analysts		1	1	4	1	1	1	1	1	1	1	1	1	1	1	1
22	Investors/	Creative Investment	1	1	I	1	1	1	1	1	I	1	1	1	1	1	1
	Analysts	Research		1	4	1	1	1	1	1	•	1	1	4		4	1
56	Investors/	Crowe Horwath (HK)	1	I	I	1	1	I	I	I	0	1	1	1	1	I	1
	Analysts	Consulting & Valuation Ltd				0				1							
57	Investors/	CSR-Today	1	I	I	0	I	I	I	I	I	1	1	1	1	1	I
50	Analysts				1	1	1	1	1	1		1	1	4		4	1
58	Accounting	Deloitte Touche Tohmatsu	1	I	I	I	I	I	I	I	I	1	I	1	1	1	I
50	profession					1		1		1							
59	Investors/	East Capital International	1	I	-1	I	I	I	I	I	I	I	1	1	1	1	I
	Analysts	AB															
60	Investors/	Energy Use Strategy	1	1	-1	1	1	I	1	1	1	1	1	1	1	1	1
	Analysts	Advisors															
61	Accounting	Ernst & Young	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	profession																
62	Investors/	Fidelity Worldwide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Analysts	Investment															
63	Investors/	Fleishman Hillard Hong	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	Analysts	Kong Ltd															
64	Investors/	Glass Lewis & Co	1	1	1	0	1	1	0	0	1	0	0	0	0	1	1
	Analysts																
65	Investors/	Hermes Investment	1	1	-1	1	1	1	1	1	1	1	1	1	1	1	1
	Analysts	Management															

Appendix B (continued)

No.	Constituents	Respondents	Q1 (Q2	Q3	Q4	Q5	Q6	Q7 (Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15
66	Investors/	Investec Asset Management	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1
	Analysts	C															
67	Accounting	KPMG	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	profession																
68	Investors/	Legal & General Investment	1	1	1	0	1	1	1	1	1	1	1	1	0	1	1
	Analysts	Management															
69	Investors/	Local Authority Pension	1	1	0	1	1	1	0	1	1	0	1	1	1	1	1
0,7	Analysts	Fund Forum	-	-	0	-		-	0		-	0	-	-	-	-	-
70	Investors/	MN	1	1	_1	1	1	1	1	1	1	1	1	1	1	1	1
10	Analysts	1/11 (-	-	-	1	1	1	1	1	-	1		-	-		-
71	Investors/	Norges Bank Investment	1	1	_1	1	1	1	1	1	1	1	1	1	1	1	1
/1	Analysts	Management	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
72	Accounting	PricewaterhouseCoopers	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
12	nrofaction	ThewaternouseCoopers	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
72	Investoral	Dainhaw Consultance I to	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1
15	A polyesto	Rambow Consultancy Ltd	-1	1	U	1	1	1	1	-1	1	1	1	1	1	1	-1
74	Analysis	Dod Links I to	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
/4	Investors/	Red Links Ltd	U	U	U	0	0	0	0	0	U	0	U	U	U	U	U
75	Analysts	DC C	0	•	0	0	0	0	0	0	0	0	0	0	0	0	0
/5	Investors/	RS Group	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Analysts	~															
76	Investors/	Sedgwick Richardson	1	1	1	1	1	1	1	l	1	1	1	1	1	1	1
	Analysts	(Hong Kong) Ltd															
77	Investors/	Shinewing Risk Services Ltd	1	1	1	1	1	1	1	1	1	1	1	1	1	-1	1
	Analysts																
78	Investors/	Teachers Insurance and	1	1	-1	1	1	1	1	1	1	1	1	1	1	1	1
	Analysts	Annuity Association of															
		America and College															
		Retirement Equities Fund															
79	Investors/	The Purpose Business Ltd	1	1	1	-1	-1	1	1	1	1	1	1	1	1	1	1
	Analysts																
80	Investors/	USS Investment	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Analysts	Management															
81	Investors/	Market Practitioner 1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Analysts																
82	Investors/	Market Practitioner 2	1	1	-1	1	1	1	1	1	1	1	1	1	1	1	1
	Analysts																
83	Investors/	Market Practitioner 3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Analysts																
84	Investors/	Market Practitioner 4	1	1	-1	1	-1	1	1	1	1	1	1	1	1	1	1
	Analysts																
85	Investors/	Market Practitioner 5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	Analysts		-		-		-	-	-	-	-			-	-		_
86	Investors/	Market Practitioner 6	1	1	0	0	0	0	0	0	1	0	0	0	0	0	1
00	Analysts		-	-	Ŭ	Ŭ	0	0	Ŭ	0	-	Ŭ	v	v	v	v	-
87	Investors/	Market Practitioner 7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
57	Analysts		U	v	v	0	0	v	v	U	v	0	0	0	0	v	
88	Investors/	Market Practitioner 8	_1	1	_1	1	1	1	1	1	1	1	1	1	1	1	1
50	Analysts			•		1	1	1	1	1		1	1	1			

Appendix B (continued)

Appendix	B	(continued)
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No. Constitu	uents Respondents	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15
89 Investor	rs/ Market Practitioner 9	1	1	0	0	1	0	0	1	1	0	1	1	1	1	1
Analyst	ts															
90 NGOs	Business Environment	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Council															
91 NGOs	Catalyst	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
92 NGOs	Ceres	1	1	-1	1	1	1	1	1	1	-1	1	1	1	1	1
93 NGOs	Civiv Exchange	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
94 NGOs	Climate Disclosure	1	1	-1	0	1	1	1	0	1	0	1	1	1	1	0
	Standards Board															
95 NGOs	Community Business Ltd	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
96 NGOs	Global Reporting Initiative	1	1	1	1	-1	1	1	-1	1	1	1	1	1	1	-1
97 NGOs	Greenpeace East Asia	1	1	1	0	1	1	0	0	1	0	1	1	1	1	0
98 NGOs	Oxfam Hong Kong	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
99 NGOs	The Women's Foundation	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Ltd															
100 NGOs	Women in Finance Asia	1	1	-1	1	1	1	1	1	1	1	1	1	1	1	1
101 NGOs	World Green Organisation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
102 NGOs	WWF Hong Kong	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
103 NGOs	NGO 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
104 NGOs	NGO 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
105 NGOs	NGO 3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
106 NGOs	NGO 4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
107 Other	American Express	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
instituti	ions International Inc.															
108 Other	British Council Hong Kong	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
instituti	ions															
109 Other	Community Investment and	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
instituti	ions inclusion Fund															
110 Other	Consumer Council	0	1	0	1	0	0	1	0	1	0	1	1	0	0	0
instituti	ions															
111 Other	Direct Link Worldwide	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
instituti	ions Company Ltd															
112 Other	Equal Opportunities	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
instituti	ions Commission															
113 Other	FTSE Russell	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
instituti	ions															
114 Other	Fuji Xerox Hong Kong Ltd	1	1	1	1	1	1	1	-1	1	1	1	1	1	1	1
instituti	ions															
115 Other	The Hong Kong Council of	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
instituti	ions Social Service															
116 Other	The University of Hong	1	1	1	1	-1	1	1	1	1	1	1	1	1	1	1
instituti	ions Kong (Centre for															
	Comparative and Public															
	Law)															
117 Other	Other Institution 1	1	1	1	1	-1	1	1	1	1	1	1	1	1	1	1
instituti	ions															
118 Other	Other Institution 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
instituti	ions															

Appendix B (continued)

No. Constitu	ients Respondents	Q1 (Q2	Q3	Q4 (Q5	Q6	Q7 (Q8	Q9	Q10	Q11	Q12	Q13	Q14 (Q15
119 Other	Other Institution 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
instituti	ons															
120 Individu	uals Ben Ridley	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
121 Individu	uals Justin Li	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
122 Individu	uals Rando Wang To Yuen	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
123 Individu	uals Vincent C.Y. Kong	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
124 Individu	uals Listed Company Staff 2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
125 Individu	uals Listed Company Staff 3	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
126 Individu	uals Listed Company Staff 5	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0
127 Individu	uals Listed Company Staff 7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
128 Individu	uals Listed Company Staff 10	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
129 Individu	uals Listed Company Staff 11	1	1	1	1	1	1	1	1	1	1	-1	-1	-1	-1	1
130 Individu	uals Sunita Subramoniam	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
131 Individu	uals Elaine Young	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
132 Individu	uals Tiffany Cheng	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
133 Individu	uals Retail Investor 1	1	-1	-1	1	1	1	1	1	-1	1	-1	-1	-1	-1	-1
134 Individu	uals Retail Investor 2	1	1	1	0	0	0	1	-1	1	1	1	1	1	1	1
135 Individu	uals Retail Investor 6	1	0	0	0	0	0	1	0	1	0	0	0	0	0	0
136 Individu	uals Retail Investor 7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
137 Individu	uals Amanda Yik	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
138 Individu	uals Ben Ami Capell Cohen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
139 Individu	uals Carmen Ng	1	0	0	0	0	0	1	0	1	0	0	0	0	0	0
140 Individu	uals Hanah Paik	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1
141 Individu	uals Hon Emily Lau	1	1	1	0	0	0	0	0	0	0	0	0	0	0	1
142 Individu	uals Hon Kenneth Leung	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
143 Individu	uals J Robert Gibson	1	1	1	1	-1	1	1	1	1	1	1	1	1	1	1
144 Individu	uals Joseph Tong	1	1	1	1	-1	1	-1	1	1	1	1	-1	1	1	1
145 Individu	uals Leung Sze Man	1	1	-1	-1	1	1	1	1	-1	-1	1	1	1	1	1
146 Individu	uals Nicola Roseman	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
147 Individu	uals Rosemary Halfhead	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
148 Individu	uals Other Individual 1	1	1	0	0	1	0	1	1	1	0	0	0	0	1	0
149 Individu	uals Other Individual 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
150 Individu	uals Other Individual 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
151 Individu	uals Other Individual 4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
152 Individu	uals Other Individual 5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
153 Individu	uals Other Individual 6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
154 Individu	uals Other Individual 7	1	1	1	0	0	0	1	0	0	0	0	0	0	0	0
155 Individu	uals Other Individual 9	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1
156 Individu	uals Other Individual 10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
157 Individu	uals Other Individual 12	1	1	1	1	1	1	1	1	1	1	1	1	-1	1	1
158 Individu	uals Other Individual 13	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
159 Individu	uals Other Individual 17	1	1	1	-1	-1	1	1	1	1	1	1	1	1	1	1
160 Individu	uals Other Individual 18	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
161 Individu	uals Other Individual 22	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Appendix C. Key differences between the 2012 Guide and the proposed 2015 Guide by themes¹²

Consultation Question	2012 Guide	2015 Guide (proposed)
1. Disclosure of "comply or explain" provisions	N/A	This Guide comprises two levels of disclosure obligations: (a) "comply or explain" provisions; and (b) recommended disclosures. An issuer must report on the "comply or explain" provisions of this Guide. If the issuer does not report on one or more of these provisions, it must provide reasons in its ESG report.
2. Annual ESG Reporting	The Exchange encourages an issuer to report regarding the same period as in the annual report.	An issuer must disclose ESG information on an annual basis and regarding the same period covered in its annual report.
3. Location and time of ESG reports	An issuer may disclose the ESG information in its annual report regarding the same period covered in the annual report, or in a separate report, in print or on its website. Where the information is included in a separate report, an issuer is free to report on any period.	An ESG report may be presented as information in the issuer's annual report, in a separate report, or on the issuer's website. Whichever format is adopted, the ESG report should be published on the Exchange's website and the issuer's website. Where not presented in the issuer's annual report, the issuer should publish this information as close as possible to, and in any event no later than three months after, the publication of the issuer's annual report.
9. Mandatory General Disclosures	All Recommended Disclosures	"Comply or explain"
11–14. Mandatory Environmental KPIs	All Recommended Disclosures	"Comply or explain"
15. Gender disclosure	All Recommended Disclosures Total workforce by employment type, age group and geographical region. Employee turnover rate by age group and geographical region.	All Recommended Disclosures Total workforce by gender, employment type, age group and geographical region. Employee turnover rate by gender, age group and geographical region.

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¹² Hong Kong Exchanges and Clearing Limited 2015, *Consultation Paper on Environmental, Social and Governance Reporting Guide*. Available from:https://www.hkex.com.hk/-/media/HKEX-Market/Listing/Rules-and-Guidance/Other-Resources/Environmental-Social-and-Governance/Exchange-Publications-on-ESG/cp201507.pdf?la=en [11 February 2019].

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Real effects of greenhouse gas disclosures

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ABSTRACT

This study investigates the valuation and real effects of the mandatory disclosure of greenhouse gas (GHG) emission costs from the perspective of "double materiality." We consider a firm with a Cobb-Douglas production function that combines GHG-related and non-GHG-related investments to produce short-term and long-term returns. In particular, the GHG-related investment entails short-term and long-term social costs of GHG emissions, including corporate costs and negative externalities. We demonstrate how the mandatory disclosure of the long-term costs of GHG emissions affects capital market valuations and corporate investment decisions relative to a non-disclosure regime. The social welfare in an accounting regime hinges on three parameters: the persistence of the short-term investment return, the ratio of the productivity of GHG-related investment to that of non-GHG-related investment, and the social cost parameter for GHG emissions. Our findings suggest that disclosing the long-term costs of GHG emissions may be detrimental to social welfare. Specifically, the non-disclosure regime results in higher social welfare than the disclosure regime for high values of these parameters. © 2024 Sun Yat-sen University. Production and hosting by Elsevier B.V. This

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1. Introduction

In recent years, proposals to mandate disclosures of greenhouse gas (GHG) emission costs have been put forward. Proponents of GHG disclosure maintain that businesses should report on financially material topics

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that influence enterprise value as well as topics material to the economy, environment, and people ("double materiality").

In 2023, the International Sustainability Standards Board issued IFRS S2-Climate-Related Disclosures, which will become effective in 2024. To comply with these standards, a company will disclose information enabling investors to assess the effect of climate-related risks and opportunities on the company. In the U. S., in 2022, the Securities and Exchange Commission (SEC) proposed new rules for disclosures of prospective risks and material impacts on the business, strategy, and outlook caused by climate change, including Scope 1 and Scope 2 GHG emissions and Scope 3 emissions if material or if the registrant has set a GHG emissions reduction target that includes Scope 3 emissions (SEC, 2022).¹ Similarly, in China, the Ministry of Ecology and Environment mandated disclosures of annual GHG emissions effective from 2022.

Proponents of GHG disclosures focus on the valuation effects. Gary Gensler, the SEC Chair, states that "investors representing literally tens of trillions of dollars support climate-related disclosures because they recognize that climate risks can pose significant financial risks to companies, and investors need reliable information about climate risks to make informed investment decisions" (SEC, 2022). However, scant attention is paid to the real effects of GHG disclosures. In this study, we investigate both the valuation and the real effects of mandatory disclosure of GHG emission costs. In particular, we highlight the negative externality of GHG emissions and elucidate the issue of double materiality.

To study the real effects of GHG disclosure, we model a Cobb-Douglas technology that requires a *combination* of GHG-related and non-GHG-related investments produce short-term and long-term investment returns. A real-world example is industrial furnaces and furnace operators, which must be combined in a production process. Moreover, the GHG-related investment K produces short-term and long-term GHG emissions. The long-term GHG emission cost is disclosed in the disclosure regime but not in the non-disclosure regime. Disclosing the long-term GHG emission costs is equivalent to disclosing the GHG-related investment K. The non-GHG-related investment I can be broadly interpreted as organization capital and is commingled with routine operating expenses (Lev and Radhakrishnan, 2005), thus remaining hidden from the capital market in both regimes. In the model, the capital market prices the firm based on accounting disclosures, and, anticipating the valuation effects of accounting, the firm chooses a combination of K and I to maximize its expectation of the market price.

To rank accounting regimes, we define the social welfare as the sum of the expected values of the short-term and long-term investment returns less the costs of investments and the sum of the short-term and long-term social costs of GHG emissions.

The main results hinge on three parameters: the persistence of the short-term investment return, the productivity ratio (the productivity of K relative to that of I), and the social cost parameter for GHG emissions. We find that the non-disclosure regime induces higher social welfare for high values of those three parameters, whereas the disclosure regime induces higher social welfare for low values of these three parameters.

Our results imply that regulators and accounting standard setters should tailor the mandatory disclosure requirements to the values of these three parameters.

Our main results are driven by the interactions between the valuation and real effects of GHG disclosures. Different disclosure regimes will induce different market price reactions. The anticipation of such different valuation effects of accounting will induce different corporate real decisions (i.e., in K and I) (Kanodia, 2007; Kanodia and Sapra, 2016). Hence, the valuation and real effects form a feedback loop and jointly influence social welfare. For this reason, broader disclosure under the disclosure regime does not necessarily imply higher social welfare.

Specifically, the valuation effects induce several corporate investment distortions in the two regimes relative to a full-information setting. A comparison of those distortions determines the ranking of the two regimes.

¹ According to the U.S. Environmental Protection Agency, Scope 1 GHG emissions are direct GHG emissions that occur from sources that are controlled or owned by an organization (e.g., emissions associated with fuel combustion in boilers, furnaces, vehicles, etc.). Scope 2 GHG emissions are indirect GHG emissions associated with the purchase of electricity, steam, heat, or cooling. Scope 3 GHG emissions are the result of activities from assets not owned or controlled by the reporting organization but that the organization indirectly affects in its value chain.
3

First, in both regimes, the non-GHG-related investment *I* is hidden from the market, and this *hidden action problem* dampens the firm's incentive to invest in *I*. Intuitively, if a productive action is unobservable to the market, a firm lacks sufficient motivation to invest in it. This is a typical example of corporate myopia induced by capital market pressures (Stein, 1989).

Moreover, a higher productivity of I implies a larger opportunity cost of insufficient I. In other words, when I is more productive, the cost of not investing sufficiently becomes more significant, intensifying the hidden action problem. Given that a higher productivity of I is equivalent to a lower productivity ratio, it is analogous to saying that a lower productivity ratio exacerbates the hidden action problem for I.

Second, the firm's incentive to invest in the GHG-related investment K differs between the two regimes, as explained below.

In the disclosure regime where K is disclosed, the firm has a *bundling incentive* to boost its K. Because the two types of investments are combined to produce returns, the capital market uses the observable K to infer the unobservable I. Hence, the firm is incentivized to boost its K to induce a higher perceived I.

The strength of the bundling incentive is influenced by the productivity ratio. A higher productivity of I implies that it is *more rewarding* for the firm to boost its K to communicate a higher I to the market. As higher productivity of I is equivalent to a lower productivity ratio, *a higher productivity ratio mitigates the bundling incentive*.

In the non-disclosure regime where K is not disclosed, two distortions of K emerge: a *hidden action problem* and a *signaling incentive*. The former discourages K and the latter encourages it.

Similar to I, K is hidden from the market in the non-disclosure regime, resulting in a hidden action problem that dampens the firm's incentive to boost K.

Because the short-term investment return is unaffected by the hidden action problem, the downward distortion of K will be worsened if the market attaches a lower weight to the short-term return. The lower the persistence of the short-term return, the less weight the market attaches to the short-term return. In brief, *lower persistence exacerbates the hidden action problem for K and strengthens the downward distortion of K*.

Furthermore, because the corporate cost parameter for GHG emissions is hidden, firms have an incentive to signal a low value of the cost parameter. As in standard signaling models (Spence, 1974), in a fully revealing signaling equilibrium, a firm uses a high level of disclosure of the short-term GHG emission cost to signal the low value of its cost parameter. To maintain that high level, the firm must choose a high level of K. In other words, the signaling incentive stimulates K.

The forces discussed above drive our main results.

Persistence. Recall that in the non-disclosure regime, lower persistence of the short-term return exacerbates the hidden action problem for K. However, such a hidden action problem does not affect the disclosure regime because K is disclosed. As such, sufficiently low persistence damages social welfare in the non-disclosure regime, making the disclosure regime more appealing. The opposite holds for sufficiently high persistence.

Productivity ratio. Recall that in both regimes, the hidden action problem for I worsens when the productivity of I is higher (equivalently, when the productivity ratio is lower). In the disclosure regime, this downward distortion of I is partially offset because a higher productivity of I stimulates the bundling incentive. This boosts K and consequently I because these two types of investments are bundled. However, in the non-disclosure regime, no countervailing force exists to offset the downward distortion of I because K is also hidden. Consequently, for a sufficiently high productivity of I (equivalently, for a sufficiently low productivity ratio), the disclosure regime becomes preferable to the non-disclosure regime. The opposite holds for a sufficiently high productivity ratio.

Social cost parameter. Recall that in the non-disclosure regime, the hidden nature of K dampens the firm's investment incentive. As a result, K is lower in the non-disclosure regime than in the disclosure regime. For a sufficiently high social cost parameter, the social planner prefers a regime that induces a lower level of K because of the significant negative externality associated with K. Thus, the non-disclosure regime becomes dominant for a sufficiently high social cost parameter, whereas the opposite holds for a sufficiently low social cost parameter.

In summary, the non-disclosure regime prevails for high values of the persistence, the productivity ratio, and the social cost parameter, whereas the disclosure regime gains dominance for low values of those parameters.

Our main results above elucidate the two components of double materiality, which IFRS S2 defines as follows: *financial materiality*, that is, how sustainability impacts the financial performance and prospects of a company; and *impact materiality*, that is, how a company's activities, operations, and value chain impact external stakeholders and the broader world. In our model, the persistence and the productivity ratio directly capture the aspects of financial materiality, whereas the social cost parameter directly captures those of impact materiality. Hence, our main results inform regulators of the potential real effects of GHG disclosures on double materiality.

The issue of GHG emissions is an example of the "environmental" in "environmental, social, and governance," that is, of the "E" in "ESG." To the extent that negative externalities exist, our model can be applied to general environmental issues in which mandatory disclosures are involved.

Related literature. Our study is at the intersection of two strands of literature, one on the economics of GHG emissions and the other on the real effects of accounting.

In the literature on the economics of GHG emissions or the broader ESG literature, many studies assume that investors prefer green activities (Friedman et al., 2021; Biais and Landier, 2022; Aghamolla and An, 2023; Goldstein et al., 2023; Xue, 2023). Conversely, in this study, we do not make this assumption, nor do Mahieux et al. (2023). Instead, we assume that investors are interested only in the firm's financial performance.

Both Mahieux et al. (2023) and our study examine the real effect of GHG disclosures in a setting in which negative externalities of GHG emissions exist. In Mahieux et al. (2023), tightening the disclosure requirement for domestic firms may induce these firms to outsource more of their production to foreign suppliers, thereby worsening the GHG emissions abroad. Hence, global coordination of disclosure regulations is needed. In our study, a mandatory GHG disclosure eliminates both the hidden action problem and the signaling incentive for the GHG-related investment but introduces a bundling incentive. The social planner needs to trade off those investment distortions in deciding whether to impose mandatory disclosure.

In the literature on the real effects of accounting, similar to our study, most research focuses on the scale of the corporate investments.² Moreover, most such studies identify a single type of distortion. For example, Stein (1989) and Kanodia and Mukherji (1996) identify a downward investment distortion due to the hidden action problem, whereas Bebchuk and Stole (1993), Kanodia and Lee (1998), and Kanodia et al. (2005) highlight an upward investment distortion due to the firm's incentive to signal its hidden information (Spence, 1974). Conversely, we introduce both downward and upward investment distortions.

Two studies identify two types of distortions. In Lu and Sivaramakrishnan (2018), the amortization schedule of the asset conveys the time pattern of future economic benefits, thereby incentivizing the firm to overinvest, whereas in Jiang et al. (2023a), the source of the upward investment distortion is signaling. In our study, the upward investment distortion arises either from a bundling incentive (in the disclosure regime) or a signaling incentive (in the non-disclosure regime). In these two studies and ours, an underinvestment incentive exists because of the hidden action problem.

Our study and that of Kanodia et al. (2004, KSV hereafter) are the only studies within the real effects literature to explore a combination of two types of investments. In both their study and ours, a bundling incentive exists in one accounting regime, whereas an underinvestment incentive exists in the other regime. In Kanodia et al. (2004), the underinvestment incentive is due to accounting classification errors, whereas our study features the coexistence of a signaling incentive and a hidden action problem.

The remainder of this study is organized as follows. Section 2 establishes the model and Section 3 describes the alternative accounting regimes. Sections 4 and 5 analyze the disclosure regime and the non-disclosure regime, respectively. Section 6 compares the two regimes in terms of social welfare. Section 7 concludes the study. The Appendix contains the proofs of the propositions.

2. Model setup

Consider a firm with a Cobb-Douglas production function that requires a *combination* of two types of investments to produce short-term and long-term investment returns. Moreover, the GHG-related investment

² There are some exceptions, such as Gigler et al. (2014) and Jiang et al. (2023b), who focus on project selection.

K will directly cause future greenhouse gas (GHG) emissions, but the non-GHG-related investment I will not. As an example, industrial furnaces (K) and furnace operators (I) must be combined in a production process. The non-GHG-related investment I can be broadly interpreted as organization capital, which is "the knowledge used to combine human skills and physical capital into systems for producing and delivering wantsatisfying products" (Evenson and Westphal, 1995).

We model both K and I for three reasons. First, in reality, K alone cannot generate investment returns. It must be combined with I (for a combination of two types of investments, see Kanodia et al. (2004) and Dessein and Prat (2022)). Second, we investigate how mandating the disclosure of GHG information may alter the investment mix of K/I, the ratio of GHG-related investment to non-GHG-related investment. Third, we aim to fill a gap in the literature on the real effects of accounting by studying two types of investments that differ in terms of externality, where the GHG-related investment K is a natural candidate for the source of an externality and the non-GHG-related investment I does not cause an externality (see Mahieux et al. (2023) for a GHG model that introduces an externality and does not distinguish between K and I).

At date 0, the firm chooses a combination of K and I that will produce a short-term return x_1 at date 1 and a long-term return x_2 at date 2. In addition, because of the GHG-related investment K, the firm incurs L_1 , a short-term cost of GHG emissions at date 1, and L_2 , a long-term cost of GHG emissions at date 2.

The investment returns x_1 and x_2 follow a joint normal distribution:

$$\binom{x_1}{x_2} \sim N\left(\binom{K^{\alpha}I^{\beta}}{K^{\alpha}I^{\beta}}, \begin{pmatrix}\sigma^2 & \rho\sigma^2\\ \rho\sigma^2 & \sigma^2\end{pmatrix}\right),\tag{1}$$

where

- K is productive ($\alpha > 0$), N is productive ($\beta > 0$), and the two types of investments generate decreasing returns to scale ($r \equiv \alpha + \beta < 1$);³
- the persistence of x_1 into x_2 is positive and imperfect (correlation coefficient $\rho \in [0, 1]$).

The GHG-related investment K entails the corporate costs of GHG emissions. Specifically, the short-term and long-term corporate costs of GHG emissions are $L_1 \equiv mK$ and $L_2 \equiv m^2 K$ respectively, where m is the corporate cost parameter for GHG emissions and its probability density function is f(m) on the support $(1, \overline{m})$.

Negative externalities are a hallmark feature of GHG-related investments. They represent the costs of climate change that are imposed on parties other than the firm creating them, that is, families, communities, businesses, and others. We introduce the *social costs* of GHG emissions, which consist of two components: the corporate costs of GHG emissions and negative externalities. Specifically, the short-term and long-term social costs of GHG emissions are sL_1 and s^2L_2 , respectively, where s > 1 is the social cost parameter.

There are cases in the real world in which GHG emissions are successfully mitigated by corporate actions, such as through carbon sequestration. As those cases are not excessively damaging to social welfare, our study focuses only on severe cases in which m > 1 and s > 1, which indicate increasing trends of corporate and social emission costs, respectively; that is, $L_2 \equiv m^2 K > L_1 \equiv mK$ and $s^2 L_2 > sL_1$.

We summarize the GHG emission costs as follows:

	short term	long term	
social GHG cost	sL_1	s^2L_2	where $s > 1$
corporate GHG cost	$L_1 \equiv mK$	$L_2 \equiv m^2 K$	where $m > 1$
negative externality	$(s-1)L_1$	$(s^2 - 1)L_2$	

To focus on a financial reporting setting, we introduce corporate disclosure Ω_A and the capital market price *P* at date 1.

³ As in Kanodia et al. (2004), one may assume that the expected output per period is μq , where $q \equiv \mathbb{E}[x_1|K, I] = \mathbb{E}[x_2|K, I] = K^{\alpha}I^{\beta}$ is a quantity and μq is a value. In both Kanodia et al. (2004) and our study, the parameter μ is irrelevant to the ranking of the disclosure and non-disclosure regimes. Thus, we normalize μ to 1 to avoid notational clutter.

We compare two accounting regimes that mandate the date 1 disclosures: a disclosure (D) regime and a non-disclosure (N) regime. Given that L_1 (the short-term corporate cost of GHG emissions) is incurred at date 1, both regimes require its disclosure. However, the disclosure (D) regime mandates the disclosure of L_2 (the long-term corporate cost of GHG emissions), whereas the non-disclosure (N) regime does not. We use $\Omega_A \in {\Omega_D, \Omega_N}$, where $A \in {D, N}$, to denote the date 1 disclosures in an accounting regime. A more detailed discussion of these two regimes is provided in the next section.

At date 1, given $\Omega_A \in \{\Omega_D, \Omega_N\}$, the market price P of the firm is formed in a competitive capital market:

$$P = \mathbb{E}[c + x_2 - L_1 - L_2|\Omega_A],\tag{3}$$

where *c* is the short-term net cash flow, x_2 is the long-term investment return, and L_1 and L_2 are the short-term and long-term corporate costs of GHG emissions, respectively. In particular, the short-term net cash flow *c* (before emission cost L_1) is the short-term investment return x_1 less the costs of investments *I* and *K*:

$$c \equiv x_1 - I - K. \tag{4}$$

At date 0, given its knowledge of *m* (the corporate cost parameter for GHG emissions), the firm chooses a combination of investments $\{K, I\}$ to maximize its expectation of its date 1 market price *P*:

$$\max_{K,I} \quad \mathbb{E}[P|K, I, m]. \tag{5}$$

We assume that the firm places importance on its capital market price P at date 1. For example, for life-cycle reasons, the existing generation of shareholders want to sell their ownership of the firm at date 1 to a new generation of shareholders. Another example is that the corporate manager's compensation is tied to the firm's market price. To highlight the interaction between the firm and investors, we focus on the capital market price P at date 1 (the interim date). Kanodia and Sapra (2016) discuss and justify in detail such price-based objective functions, which place into sharp relief the corporate investment distortions caused by short-term capital market pressure.⁴ If, instead, it was assumed that the firm maximizes its date 2 terminal value, the interim accounting reports at date 1 would be irrelevant.

Expression (3) indicates the valuation effects of accounting: the price P is formed on the basis of the information set Ω_A , which is derived from the firm's accounting reports.

Expression (5) implies the real effects of accounting: the anticipation of the date 1 valuation effects of accounting influences the date 0 corporate real decisions, namely, K and I. Hence, the valuation and real effects of accounting form a feedback loop and jointly influence corporate value creation.

Fig. 1 illustrates the timeline.

3. Accounting regimes

Before introducing alternative accounting regimes, we first derive the equilibrium in a benchmark regime, the full-information regime (Regime F), where neither hidden information nor hidden actions exist at date 1. In this case, the information set of the capital market investors at date 1 is $\Omega_F \equiv \{I, x_1, L_1, L_2\}$, where *I* is the non-GHG-related investment, x_1 is the short-term investment return, and L_1 and L_2 are the short-term and long-term corporate costs of GHG emissions, respectively.

Disclosing both L_1 and L_2 is equivalent to disclosing *m* (the corporate GHG cost parameter) because $L_2 \equiv m^2 K = m \times mK = mL_1$ from (2). In addition, disclosing both L_1 and L_2 is equivalent to disclosing *K* (the GHG-related investment) because $K = \frac{L_1^2}{L_2} = \frac{(mK)^2}{m^2 K}$.

At date 1, given the investors' information set $\Omega_F \equiv \{I, x_1, L_1, L_2\}$, the market price of the firm is

$$P_F = c + \left[\rho x_1 + (1-\rho)K^{\alpha}I^{\beta}\right] - L_1 - L_2, \tag{6}$$

⁴ Alternatively, one may assume that the firm's objective function is its expectation of a weighted average of the short-term price and the terminal value. This alternative assumption would not alter the nature of our results because the firm continues to care about the short-term price P, albeit to a lesser extent.



Fig. 1. Illustrates the timeline.

which is derived in the proof of Proposition 1 in the Appendix. In (6), $c \equiv x_1 - I - K$ is the short-term net cash flow, and $\rho x_1 + (1 - \rho)K^{\alpha}I^{\beta}$ is the investors' date 1 estimate of the date 2 investment return x_2 . This estimate is a weighted average of the short-term investment return x_1 and the prior mean $K^{\alpha}I^{\beta}$ of x_2 , where the weight on x_1 is ρ , representing the persistence of x_1 .

Next, we derive both the level and the mix of investments K and I, where *investment mix* is defined as a ratio of the GHG-related investment K to the non-GHG-related investment I.

Proposition 1. In the full-information regime (Regime F), the optimal investment mix is

$$\frac{K_F}{I_F} = \frac{\alpha/(1+m+m^2)}{\beta} \tag{7}$$

and the optimal investment levels are

$$K_F = \left(2(\alpha/(1+m+m^2))^{1-\beta}\beta^{\beta}\right)^{\frac{1}{1-\alpha-\beta}}$$

$$I_F = \left(2(\alpha/(1+m+m^2))^{\alpha}\beta^{1-\alpha}\right)^{\frac{1}{1-\alpha-\beta}}$$
(8)

In (7), the investment mix K_F/I_F equals α/β , adjusted for $1 + m + m^2$. The ratio α/β captures the productivity of the GHG-related investment K relative to that of the non-GHG-related investment I. The adjustment $1 + m + m^2$ reflects the marginal corporate cost of emissions caused by K : m is the marginal corporate cost of the short-term GHG emissions $(L_1 \equiv mK)$ and m^2 is the marginal corporate cost of the long-term GHG emissions $(L_2 \equiv m^2K)$.

The full-information regime serves as a benchmark for the two alternative regimes, the disclosure regime (Regime D) and the non-disclosure regime (Regime N). The two regimes share two features.

First, in both regimes, $c \equiv x_1 - I - K$ (the short-term net cash flow before the emission costs) is disclosed at date 1. However, in both regimes, both x_1 (the short-term investment return) and I (the non-GHG-related investment) are buried in c (Kanodia et al., 2004) and thus hidden from the market. Recall that I can be interpreted broadly as organization capital. As Evenson and Westphal (1995) note, organization capital is "tacit, not physically embodied and neither codified nor readily transferable." As a result, disclosures of this kind of information cannot be ex-post corroborated or ex-ante verified (Jiang et al., 2023a), and organization capital is expensed as incurred and commingled with routine operating expenses, such as selling, general, and

administrative expenses (Lev and Radhakrishnan, 2005; Eisfeldt and Papanikolaou, 2013).⁵ As a result, neither x_1 nor I is separately disclosed and both are buried in $c \equiv x_1 - I - K$.⁶

Second, accounting standards require an entity to disclose the near-term effects of environmental matters (FASB, 2021). Accordingly, the short-term corporate cost of GHG emissions, L_1 , is disclosed at date 1 in both regimes.

The two regimes differ in the accounting treatment of GHG-related activities. Regime D requires firms at date 1 to disclose L_2 (the long-term corporate cost of GHG emissions). Because $K = \frac{L_1^2}{L_2}$ by (2) and L_1 is required to be disclosed in both regimes, Regime D effectively requires disclosure of K. In contrast, in Regime N, no disclosure of L_2 exists and thus, effectively, K is not disclosed.⁷ Naturally, Regime D mandates a broader date 1 disclosure than Regime N:

$$\Omega_D \equiv \{c, L_1, L_2\}
\Omega_N \equiv \{c, L_1\}$$
(9)

We define an equilibrium as follows:

Definition 1. Given the disclosures Ω_A in the regime $A \in \{N, D\}$ in (9), a perfect Bayesian equilibrium consists of the following components:

- given Ω_A and the investors' conjecture of corporate investment strategy, the date 1 capital market price *P* is described by (3);
- given its knowledge of the corporate cost parameter *m* for GHG emissions and its conjecture of the market's valuation rule, the firm chooses a combination of investments $\{K, I\}$ at date 0 to maximize its objective in (5); and
- the investors' conjecture of the corporate investment strategy is consistent with the actual corporate investment strategy, and the firm's conjecture of the market's valuation rule is consistent with the actual valuation rule.

To rank accounting regimes, we define the social welfare V as the sum of the expected values of the short-term and long-term investment returns ($\mathbb{E}[x_1] = \mathbb{E}[x_2] = K^{\alpha}I^{\beta}$), less the costs of investments I + K and the sum of the short-term social cost (sL_1) and the long-term social cost (s^2L_2) of GHG emissions:

$$V \equiv 2K^{\alpha}I^{\beta} - I - K - sL_1 - s^2L_2 = 2K^{\alpha}I^{\beta} - I - (1 + sm + s^2m^2)K.$$
(10)

Broader disclosure in Regime D does not necessarily imply higher social welfare V than in Regime N. This is due to the real effects of accounting. Different accounting regimes induce differential market price reactions. The anticipation of such different valuation effects of accounting induces different corporate real decisions (K and I). In turn, these lead to varying levels of social welfare V. Next, we explore which accounting regime achieves a higher level of V in terms of (i) the productivity ratio α/β , (ii) the persistence ρ , and (iii) the social cost parameter s.

⁵ Many firms do not report any information on their R&D activities and indeed commingle R&D expenditures with routine operating expenses. Koh and Reeb (2015) find that 10.5% of non-reporting R&D firms receive patents and that among the firms that have not reported any information on R&D for more than 20 years, 40% have applied for or received patents.

⁶ To see this formally, let OR_1 denote the operating revenue and OE_1 denote the routine operating expense. Then, the short-term return is $x_1 \equiv OR_1 - OE_1$. The organization capital *I* is commingled with OE_1 and thus buried in $OR_1 - (OE_1 + I) = x_1 - I$ included in *c*.

⁷ In the statement of cash flows and the accompanying notes, capital expenditures are not classified into GHG-related and non-GHG-related expenditures. For example, Starbucks disclosed that its capital expenditures were \$2.3 billion in fiscal year 2023 without distinguishing between GHG-related and non-GHG-related investments.



Fig. 2. Investment Distortion in Regime D. The values of parameters are as follows: $\alpha = 0.15$, $r \equiv \alpha + \beta = 0.50$, and m = 1.50.

4. The disclosure regime

In Regime D, the investors' information set at date 1 is $\Omega_D \equiv \{c, L_1, L_2\}$, where c is the short-term net cash flow and L_1 and L_2 are the corporate costs of GHG emissions in the short term and the long term, respectively. The GHG-related investment K is effectively disclosed because $K = \frac{L_1^2}{L_1^2}$.⁸ In this regime, the hidden variables are $\{I, x_1\}$. Because investments K and I are bundled, the investors use K to derive \hat{I} , their inference of I.⁹ Moreover, because $c \equiv x_1 - I - K$ by (4), the investors estimate $\hat{x}_1 = c + \hat{I} + K$.

At date 1, the equilibrium market price of the firm is

$$P_D = c + \left[\rho \hat{x}_1 + (1-\rho)K^{\alpha} \hat{I}^{\beta}\right] - L_1 - L_2,$$
(11)

which is derived in the proof of Proposition 2 in the Appendix.

We define over-mix as $\frac{K_A/I_A}{K_F/I_F} > 1$ and under-mix as $\frac{K_A/I_A}{K_F/I_F} < 1$, where $A \in \{N, D\}$. **Proposition 2.** The optimal investment mix in Regime D relative to that of Regime F is

$$\frac{K_D/I_D}{K_F/I_F} = y_D \equiv 1 + \frac{1}{1-\beta} > 1$$
(12)

and the optimal investment levels in Regime D relative to those in Regime F are

$$\frac{K_D}{K_F} = \left(\frac{y_D^{1-\beta}}{2}\right)^{\frac{1}{1-\alpha-\beta}} < 1$$

$$\frac{I_D}{I_F} = \left(\frac{y_D^{\alpha}}{2}\right)^{\frac{1}{1-\alpha-\beta}} < 1$$
(13)

Therefore, over-mix and underinvestment exist in Regime D.

Fig. 2 illustrates the distortions in the investment levels and investment mix in Regime D relative to the benchmark, Regime F.

To explore the investment distortions in Regime D, we compare the investment mix and levels between Regime D and Regime F and identify the following effects.

Effect D1 (downward distortion in *I*).

This effect is caused by the hidden nature of I. The investors estimate the long-term investment return x_2 as

$$\widehat{x}_2 = \rho \widehat{x}_1 + (1 - \rho) K^{\alpha} \widehat{I}^{\beta}, \text{ where } \widehat{x}_1 = c + \widehat{I} + K, \tag{14}$$

⁸ In addition, the investors can infer *m* using L_2 and *K*: $m = \sqrt{\frac{L_2}{K}}$. ⁹ As shown in the proof of Proposition 2, $\hat{I} = (\beta K^{\alpha})^{\frac{1}{1-\beta}}$ in equilibrium.

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T	υ	

Table 1				
Investment	distortions	in	regime D.	

Effect	Investment Distortion	Reason
D1	downward distortion in I	hidden action I
D2	upward distortion in K	bundling incentive

that is, \hat{x}_2 is a weighted average of the estimated short-term investment return \hat{x}_1 and the estimated prior mean $K^{\alpha} \hat{I}^{\beta}$ of x_2 , where the weight on \hat{x}_1 is ρ , representing the persistence of x_1 .

The firm's incentive to invest in *I* is weaker in Regime D than in Regime F for two reasons. (i) A higher level of *I* decreases the short-term net cash flow $c \equiv x_1 - I - K$ relative to that in Regime F. In turn, this decrease lowers $\hat{x}_1 = c + \hat{I} + K$ and thus lowers the market price P_D . (ii) The market's conjecture \hat{I} and thus $K^{\alpha} \hat{I}^{\beta}$ are unaffected by the firm's actual choice of *I*. Taken together, (i) and (ii) imply that the firm's incentive to invest in *I* is distorted downward.

Effect D2 (upward distortion in K).

A higher value of \hat{I} boosts the market's estimate of x_2 in (14) because it leads to both a higher estimate of the short-term return $\hat{x}_1 = c + \hat{I} + K$ and a higher prior mean $K^* \hat{I}^\beta$ of x_2 . Recall that the market uses the observed K to conjecture \hat{I} . Because K and I are bundled, the market conjectures that a higher level of the former implies a higher level of the latter. Given this market inference, the firm is incentivized to increase K to boost the market's conjecture of \hat{I} . That is, relative to its counterpart in Regime F, K in Regime D is distorted upward.

We summarize the above discussion in Table 1.

Now, we interpret Proposition 2 in terms of Effect D1 and Effect D2.

First, the upward distortion in K (D2) and the downward distortion in I (D1) collectively lead to over-mix, $\frac{K_D/I_D}{K_F/I_F} > 1$.

Second, the hidden nature of I (Effect D1) results in underinvestment in I, that is, $\frac{I_D}{I_E} < 1$.

Third, there are two opposing effects that distort K. One effect distorts K downward. Specifically, because K and I are complementary inputs in the Cobb-Douglas production function, a downward distortion in I (Effect D1) leads to a downward distortion in K.

The other effect distorts K upward. Specifically, the bundling incentive (Effect D2) induces an upward distortion in K. To see this, note from (36) in the Appendix that the first-order condition with respect to K in equilibrium is given by

$$2\alpha K^{\alpha-1}I^{\beta} + \frac{\alpha}{1-\beta}\frac{I}{K} - \left(1+m+m^2\right) = 0$$

Compared with its counterpart in Regime F, (26) in the Appendix, there is an extra term, namely, $\frac{\alpha}{1-\beta} \frac{I}{K} > 0$, which reflects Effect D2.

Which of the above two effects dominates? We find that Effect D1 dominates Effect D2, resulting in underinvestment in *K*, that is, $\frac{K_D}{K_F} < 1.^{10}$ There are two reasons for this result. First, Effect D1 is more fundamental than Effect D2. Without the hidden nature of *I* (which causes Effect D1), Effect D2 would not occur because it is the existence of the hidden action *I* that gives rise to the incentive to use *K* to communicate *I* in the first place. Second, the extent of Effect D2 is limited by the decreasing returns to scale ($\alpha + \beta < 1$) of the technology. Note from (33) in the Appendix that the elasticity of \hat{I} with respect to *K* is

$$\frac{d\widehat{I}}{dK}\frac{K}{\widehat{I}} = \frac{\alpha}{1-\beta} < 1.$$

¹⁰ As $L_1 + L_2 = (m + m^2)K$, the total emission costs move in the same direction as K. Therefore, a downward distortion of K will lead to a decrease in $L_1 + L_2$, and vice versa.

That is, on observing a 1 conjecture \hat{I} will increase by less than 1 This limits the firm's incentive to boost K to communicate I, thereby limiting Effect D2. (However, in a setting of constant or increasing returns to scale, Effect D2 may dominate.)

We define α/β as the productivity ratio, which is the ratio of the productivity of *K* (the GHG-related investment) to that of *I* (the non-GHG-related investment). Next, we delve into the effects of productivity ratio α/β on the investment distortions.

Proposition 3. In Regime D, as the productivity ratio α/β decreases,

(A) the over-mix increases,

(B) the magnitude of underinvestment in I increases, and

(C) the magnitude of underinvestment in K increases.

The intuition behind Proposition 3 is as follows. The lower the value of α/β , the more productive *I* is relative to *K*. Therefore, it is more rewarding for the firm to induce a higher level of \hat{I} (the market's conjecture of *I*). Because the market believes that the two types of investments are bundled, the firm is more motivated to boost its investment in *K*. In other words, as α/β decreases, Effect D2 becomes stronger, resulting in a greater degree of over-mix.

The productivity ratio α/β also affects the *levels* of the investments. In the extreme case where β is 0, meaning that *I* is not productive at all, it is optimal to avoid investing in *I* in Regimes F and D. In other words, *I* is 0 in both regimes and thus no underinvestment in *I* exists at all. When the productivity of *I* is higher (that is, when α/β is lower), the hidden action problem for *I* becomes more severe, and the firm sacrifices greater benefits due to underinvestment. Thus, $\frac{I_D}{I_F}$ becomes smaller; in other words, the magnitude of the underinvestment in *I* is larger.

Because I and K are bundled, a larger magnitude of underinvestment in I is bundled with a larger magnitude of underinvestment in K^{11} .

5. The non-disclosure regime

In Regime N, the investors' information set at date 1 is $\Omega_N \equiv \{c, L_1\}$, where *c* is the short-term net cash flow and L_1 is the corporate cost of GHG emissions in the short term.

As $L_1 = mK$, the market makes a conjecture, \hat{K} , and utilizes it, along with L_1 , to make an inference about m: $\hat{m}(\hat{K}, L_1)$. The market also uses \hat{K} to derive \hat{I} (its conjecture of I) because investments K and I are bundled.¹² Moreover, because $c \equiv x_1 - I - K$ by (4), the investors estimate x_1 as $\hat{x}_1 = c + \hat{I} + \hat{K}$. Finally, using the disclosure of L_1 and its conjecture \hat{K} , the market estimates $L_2 : \hat{L}_2 = \frac{L_1^2}{2}$.

At date 1, the equilibrium market price of the firm is

$$P_N = c + \left[\rho \widehat{x}_1 + (1-\rho) \widehat{K}^{\alpha} \widehat{I}^{\beta}\right] - L_1 - \widehat{L}_2, \tag{15}$$

which is derived in the proof of Proposition 4 in the Appendix.

Proposition 4. The optimal investment mix in Regime N relative to that of Regime F is

$$\frac{K_N/I_N}{K_F/I_F} = y_N \equiv 1 + \frac{\rho m - (1-\rho)m^2}{1+\rho + m + 2m^2}$$
(16)

and the optimal investment levels in Regime N relative to those of Regime F are

¹² As shown in the proof of Proposition 4, $\hat{I} = \left(\beta \hat{K}^{\alpha}\right)^{\frac{1}{1-\beta}}$ in equilibrium.

¹¹ Recall from the earlier discussion that a lower value of α/β strengthens Effect D2 and thus enhances the firm's incentive to invest in *K*. However, the extent of Effect D2 is limited, as discussed. Therefore, the net effect is that a lower value of α/β induces larger magnitude of underinvestment in *K*.

$$\frac{K_N}{K_F} = \left(\frac{y_N^{1-\beta}}{2}\right)^{\frac{1}{1-\alpha-\beta}}$$

$$\frac{I_N}{I_F} = \left(\frac{y_N^{\alpha}}{2}\right)^{\frac{1}{1-\alpha-\beta}}$$
(17)

Underinvestment in I and K exists: $\frac{I_N}{I_F} < 1$ and $\frac{K_N}{K_F} < 1$.

Fig. 3 illustrates the distortions in the investment mix and levels in Regime N.

To delve into the investment distortions in Regime N, we compare the investment mix and levels between Regime N and Regime F and identify the following effects.

Effect N1 (downward distortion in *I*).

The intuition mirrors that of Effect D1 in Regime D. Hidden action I results in a hidden action cost and thus an insufficient investment incentive in I.

Effect N2 (downward distortion in K).

The intuition resembles that of Effect N1, as hidden action K results in hidden action costs and thus an insufficient investment incentive in K.

Effect N3 (upward distortion in K).

This effect is due to the firm's signaling incentive. Recall that m (the corporate cost parameter) is hidden. As in standard signaling models, a low type (a firm with a low value of m) uses a high level of L_1 as a signal. A high type naturally has an incentive to mimic the low type by choosing the same level of L_1 . However, because

the market uses L_1 to conjecture the long-term corporate cost of GHG emissions $(\hat{L}_2 = \frac{L_1^2}{K})$, mimicking is very

costly for a high type because \hat{L}_2 is increasing in L_1 at an increasing rate. In a fully revealing signaling equilibrium, a low type successfully signals its low value of *m* to the market.

The above effects are summarized in Table 2.

As Table 2 implies, Effect N1 causes underinvestment in I. Effect N2 causes a downward distortion in K, whereas Effect N3 causes an upward distortion in K. However, Effect N3 is limited because signaling is costly for firms. As a result, Effect N2 overwhelms Effect N3, resulting in underinvestment in K.

Next, we examine the effects of persistence ρ and the productivity ratio α/β on the investment distortions. **Proposition 5A**.

(i) $\frac{K_N/I_N}{K_F/I_F} > 1 \iff \rho > \underline{\rho} \equiv \frac{m}{1+m}$: under-mix occurs for $\rho < \underline{\rho}$ and over-mix occurs for $\rho > \underline{\rho}$.

(ii) The magnitudes of underinvestment in I and K are larger for lower values of ρ .

Recall that Effect N2 identifies a downward distortion in K, which is caused by the insensitivity of the prior mean $\hat{K}^{\alpha}\hat{I}^{\beta}$ to K. The larger the weight attached to $\hat{K}^{\alpha}\hat{I}^{\beta}$, the more severe is the downward distortion in K. As



Fig. 3. Investment Distortion in Regime N. The values of parameters are as follows: $\alpha = 0.15$, $r \equiv \alpha + \beta = 0.5$, and m = 1.50.

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Effect	Investment Distortion	Reason
N1	downward distortion in I	hidden action I
N2	downward distortion in K	hidden action K
N3	upward distortion in K	signaling m

the weight attached to $\widehat{K}^{\alpha}\widehat{I}^{\beta}$ is $1 - \rho$, the lower the persistence ρ , the stronger is Effect N2, which explains Proposition 5A(i).

Effect N2 is strong for lower values of ρ , which leads to more severe underinvestment in K. Because K and I are bundled, underinvestment in I is also more severe for lower values of ρ , which explains Proposition 5A(ii).

Proposition 5B.

In the case of over-mix, the magnitudes of underinvestment in I and K are larger for lower values of α/β . In the case of under-mix, the magnitudes of underinvestment in I and K are larger for higher values of α/β .

In the case of over-mix, the magnitudes of underintestment in I and K are target for higher values of α/β . In the case of over-mix (Panel A in Fig. 3), the distortion in I is more severe than the distortion in K. The higher the productivity of I (i.e., the lower the value of α/β), the more severe is the underinvestment in I. Because K and I are bundled, underinvestment in K is also more severe for a lower value of α/β .

In the case of under-mix (Panel B in Fig. 3), the distortion in K is more severe than the distortion in I. The lower the productivity of I (i.e., the higher the value of α/β), the more severe is the underinvestment in K. Because K and I are bundled, underinvestment in I is also more severe for a higher value of α/β .

6. Comparison of regimes

Which accounting regime is more desirable? To address this question, we use a measure of social welfare V as described in (10):

$$V \equiv 2K^{\alpha}I^{\beta} - I - K - sL_1 - s^2L_2 = 2K^{\alpha}I^{\beta} - I - (1 + sm + s^2m^2)K.$$
(18)

As a result of the real effects of accounting, the equilibrium *K* and *I* differ between Regimes N and D, leading to different equilibrium values of social welfare:

$$V_{N} \equiv 2K_{N}^{\alpha}I_{N}^{\beta} - I_{N} - (1 + sm + s^{2}m^{2})K_{N}$$

$$V_{D} \equiv 2K_{D}^{\alpha}I_{D}^{\beta} - I_{D} - (1 + sm + s^{2}m^{2})K_{D}$$
(19)

Proposition 6

(a) $V_N > V_D$ for sufficiently large values of the persistence ρ .

(b) $V_N > V_D$ for sufficiently large values of the productivity ratio α/β .

(c) $V_N > V_D$ for sufficiently large values of the social cost parameter s.

In the choice between Regime N and Regime D, the social planner balances the investment distortions N1, N2, and N3 in Regime N against investment distortions D1 and D2 in Regime D. In these two regimes, N1 and D1 are identical distortions, reflecting the downward distortion of I arising from hidden action costs. Therefore, in essence, the comparison of the two regimes involves evaluating N2 and N3 in Regime N, described in Section 5, compared with D2 in Regime D, described in Section 4.

We compare Regime N and Regime D from three perspectives, as Proposition 6 describes: (a) ρ , the persistence of the short-term investment return x_1 into the long-term investment return x_2 ; (b) α/β , the productivity of the GHG-related investment K relative to that of the non-GHG-related investment I; and (c) s, the social cost parameter for GHG emissions.

In the following, we provide the intuitions behind Proposition 6 and use the example of industrial furnaces (K) and furnace operators (I) to illustrate the policy implications.

(a) N dominates D for large values of ρ .

Effect N2 states that the lower the persistence ρ , the stronger is Effect N2. This implies that for sufficiently low values of persistence ρ , Effect N2 is potent enough to cause a severe downward distortion in K_N , which

strengthens the desirability of Regime D relative to that of Regime N. In other words, Regime N is more desirable than Regime D for larger values of ρ .

In the example of industrial furnaces (K) and furnace operators (I), firms in the maturity stage of their life cycle (such as U.S. Steel) typically exhibit high persistence of investment returns. For such firms, the nondisclosure regime is recommended. On the other hand, startups (such as Electra) tend to experience low persistence of returns. For such firms, the disclosure regime is recommended.

(b) N dominates D for large values of α/β .

Effect D2 states that the higher the productivity ratio α/β , the weaker is Effect D2. This implies that for sufficiently high values of the productivity ratio α/β , Effect D2 is sufficiently weak and suppresses the upward distortion in K_D , worsening the underinvestment in K_D . As a result, Regime D is less appealing than Regime N. In other words, Regime N is more desirable than Regime D for larger values of α/β .

In the example of industrial furnaces (K) and furnace operators (I), for those firms with a high productivity ratio (such as a steel mill), the non-disclosure regime is recommended. Conversely, for firms with a low ratio (such as a textile mill), the disclosure regime is recommended.

(c) N dominates D for large values of s.

Recall that K is hidden in Regime N but not in Regime D. As a result, the equilibrium GHG-related investment is lower in Regime N than in Regime D, that is, $K_N < K_D$, as shown at the end of the proof of Proposition 6. For sufficiently large values of s, the social planner favors a regime that induces a lower amount of K because it produces a lower social cost of GHG emissions. In other words, Regime N dominates Regime D for large values of s.

In the example of industrial furnaces (K) and furnace operators (I), for firms with furnaces that release nitrous oxide, the social cost per unit is high (\$18,000 per metric ton according to the Interagency Working Group (2021)), and the non-disclosure regime is recommended. Conversely, for firms with furnaces that release carbon dioxide, the social cost per unit is low (\$51 per metric ton), and the disclosure regime is recommended.

Discussion of assumptions¹³

Negative social value of the firm. Proposition 6 requires the assumption that the social value of the firm is positive, that is, $V_A > 0$ where $A \in \{D, N\}$, which is satisfied if $\frac{1-\beta}{\alpha} > \frac{1+sm+s^2m^2}{1+m+m^2}$ (see (48) in the Appendix). See footNote 14 for an analysis of $V_A < 0$.

In the case of negative social values of the firm, regulators may need to intervene by imposing restrictions on corporate real decisions, such as capping the scale of GHG-related investments and fining the firm for any violations. As this study focuses exclusively on disclosure issues, we leave the discussion of such regulation of real decisions to future research.

Output-based emission costs. In our model, we assume input-based emission costs ($L_1 \equiv mK$ and $L_2 \equiv m^2K$). Specifically, K (e.g., an industrial furnace) directly entails emission costs, whereas I (e.g., a furnace operator) does not. Alternatively, one may assume output-based emission costs: $L_1 \equiv mq$ and $L_2 \equiv m^2q$ where $q \equiv \mathbb{E}[x_1|K, I] = \mathbb{E}[x_2|K, I] = K^{\alpha}I^{\beta}$ is the expected output per period.

As K and I are optimally combined in equilibrium, q is increasing in K in equilibrium. Hence, output-based emission costs are increasing in K, in line with input-based emission costs. For simplicity and without loss of generality, we adopt input-based emission costs in the model.

Specifically, in Regime F, the optimal investment mix in (7) is $mix_F \equiv \frac{K_F}{I_F} = \frac{\alpha/(1+m+m^2)}{\beta}$ and thus $I_F = \frac{K_F}{mix_F}$. Then, the expected output is $q_F = K_F^{\alpha} I_F^{\beta} = \frac{K_F^{\alpha+\beta}}{(mix_F)^{\beta}}$, which is increasing in K_F . Analogously, in Regimes D and N, the expected output is $q_D = K_D^{\alpha} I_D^{\beta} = \frac{K_D^{\alpha+\beta}}{(mix_F \times y_D)^{\beta}}$ and $q_N = K_N^{\alpha} I_N^{\beta} = \frac{K_N^{\alpha+\beta}}{(mix_F \times y_N)^{\beta}}$, respectively. Overall, q_A is increasing in K_A where $A \in \{F, D, N\}$.

Returns to scale. In our model, we assume a decreasing-returns-to-scale technology, that is, $\alpha + \beta < 1$. We make this assumption for tractability because the second-order condition for the optimization problem is satisfied globally under this assumption. However, constant and even increasing returns to scales exist in the

¹³ We thank an anonymous reviewer for suggesting the discussion of the following issues.

	α/β	S	V_D	V_N
Case 1	5.0	1.7	0.000	0.059
Case 2	5.0	1.4	0.064	0.071
Case 3	0.2	1.7	0.334	0.321
Case 4	0.2	1.4	0.364	0.329

Table 3 Regime N versus Regime D in Terms of α/β and s.

Notes: $\rho = 0.50, m = 1.05$, and $r \equiv \alpha + \beta = 0.60$.

economy (see Burnside et al. (1995) and Basu and Fernald (1997) for the macroeconomic evidence and Chang et al. (2009) for the evidence in the public accounting industry). These studies show that heterogeneity in returns to scale exists across industries and across firm sizes. Therefore, our model concerns a subset rather than the whole population of firms and industries. In future research, the model could be extended to cases of constant and increasing returns to scale.

Configuration of parameters. Proposition 6 presents the desirability of Regime N versus Regime D in terms of a particular parameter, taking the values of other parameters as given. Therefore, one may wonder which regime is more desirable if the parameters covary. For example, for different industries accompanying different productivity ratios (α/β), the social cost parameter (s) may vary. We provide a numerical example here to illustrate this issue.

As expected from Proposition 6, when both α/β and *s* are high (Case 1), $V_N > V_D$, and thus Regime N is more desirable than Regime D. Conversely, when both α/β and *s* are low (Case 4), $V_N < V_D$, and thus Regime D is the more desirable regime of the two. In the intermediate cases (Cases 2 and 3), either Regime N or Regime D can be desirable depending on particular combinations of the parameter values. Table 3 shows that a combination of a high value of α/β and a low value of *s* (Case 2) makes Regime N more desirable than Regime D, and a combination of a low value of α/β and a high value of *s* (Case 3) makes Regime D more desirable than Regime N. However, if one alters the values of other parameters such as *m* and ρ , the rankings in Cases 2 and 3 can be reversed.

Voluntary disclosure/silence. In this study, we focus on mandatory disclosure issues. Here, we briefly touch on voluntary disclosure of $L_2 \equiv m^2 K = mL_1$. Because $L_1 \equiv mK$ is required to be disclosed (FASB, 2021), a disclosure of L_2 is equivalent to a disclosure of m, which in turn implies a disclosure of K. There are two ways to communicate m.

One is *auditing*, that is, the firm voluntarily discloses *m* and hires an auditor to attest to it. In this approach (Regime *a*), the social welfare is $V_a \equiv 2K_a^{\alpha}I_a^{\beta} - I_a - (1 + sm + s^2m^2)K_a - F$, where *F* denotes the audit fee.

The other method is *signaling*, that is, the firm uses L_1 to signal *m*. This approach is similar to our Regime N and the social welfare is similar to V_N .

The tradeoff between the signaling cost and the audit cost determines the firm's choice. When the signaling cost exceeds the audit cost, the firm will choose the auditing approach, which involves voluntary disclosure. Otherwise, it will choose the signaling approach, which involves voluntary silence (that is, no direct reporting of m). We leave this important avenue of research for the future.

7. Conclusion

In this study, we investigate the valuation and real effects of mandatory disclosure of the long-term corporate cost of GHG emissions and identify the conditions under which the mandatory disclosure impairs or improves social welfare.

Although disclosures inform investors in the capital markets and thus have valuation effects, they do not solely play the role of "messenger." While making corporate real decisions, firms anticipate the capital market responses to future disclosures and structure their real decisions accordingly. In this sense, by reflecting the world, disclosures do indeed affect the world.

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. Appendix A. Appendix

Proof of Proposition 1

The investors' date 1 information set is $\Omega_F \equiv \{I, x_1, L_1, L_2\}$. By (3), the equilibrium capital market price of the firm is

$$P_F = \mathbb{E}[c + x_2 - L_1 - L_2 | \Omega_F] = c + \mathbb{E}[x_2 | x_1, K, I] - L_1 - L_2,$$
(20)

where $c \equiv x_1 - I - K$ in (4) is known because Ω_F directly discloses *I* and x_1 and indirectly discloses *K* because $K = \frac{L_1^2}{L_2}$.

From the distribution of x_1 and x_2 in (1),

$$\mathbb{E}[x_2|x_1, K, I] = \mathbb{E}[x_2] + \frac{Cov[x_1, x_2]}{Var[x_1]} \times (x_1 - \mathbb{E}[x_1])$$

= $K^{\alpha}I^{\beta} + \frac{\rho\sigma^2}{\sigma^2} \times (x_1 - K^{\alpha}I^{\beta})$
= $\rho x_1 + (1 - \rho)K^{\alpha}I^{\beta}.$

Hence, (20) becomes

$$P_F = c + \left| \rho x_1 + (1 - \rho) K^{\alpha} I^{\beta} \right| - L_1 - L_2.$$
(21)

At date 0, the firm chooses its investments K and I to maximize its objective in (5):

$$\max_{K,I} \quad \mathbb{E}[P_F|K,I,m]. \tag{22}$$

From (21), c in (4), and L_1 and L_2 in (2), (22) becomes

$$\max_{K,I} \quad \mathbb{E} \Big[x_1 - I - K + \rho x_1 + (1 - \rho) K^{\alpha} I^{\beta} - mK - m^2 K | K, I, m \Big].$$
(23)

Moreover, from $\mathbb{E}[x_1|K, I] = K^{\alpha}I^{\beta}$ in (1), (23) becomes

$$\max_{K_{I}} 2K^{\alpha}I^{\beta} - I - (1 + m + m^{2})K.$$
(24)

The first-order condition with respect to I is

$$2\beta K^{\alpha} I^{\beta-1} - 1 = 0 (25)$$

and the first-order condition with respect to K is

$$2\alpha K^{\alpha-1} I^{\beta} \quad -(1+m+m^2) = 0.$$
⁽²⁶⁾

It is straightforward to check that the second-order conditions are satisfied because $\alpha + \beta < 1$. Solving the system of equations (25) and (26) yields (7) and (8) in the statement of the proposition.

Proof of Proposition 2

The investors' date 1 information set is $\Omega_D \equiv \{c, L_1, L_2\}$. Because K and I are bundled to produce investment returns, investors use the observable K to derive \hat{I} , their estimate of I. In addition, because $c \equiv x_1 - I - K$ by (4), using their estimate \hat{I} and the observable K, the investors estimate $x_1 : \hat{x}_1 = c + \hat{I} + K$. Then, analogous to the market's pricing function (6) in the full-information regime, the pricing function in the disclosure regime is

$$P_D = c + \left[\rho \widehat{x}_1 + (1-\rho)K^{\alpha} \widehat{I}^{\beta}\right] - L_1 - L_2.$$
(27)

At date 0, the firm chooses its investments K and I to maximize its objective in (5):

$$\max_{K,I} \quad \mathbb{E}[P_D|K, I, m]. \tag{28}$$

From (27), c in (4), and L_1 and L_2 in (2), (28) becomes

$$\max_{K,I} \quad \mathbb{E}\Big[(1+\rho)(x_1-I) + \rho \widehat{I} + (1-\rho)K^{\alpha} \widehat{I}^{\beta} - (1+m+m^2)K|K,I,m\Big].$$
(29)

Moreover, from $\mathbb{E}[x_1|K, I] = K^{\alpha}I^{\beta}$ in (1), (29) becomes

$$\max_{K,I} \quad (1+\rho)K^{\alpha}I^{\beta} + (1-\rho)K^{\alpha}\widehat{I}^{\beta} - (1+\rho)I + \rho\widehat{I} - (1+m+m^2)K.$$
(30)

The first-order condition with respect to I is

$$(1+\rho)\big(\beta K^{\alpha}I^{\beta-1}-1\big) = 0 \tag{31}$$

and the first-order condition with respect to K is

$$(1+\rho)\alpha K^{\alpha-1}I^{\beta} + (1-\rho)\alpha K^{\alpha-1}\widehat{I}^{\beta} + \frac{\partial\widehat{I}}{\partial K}\left[(1-\rho)\beta K^{\alpha}\widehat{I}^{\beta-1} + \rho\right] - \left(1+m+m^{2}\right) = 0.$$
(32)

By (31), $\beta K^{\alpha} I^{\beta-1} = 1$, which implies that $I = (\beta K^{\alpha})^{\frac{1}{1-\beta}}$. Thus, adopting the firm's perspective, the investors use the observed value of *K* to conjecture $\widehat{I} = (\beta K^{\alpha})^{\frac{1}{1-\beta}}$, which implies that $\frac{\partial \widehat{I}}{\partial K} = \frac{\alpha}{1-\beta} \frac{\widehat{I}}{K}$, or equivalently, the elasticity of \widehat{I} with respect to *K* is

$$\frac{\partial I}{\partial K}\frac{K}{\widehat{I}} = \frac{\alpha}{1-\beta} < 1,\tag{33}$$

where the inequality is from the assumption that $\alpha + \beta < 1$.

Using (33), the first-order condition with respect to K in (32) becomes

$$(1+\rho)\alpha K^{\alpha-1}I^{\beta} + (1-\rho)\alpha K^{\alpha-1}\widehat{I}^{\beta} + \frac{\alpha}{1-\beta}\frac{\widehat{I}}{K}\Big[(1-\rho)\beta K^{\alpha}\widehat{I}^{\beta-1} + \rho\Big] - (1+m+m^2) = 0.$$
(34)

In equilibrium, $\hat{I} = I$. Thus, (34) becomes

$$(1+\rho)\alpha K^{\alpha-1}I^{\beta} + (1-\rho)\alpha K^{\alpha-1}I^{\beta} + \frac{\alpha}{1-\beta}\frac{I}{K} \times \left[(1-\rho)\beta K^{\alpha}I^{\beta-1} + \rho\right] - \left(1+m+m^{2}\right) = 0.$$
(35)

Because $\beta K^{\alpha} I^{\beta-1} = 1$ by (31), (35) becomes

$$2\alpha K^{\alpha-1}I^{\beta} + \frac{\alpha}{1-\beta}\frac{I}{K} - (1+m+m^2) = 0.$$
(36)

It is straightforward to check that the second-order conditions are satisfied because $\alpha + \beta < 1$. Solving the system of equations (31) and (36) yields the optimal investment mix

$$\frac{K_D}{I_D} = \frac{\alpha/(1+m+m^2)}{\beta} \times \frac{2-\beta}{1-\beta} = \frac{K_F}{I_F} \times \frac{2-\beta}{1-\beta}$$
(37)

and the optimal investment levels

$$K_{D} = \left(\left(\frac{2-\beta}{1-\beta}\right)^{1-\beta} (\alpha/(1+m+m^{2}))^{1-\beta} \beta^{\beta} \right)^{\frac{1}{1-\alpha-\beta}} = K_{F} \left(\frac{\left(\frac{2-\beta}{1-\beta}\right)^{1-\beta}}{2} \right)^{\frac{1}{1-\alpha-\beta}}$$

$$I_{D} = \left(\left(\frac{2-\beta}{1-\beta}\right)^{\alpha} (\alpha/(1+m+m^{2}))^{\alpha} \beta^{1-\alpha} \right)^{\frac{1}{1-\alpha-\beta}} = I_{F} \left(\frac{\left(\frac{2-\beta}{1-\beta}\right)^{\alpha}}{2} \right)^{\frac{1}{1-\alpha-\beta}}$$
(38)

where $\frac{K_F}{I_F}$ is given in (7) and I_F and K_F are given in (8) in Proposition 1.

Because $r \equiv \alpha + \beta$ by assumption, (38) can be rewritten as

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$$\frac{K_D}{K_F} = \left(\frac{\left(\frac{2-\beta}{1-\beta}\right)^{1-\beta}}{2}\right)^{\frac{1}{1-r}}$$

$$\frac{I_D}{I_F} = \left(\frac{\left(\frac{2-\beta}{1-\beta}\right)^{\alpha}}{2}\right)^{\frac{1}{1-r}}$$
(39)

By the mathematical fact that $(1+\frac{1}{z})^z$ is increasing in z, one can easily show that $\left(\frac{2-\beta}{1-\beta}\right)^{1-\beta} = \left(1+\frac{1}{1-\beta}\right)^{1-\beta} \in (1,2)$ because $\beta \in (0,1)$. Thus, $\frac{K_D}{K_F} < 1$. Moreover, $\alpha + \beta < 1$ by assumption, and thus $\left(\frac{2-\beta}{1-\beta}\right)^{\alpha} < \left(\frac{2-\beta}{1-\beta}\right)^{1-\beta} < 2$, which implies that $\frac{I_D}{I_F} < 1$.

Finally, we define $y_D \equiv \frac{2-\beta}{1-\beta} = 1 + \frac{1}{1-\beta}$, which exceeds 2 because $\beta > 0$ and y_D is increasing in β .

Recall that $r \equiv \alpha + \beta$, which implies that $\beta \in (0, r)$. It is obvious that $\frac{2-\beta}{1-\beta} = 1 + \frac{1}{1-\beta}$ is increasing in β . Hence, $\frac{2-\beta}{1-\beta} \in (2, \frac{2-r}{1-r})$. Because $\left(1 + \frac{1}{1-\beta}\right)^{1-\beta}$ is decreasing in β for $\beta \in (0, r), \frac{K_D}{K_F}$ in (39) is decreasing in β . Because $\alpha = r - \beta = (1 - \beta) - (1 - r)$, we rewrite $\frac{I_D}{I_F}$ in (39) as follows:

$$\frac{I_D}{I_F} = \left(\frac{\left(\frac{2-\beta}{1-\beta}\right)^{\alpha}}{2}\right)^{\frac{1}{1-r}} = \left(\frac{\left(\frac{2-\beta}{1-\beta}\right)^{1-\beta}}{\left(\frac{2-\beta}{1-\beta}\right)^{1-r} \times 2}\right)^{\frac{1}{1-r}}$$

Because $\left(1+\frac{1}{1-\beta}\right)^{1-\beta}$ is decreasing in β and $\left(1+\frac{1}{1-\beta}\right)^{1-r}$ is increasing in β for $\beta \in (0,r), \frac{I_D}{I_F}$ in (39) is decreasing in β .

Proof of Proposition 4

The investors' date 1 information set is $\Omega_N \equiv \{c, L_1\}$. The investors conjecture \widehat{K} and then derive (i) $\widehat{m}(\widehat{K})$, their estimate of *m*, and (ii) $\widehat{I}(\widehat{K})$, their estimate of *I*.

Because $L_1 \equiv mK$ by (2), using the disclosure of L_1 and their conjecture \widehat{K} , the investors estimate $m : \widehat{m} = \frac{L_1}{K}$. Because $L_2 \equiv m^2 K$ by (2), using their estimates \widehat{m} and \widehat{K} , the investors estimate $L_2 : \widehat{L}_2 = \widehat{m}^2 \widehat{K} = \frac{L_1^2}{\widehat{K}} = \frac{m^2 K^2}{\widehat{K}}$. Because $c \equiv x_1 - I - K$ by (4), using their estimates \widehat{K} and $\widehat{I}(\widehat{K})$, the investors estimate $x_1 : \widehat{x}_1 = c + \widehat{I}(\widehat{K}) + \widehat{K} = x_1 - I - K + \widehat{I}(\widehat{K}) + \widehat{K}$.

Substituting these estimates into $P_N = c + \left[\rho \widehat{x}_1 + (1-\rho)\widehat{K}^{\alpha}\widehat{I}^{\beta}\right] - L_1 - \widehat{L}_2$ in (15), we obtain

$$P_{N} = x_{1} - I - K + \left[\rho\left(x_{1} - I - K + \widehat{I}\left(\widehat{K}\right) + \widehat{K}\right) + (1 - \rho)\widehat{K}^{\alpha}\widehat{I}\left(\widehat{K}\right)^{\beta}\right] - mK - \frac{m^{2}K^{2}}{\widehat{K}}$$

$$= (1 + \rho)(x_{1} - I - K) + \rho\left(\widehat{I}\left(\widehat{K}\right) + \widehat{K}\right) + (1 - \rho)\widehat{K}^{\alpha}\widehat{I}\left(\widehat{K}\right)^{\beta} - mK - \frac{m^{2}K^{2}}{\widehat{K}}.$$

$$(40)$$

At date 0, the firm chooses its investments K and I to maximize its objective in (5). From (40) and by $\mathbb{E}[x_1|K, I] = K^{\alpha}I^{\beta}$ in (1), we have

$$\mathbb{E}[P_N|K,I,m] = (1+\rho)\left(K^{\alpha}I^{\beta} - I - K\right) + \rho\left(\widehat{I}\left(\widehat{K}\right) + \widehat{K}\right) + (1-\rho)\widehat{K}^{\alpha}\widehat{I}\left(\widehat{K}\right)^{\beta} - mK - \frac{m^2K^2}{\widehat{K}}.$$
(41)

The first-order condition with respect to I is

$$(1+\rho)\big(\beta K^{\alpha} I^{\beta-1} - 1\big) = 0 \tag{42}$$

and the first-order condition with respect to K is

$$(1+\rho)(\alpha K^{\alpha-1}I^{\beta}-1) - m - 2m^{2} \times \frac{K}{\hat{K}} = 0.$$
(43)

By (42), $\beta K^{\alpha} I^{\beta-1} = 1$, which implies that $I = (\beta K^{\alpha})^{\frac{1}{1-\beta}}$. Thus, the investors can place themselves in the firm's position and use the conjectured \widehat{K} to conjecture $\widehat{I} = \left(\beta \widehat{K}^{\alpha}\right)^{\frac{1}{1-\beta}}$

As an aside, note that by (43), the single crossing property is satisfied: $\frac{\partial}{\partial m} \left(\frac{\partial \mathbb{E}[P_N|K,I,m]}{\partial K} \right) < 0.$

In equilibrium, $\hat{K} = K$. The first-order condition with respect to I is the same as (42):

$$(1+\rho)\big(\beta K^{\alpha}I^{\beta-1}-1\big) = 0.$$
(44)

Now, the first-order condition with respect to K becomes

$$(1+\rho)(\alpha K^{\alpha-1}I^{\beta}-1) - m - 2m^{2} = 0.$$
(45)

It is straightforward to check that the second-order conditions are satisfied. Solving the system of Eqs. (44) and (45) yields (16) and (17) in the statement of the proposition.

By (17), $L_1 = mK_N = \left(\frac{\beta^{\beta} \alpha^{1-\beta} (1+\rho)^{1-\beta} m^{1-\alpha-\beta}}{(1+\rho+m+2m^2)^{1-\beta}}\right)^{\frac{1}{1-\alpha-\beta}}$. Therefore, $\frac{dL_1}{dm} < 0$ if and only if $(1+\rho+m+2m^2)(1-\alpha-\beta) < (m+4m^2)(1-\beta)$, which holds if $1+\rho < 2m^2$. The last inequality holds because (1) the maximum value of $1 + \rho$ is 2 because $\rho \le 1$ and (2) the minimum value of $2m^2$ is 2 because m > 1.

We define $y_N \equiv 1 + \frac{\rho m - (1-\rho)m^2}{1+\rho+m+2m^2}$, which is increasing in ρ and decreasing in m. When $\rho = 1$ and $m = 1, y_N = 1.2$. When $\rho = 0$ and $m = \infty, y_N = 0.5$. Because $\rho \in [0, 1]$ and $m \ge 1, y_N \in [0.5, 1.2]$.

 $\frac{I_N}{I_F} = \left(\frac{y_N^{\alpha}}{2}\right)^{\frac{1}{1-\alpha-\beta}} < 1 \text{ because } y_N < 2 \text{ and } \alpha < 1. \\ \frac{K_N}{K_F} = \left(\frac{y_N^{1-\beta}}{2}\right)^{\frac{1}{1-\alpha-\beta}} < 1 \text{ because } y_N < 2 \text{ and } 1-\beta < 1.$

Proof of Proposition 5A

Let $\rho \equiv \frac{m}{1+m}$ denote the value of ρ that satisfies $y_N = 1$. Proof of part (i). $\frac{K_N/I_N}{K_F/I_F} = y_N$. Because y_N is increasing in $\rho, \frac{K_N/I_N}{K_F/I_F}$ is increasing in ρ and $\frac{K_N/I_N}{K_F/I_F} > 1 \iff \rho > \rho$.

Proof of part (ii). Because y_N is increasing in ρ , both $\frac{I_N}{I_F} = \left(\frac{y_N^2}{2}\right)^{\frac{1}{1-\alpha-\beta}}$ and $\frac{K_N}{K_F} = \left(\frac{y_N^{1-\beta}}{2}\right)^{\frac{1}{1-\alpha-\beta}}$ are increasing in ρ . Therefore, the lower the value of ρ , the larger are the magnitudes of underinvestment in K and I.

Proof of Proposition 5B

By
$$r \equiv \alpha + \beta$$
, $\frac{I_N}{I_F} = \left(\frac{y_N^{\alpha}}{2}\right)^{\frac{1}{1-r}}$ and $\frac{K_N}{K_F} = \left(\frac{y_N^{1-r+\alpha}}{2}\right)^{\frac{1}{1-r}}$ from (17).

In the case of $y_N < 1$ (under-mix), both $\frac{I_N}{I_F} = \left(\frac{y_N^2}{2}\right)^{\frac{1}{1-r}}$ and $\frac{K_N}{K_F} = \left(\frac{y_N^{1-r+\alpha}}{2}\right)^{\frac{1}{1-r}}$ are decreasing in α/β . Therefore, the higher the value of α/β , the larger are the magnitudes of underinvestment in K and I.

In the case of $y_N > 1$ (over-mix), both $\frac{I_N}{I_F} = \left(\frac{y_N^{\alpha}}{2}\right)^{\frac{1}{1-r}}$ and $\frac{K_N}{K_F} = \left(\frac{y_N^{1-r+\alpha}}{2}\right)^{\frac{1}{1-r}}$ are increasing in α/β . Therefore, the lower the value of α/β , the larger are the magnitudes of underinvestment in K and I.

Proof of Proposition 6

By (18), the generic form of social welfare for Regime A, where $A \in \{N, D\}$, is as follows:

$$V_A \equiv 2K_A^{\alpha} I_A^{\beta} - I_A - \left(1 + sm + s^2 m^2\right) K_A.$$
(46)

By the equilibrium investments in Propositions 2 and 4, we further write a generic form of the equilibrium investments as follows:

$$K_A = \left(y_A^{1-\beta} \beta^\beta (\alpha/(1+m+m^2))^{1-\beta} \right)^{\frac{1}{1-\alpha-\beta}}$$
$$I_A = \left(y_A^{\alpha} \beta^{1-\alpha} (\alpha/(1+m+m^2))^{\alpha} \right)^{\frac{1}{1-\alpha-\beta}}$$

Thus, (46) can be rewritten as

$$V_{A} = \beta^{\frac{\beta}{1-\alpha-\beta}} (\alpha/(1+m+m^{2}))^{\frac{\alpha}{1-\alpha-\beta}} y_{A}^{\frac{\alpha}{1-\alpha-\beta}} [2-\beta - Q\alpha y_{A}],$$

$$(47)$$

where $Q \equiv \frac{1 + sm + s^2m^2}{1 + m + m^2}$.

In this study, we focus on the case in which $V_A > 0$, that is, $2 - \beta - Q\alpha y_A > 0$. Recall from the proof of Proposition 4 that $y_N \equiv 1 + \frac{\rho m - (1-\rho)m^2}{1+\rho+m+2m^2} \in [0.5, 1.2]$ and $y_D \equiv 1 + \frac{1}{1-\beta}$ is greater than 2. Thus, $\frac{y_N}{y_D} < \frac{3}{5}$. As $y_D > y_N$, the condition that $2 - \beta - Q\alpha y_A > 0$ is satisfied if $2 - \beta - Q\alpha y_D > 0$ or, equivalently, if $\frac{1 - \beta}{\alpha} > Q$. Hence, for the rest of the analysis, we assume that

$$\frac{1-\beta}{\alpha} > Q \equiv \frac{1+sm+s^2m^2}{1+m+m^2}.$$
(48)

We define $f(y) \equiv y^{\frac{\alpha}{1-\alpha-\beta}}[2-\beta-Q\alpha y]$. From (47), $V_N > V_D \iff \frac{f(y_N)}{f(y_D)} > 1$. By $r \equiv \alpha + \beta, y_D \equiv 1 + \frac{1}{1-\beta} = 1 + \frac{1}{1-r+\alpha}$ and $f(y) = y^{\frac{\alpha}{1-r}}[2-r+\alpha-Q\alpha y] = y^{\frac{\alpha}{1-r}}[(1-r+\alpha)y_D - Q\alpha y]$, which implies that

$$\frac{f(y_N)}{f(y_D)} = \left(\frac{y_N}{y_D}\right)^{\frac{\alpha}{1-r}} \frac{1-r+\alpha - Q\alpha \times \frac{y_N}{y_D}}{1-r+\alpha - Q\alpha}.$$
(49)

From (49), $\frac{\partial \left(\frac{f(y_N)}{f(y_D)}\right)}{\partial \left(\frac{y_N}{y_D}\right)} > 0 \iff \frac{y_N}{y_D} < \frac{1}{Q}$ if $1 - r + \alpha - Q\alpha > 0$. Because $r \equiv \alpha + \beta$, the condition $1 - r + \alpha - Q\alpha > 0$

is equivalent to $\frac{1-\beta}{\alpha} > Q$, which holds by (48). From (49), $\frac{f(y_N)}{f(y_D)}$ attains its maximal value at $\frac{y_N}{y_D} = \frac{1}{Q}$, $\frac{f(y_N)}{f(y_D)} = 0$ at $\frac{y_N}{y_D} = 0$, and $\frac{f(y_N)}{f(y_D)} = 1$ at $\frac{y_N}{y_D} = 1$. Fig. 4 illustrates $\frac{f(y_N)}{f(y_D)}$ as a function of $\frac{y_N}{y_D}$. Recall from the earlier analysis in this proof that $\frac{y_N}{y_D} < \frac{3}{5}$. Thus, in Fig. 4, the value of $\frac{y_N}{y_D}$ exceeding $\frac{3}{5}$ is infeasible. In addition, $\frac{1}{Q} < 1$ in Fig. 4 because $Q \equiv \frac{1+sm+s^2m^2}{1+m+m^2} > 1$.



Fig. 4. The ratio $\frac{f(y_k)}{|y_k|}$. The values of parameters are as follows: $\alpha = 0.15, r = 0.50, s = 1.64, m = 1.50$, and Q = 2.00.



Fig. 5. The effect of α on $\frac{f(y_n)}{f(y_n)}$. The values of parameters are as follows: r = 0.50, s = 1.64, m = 1.50, and Q = 2.00.

Recall from the above discussion that $V_N > V_D \iff \frac{f(y_N)}{f(y_D)} > 1$. Therefore, from Fig. 4, the region in which Regime N dominates Regime D is $\frac{y_N}{y_D} \in (z, \frac{3}{5}]$, where z is the value of $\frac{y_N}{y_D}$ on the left side of $\frac{1}{Q}$ such that $\frac{f(y_N)}{f(y_D)} = 1$. That is, z is defined by

$$z^{\frac{\alpha}{1-r}}\frac{1-r+\alpha-Q\alpha z}{1-r+\alpha-Q\alpha} = 1.$$
(50)

Fig. 4 clearly indicates the following results: (i) for $\frac{v_N}{y_D} < z$, $\frac{f(v_N)}{f(v_D)} < 1$ and thus $V_N < V_D$; and (ii) for $\frac{v_N}{y_D} > z$, $\frac{f(v_N)}{f(v_D)} > 1$, and thus $V_N > V_D$.¹⁴ Proof of part (a):(i) As ρ increases, z does not change because (50) is unaffected by ρ .(ii) As ρ increases,

Proof of part (a):(i) As ρ increases, z does not change because (50) is unaffected by ρ .(ii) As ρ increases $y_N \equiv 1 + \frac{\rho m - (1-\rho)m^2}{1+\rho+m+2m^2}$ increases $(\frac{dy_N}{d\rho} > 0)$, and thus $\frac{y_N}{y_D}$ increases.

By (i) and (ii), for sufficiently high values of ρ , $\frac{v_N}{v_D} > z$ and thus $\frac{f(v_N)}{f(v_D)} > 1$, which implies that $V_N > V_D$. Proof of part (b): We first prove the following claim.

Claim: As α increases, z decreases.

Proof: Let us define $R \equiv \frac{f(y_N)}{f(y_D)}$ and $w \equiv \frac{y_N}{y_D}$. Then, (49) can be rewritten as

$$R = w^{\frac{\alpha}{1-r}} \frac{1-r+\alpha - Q\alpha w}{1-r+\alpha - Q\alpha}.$$
(51)

We define the elasticity of R with respect to w as $\varepsilon(R, w) \equiv \frac{\partial R}{\partial w} \frac{w}{R}$. By (51), $\varepsilon(R, w) = \frac{\alpha}{1-r} - \frac{Q\alpha w}{1-r+\alpha-Q\alpha w}$. Then, $\frac{\partial \varepsilon(R,w)}{\partial \alpha} = \frac{1}{1-r} - \frac{Qw(1-r)}{(1-r+\alpha-Q\alpha w)^2}$, which implies that $\frac{\partial \varepsilon(R,w)}{\partial \alpha}$ is decreasing in w and is equal to 0 at $w = \frac{1}{Q}$.

¹⁴ The condition (48) does not hold when $V_A < 0$ where $A \in \{D, N\}$, which is equivalent to $1 - r + \alpha - Q\alpha \frac{y_N}{y_D} < 0$. In this case, $\frac{f(y_N)}{f(y_D)}$ is U-shaped in $\frac{y_N}{y_D}$ (opposite to Fig. 4), which in turn implies that Regime N is preferable to Regime D for low values of $\frac{y_N}{y_D}$, whereas Regime D is preferable to Regime N for high values of $\frac{y_N}{y_D}$.



Fig. 6. The effect of s on $\frac{f(y_n)}{f(y_n)}$. The values of parameters are as follows: $\alpha = 0.15, r = 0.50$, and m = 1.50.

Thus, for $w < \frac{1}{Q}, \frac{\partial \varepsilon(R,w)}{\partial \alpha} > 0$, which means that as α increases, $\varepsilon(R, w)$ increases; that is, as α increases, $R \equiv \frac{f(v_N)}{f(v_D)}$ responds more strongly to $w \equiv \frac{v_N}{v_D}$, as Fig. 5 indicates for $w < \frac{1}{Q}$. Because the intersection of $R \equiv \frac{f(y_N)}{f(y_D)}$ and the horizontal line 1 determines the location of z, the above fact implies that z decreases. \Box .

From the above claim, as α increases, z decreases. In addition, as α increases, $y_D = 1 + \frac{1}{1-r+\alpha}$ decreases and thus $\frac{y_N}{y_D}$ increases. By these two facts, for sufficiently high values of $\alpha, \frac{f(y_N)}{f(y_D)} > 1$, and thus $V_N > V_D$. Proof of part (c):(i) As *s* increases, neither y_N nor y_D is affected and thus $\frac{y_N}{y_D}$ does not change.(ii) Because

 $\frac{\partial \left(\frac{f(y_N)}{f(y_D)}\right)}{\partial O} > 0 \text{ and } \frac{dO}{ds} > 0, \text{ as } s \text{ increases, } \frac{f(y_N)}{f(y_D)} \text{ increases. Because the intersection of } \frac{f(y_N)}{f(y_D)} \text{ and the horizontal line}$ 1 determines the location of z, the above fact implies that when s increases, z decreases, as Fig. 6 illustrates.

As s increases, $\frac{y_N}{y_D}$ does not change but z decreases. By (i) and (ii), for sufficiently high values of s, $\frac{f(y_N)}{f(y_D)} > 1$, and thus $V_N > V_D$.

As an aside, we show that $K_N < K_D$. By (17) and (13), $K_N < K_D$ if and only if $y_N < y_D$, which is always true because $y_N < 1.2$ and $y_D > 2$, as shown in the proofs of Propositions 4 and 2, respectively.

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Intangibles and management earnings forecasts

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ABSTRACT

We investigate how the accounting treatment of intangible assets on managers' likelihood of issuing voluntary earnings guidance (MEF). We find that unrecognized intangibles (immediately expensed) are negatively associated with MEF issuance, while recognized intangibles (capitalized) show a positive association. These findings hold across various factors such as analysts' coverage, industry type and for a subsample that excludes software firms permitted to capitalize software development costs under SFAS No. 86. In additional, we investigate the cross-sectional determinants of MEF issuance based on the characteristics of firm intangibility. We find a significant increase in the likelihood of MEF issuance for higher unrecognized intangibles with greater earnings uncertainty. This suggests that managers may prioritize delivering value-relevant information to market participants to alleviate uncertainty.

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1. Introduction

In this study, we investigate the association between managers' voluntary decision to issue a forecast/earnings guidance (hereafter MEF) and the accounting treatment of intangible assets (recognized versus unrecognized). Investments in intangible assets may lead to differing perceptions of firm value among users of financial statements (Aboody and Lev, 2000; Lev, 2001; Barron et al., 2002), introducing the element of information risk. Managers may be motivated to elevate this risk, especially in higher information risk environments, such as in drug discovery firms, where a substantial portion of intangible assets is expensed. In response, managers

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may issue MEFs to enhance transparency, signal credibility and manage investor expectations. However, information risk may vary between recognized and unrecognized intangibles.

The conservative practice¹ of expensing most intangibles, as mandated by Generally Accepted Accounting Principles (GAAP), may lessen the information content of financial reports because of increased information asymmetry (Lev and Zarowin, 1999; Lev, 2001; Lev, 2004). This practice may complicate and potentially bias firm valuation (Amir and Lev, 1996; Sougiannis and Yaekura, 2001; Monahan, 2005; Ciftci and Darrough, 2015). In contrast, capitalizing intangible assets provides useful information to capital market participants and reduces information asymmetry concerning the value of these assets and the uncertainty regarding the timing and magnitude of earnings. Research from countries such as Australia that allow managers discretion in the treatment of intangible assets suggests that managers tend to capitalize intangible assets when they are more certain about the investment's ultimate payoff (Wyatt, 2005; Matolscy and Wyatt, 2006).

Because of the variations in information asymmetry and uncertainty related to investments in intangibles, managerial incentives to issue MEFs may differ based on the proportions of expensed and capitalized intangibles. Managers may also have reservations regarding the issuance of MEFs, particularly in high-intangibility firms, where they might prefer to retain proprietary information internally rather than risk disclosing it to competitors. Additionally, concerns about credibility damage (Williams, 1996; Hirst et al., 1999; Yang, 2012), exposure to litigation and threats to human capital related to job security (Lee et al., 2012) may deter management from providing inaccurate forward-looking forecasts.

Our primary empirical analysis examines whether managers signal the relative information risk associated with their investment in intangible assets through the voluntary disclosure of annual earnings guidance. We also investigate whether this discretionary behavior is influenced by the proportions of recognized and unrecognized intangibles. To our knowledge, this study is the first to assess how managers weigh the costs and benefits of MEFs across various degrees of recognized and unrecognized intangible assets.

Using a pooled cross-sectional logistic regression, we regress a dichotomous (1/0) variable indicating whether managers issue an earnings forecast (MEF) at time *t* on the relative proportions of intangible assets, both recognized and unrecognized (R&D and advertising expense), at time *t*-1 while controlling for earnings forecast determinants at time *t*-1. Our analysis reveals a significant negative association between MEFs and a firm's composition of unrecognized intangibles that is driven by the ratio of R&D to sales. This suggests that managers may prioritize concerns about the accuracy of their forecasts over addressing information asymmetry in the presence of high investment in unrecognized intangibles. In contrast, we document a significant positive association between MEF issuance and recognized intangibles. This implies that for managers, the objective of minimizing information asymmetry related to investments in recognized intangibles may outweigh concerns about potential damage to their reputation resulting from inaccurate earnings forecasts.

These findings remain robust when we account for 1) the unique U.S. GAAP treatment under Statement of Financial Accounting Standards (SFAS) No. 86, which allows the capitalization of certain software development costs, 2) the variations between high- and low-technology-oriented firms, 3) the differences between high- and low-litigation industries and 4) the number of analysts following the firm. Additionally, the robustness persists when we use operating expenses instead of sales as a scalar of R&D intensity.

We also attempt to differentiate between the impacts of information asymmetry and earnings uncertainty on the association between MEF issuance and the proportions of both recognized and unrecognized intangibles. We find no consistent evidence of an incremental information asymmetry effect on the managerial MEF issuance decision in the presence of high proportions of unrecognized intangibles.

Regarding the impact of earnings uncertainty on the MEF issuance decision, we find that managers of firms with high proportions of unrecognized intangibles are less likely to issue MEFs. However, they are more willing to provide earnings guidance with increased levels of earnings uncertainty. This trend is particularly noticeable in the context of a high proportion of R&D expenses. This analysis suggests that managers might feel compelled to convey their expectations regarding returns from investments in unrecognized intangibles to

¹ This is a form of unconditional conservatism, defined as follows: "Unconditional conservatism occurs through the consistent underrecognition of accounting net assets. Unlike conditional conservatism, unconditional conservatism does not depend on news events. Examples of unconditional conservatism include immediately expensing research and development expenditures and accelerated depreciation" (Ruch and Taylor, 2015, P. 20).

market participants, even in the face of challenges to providing precise earnings guidance. Alternatively, it could indicate managers' confidence in these investments and their ability to accurately forecast future earnings.

Our study makes several contributions to the literature. Prior research investigates the information risk of intangible assets from the perspective of analysts, examining their use of heuristics and their earnings forecast errors for intangibility-oriented firms (Barron et al., 2002; Demers, 2002; Gu and Wang, 2005; Dehning et al., 2006; Matolcsy and Wyatt, 2006; Chalmer et al., 2012). We shift the focus from external analysts to internal managers. Managers possess greater insights into the probability distribution of future payouts from investments in intangible assets than do outsiders. As a result, they are in a unique position to offer market participants insights into future payoffs through the issuance of MEFs. Importantly, we explicitly acknowledge the inherent costs associated with MEF issuance.

Furthermore, various studies in the Australian context indicate potential benefits associated with granting managers the discretion to make voluntary capitalization decisions, especially compared with more restrictive regulations in the U.S. We contribute to this line of research by exploring whether MEFs play a complementary role in signaling managers' expectations regarding future benefits from intangible investments in accounting standards regimes that provide managers with less discretion in their accounting treatment of intangibles. Therefore, the assessment of the combined effect of discretionary earnings guidance and the less discretionary accounting treatment of intangibles may contribute to the regulatory debate regarding the information content of intangibles valuation and shed light on managers' perceptions of uncertainties surrounding intangible investments.

In addition, we add to the ongoing debate regarding whether MEFs have value or are distortionary. Academic research indicates that there are negative market reactions to announcements of discontinuing quarterly earnings guidance (Chen et al., 2011),^{2,3} and executives' reluctance to cease issuing MEFs (Hsieh et al., 2006).⁴ Conversely, public think tanks, investor groups and industry organizations suggest that short-term guidance may encourage myopic managerial behavior, distorting investments and incentivizing earnings management (CFA Institute, 2006; The Aspen Institute, 2007; Karageorgiou and Serafeim, 2014). Our paper contributes to this debate and has the potential to inform both academics and practitioners.

The remainder of the study is organized as follows. Section 2 outlines the literature review and our hypotheses. Section 3 discusses the research design. Section 4 presents the sample selection method, descriptive statistics and Pearson correlations. Section 5 provides our empirical results. Section 6 presents additional analysis and robustness checks. Finally, Section 7 provides the conclusions.

2. Literature review and hypotheses

2.1. MEF disclosures

Barry and Brown (1985, 1986) argue that because managers have more information than investors, the latter will demand a premium for information risk. Accordingly, managers can reduce the cost of capital by reducing information risk through voluntary disclosures. MEFs are an important component of a firm's information environment (Beyer et al., 2010)⁵ and is one of the key forward-looking voluntary disclosure mechanisms. Through this disclosure mechanism, managers seek to manage market earnings expectations, communicate earnings projections, preempt litigation concerns and enhance their reputation for transparent and accurate reporting (Hirst et al., 2008; Kim and Park, 2012). Consistent with this notion, Rogers et al.

² Other potential effects of discontinuing these disclosures include increased analyst forecast dispersion, decreased forecast accuracy (Houston et al., 2010; Chen et al., 2011) and even lower numbers of analysts following (Houston et al., 2010).

³ Cheng et al. (2006) compare a sample of frequent guiders to non-frequent (occasional or non–) guiders and conclude that non-frequent guiders engage in less R&D, which implies that guidance contributes to managerial short-termism.

⁴ The authors find that 83% of surveyed executives report that they would stop issuing guidance for fear of an increase in stock price volatility when earnings are released, a potential decline in stock prices and a loss of visibility with investors and analysts.

⁵ The authors document that MEFs provide 55% of the accounting-based information in the quarter, while analyst forecasts provide only 22% and earnings announcements provide merely 8%, which suggests that MEFs are the most informative disclosures to equity investors.

(2009) find that MEFs are associated with stock price volatility, which suggests that they change investor perceptions. In a similar vein, Jiang et al. (2023) examine whether MEFs decrease the stock return seasonality associated with earnings seasonality around earnings announcements in Chinese A-share firms. They find that voluntary MEFs have a higher reduction effect than mandatory MEFs on the seasonal predictability of returns, volume and volatility around earnings announcements.

MEFs are also associated with a reduction in information asymmetry (Frankel et al., 1995; Kasznik and Lev, 1995; Coller and Yohn, 1997; Ajinkya et al., 2005, Bozanic et al., 2018). For example, Frankel et al. (1995) find evidence of a higher likelihood of MEF issuance by managers that anticipate accessing capital markets in the near future, as they hope that MEFs will reduce information asymmetry and mitigate the adverse selection problem, thus facilitating a lower cost of capital. Similarly, Bozanic et al. (2018) find that MEFs reduce information asymmetry between firms and investors, correct investors' earnings expectation errors and improve pricing efficiency.

2.2. Unrecognized versus recognized intangible assets

Intangible assets play a substantial role in today's economy and are positively correlated with market value (Sougiannis, 1994; Lev and Sougiannis, 1996). The U.S. GAAP distinguishes between two categories of intangibles: purchased and internally developed intangibles. Purchased intangibles such as acquired patents, copyrights and customer lists are recognized on the balance sheet as assets and then amortized over certain years, while goodwill is tested for amortization. With few exceptions,⁶ internally developed intangible assets such as those that arise from investments in brand development, advertising and marketing and other R&D remain off the balance sheet and are expensed as incurred.

2.2.1. Unrecognized intangibles

The conservative accounting practice of immediately expensing investments in internally developed intangibles (e.g., R&D and advertising) is used because of the difficulty of forecasting future payoffs from these activities, which are characterized by high information asymmetry. Aboody and Lev (2000) highlight distinctions between R&D expenditures and other capital and financial investments with regard to information asymmetry. Unlike financial investments subject to marking-to-market and physical assets with recognized value impairments, R&D is immediately expensed. This results in a lack of reported information on changes in R&D value and productivity, which potentially contributes to increased information asymmetry. Additionally, the unique and firm-specific nature of many R&D projects, especially in areas such as drug development, limits investors' ability to gain insights from other firms in the industry. Unlike physical and financial assets traded in organized markets, R&D lacks centralized markets for price discovery external to the firm.

The immediate expensing practice of R&D investments is a matter of debate in the literature. Proponents of this treatment argue that the immediate expensing rather than capitalizing of intangibles reminds investors of the speculative nature of the payoffs from these investments; expensing thereby serves as a form of risk communication, and the expenditures disclosed in the income statement provide investors with *ex-ante* information on uncertain future payoffs (Penman, 2016).⁷

Opponents of this treatment suggest that immediate expensing of intangibles distorts the informativeness of financial reports (Amir and Lev, 1996; Lev and Sougiannis, 1996; Lev and Zarowin, 1999; Lev, 2001; Lev, 2004; Lev et al., 2005) because of misalignment between the costs and benefits of the investments in financial reports. Lev (2004) states that "the expensing mentality towards intangibles ... should be replaced by an asset mentality, P. 15." to address the mis-valuation of expensed intangibles. Lev and Zarowin (1999) present empirical evidence of a decline in the informativeness of reported earnings that is primarily linked to increased R&D spending over time. Amir and Lev (1996) demonstrate that key financial variables, such as earnings and book values, exhibit negative, excessively depressed or seemingly unrelated relationships to market values in

⁶ Examples include production stage software development, R&D costs related to tangible assets that have alternative future uses and direct-response advertising under certain conditions.

⁷ This important role of *ex-ante* risk communication characterizes GAAP principles and serves as a criticism of International Accounting Standards (IAS) 38, which does not require the immediate expensing of some R&D investment activities.

high-intangibility firms. Furthermore, research suggests that conservative accounting practices, particularly in R&D-intensive firms, may impair capital market participants' ability to assess firm value. As Monahan (2005) finds, R&D-intensive firms tend to have understated future earnings estimates. Sougiannis and Yaekura (2001) suggest that biases and inaccuracies observed in long-horizon earnings-based valuation models may result from the omission of intangibles from the balance sheet. These findings collectively highlight the intricate relationship between accounting treatment, intangibility and the challenges associated with accurately valuing firms or predicting the future payoffs of R&D expenditures.

2.2.2. Recognized intangibles

Capitalizing or recognizing intangible assets offers valuable information for financial statement intermediaries and, consequently, investors. This was particularly evident in the Australian context before the adoption of the International Financial Reporting Standards (IFRS). During the pre-IFRS era, managers routinely engaged in the voluntary capitalization of intangible assets, a practice permitted by the regulatory environment. Matolcsy and Wyatt (2006) find that firms with higher proportions of capitalized intangibles experienced lower analyst forecast errors, providing support for the informative role of capitalization.

The transition to the IFRS in Australia marked a shift toward more restrictive reporting guidelines for intangible assets, resulting in reduced capitalization. Chalmers et al. (2012) corroborate Matolcsy and Wyatt's (2006) findings in the pre-IFRS period but observe no decline in the association between intangible assets and analyst forecast errors post-IFRS. This indicates a potential reduction in the usefulness of financial reporting with fewer capitalized intangibles.

In the U.S. under GAAP reporting, the relationship between capitalized intangibles and analyst forecast errors appears complex. Barron et al. (2002) and Gu and Wang (2005) report a positive association, suggesting that information asymmetry arises from investments in recognized intangible assets. However, Mohd (2005) contradicts these findings, focusing on software development firms that could capitalize some R&D costs under SFAS No. 86 and revealing a negative association between capitalized intangibles and information asymmetry. Additionally, Kimbrough (2007) finds that recognized R&D investments were incorporated into equity values in business combinations under SFAS No. 141, which supports the view that capitalizing intangible assets enhances the informativeness of accounting data.

Intriguingly, Ju et al. (2019) explore the impact of IFRS enforcement on the relationship between mandatory IFRS adoption and firms' voluntary disclosure. Their findings suggest that the increase in the frequency of management forecasts after IFRS adoption was more pronounced for firms from non-IFRS-mandating countries, indicating that IFRS enforcement served as a substitute for firms' voluntary disclosure.

In summary, the distinct accounting treatment of intangible assets, whether recognized or unrecognized, plays a pivotal role in shaping managers' decisions regarding the issuance of voluntary earnings guidance. This differentiation significantly impacts information asymmetry, forecast accuracy and the overall informativeness of financial reporting across diverse regulatory environments.

2.3. MEF and intangible assets

Although there is an extensive body of literature on the accounting treatment of intangibles, to our knowledge, only a few studies investigate the relationship between voluntary disclosures and the accounting treatment of intangibles. These studies investigate the association between product market competition and capital market disclosure, relying on the proportion of R&D expenditures as a proxy for competition (e.g., Cao et al., 2018). Cao et al. (2018) investigate the association between "technological peer pressure" (the relative threat of competitors' technological advancement to a firm's technological preparedness⁸) and voluntary product press-release disclosures. They find a significant negative association between TPP and product release disclosures, which suggests that product release disclosures are characterized by economically meaningful proprietary costs. In contrast, when they substitute MEF frequency for product release disclosures, they

⁸ Cao et al. (2018) rely on R&D stock to determine both measures of threats from competitors' technological advances and the firm's technological preparedness but do not consider the direct link between voluntary disclosure and R&D expenditures.

fail to find a significant association between voluntary disclosures and TPP, which suggests that MEFs provide little proprietary information to competitors.⁹ Jones (2007) develops a disclosure index based on numerical and descriptive information about R&D-related activities, such as information concerning R&D spending, R&D projects in progress and development-stage R&D, but does not find a significant relationship between R&D and her voluntary disclosure index.¹⁰

Wang (2007) investigates a potential "chilling effect" post-Regulation Fair Disclosure (Reg FD) following the use of private MEF guidance in the pre-Reg FD period. She finds that pre-Reg FD private MEF issuers with lower information asymmetry and higher proprietary costs (proxied by the proportion of R&D expenditures to total assets) are less likely to provide public earnings guidance post-Reg FD, as they have greater incentives to stay silent.¹¹ Mohd (2005) finds a negative association between capitalized intangibles and information asymmetry using a sample of software development firms that are able to capitalize some R&D costs under SFAS No. 86. Kimbrough (2007) uses a sample of acquirers in business combinations required under SFAS No. 141 to estimate the fair value of the target's R&D capital and finds that recognized R&D investments are incorporated into equity values, which supports the conjecture that the process of capitalizing intangible assets supports the informativeness of accounting data. Interestingly, Gu et al. (2019) investigate whether the changes in mandatory financial reporting through IFRS enforcement affect the relationship between mandatory IFRS adoption and firms' voluntary disclosure. Their findings reveal that the increase in or the frequency of the issuance of management forecasts after IFRS adoption is higher for firms from non-IFRS-mandating countries than for those from IFRS-mandating countries, indicating that IFRS enforcement is a substitute for firms' voluntary disclosure.

2.3.1. Hypothesis 1: MEFs and unrecognized intangibles

Intangibles are characterized by greater information asymmetry between managers and investors. This asymmetry is particularly pronounced in the case of unrecognized intangibles (Barron et al., 2002). Empirical findings suggest that the immediate expensing of intangibles reduces the value relevance of financial reports, potentially distorts earnings and book values and complicates firm valuation. Hence, managers may be motivated to mitigate this asymmetry by disclosing MEFs, aiming to reduce both information asymmetry and uncertainty regarding future payoffs from investments in unrecognized intangibles. MEFs are considered one of the most informative voluntary disclosure mechanisms for equity market participants (Beyer et al., 2010) that present relatively lower proprietary cost concerns for managers (Ajinkya et al., 2005; Cao et al., 2018) compared with direct product release disclosures.¹² Therefore, MEFs could be used to manage and communicate future earnings expectations from investments in unrecognized intangibles, thus alleviating some of the information risk facing capital market participants.

Unrecognized intangibles are also characterized by greater future earnings uncertainty (Kothari et al., 2002; Amir et al., 2007; Pandit et al., 2011). The increased uncertainty in earnings associated with unrecognized intangibles could result in inaccurate managerial earnings guidance, potentially undermining management's credibility (Yang, 2012) and negatively impacting managers' job security (Lee et al., 2012). Therefore, in spite of managerial incentives to reduce information asymmetry by issuing MEFs, managers of firms with higher unrecognized intangibility might refrain from this voluntary disclosure mechanism.

Despite the competing arguments regarding managerial incentives to disclose MEFs in the presence of higher proportions of unrecognized intangibles, we argue that the costs of issuing inaccurate earnings guidance carry more weight for managers than the benefits of MEF in reducing information asymmetry. Conse-

⁹ They find a weak correlation between MEF frequency and their developed disclosure measure and suggest that "managers treat product disclosures and MEFs as distinct types of disclosure, each with its own purpose" (Cao et al., 2018, p. 97).

¹⁰ The primary difference between our study and that of Jones (2007) is that we use MEF instead of a self-developed voluntary disclosure index, which is subjective and cannot be easily replicated (Francis et al., 2008). Jones (2007) also uses R&D expenses as a proxy for proprietary costs, whereas we focus on the accounting treatment of intangibles (both recognized and unrecognized) and assess the tradeoff between information asymmetry and earnings uncertainty in MEF decisions.

¹¹ She finds that a one standard deviation increase in R&D expenses increases the likelihood of post-Reg FD non-disclosure by 55.15%. ¹² Ajinkya et al. (2005) do not find an association between voluntary disclosure of earnings forecasts and proprietary costs, whereas Wang (2007) finds that firms with high proportions of R&D expenses elected to replace private earnings guidance prior to the enactment of Reg FD with non-disclosures rather than with public disclosures. We thank an anonymous reviewer for this comment.

quently, we predict that the negative relationship between MEF issuance and unrecognized intangibles is driven by higher levels of earnings uncertainty.

Furthermore, firms with a high proportion of unrecognized intangibles, such as R&D expenses, may experience higher levels of information risk because of the expensing nature of these items. The inherent uncertainty in predicting future earnings accurately may lead managers to be more cautious in issuing MEFs. By refraining from providing explicit forecasts, managers aim to mitigate the potential for forecast inaccuracies and maintain a conservative approach in their communication with market participants. Therefore, we hypothesize that managers of firms with greater unrecognized intangibles will be less inclined to issue voluntary earnings guidance. We thus present our first hypothesis, in alternative form, as follows:

H1. Firms with higher proportions of unrecognized intangible assets are associated with a lower likelihood of MEF issuance.

2.3.2. Hypothesis 2: MEFs and recognized intangibles

The issuance of MEFs for firms with relatively high proportions of recognized intangible assets on the balance sheet is also a subject of debate. On the one hand, if managers regard future payoffs from investment in recognized intangibles as uncertain relative to those from investment in tangible assets because of the potential for future impairment revisions of recognized intangibles, they may refrain from issuing an MEF for fear of providing an inaccurate forecast and facing the ensuing human capital and reputational capital consequences. This argument suggests a non-significant or even negative association between the proportions of recognized intangibles and MEF issuance. Furthermore, if managers find that firms with a high proportion of recognized intangible assets have significantly more analysts following and lower analyst earnings forecast errors (Zoltan and Wyatt, 2006), they may believe that issuing MEFs to manage or communicate earnings expectations may be redundant. This notion would thus suggest no (or a negative) association between the presence of high proportions of recognized intangibles and MEFs.

On the other hand, managers of firms with a higher proportion of recognized intangible assets may be more likely to issue management earnings forecasts for several reasons. First, because recognized intangibles undergo the capitalization process, they are typically associated with more stable and predictable future cash flows. This enhanced predictability in forecasting reduces the likelihood of errors in MEFs. Managers prioritizing accurate forecasts for job security may feel more confident in issuing forecasts for firms with recognized intangibles (Healy et al., 2001). Second, recognized intangible assets that are reflected in the balance sheet provide a transparent representation of the firm's value. Managers of firms with a high proportion of recognized intangibles may issue forecasts to reinforce credibility, signal transparency and enhance investor confidence (Watts and Zimmerman, 1986). Third, capitalizing intangible assets allows investors to assess the firm's commitment to innovation and long-term value creation. Managers may issue forecasts to manage investor expectations and provide insights into the potential returns from their recognized intangible assets (Lev and Sougiannis, 1996). That is, managers may use management forecasts as a communication tool to keep stakeholders informed about the expected benefits and outcomes associated with these strategic intangible assets. Finally, recognized intangibles that are being accounted for on the balance sheet alleviate the information asymmetry between management and investors. Issuing management forecasts can further bridge this gap by providing forward-looking guidance that enhances investors' understanding of the firm's financial prospects (Barth, 2001; Kannan et al., 2023).

In summary, the capitalization of intangible assets provides a structured framework for managers to communicate valuable information to the market. By issuing MEFs, managers of firms with a higher proportion of recognized intangibles aim to enhance transparency, booster credibility, manage investors' expectations, maintain investors' confidence and foster positive perceptions of the firm's intrinsic value. Therefore, we argue that managers of firms with higher proportions of recognized intangible assets could be more inclined to issue voluntary earnings guidance. We thus present our second hypothesis, in alternative form, as follows:

H2. Firms with higher proportions of recognized intangible assets are associated with a higher likelihood of MEF issuance.

3. Research design

To test *H1* and *H2*, we investigate the association between intangibles (both recognized and unrecognized) and the likelihood of MEF issuance using the following pooled cross-sectional logistic regression, aggregating intangible assets into unrecognized (*UNREC_INTAN*) and recognized (*REC_INTAN*) subgroups, consistent with Barth et al. (2001).

$$OCCUR_{it} = \beta_{0} + \beta_{1}UNREC_INTAN_{it-1} + \beta_{2}REC_INTAN_{it-1} + \beta_{3}LagOCCUR_{it-1} + \beta_{4}CAPXS_{it-1} + \beta_{5}STDRET_{it-1} + \beta_{6}MTB_{it-1} + \beta_{7}STDEARN_{it-1} + \beta_{8}ANALYST_{it-1} + \beta_{9}LEV_{it-1} + \beta_{10}LMV_{it-1} + \beta_{11}ROE_{it-1} + \beta_{12}ISSUE_{it-1} + \beta_{13}\Delta EPS_{it-1} + \beta_{14}INST_{it-1} + \beta_{15}AUDIT_{it-1} + \beta_{16}LOSS_{it-1} + \sum Industry and Year effects + \varepsilon_{it}$$
(1)

Furthermore, we disaggregate *UNREC_INTAN* into *RNDS* and *ADVS*, also consistent with Barth et al. (2001), and use the following pooled cross-sectional logistic regression.

$$OCCUR_{it} = \beta_0 + \beta_1 RNDS_{it-1} + \beta_2 ADVS_{it-1} + \beta_3 REC_{INTAN_{it-1}} + \sum Controls + \sum Industry and Year effects + \varepsilon_{it}$$

$$(2)$$

Variable definitions are given in Appendix A. We measure the dependent variable (*OCCUR*) in Eqs. (1) and (2) in year t and the independent variables in year t-1 consistent with Cao et al. (2018) to ensure that financial statement information is available to managers before the issuance of earnings forecasts.¹³ We include year and industry indicator variables in all of the estimations to control for year and industry fixed effects. We use Fama and French's (1997) 48 industry definitions for the industry indicator variables. We cluster firm-year observations by firm to eliminate autocorrelations, as recommended by Petersen (2009). To alleviate the influence of outliers, we winsorize ratio-type variables (*REC_INTAN*, *MTB*, *STDEARN*, *LEV*, *ROE*, *ISSUE*, *AEPS* and *INST*) at the top and bottom 1 % of their annual distributions. We winsorize the sales-deflated variables (*RNDS*, *ADVS*, and *CAPXS*) at 1.¹⁴

H1 predicts a significant negative association between MEF issuance and the proportion of unrecognized intangibles to total sales. Hence, we anticipate a negative coefficient for $UNREC_INTAN$ (β_1) in Eq. (1) and negative coefficients for RNDS (β_1) and ADVS (β_2) in Eq. (2). *H2* predicts a significant positive association between MEF issuance and the proportion of recognized intangibles to total assets. Hence, we anticipate positive coefficients for REC_INTAN (β_2 in Eq. (1) and β_3 in Eq. (2)).

The control variables in our model are based on the literature (e.g., Ajinkya et al., 2005; Jones, 2007; Wang, 2007; Cao et al., 2018). We include *LagOCCUR* to control for the potential stickiness of MEF issuance following Cao et al. (2018) and capital expenditures, *CAPXS*, to control for tangible investments. Consistent with Jones (2007), we control for information asymmetry by using the standard deviation of market-adjusted daily stock returns, *STDRET*. Following Ajinkya et al. (2005), we also control for the market-tobook ratio, *MTB*, and leverage, *LEV*. Waymire (1985) documents an association between earnings volatility and the frequency of earnings forecasts. Accordingly, we control for the standard deviation of earnings (*STDEARN*). Consistent with Lang and Lundholm (1993), who document a positive association between company disclosures and analyst following, we include the log number of analysts following a firm, *ANLST*. Kasznik and Lev (1995) provide evidence of a positive association between firm size and the issuance of MEFs. Hence, we include *LMV* to control for firm size. Following Wang (2007), we control for return on equity (*ROE*) and the issuance of both debt and equity (*ISSUE*). Baginski et al. (2002) suggest that earnings news is negatively related to the issuance of MEFs. Accordingly, consistent with Baginski et al. (2002), we include *AEPS* in the model to control for earnings news. We include *INST* following Cao et al. (2018) and

 $^{^{13}}$ Our conclusions regarding H1 are not affected when we use contemporaneous independent variables instead of lagged independent variables.

 $^{^{14}}$ We winsorize sales-deflated variables at 1 instead of at the top and bottom 1% of their distributions because for some observations, the sales deflator is too small. Consequently, winsorizing at the top and bottom 1% of their distributions does not eliminate extreme observations for sales-deflated variables.

Ajinkya et al. (2005) to control for institutional investors' holdings. Because firms audited by Big N auditors have better disclosures than other firms (Lang and Lundholm, 1993), we include *AUDIT*, a dichotomous variable, to control for the effects of Big N auditors. Hayn (1995) suggests that earnings are not useful in the valuation of loss-making firms. In the same vein, Ajinkya et al. (2005) suggest that managers experience more problems forecasting earnings for loss firms, and they find that loss firms are less likely to issue MEFs. Accordingly, we include a *LOSS* dichotomous variable in the regression models.

4. Sample selection, descriptive statistics and Pearson correlations

4.1. Sample selection

We use all of the firm-year observations included in the Compustat Annual Files, Center for Research in Security Prices (CRSP) and I/B/E/S files with data required for the estimation of Eq. (1). In addition, we require firm-year observations to have positive sales revenue, total assets and book value of equity. We also require firm-year observations to have at least one analyst following a firm.

Chuk et al. (2013) suggest that MEF data coverage in the pre-1998 period is incomplete, that there is a large increase in MEF data coverage after 1998 and that MEF data are more likely to cover firms with high numbers of analysts following. Therefore, our sample covers the period from 1998 to 2018. Financial data are drawn from Compustat Annual Files, analyst following and MEF data are from the I/B/E/S files and stock returns are from the CRSP. Our sample includes 14,605 firm-year observations that satisfy the above sample selection criteria.

4.2. Descriptive statistics and Pearson correlations

Table 1 presents the mean, median, bottom quartile (Q1), top quartile (Q3) and standard deviation of each variable included in Eq. (1). The mean value of OCCUR, MEF issuance, is 38.4 %, which suggests that approximately 40 % of our firm-year observations issue at least one MEF annually. The mean value of the R&D expense to sales ratio, RNDS, is 14.8 %, and the mean value of the advertising expense to sales ratio, ADVS, is 1.1 %, which suggests that our sample firms spend approximately 14 times more on R&D than

Table 1	
Descriptive	statistics.

	Ν	MEAN	STD	Q1	MEDIAN	Q3
OCCUR	17,228	0.384	0.486	0.000	0.000	1.000
UNREC_INTAN	17,228	0.159	0.241	0.019	0.069	0.184
RNDS	17,228	0.148	0.241	0.010	0.058	0.167
ADVS	17,228	0.011	0.028	0.000	0.000	0.007
REC_INTAN	17,228	0.297	0.319	0.021	0.190	0.481
LagOCCUR	17,228	0.364	0.481	0.000	0.000	1.000
CAPXS	17,228	0.070	0.129	0.020	0.037	0.066
STDRET	17,228	0.030	0.016	0.018	0.026	0.038
MTB	17,228	3.740	4.017	1.594	2.573	4.201
STDEARN	17,228	0.078	0.100	0.019	0.040	0.096
ANALYST	17,228	1.700	0.917	1.098	1.791	2.397
LEV	17,228	0.160	0.170	0.000	0.114	0.273
LMV	17,228	6.660	1.811	5.387	6.539	7.810
ROE	17,228	-0.025	0.420	-0.052	0.078	0.154
ISSUE	17,228	0.130	0.212	0.009	0.036	0.154
ΔEPS	17,228	-0.006	0.172	-0.023	0.003	0.021
INST	17,228	0.665	0.264	0.483	0.716	0.872
AUDIT	17,228	0.870	0.336	1.000	1.000	1.000
LOSS	17,228	0.309	0.462	0.000	0.000	1.000

Notes: This table shows the mean (MEAN), standard deviation (STD), bottom quartile (Q1), median (MEDIAN) and top quartile (Q3) of firm characteristics measured using Eq. (1). Variable definitions are presented in Appendix A.

on advertising. This finding denotes the importance of R&D investment relative to advertising. The mean *CAPXS* is 7.0 %, which suggests that our sample firms spend less than half the amount on capital expenditures that they do on R&D. The mean value of purchased intangibles, *REC_INTAN*, is approximately 30 % of total assets.

Table 2 presents the Pearson correlations. The correlation between OCCUR and LagOCCUR is 0.72, which suggests a persistent nature of MEF issuance: firms that issue MEFs in one year continue to issue them in the following year. There is a negative correlation between R&D expenditures and MEF issuance (i.e., the correlation between RNDS and OCCUR is -0.22) and a positive correlation between MEF issuance and recognized intangibles (i.e., the correlation between REC_INTAN and OCCUR is 0.29). Furthermore, advertising expenses show a slight positive correlation with MEF issuance (the correlation between ADVS and OCCUR is 0.03). Overall, these correlations suggest that R&D is inherently different from recognized intangibles with respect to MEF issuance and provide initial findings consistent with H1 and H2.

There is a positive correlation between *RNDS* and *STDRET* (0.34), which suggests that information asymmetry increases with R&D expenses. However, there is a negative correlation between *REC_INTAN* and *STDRET* (-0.30), which suggests that information asymmetry decreases with recognized intangibles. These opposing correlations suggest important differences between recognized and unrecognized intangibles with respect to information asymmetry.

Table 2 Pearson Correlations.

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	OCCUR	1.00																
2	LagOCCUR	0.72	1.00															
3	RNDS	_	_	1.00														
		0.22	0.22															
4	ADVS	0.03	0.03	_	1.00													
				0.02														
5	REC_INTAN	0.29	0.29	_	0.04	1.00												
				0.21														
6	CAPXS	_	_	0.44	_	_	1.00											
		0.12	0.12		0.00	0.18												
7	STDRET	_	_	0.34	0.02	_	0.19	1.00										
		0.29	0.30			0.30												
8	MTB	0.04	0.02	0.18	0.10	_	0.05	-	1.00									
						0.10		0.00										
9	STDEARN	_	-	0.41	0.04	-	0.11	0.42	0.10	1.00								
		0.21	0.21			0.17												
10	ANALYST	0.27	0.27	_	0.07	0.18	-	_	0.14	_	1.00							
				0.08			0.00	0.35		0.17								
11	LEV	0.14	0.14	_	0.00	0.25	0.02	_	0.09	_	0.17	1.00						
				0.21				0.18		0.18								
12	LMV	0.33	0.31	_	0.04	0.24	_	_	0.26	_	0.74	0.21	1.00					
				0.17			0.04	0.56		0.29								
13	ROE	0.22	0.20	-	_	0.13	-	_	_	-	0.17	0.02	0.36	1.00				
				0.51	0.03		0.22	0.44	0.11	0.48								
14	ISSUE	_	_	0.18	0.00	0.03	0.17	0.09	0.15	0.07	_	0.27	_		1.00			
		0.00	0.01								0.05		0.03	0.17				
15	ΔEPS	0.03	-	0.00	_	0.00	_	_	0.05	_	_	_	0.05	0.22	_	1.00		
			0.01		0.01		0.03	0.05		0.02	0.03	0.04			0.00			
16	INST	0.27	0.27	-	_	0.25	_	_	0.05	_	0.49	0.15	0.52	0.26	-	_	1.00	
				0.18	0.00		0.11	0.51		0.23					0.00	0.01		
17	AUDIT	0.13	0.12	0.03	0.01	0.01	0.01	-	0.04	-	0.29	0.10	0.29	0.06	-	-	0.22	1.00
10	1000			0.50	0.02		0.01	0.07	0.02	0.04					0.01	0.00		
18	LOSS	-	-	0.50	0.03	-	0.21	0.45	0.03	0.41	-	-	-	-	0.11	- 17	-	-
		0.25	0.24			0.13					0.18	0.08	0.37	0.63		0.17	0.27	0.06

Notes: This table presents the Pearson correlations. Bold correlations are NOT significant at 5%. Variable definitions are presented in Appendix A.

The correlation between *RNDS* and *STDEARN* is 0.41, that between *ADVS* and *STDEARN* is 0.04 and that between *REC_INTAN* and *STDEARN* is -0.17. These results suggest a significant positive correlation between unrecognized intangibles (i.e., R&D and advertising expenses) and earnings uncertainty and a significant negative correlation between recognized intangibles and earnings uncertainty. In addition, the correlation between R&D expenses and earnings uncertainty is approximately 10 times that between advertising expenses and earnings uncertainty. These correlations suggest important differences for recognized versus unrecognized intangibles with respect to uncertainty. R&D activities involve both technical and commercial uncertainty, while advertising and purchased intangibles involve only commercial uncertainty. Innovation is a highly uncertain endeavor. In the R&D stage, it is highly uncertain whether an innovation activity will produce new knowledge or a new product. However, once new knowledge of a product is generated and technical uncertainty is eliminated, the only form of uncertainty remaining is commercial uncertainty. Consequently, overall earnings uncertainty for R&D investments is much greater than that for advertising investments and purchased intangibles.

5. Empirical results

5.1. MEF issuance and intangibles

Table 3 presents the pooled cross-sectional logistic regression results of Eqs. (1) and (2). We include industry and year fixed effects in all of the estimations. Model (1) is the baseline model, in which we regress *OCCUR* at time t on *OCCUR* determinants at time t-1 while excluding the variables of interest (intangible invest-

Table 3

MEF Issuance and Intangibles.

<i>H1:</i> Firms with higher proposed <i>H2:</i> Firms with higher proposed	rtions of unrecognized in rtions of recognized inta	ntangible assets are associated ngible assets are associated wi	with a lower likelihood of ith a higher likelihood of N	MEF issuance. IEF issuance.
	Expected Sign	Model 1	Model 2	Model 3
UNREC_INTAN (H1)	_		-1.068(-5.85)***	
RNDS	_		~ /	-1.130(-5.13)***
ADVS	_			-0.065(-0.07)
REC_INTAN (H2)	+		0.699(7.71)***	0.690(762***
LagOCCUR	+	2.243(40.08)***	2.243(39.67)***	2.243(39.65)***
CAPXS	+/_	-0.901(-3.93)***	-0.277(-1.14)	0.250(-1.02)
STDRET	_	-9.442(-4.12)***	-7.766(-3.35)***	-7.850(-3.39)***
MTB	_	-0.006(-0.97)	0.007(1.19)	0.007(1.18)
STDEARN	_	-1.348(-4.50)***	-1.039(-3.45)***	-1.043(-3.46)***
ANALYST	+	0.009(0.25)	0.030(0.83)	0.029(0.79)
LEV	_	0.716(4.61)***	0.203(1.23)	0.202(1.23)
LMV	+	0.240(9.12)***	0.209(7.87)***	0.208(7.84)***
ROE	+	0.202(2.20)**	0.124(1.31)	0.120(1.27)
ISSUE	+	0.225(1.99)**	0.261(2.16)**	0.267(2.21)**
ΔEPS	+	0.324(2.16)**	0.416(2.73)***	0.423(2.79)***
INST	+	0.429(3.31)***	0.392(3.01)***	0.396(3.04)***
AUDIT	+	0.158(1.74)*	0.211(2.30)**	0.212(2.31)**
LOSS	_	-0.263(-4.07)***	-0.212(-3.23)***	-0.211(-3.22)***
Constant		-2.439(-6.40)***	-2.507(-5.85)***	-2.523(-5.80)***
Industry and year effects		Yes	Yes	Yes
N		17,228	17,228	17,228
Psuedo-R ²		63.84 %	64.26 %	64.26 %
Model chi ²		37.05***	34.83***	31.96***

Z statistics are shown in parentheses. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.

 $OCCUR_{it} = \beta_0 + \beta_1 UNREC_{INTAN_{it-1}} + \beta_2 REC_{INTAN_{it-1}} + \sum Controls + \sum Industry and Year effects + \varepsilon_{it} (1).$

 $OCCUR_{it} = \beta_0 + \beta_1 RNDS_{it-1} + \beta_2 ADVS_{it-1} + \beta_3 REC_INTAN_{it-1} + \sum Controls + \sum Industry and Year effects + \varepsilon_{it} (2).$

Notes: This table presents the cross-sectional pooled logistic regression results for Eq. (1). The dependent variable is *OCCUR*. We include industry and year fixed effects in all of the estimations. Firm-year observations are clustered by firm to eliminate autocorrelations, as recommended by Petersen (2009). Variable definitions are presented in Appendix A.

ments). For Model (1), on average, firms with prior period earnings guidance (*LagOCCUR*), more leverage (*LEV*), of a larger size (*LMV*) and that have a higher percentage of institutional ownership (*INST*) are significantly more likely than other firms to issue contemporaneous MEFs (*OCCUR*) (p < 0.01). Furthermore, we find that firms experiencing greater EPS change (ΔEPS) and with greater return on equity (*ROE*) at time t-1 are significantly more likely than other firms to issue an MEF at time t (p < 0.05).

The findings for Model (1) also suggest that firms with higher capital expenditures (*CAPXS*), higher standard deviations of returns (*STDRET*) and higher earnings uncertainty (*STDEARN*) and firms that incur losses (*LOSS*) at time t-1 issue significantly fewer contemporaneous MEFs than other firms.

As shown in Table 3, Models (2) and (3) include the variables of interest in addition to the vector of *OCCUR* determinants included in Model (1). Model (2) includes an aggregate proxy for unrecognized intangible assets, *UNREC_INTAN* (the sum of *RNDS* and *ADVS*) and a proxy for recognized intangibles (*REC_INTAN*), whereas Model (3) disaggregates *UNREC_INTAN*.

The findings for Model (2) indicate a significant negative association between *OCCUR* at time t and *UNREC_INTAN* at time t-1 (p < 0.01) consistent with H1 and a significant positive association between *OCCUR* and *REC_INTAN* (p < 0.01) consistent with H2. The coefficient of *REC_INTAN* in Model (2) is 0.699 (p < 0.01), indicating that a one standard deviation increase in purchased intangibles leads to an approximately 25 % increase in the odds of issuing MEFs.¹⁵

When $UNREC_INTAN$ is disaggregated into RNDS and ADVS, the findings for Model (3) indicate that the negative association between OCCUR and $UNREC_INTAN$ in Model (2) is driven by the ratio of R&D expenses to sales (RNDS). The coefficient of RNDS is -1.130 (p < 0.01), which suggests that MEF issuance decreases with R&D intensity, consistent with H1. A one standard deviation increase in RNDS leads to a 24 % decrease in the odds ratio of issuing an MEF. The coefficient of ADVS is -0.065, which is not significant; this suggests that the ratio of advertising expenses to total sales at time t-1 does not significantly affect managers' decision to issue an MEF at time t.

As discussed, there are important differences between R&D and purchased intangibles with respect to information asymmetry and earnings uncertainty, both of which are likely to affect MEF issuance. The negative association found between R&D intensity and MEF issuance suggests that the impact of earnings uncertainty dominates the impact of information asymmetry for R&D. However, the positive association found between purchased intangibles and MEF issuance suggests that the impact of information asymmetry dominates the impact of uncertainty for purchased intangibles. The non-significant result for advertising suggests that the impact of information asymmetry offsets the impact of uncertainty for intangible assets to be generated from advertising expenses and marketing spending.

Overall, the results shown in Table 3 suggest that there are important differences between intangibles with respect to information asymmetry and uncertainty, both of which lead to differences in associations between intangibles and MEF issuance.,^{16,17} Furthermore, our combined results are consistent with the argument that management credibility is a leading driver of management's decision to voluntarily issue earnings forecasts for both recognized and unrecognized intangibles.

¹⁵ % change in odds = 100[exp $(S_i\beta_i) - 1$], where S_i is the standard deviation of variable *i* and β_i is the coefficient of variable *i*.

¹⁶ Our findings in Table 3 are robust to alternative scaling (total assets as a scalar for *RNDS* and *ADVS* rather than sales) and the use of probit rather than logit regression analysis. In addition, given the strong correlation between *OCCUR* and *LagOCCUR*, we repeat the Table 3 analysis after excluding *LagOCCUR* and find qualitatively similar results, although the R^2 value drops from approximately 64% to 35%.

 $^{^{17}}$ To check for multicollinearity, we estimate the variance inflation factors (VIFs) for the independent variables shown in Table 3. The cutoff point for severe multicollinearity is 10 (Hair et al., 1995). We use ordinary least squares (OLS) regression when calculating the VIFs instead of logistic regression. All of the VIFs in Table 3 are less than 10, which suggests that multicollinearity is not a concern for the independent variables in Table 3.

6. Additional analysis and robustness checks

6.1. Cross-sectional analysis

In this section, we investigate the cross-sectional determinants of the relationship between intangibles and MEF issuance in an attempt to distinguish between competing arguments for MEF issuance in the presence of higher proportions of recognized and unrecognized intangible assets. Specifically, Panel A of Table 4 shows the impact of information asymmetry on the association between MEFs and both recognized and unrecognized intangibles. We use two proxies for information asymmetry (*ASYMMETRY*) identified in the literature:

Table 4

The Cross-Sectional Determinants of MEF Issuance.

	Information Asymmetry					
	STDRET	AFD				
	Model 1	Model 2				
RNDS	-1.265(-3.25)***	-0.842(-2.91)***				
ADVS	-2.445(-1.07)	1.585(1.18)				
REC_INTAN	0.861(4.81)***	0.473(3.83)***				
ASYMMETRY	-7.904(-2.60)***	-3.738(-6.31)***				
RNDS*ASYMMETRY	3.260(0.40)	-1.989(-1.29)				
ADVS*ASYMMETRY	81.066(1.22)	$-20.440(-1.71)^*$				
REC_INTAN*ASYMMETRY	-6.298(-1.13)	1.088(1.00)				
Constant	-2.524(-5.74)***	-2.126(-5.29)***				
\sum controls	Yes	Yes				
Industry and year effects	Yes	Yes				
N	17,228	15,302				
Psuedo-R ²	64.28 %	65.52 %				
Model chi ²	28.28***	67.28***				

Panel B: The effect of earnings uncertainty on the association between intangible assets and MEFs

	Earnings Uncertainty			
	$PRE_STDEARN \\ (t-5 - t-1)$	$\begin{array}{l} POST_STDEARN\\ (t+1-t+4) \end{array}$		
	Model 1	Model 2		
RNDS	-1.572(-5.62)***	-1.258(-4.36)***		
ADVS	-0.536(-0.41)	-1.814(-1.64)		
REC_INTAN	0.659(5.76)***	0.715(6.45)***		
STDEARN	-1.873(-3.54)***	-1.071(-2.79)***		
RNDS*STDEARN	3.211(2.76)***	1.292(1.45)		
ADVS*STDEARN	7.932(0.60)	10.543(4.31)***		
REC_INTAN*STDEARN	0.408(0.36)	0.460(0.84)		
Constant	$-2.260(-5.48)^{***}$	-2.306(-4.86)***		
\sum controls	Yes	Yes		
Industry and year effects	Yes	Yes		
N	17,228	15,058		
Psuedo-R ²	64.28 %	61.18 %		
Model chi ²	29.84***	26.93***		

Z statistics are shown in parentheses. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively. $OCCUR_{it} = \beta_0 + \beta_1 RNDS_{it-1} + \beta_2 ADVS_{it-1} + \beta_3 REC_INTAN_{it-1} + \beta_4 ASYMMETRY_{it-1} + \beta_5 (RNDS^*ASYMMETRY)_{it-1} + \beta_6 - (ADVS^*ASYMMETRY)_{it-1} + \beta_7 (REC_INTAN^*ASYMMETRY)_{it-1} + \sum Controls + \sum Industry and Year effects + \varepsilon_{it} (3).$ $OCCUR_{it} = \beta_0 + \beta_1 RNDS_{it-1} + \beta_2 ADVS_{it-1} + \beta_3 REC_INTAN_{it-1} + \beta_4 STDEARN_{it-1} + \beta_5 (RNDS^*STDEARN)_{it-1} + \beta_6 - (ADVS^*STDEARN)_{it-1} + \beta_7 (REC_INTAN^*STDEARN)_{it-1} + \sum Controls + \sum Industry and Year effects + \varepsilon_{it} (4).$

Notes: This table presents the cross-sectional pooled logistic regression results for Eqs. (3) and (4). The dependent variable in all of the Table 4 analysis is *OCCUR*. We include industry and year fixed effects in all of the estimations. Firm-year observations are clustered by firm to eliminate autocorrelations, as recommended by Petersen (2009). Variable definitions are presented in Appendix A.

(1) the standard deviation of returns (*STDRET*) at time t-1 (Model 1) and (2) analyst earnings forecast dispersion (*AFD*) calculated as the standard deviation of these forecasts at time t-1 (Model 2). Panel B of Table 4 assesses the impact of earning uncertainty (*STDEARN*) on the association between MEFs and both recognized and unrecognized intangibles. We use two proxies for earnings uncertainty: (1) the standard deviation of earnings from year t-5 to year t-1 (*PRE_STDEARN*¹⁸ in Model 1) and (2) the forward-looking standard deviation of earnings from years t + 1 to year t + 4 (*POST_STDEARN* in Model 2). In both panels, we disaggregate the *UNREC_INTAN* measure using *RNDS* and *ADVS* to offer detailed insights into the unique features of both intangible asset investments and provide untabulated findings on the aggregate unrecognized intangible measure (*UNREC_INTAN*). For all of the results shown in Table 4, we control for the MEF determinants identified in Eq. (1) as well as industry and year fixed effects. For brevity, Table 4 does not display the results for the MEF determinants.

In Table 4, Model 1, Panel A demonstrates a significant negative association between *RNDS* and *OCCUR* (p < 0.01) and a significant positive association between *REC_INTAN* and *OCCUR* (p < 0.01), consistent with *H1* and *H2* and the results shown in Table 3. We also find a significant negative main effect association between *OCCUR* and *ASYMMETRY* when using *STDRET* as a proxy (p < 0.01), which suggests that information asymmetry reduces the likelihood of MEF issuance, perhaps because of human capital considerations or fear of harm to reputational capital. We find no significant incremental effect of *ASYMMETRY* on the associations between *OCCUR* and *RNDS*, *ADVS* and *REC_INTAN*. Using the aggregate intangibility measure *UNREC_INTAN*, we also find a non-significant interaction effect.¹⁹

In Table 4, Model 2, Panel A uses analyst earnings forecast dispersion as a proxy for *ASYMMETRY*, which is measured by the standard deviation of these forecasts for all analysts following a specific firm at time t-1. The main effect findings for Model 1 shown in Table 4 hold and the main effect on *ASYMMETRY* is negative and significant (p < 0.01). We also find a marginally negative association between *OCCUR* and *ADVS*ASYMMETRY* (p < 0.10), which suggests that managers may be reluctant to issue an MEF in the period following greater analyst forecast dispersion. It may also be that high analyst dispersion could suggest high earnings uncertainty, which could result in managers' hesitance to issue MEFs.

In Table 4, Panel B assesses the effect of future earnings uncertainty (*STDEARN*) on the associations between *OCCUR* and the proportions of intangibles. Model 1 in Panel B uses *PRE_STDEARN* as a proxy for future earnings uncertainty, whereas Model 2 uses *POST_STDEARN*. Both Models 1 and 2 find a significant negative association between *OCCUR* and *RNDS* (p < 0.01) and a significant positive main effect association between *OCCUR* and *REC_INTAN* (p < 0.01), consistent with *H1* and *H2*. Furthermore, we find a significant negative main effect association between *OCCUR* and *REC_INTAN* (p < 0.01), consistent with *H1* and *H2*. Furthermore, we find a significant negative main effect association between *OCCUR* and both *STDEARN* proxies (*PRE_STDEARN* and *POST_STDEARN*) (p < 0.01), which suggests a reduced likelihood of earnings guidance issuance in the presence of greater earnings uncertainty. Regarding the interaction effect, we find from Models 1 and 2 that more earnings uncertainty may moderate the associations between *OCCUR* and *RNDS*STDEARN* (p < 0.01) and Model 1 finds a significant positive association between *OCCUR* and *ADVS*STDEARN* (p < 0.01) and Model 2 finds a significant positive association between *OCCUR* and *ADVS*STDEARN* (p < 0.01).

In untabulated analysis, the association between OCCUR and the interaction term UNREC_INTAN*ST-DEARN is also positive and significant (p < 0.01 in both Models 1 and 2). This result runs counter to the argument that managers may be reluctant to issue MEFs in the presence of high earnings uncertainty. The results shown in Panel B suggest that in the presence of highly unrecognized intangibles, there may be a level of uncertainty at which managers may need to shift their focus from forecast accuracy to managing market and analyst earnings expectations in this highly uncertain environment. In addition, managers of firms with high earnings volatility and high proportions of unrecognized intangibles face a tradeoff between decreasing information asymmetry regarding future payoffs, high proprietary costs and a high likelihood of reputational capital loss inherent in providing inaccurate voluntary earnings forecasts. Given that MEFs exhibit lower proprietary

 $^{^{18}}$ This is equivalent to the *STDEARN* control variable used in Tables 1–3 and defined in Appendix A. We change the name of this variable in Table 4, Panel B to distinguish it from the *POST_STDEARN* variable.

¹⁹ We assess the VIFs of all of the Panel A analyses, including the industry and year dichotomous variables. We find that all of the variable VIFs do not exceed the severe multicollinearity cutoff of 10 (Hair et al., 1995).

Dependent Variable	OCCUR				FREQ	
	High analyst following(5 or more)		Low analyst following(fewer than 5)		FREQ	FREQ = zero
	Model 1		Model 2		Model 3	Model 4
RNDS		-1.465(-4.97)***		-0.582(-2.17)**	-0.131(3.02)*	-0.926(93.48)***
ADVS		0.227(0.19)		0.194(0.12)	-0.379(2.25)	-0.279(0.55)
REC_INTAN		0.663(5.83)***		1.028(7.81)***	0.075(10.34) ***	0.289(68.48)***
Constant		-2.643(-7.24)***		-4.066(-10.12)***	0.048(0.12)	-2.430(131.73)
\sum controls	Yes		Yes		Yes	Yes
Industry and year effects	Yes		Yes		Yes	Yes
N		10,432		6,796	6,620	17,228
\mathbb{R}^2		65.77 %		54.42 %	29.53 %	52.88 %
Model		31.80***		9.81	232.24***	83.52***

Z statistics (chi-square statistics) in Models 1 and 2 (Model 3 and 4) are shown in parentheses. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.

Notes: This table presents the cross-sectional pooled logistic regression results for Eq. (1) (presented in Table 3) for high analyst following (Model 1) and low analyst following (Model 2). The high (low) analyst following subsample includes firm-year observations involving at least five (fewer than five) analysts following the firm. Models 3 and 4 provide the cross-sectional pooled negative binomial regression results for Eq. (1) (presented in Table 3) after we replace the dichotomous *OCCUR* variable with a count variable (*FREQ*). Model 3 excludes all firm-year observations with missing *FREQ* values, whereas Model 4 replaces missing *FREQ* values with 0. We include industry and year fixed effects in all of the estimations. Firm-year observations are clustered by firm to eliminate autocorrelations, as recommended by Petersen (2009). Variable definitions are presented in Appendix A.

costs than product release disclosures, what appears to be a higher propensity to issue MEFs by these managers may reflect a higher likelihood of MEF issuance relative to other types of more potentially dangerous disclosures that might reveal more proprietary information to competitors. In addition, as per Garcia Osma (2020), managers may signal confidence in future cash flows using MEF disclosure because it is a credible signal that cannot be mimicked by managers who are less confident in the ultimate payoffs from their R&D investments.

6.2. Analyst following

Table 5

We perform several robustness checks of the results presented in Table 3. Chuk et al. (2013) suggest that MEF data are more likely to cover firms with high analyst following. To assess the sensitivity of our findings to analyst following, we repeat our analysis presented in Table 3 for a subsample of firms with high analyst following (five or more analysts) in Model 1 of Table 5 and for a subsample of firms with low analyst following (fewer than five analysts) in Model 2 of Table 5. Regardless of analyst coverage, we still find a significant negative association between *OCCUR* and *RNDS* (p < 0.01 in Model 1 and p < 0.05 in Model 2) and a significant positive association between *OCCUR* and *REC_INTAN* (p < 0.01 in Models 1 and 2 of Table 5). These results suggest that the main findings presented in Table 3 are not driven by analyst coverage.

6.3. MEF frequency

In all of the analyses, we use a dichotomous (1/0) MEF issuance dependent variable as our proxy for voluntary disclosures. An alternative voluntary disclosure measure could be MEF frequency, although the two measures may be considered distinct decisions that managers make regarding voluntary disclosures. MEF frequency may be a secondary decision made after managers determine whether to issue an MEF.²⁰ As a robust-

 $^{^{20}}$ A major limitation of using MEF frequency concerns the reduction in sample size and thus the effect on the generalizability of the findings.
ness check, we investigate the relationship between MEF frequency (*FREQ*), a count variable, and intangibles using a generalized negative binomial model, and we present our findings for Models 3 and 4 in Table 5. Model 3 removes all of the missing *FREQ* observations, consistent with Ajinkya et al. (2005), whereas Model 4 replaces the missing *FREQ* values with 0, consistent with Cao et al. (2018).

For a reduced sample (n = 6,620), after we exclude missing *FREQ* firm-year observations, the analysis shown in Model 3 indicates a marginally significant negative association between *FREQ* and *RNDS* (p < 0.10) and a significant positive association between *FREQ* and *REC_INTAN* (p < 0.01). For the full sample (n = 17,228), after we replace missing *FREQ* values with 0, Model 4 finds that *FREQ* is negatively associated with *RNDS* (p < 0.01) and positively associated with *REC_INTAN* (p < 0.01). These findings are consistent with the findings shown in Table 3 and with *H1* and *H2*. Overall, both the decision to issue MEFs and the frequency of this issuance are influenced by the proportions of recognized and unrecognized intangibles.

6.4. Other robustness checks

According to the U.S. GAAP, SFAS No. 86 provides an exception to the immediate expensing of R&D investments, allowing for the option to capitalize some software development costs. Therefore, the accounting treatment of this subgroup may differ from that of the rest of the sample. We assess whether our results on capitalized intangibles are driven by the software industry and by SFAS No. 86 by excluding 2,446 software industry (SIC codes 7370–7373) firm-year observations. In untabulated analysis, we find evidence consistent with the full sample analysis and with the findings given in Table 3. Specifically, we find a significant negative association between *OCCUR* and *RNDS* (p < 0.01) and a significant positive association between *OCCUR* and *REC_INTAN* (p < 0.01). These findings suggest that our preliminary results are not influenced by exceptional rulings for the software firms included in our full sample.

We further assess whether our findings regarding the proportion of expensed R&D costs are driven by hightech industries that invest heavily in R&D. We divide our sample into high-tech²¹ and non-high-tech industries and repeat our analysis. Untabulated findings for the two subgroups yield similar results consistent with the findings given in Table 3 and with H1 and H2.

We also reassess our findings regarding H1 and H2 using operating expenses rather than sales as a scalar, consistent with the methodology of Barth et al. (2001) and Barron et al. (2002). RND_F is firm *i*'s R&D expenses at time *t* divided by firm *i*'s total operating expenses at time *t* minus the sum of R&D expenses for firms in the industry at time *t* divided by the sum of total operating expenses for firms in the same industry at time *t*. ADV_F is firm *i*'s advertising expenses at time *t* divided by firm *i*'s total operating expenses for firms in the same industry at time *t*. ADV_F is firm *i*'s advertising expenses at time *t* divided by firm *i*'s total operating expenses at time *t* minus the sum of advertising expenses for firms in the industry at time *t*. ADV_F is the same industry at time *t*. REC_INTAN_F is the ratio of recognized intangible assets to total assets minus the median ratio of industry firms' recognized intangible assets to total assets. In untabulated analysis, we find a significant negative association between MEF and $UNREC_INTAN_F$ (p < 0.01), consistent with the findings in Table 3 and supporting H1. We find a significant positive association between MEF and REC_INTAN_F (p < 0.01), consistent with the findings in Table 3 and supporting H1. We find a significant negative association between MEF and supporting H2. We also find that the significant negative association between MEF and $UNREC_INTAN_F$ is driven by RND_F , as the association between RND_F and MEF is negative and significant (p < 0.01), also consistent with the findings shown in Table 3.

Finally, we divide our sample into high- and low-litigation industries²² to assess whether managers' fear of litigation may influence their disclosure behavior in the presence of distinct intangibles and their accounting treatments. For the low-litigation subgroup, we find that managers are more likely to issue an MEF in the presence of greater recognized intangibles REC_INTAN_F (p < 0.01), consistent with H2. This finding could

²¹ We rely on the high-tech industry classification given by Barron et al. (2002) and use the following three-digit SIC codes: 283 (drugs), 284 (chemicals), 357 (computer and office equipment), 366 (communications equipment), 367 (electronics), 371 (motor vehicles), 382 (measurement and control devices), 384 (medical instruments) and 737 (software).

 $^{^{22}}$ We rely on the litigation risk industry classification given by Francis et al. (1994) and use the following four-digit SIC codes: 2833–2836, 3570–3577, 3600–3674 and 5200–5961.

suggest that managers are more confident in their guidance and thus less fearful of litigation for inaccurate guidance in the presence of greater recognized intangibles. For the same subgroup, we do not find significant associations between *OCCUR* and the unrecognized intangible assets (*RNDS* and *ADVS*).

7. Conclusion

Debate persists as to whether managers should continue to issue MEFs or whether MEFs should cease to exist. Another debate revolves around the immediate expensing of intangible investments. We contribute to both debates by assessing MEF disclosure behavior in the presence of varying proportions of recognized and unrecognized intangibles. Managers must assess the potential benefits of issuing guidance (e.g., reducing information asymmetry and cost of capital), particularly for high intangibility-oriented firms, against the costs of providing inaccurate forecasts (reputational damage and even turnover). We hypothesize and find that managers of intangibles to reduce information asymmetry and under higher levels of predictability and capabilities to make annual modifications (i.e., impairment adjustments). We also hypothesize and find that managers provide fewer MEFs in the presence of high proportions of unrecognized intangibles as a precautionary measure against issuing inaccurate forecasts.

Research suggests that there is a greater likelihood of MEF issuance when there are more innovation outputs such as patents and citations. We focus on innovation inputs (R&D and advertising expenses) rather than on innovation outputs and on the embedded uncertainties of these investments. We find that managers are less likely to issue MEFs in the presence of high proportions of R&D expenditures. We also find that managers are more likely to issue MEFs in the presence of higher proportions of recognized intangibles.

Our paper highlights various avenues for future research. It would be interesting to identify environments and situations in which managers' incentives to reduce information asymmetries outweigh potential fears of providing earnings forecast errors for firms with high unrecognized intangibles. This may lead managers to provide additional signals conveying their optimism for firms' R&D investments, which would enhance the information content of financial reports and potentially address some documented mis-valuation of intangible-intensive firms. However, identifying situations that result in managerial hesitance to provide MEFs for firms with high recognized intangibles may signal to market participants a level of uncertainty that may need to be accounted for. Furthermore, assessing the complementary nature of managers' MEFs and analysts' earnings forecasts may contribute to the information content of high intangibility firms' financial reports.

The seemingly opposing results between MEF issuance and unrecognized/recognized intangibles reflect the complex considerations that managers face in their decision-making and provide a foundation for further exploration of the intricate interplay between concerns for forecast accuracy and information asymmetry. It is crucial to recognize that these two concerns often involve tradeoffs and that managerial decisions are likely to be influenced by various factors, as the nature of the intangible assets, industry characteristics, the competitive landscape and the regulatory environment all play a role in shaping managerial choices. Future research could further explore the tradeoffs and managerial considerations involved in navigating these complex dynamics.

Finally, our study examines the occurrence (or absence) of management forecasts but does not delve into the accuracy of management guidance. Exploring whether management guidance is indeed less accurate for firms with high unrecognized intangibles could be an interesting avenue for future research.

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. Definitions of variables

Variable	Definition
Dependent Variables	5
OCCUR	Indicator variable equal to 1 if a firm issues an MEF in year t and 0 otherwise. We draw
	MEFs from the I/B/E/S database.
FREQ	Number of MEFs made in year t , from the I/B/E/S database.
Treatment and Inter	action Variables
UNREC_INTAN	Sum of RNDS and ADVS (defined below) at the end of year t-1.
RNDS	R&D expenses (XRD from Compustat) divided by sales (SALE from Compustat) at the end of year $t-1$. RNDS is winsorized at 1.
ADVS	Advertising expenses (XAD from Compustat) divided by sales at the end of year $t-1$. ADVS is winsorized at 1. If XAD is missing, it is set to 0.
REC_INTAN	Intangible assets (INTAN from Compustat) divided by total assets (AT from Compustat) at the end of year $t-1$. If INTAN is missing, it is set to 0.
AFD	Analyst forecast dispersion calculated by the standard deviation of these forecasts over year $t-1$.
PRE_STDEARN	Standard deviation of earnings (IB from Compustat) divided by total assets (AT from Compustat) for the past 5 years (from year $t-1$ to year $t-5$).
POST_STDEARN	Standard deviation of earnings (IB from Compustat) divided by total assets (AT from Compustat) from year $t + 1$ to year $t + 4$.
Control Variables	
LagOCCUR	Indicator variable equal to 1 if a firm issues an MEF in year t-1 and 0 otherwise.
CAPEX	Capital expenditures (CAPX from Compustat) divided by sales revenue at the end of year t -1. CAPXS is winsorized at 1.
STDRET	Standard deviation of market-adjusted daily returns over fiscal year <i>t</i> –1. Market- adjusted daily returns are calculated as a firm's daily returns (RET from CRSP) minus value-weighted daily market returns (VWRETD from CRSP).
MTB	Market-to-book ratio at the end of year t -1. The market-to-book ratio is calculated as the market value of equity divided by the book value of equity (CEQ from Compustat). The market value of equity is calculated as the share price (PRCC_F from Compustat) times the number of shares outstanding (CSHO from Compustat). We exclude from our sample firm-year observations with a negative book value of equity.
STDEARN	Standard deviation of earnings (IB from Compustat) divided by total assets (AT from Compustat) for the past 5 years (from year $t-1$ to year $t-5$)
ANLST	Log number of analysts issuing earnings per share (EPS) forecasts in year $t-1$. The number of analysts is drawn from I/B/E/S. We include in our sample only firm-year observations with at least one analyst following.
LEV	Leverage at the end of year $t-1$ calculated as long-term debt (DLTT from Compustat) plus the current portion of long-term debt (DLC from Compustat) divided by total assets (AT from Compustat).
LMV	Log of the market value of equity at the end of year $t-1$. The market value of equity is calculated as the stock price (PRCC_F from Compustat) times the number of shares outstanding (CSHO from Compustat).
ROE	Return on equity at the end of year $t-1$. ROE is calculated as income before extraordinary items (IB from Compustat) divided by the book value of equity (CEQ from Compustat).

Appendix A (continued)

Variable	Definition
ISSUE	Sum of stock and debt issuance divided by total assets in year $t-1$. Stock issuance is measured from SSTK from Compustat, and debt issuance is measured from DLTIS from Compustat.
INST	The percentage of shares owned by institutional investors in December of year $t-1$. The percentage is calculated as the number of shares owned by institutional investors (SHARES from Thomson Reuters' Institutional Holdings 13F database) divided by the number of shares outstanding (SHROUT from CRSP).
ΔEPS	Change in EPS calculated as EPS (EPSPX from Compustat) in year $t-1$ minus that in year $t-2$ divided by the stock price (PRCC_F from Compustat) at the end of year $t-1$.
AUDIT	Indicator variable equal to 1 if a company's auditor in year $t-1$ is a Big N auditor and 0 otherwise. Company auditors are identified from AU from Compustat. We identify a firm Big N as having an auditor with an AU value of 1, 3, 4, 5, 6 or 7.
LOSS	Indicator variable equal to 1 if earnings (IB from Compustat) in year $t-1$ are negative and 0 otherwise.

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Audit-firm serving experience heterogeneity and audit knowledge integration: Evidence from the disclosure of key audit matters

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ABSTRACT

Audit practice is a team effort led by signing auditors. We examine the impact of the heterogeneity of signing auditors' audit-firm serving experiences on the disclosure of key audit matters (KAMs). Auditors with more heterogeneous serving experiences demonstrate more adequate KAM disclosure, as evidenced by more KAMs, longer texts and clearer attributions in their disclosures. This effect is influenced by the quality of audit knowledge that auditors accumulate from different serving experiences and the team- and audit-firm-level knowledge integration environment. Furthermore, signing auditors with more diverse service experience tend to improve audit quality, reduce the incidence of restatement or misconduct and enhance the informativeness of financial reports. Our findings enrich the KAM disclosure research and provide insights into audit firms' human resource allocation and internal management. © 2024 Sun Yat-sen University. Production and hosting by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

1. Introduction

In 2016, China's Ministry of Finance mandated new audit report standards, introducing Key Audit Matters sections in listed companies' audit reports to bolster transparency and highlight financial statement risks through auditors' judgment (Chen et al., 2021). Studying the disclosure of key audit matters (KAMs) is pivotal for enriching the content of audit report information and nurturing capital market health (Reid et al., 2015; Wang et al., 2018; Li et al., 2019). Research predominantly examines the economic consequences of KAM disclosure (Wang and Li, 2019; Liu and Lei, 2020; Zhou et al., 2020b). Only a few studies investigate the

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determinants of KAM disclosure, with major focuses on client characteristics (Pinto and Morais, 2019; Li et al., 2020; Qian et al., 2022), individual auditor attributes (Cao, 2021; Chen et al., 2021), client–auditor relationships (Hu and Hu, 2021) and abnormal audit fees (Chen et al., 2022). Audit practice is inherently team work, with the leading signing auditors critically influencing team efficiency (Jiang and Tang, 2016; Yan et al., 2017). In the context of integrated management within accounting firms, exploring effective personnel allocation for audit teams is important for promoting the integration of internal resources within organizations and driving the audit market toward intrinsic, high-quality development. We investigate how the heterogeneity of signing auditors' audit-firm serving experience affects KAM disclosure from a team theory perspective.¹

Auditing is a profession characterized by a relatively high turnover rate, with auditors often transitioning between audit firms (Hermanson et al., 2016). For instance, the Shanghai Institute of Certified Public Accountants announced that in September 2022, 122 certified public accountants in Shanghai handled issues related to transferring to other firms. The professional experiences gained in various firms have a profound impact on individual auditors' knowledge acquisition and cognitive processes (Che et al., 2020; Tian et al., 2021). Furthermore, the diversity in the audit-firm serving experiences of signing auditor pairs may influence their knowledge integration, which has implications for their audit judgments (Carpenter, 2007; Bonner et al., 2022).

Grounded in social identity theory (Haslam and Platow, 2001), similar serving experience has the potential to strengthen the trust and sense of identification between auditor partners (Hwang and Kim, 2009; Collins and Parker, 2010). This can enhance individual risk-taking capabilities and improve communication efficiency among team members (Cameran et al., 2017). Consequently, auditors are more inclined to proactively disclose problems in financial reports (Pittman et al., 2023), which results in more comprehensive and detailed KAM disclosure. Different audit-firm serving experiences can promote knowledge sharing and prevent the homogenization of cognitive resources. By leveraging collective intelligence, auditors can analyze potential significant risks from various angles, leading to more comprehensive KAM disclosure (De Vaan et al., 2015). Therefore, the impact of auditor partners' heterogeneous audit-firm serving experience on KAM disclosure is unclear and requires further exploration.

In this study, we focus on the Chinese audit market in examining the impact of the diverse serving experiences of signing auditors on KAM disclosure from 2016 to 2021. The findings suggest that signing auditors whose serving experience is more heterogeneous are more inclined to disclose a larger quantity of KAMs in their audit reports. Additionally, these disclosures tend to exhibit longer textual contents and clearer attributions. This implies that work experience diversity within audit teams can assist auditors in integrating novel viewpoints and uncovering a greater number of potential significant risk factors. Our main findings remain robust to the additional auditor factors, namely tenure, project scale across different audit-firms and the chronological order of experience, used to construct our proxy for serving experience heterogeneity. Mechanism analysis indicates that the quality of knowledge accrued from diverse serving experiences and the knowledge integration environment at both the team and firm levels significantly impact the effect of audit team experience heterogeneity on KAM disclosure. Specifically, higher audit quality of auditors' serving firms, greater educational gaps between auditors, higher seniority of the signing auditor and smaller audit firm sizes can amplify the impact of experience heterogeneity on KAM disclosure. Finally, we find that the serving experience heterogeneity of signing auditors tends to improve audit quality, reduce the incidence of restatement or misconduct with more audit input in their teamwork and enhance the informativeness of financial reports.

This study contributes to literature by offering novel evidence of the determinants of KAM disclosure. We show the impact of signing auditors' heterogeneous audit-firm serving experiences on KAM disclosure, integrating insights from psychology, organizational behavior and knowledge management. In so doing, we open the "black box" of audit practice by analyzing the influence of audit team structure on service production and the internal transmission of auditors' tacit knowledge (He et al., 2022). Our findings offer a theoretical basis for human resource management in accounting firms and audit market integrated management. Furthermore, we highlight how strategic audit team structures can cater to the urgent information needs of users, which

¹ In this study, we emphasize auditors' audit-firm serving experience because, compared with educational backgrounds and other professional experiences, experience within audit firms exerts a more direct influence on the development of auditors' audit-related knowledge and perspectives. In addition, this experience is closely intertwined with auditors' auditing decisions, as elaborated in Section 3.

offers important policy implications for regulatory bodies to steer accounting firms toward improved governance and foster robust capital market growth.

2. Literature review

Our study is related to three major streams of literature: factors influencing KAM disclosure, auditors' professional experiences and structural characteristics of audit teams.

First, in terms of the factors influencing KAM disclosure, the literature primarily explores the impact of client-level factors, including business complexity (Sierra-García et al., 2019), profitability (Li et al., 2020), risk level (Qian et al., 2022), the relationship between management and auditors (Hu and Hu, 2021) and industry characteristics (Pinto and Morais, 2019). A few studies consider the influence of audit firm characteristics on KAM disclosure. Sierra-García et al. (2019) show that KAM disclosure follows certain firm-related styles. For example, PricewaterhouseCoopers tends to disclose more KAMs related to overall client risk, while KPMG tends to disclose more KAMs related to individual account risks. Griffith et al. (2022) find that firm training guidance and organizational culture can affect audit efficiency and auditors' compliance with policies, thereby ultimately influencing the quality of KAM disclosure.

Research on the impact of individual auditors on KAM disclosure is still in its infancy. Some literature analyzes abnormal audit fees (Chen et al., 2022), auditor industry expertise (Chen et al., 2021), auditor gender (Cao, 2021), decision-making styles (Rousseau and Zehms, 2024), auditor changes (Chen et al., 2023) and their influence on KAM disclosure. However, studies mostly consider the decision-making unit of audit activities as a whole, focusing on how the individual characteristics, personal audit styles and experience and abilities of auditors affect their KAM disclosure while overlooking the collaborative nature of audit service operations within a team (Cameran et al., 2017; Shi et al., 2019). Through positive interactions with one another, team members can integrate an organization's available knowledge resources, refine individual existing capabilities and stimulate new learning motivations (Liu et al., 2014), thereby enhancing the team's ability to process complex information. When a signing auditor encounters significant issues requiring professional judgment during the practice process, the knowledge resources and experience provided by the audit team and explore its core leadership. Specifically, we examine the impact of serving experience heterogeneity between signing auditors on KAM disclosure, thus contributing more evidence to this field of research and offering a reference for audit teams' human resource allocation.

Second, we contribute to the literature on the professional experiences of signing auditors. One strand of literature focuses on business-level working experience. Researchers find a positive correlation between the number of audit reports signed, years of practice (Cahan and Sun, 2015; Wang et al., 2016; Pan and Zhang, 2019), the cumulative number of reports issued in specific industries (Liu and Li, 2022) and audit quality. More relevant to our study is another strand of literature that explores the impact of firm-level serving experience on auditor behavior. For example, some scholars show that auditors with experience at Big 4 audit firms exhibit greater independence and sharper professional judgment and demonstrate higher audit quality (Gul et al., 2013; Che et al., 2020). Researchers also document that accounting firms can weaken the differentiated impact of individual auditor traits on audit quality through unified training and personnel assessments, forming a firm-level audit style. As a result, the audit-firm serving experience significantly influences individual auditors' audit practice and thought patterns (Francis et al., 2014; Tian et al., 2021), and this influence possesses a certain level of continuity with changes in auditor tenure experience (Gul et al., 2013), laying the foundation for us to explore the role of firm tenure experience in shaping auditor styles and thought patterns in this study.

Third, this study is related to the literature on the structural characteristics of audit teams. The literature mainly focuses on the impacts of stability, homogeneity, heterogeneity and other structural characteristics of audit teams on audit quality. For instance, Yan et al. (2017) find that the stability of signing auditor partnerships significantly enhances audit quality. Findings on the roles of audit team homogeneity and heterogeneity are inconsistent. Some studies suggest that homogeneity is more likely to generate strong cohesion and higher work efficiency, and thus the homogeneity of signing auditor partnerships promotes audit quality (Chin and Chi, 2008; Shi and Cheng, 2011). However, other studies indicate that the diverse perspectives of auditor partnerships generate cognitive conflicts, forcing them to consider a broader range of information, gather more evidence to assess risks and significantly increase the probability of issuing modified audit opinions (Liu and Bi, 2019). The literature on the homogeneity and heterogeneity of audit teams mostly focuses on demographic characteristics, such as auditor gender, age and education. In contrast, we focus on auditors' serving experiences in different audit firms; as mentioned earlier, this characteristic is more closely related to the accumulation of knowledge and thought patterns associated with auditors' practice and more directly influences audit judgments. We construct an indicator to capture the heterogeneity of signing auditors' professional judgment. In so doing, we not only enrich the literature on the structural characteristics of audit teams but also provide new insights for project management through the full exploration of individual auditor information.

3. Hypothesis development

3.1. Heterogeneity of audit-firm serving experience and KAM disclosure

Signing auditors rely on their professional knowledge and risk perception to identify significant misstatement risks in financial reports and to determine the quantity and detail of disclosure matters (Li and Lu, 2021). Heterogeneous firm serving experiences shape auditors' audit styles and knowledge systems differently, further affecting KAM disclosure through knowledge integration within the team.

The literature suggests that audit firms can shape auditors' styles and knowledge systems through unified training, assessments and cooperation to ensure that auditors' behaviors reflect the unique work norms and standardized processes of a given firm (Francis et al., 2014; Che et al., 2020; Wang and Hu, 2020; Wang et al., 2022). For example, Francis et al. (2014) point out the similarity in the financial reports of clients from the same firm due to firms' internal norms for interpreting and implementing standards, which is fostered through internal training and the provision of other tools, libraries and employee resources. Taking KAM disclosure as an example, Lu and Zhang (2018) observe industry-firm-level effects in the form and audit response procedures of KAMs: most impairment-related KAMs are issued by Big 4 audit firms, while domestic audit firms (e.g., Shinewing) are more sensitive to revenue recognition issues in manufacturing companies, issuing more revenue-related KAMs and conducting additional audit procedures. Consistent with this, Sierra-García et al. (2019) find that compared with other Big N audit firms, PricewaterhouseCoopers discloses more KAMs related to overall client risk. Therefore, different firm serving experiences can endow auditors with different audit styles and knowledge systems.

Differences between signing auditors' audit-firm serving experiences may also affect the auditors' knowledge integration and, ultimately, audit team output. Based on social identity theory (Haslam et al., 2020; Haslam and Platow, 2001), signing auditors with common serving experiences have stronger risk-sharing capabilities and higher communication efficiency, prompting them to disclose more KAMs. High similarity in serving experience can enhance trust and identification among auditors (Collins and Parker, 2010), thus improving their willingness to reveal misstatement risks in financial reports (Pittman et al., 2023). Auditors also tend to engage in more in-depth discussions with colleagues who have similar mindsets and knowledge systems (Li and Hambrick, 2005; Bezrukova et al., 2009; Christian et al., 2009; He et al., 2022), facilitating knowledge transfer and absorption (Song and Wang, 2020) and thereby helping audit teams uncover more detailed and clearly attributable KAMs (Tian et al., 2021).

Heterogeneous serving experiences can alleviate the herd effect among audit team members, providing fresh perspectives for audit team decision-making and thereby promoting the identification of more comprehensive and appropriate KAMs. According to social loafing theory (Steiner, 1972; Boeker, 1997), when the homogeneity within a group is high, given similar knowledge systems and mindsets, team members tend to trust each other's decisions. This trust can reduce benign task conflicts, leading to a decrease in individual effort (Ni et al., 2013; Wang et al., 2020) and creating a herd effect. Under the influence of the herd effect and in an effort to play it safe, auditors within a team may choose to go along with the majority to avoid uncertainty, which can inhibit the disclosure of uncertain matters and thereby reduce the adequacy of KAM disclosure (Dannemiller et al., 2022). In contrast, in a highly heterogeneous environment, proposing different viewpoints will not threaten auditors' sense of belonging. Thus, heterogeneity in serving experience can allow individual professional knowledge to spread throughout the team (Dhanaraj et al., 2004; Song and Wang, 2020) and enhance the integration and utilization of team knowledge (Sun and Wei, 2011). Heterogeneous serving experiences can also introduce fresh perspectives (Chen et al., 2013), help auditors analyze potential significant risks to their companies from multiple perspectives, reduce selective biases due to path dependence in the KAM determination process (De Vaan et al., 2015; Cameran et al., 2017) and increase the adequacy of KAM disclosure. Essentially, continuous organizational knowledge accumulation and collective learning can induce knowledge convergence (Gulati et al., 2012; Zhou and Chen, 2015) as well as create exclusion effects, hindering the flow of new knowledge (Sytch et al., 2012). In a team context, strong heterogeneity in auditors' serving experiences implies less overlap in their knowledge and skills. This broadens the audit team's information pool (Li and Wu, 2017), increases the organization's knowledge stock, updates the team's knowledge structure and leads to continuous knowledge creation (Rosenkopf and Padula, 2008).

Accordingly, we propose two competing hypotheses:

H1a: Signing auditors with more heterogeneous audit-firm serving experience demonstrate lower KAM disclosure adequacy.

H1b: Signing auditors with more heterogeneous audit-firm serving experience demonstrate higher KAM disclosure adequacy.

As discussed above, serving experience heterogeneity influences knowledge accumulation and integration within audit teams. Next, we delve further into the mechanisms through which heterogeneous audit-firm serving experiences exert their influence, focusing on both the quality of knowledge accumulation and the environment for knowledge integration.

3.2. Quality of knowledge accumulation

The usefulness of implicit organizational knowledge is contingent upon the quality of that knowledge (Hill and Rothaermel, 2003; Demirkan et al., 2013). High-caliber knowledge substantially elevates the knowledge integration process, augmenting the organizational knowledge base (Kang and Liu, 2021). The literature indicates that auditors who work in high-audit-quality firms exhibit stringent quality controls, accruing superior business acumen through diverse knowledge resources and thereby enhancing audit quality (Zhou et al., 2020a; Liu and Li, 2022). This suggests that audit teams benefit from high-quality audit knowledge integration.

Conversely, auditors from firms with audit failures tend to amass low-quality audit knowledge, which increases misreporting risks (Francis and Michas, 2013). In such scenarios, the utility of heterogeneous serving experiences in mitigating significant misreporting risks is diminished. This leads to our second hypothesis:

H2: When auditors accumulate higher-quality knowledge from prior audit-firm serving experiences, the impact of their heterogeneous experiences on KAM disclosure is more pronounced.

3.3. Knowledge integration environment

3.3.1. Team-level knowledge integration environment

According to knowledge grid theory (Gu et al., 2006), an optimal knowledge gap between transmitters and receivers engenders a knowledge potential difference, catalyzing effective knowledge sharing and integration (Yang and Li, 2008; Cricelli and Grimaldi, 2010). Therefore, knowledge potential difference between signing auditors can foster a conducive knowledge integration environment.

The educational disparity among auditors within an audit team can affect individuals' knowledge reserves and information absorption abilities, thereby creating a knowledge gap (Jensen and Zajac, 2004). Auditors with higher education levels typically possess stronger cognitive abilities (Du and Hou, 2019), enabling them to better digest and understand relevant policies regarding audit reforms and make more accurate KAMrelated judgments. Therefore, auditors with higher education levels are more capable of sharing risk identification techniques with team members who have relatively lower educational backgrounds through work communication, further promoting the integration and transfer of tacit knowledge (Ye, 2021).

However, differences in seniority among signing auditors can also lead to knowledge differentials within the team, thereby affecting the efficiency of knowledge transfer. Audit engagements are executed by audit teams to

complete audit procedures, with review and engagement partners providing guidance, supervision and review throughout the entire audit process. The work focuses and responsibilities of the two signing auditors are slightly different. The primary responsibility of the review partner is to conduct the final quality review of significant issues, such as audit risks identified by the team and their corresponding responses, and the appropriateness of audit reports, whereas the engagement partner is primarily responsible for fieldwork, providing specific on-site guidance and supervision (Wang et al., 2016; Liu and Li, 2022; Yan et al., 2022). In practice, given the high level of tacit knowledge obtained through their extensive professional experiences, review partners typically have more seniority than engagement partners and thus exert relatively greater influence on audit decisions. Review partners also demonstrate a stronger capability to identify misstatement risks (Han, 2016; Chen et al., 2017).

We thus expect review partners to be better able to utilize their position, professional experience and expertise to transmit tacit knowledge to engagement auditors in weaker knowledge positions, facilitating internal knowledge transfer and integration. Furthermore, engagement auditors tend to absorb the knowledge and skills of review partners with richer tacit knowledge, resulting in better diffusion and integration of knowledge. As a result, the impact of review partners' heterogeneous serving experiences on knowledge integration is more pronounced. Therefore, we propose our third hypothesis as follows:

H3a: Educational gaps among audit partners amplify the impact of heterogeneous experiences on KAM disclosure.

H3b: Review partners exert a more significant influence on KAM disclosure than engagement partners through their heterogeneous serving experiences.

3.3.2. Audit-firm-level knowledge integration environment

Studies suggest that the collective mindset and standardized organizational characteristics of audit firms, such as audit procedures, can influence auditors' identification and judgment of KAMs (Tian et al., 2021). Specifically, small audit firms are often limited by factors such as human resources, quality control systems and technology, resulting in a lower level of standardization and uneven internal knowledge levels. Their determination of KAMs can be more influenced by the professional sensitivity of signing auditors. In contrast, big audit firms (e.g., domestic and international Big 4 audit firms) have developed more mature internal systems for judging KAMs internally. Additionally, auditors employed by larger firms typically undergo systematic training and continuing education (Che et al., 2020; Liu and Li, 2022), enabling them to utilize standardized procedures for identifying KAMs and apply uniform thinking processes and workflows to ensure audit quality (Tian et al., 2021). Such highly homogenized knowledge environments limit the complementary effect of knowledge. Based on this, we propose our fourth hypothesis as follows:

H4: The influence of auditors' heterogeneous serving experiences on KAM disclosure is more pronounced in smaller audit firms.

4. Data and research methodology

4.1. Sample selection and data sources

Following prior research (Chen et al., 2021; He et al., 2021; Cai et al., 2022), we use Chinese A-share listed companies that disclosed KAMs from 2016 to 2021 as the initial sample. To facilitate our analyses, we further exclude the following observations: (1) firms in the finance industry, (2) samples with a missing number of signing auditors or other than two signing auditors, (3) special treatment firms (i.e., marked ST or *ST) and (4) samples with missing variables. The final sample includes 12,570 firm-year observations. We manually collect data on the auditors' experience and personal characteristics from the Chinese Institute of Certified Public Accountants and annual reports, and we obtain the companies' financial statement data from the China Stock Market and Accounting Research database. To mitigate the effect of outliers, all of the continuous variables are winsorized at the 1st and 99th percentiles.

4.2. Definitions of key variables and model construction

4.2.1. Adequacy of KAM disclosure

Following Zhou et al., (2020b) and Chen et al. (2021), we capture the adequacy of KAM disclosure via the quantity and quality of disclosure. The quantity of KAM disclosure is assessed using the natural logarithm of the number of KAM disclosure items (*LnKAM*) as well as the natural logarithm of the word count of KAM disclosures (*LnWord*). The quality of KAM disclosure is determined through a keyword search method, in which the presence of keywords such as "significant misstatement risk," "significant judgment" and "significant transactions or matters" within the Key Audit Matters section is considered indicative of clear KAM attribution (*LnClear*) and the count of such clear attributions is log-transformed (plus 1). Consequently, higher values of *LnKAM*, *LnWord* and *LnClear* indicate more comprehensive KAM disclosure.

4.2.2. Heterogeneity of signing auditors' serving experience

We use *Difference* to capture the degree of heterogeneity in the signing auditors' serving experiences. *Difference* equals the number of non-overlapping audit firms served by the signing auditors divided by the total number of unique firms served²:

$$Difference = 1 - \frac{\text{the intersetion set of auditor pairs' audit - firm experience}}{\text{the union set of auditor pairs' audit - firm experience}}$$
(1)

In the robustness test, we consider additional factors (i.e., the auditors' tenure, their project scales across different firms and the chronological order of their experiences) and re-construct the *Difference* proxy.

4.2.3. Models

To test our main hypotheses, we construct the following model:

$$A dequacy_{it} = \alpha_0 + \alpha_1 Difference_{it} + \sum Controls_{it} + \sum Industry + \sum Year + \varepsilon_{it}$$
(2)

where Adequacy indicates the adequacy of KAM disclosure, as captured by LnKAM, LnWord and LnClear. Difference refers to the heterogeneity of signing auditors' audit-firm serving experiences. Following prior research (Chen et al., 2021; Lennox et al., 2023), we further control for client, auditor and audit-team-level characteristics, including client size (Size), leverage (Lev), profitability (ROA), incurrence of loss (Loss), sales growth (Growth), operating cash flow (CFO), accounts receivable (AR), the current ratio (CR), inventory (INV), ownership structure (SOE), largest shareholder ownership (Top1), years listed (ListAge), auditor changes (Change), whether audited by an international Big 4 firm (Big4), audit opinion (MAO), years of experience as an engagement partner (Experience), length of collaboration (Collaboration), gender differences (GenderDIFF), educational differences (EduDIFF) and tenure differences between signing auditors (ExpDIFF). Table 1 provides detailed variable definitions. We also control for industry (Industry) and year (Year) fixed effects in the model.

² We illustrate the concept of tenure heterogeneity using two examples. In example 1, auditor A has experience at Yuehua Accounting Firm, Zhongrui Yuehua Accounting Firm and ShineWing Accounting Firm. Her partner, auditor B, has served at Shanghai Donghua Accounting Firm and ShineWing. The total number of non-overlapping firms between them is three (Yuehua, Zhongrui Yuehua and Shanghai Donghua), with four audit firms served collectively (Yuehua, Zhongrui Yuehua, Shanghai Donghua and ShineWing). Thus, their serving experience heterogeneity, denoted as *Difference*, is 0.75 (=3/4). In example 2, auditor C has experience at Shenzhen Nanfang Minhe Accounting Firm, China Audit International Accounting Firm, Dahua Accounting Firm and Zhongshen Hua Accounting Firm. Her partner, Auditor D, has served at Shenzhen Nanfang Minhe, China Audit International and Zhongshen Hua. Here, the non-overlapping firm count is one (Dahua), with four audit firms served collectively. Consequently, *Difference* in this case is 0.25 (=1/4).

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Table I	
Variable	definitions.

Туре	Variable	Definition
Dependent variables	LnKAM LnWord LnClear	The natural logarithm of the number of items disclosed in the Key Audit Matters section. The natural logarithm of the number of words used to describe and respond to KAMs. The natural logarithm of the number of KAMs with keywords such as "significant misstatement risk," "significant judgment" and "significant transactions or matters."
Independent variable	Difference	The number of non-overlapping audit firms served by the signing auditors, divided by the total number of unique firms served.
Control variables	Size Lev ROA Loss Growth CFO AR CR INV SOE TOP1 ListAge Change Big4 MAO Experience Collaboration GenderDIFF	The natural logarithm of total assets. The ratio of total liabilities to total assets. The ratio of net income to total assets. Equals 1 if the company reports negative net income in the current year, and 0 otherwise. Sales growth, computed as the percentage change in sales from the prior year to the current year. Operating cash flow divided by the average of beginning and ending total assets. The ratio of accounts receivable to total assets. The ratio of current assets to current liabilities. The ratio of inventory to total assets. Equals 1 for state-owned companies, and 0 for private companies. The percentage of shares held by the largest shareholder. The number of years a company has been listed. Equals 1 if the auditor changes in the current year, and 0 otherwise. Equals 1 if the company receives a modified audit opinion, and 0 otherwise. Equals 1 if the company receives a modified audit opinion, and 0 otherwise. The number of years since the first year in which an auditor served as an engagement partner of a publicly listed company. The number of years the signing auditor partners have continuously collaborated in their current audit firm. Equals 1 if the audit team members are of the same gender, and 0 otherwise.
	EduDIFF ExpDIFF	Equals 1 if the audit team members have the same education levels, and 0 otherwise. The absolute difference in total years of auditing experience between the signing auditor pairs.
Variables in mechanism analysis	Biglocal	Equals 1 if the non-overlapping serving firms consist of domestic or international Big 4 audit firms, and 0 otherwise.
·	Misconduct BigAF	Equals 1 if the non-overlapping serving firms were penalized during signing auditors' serving period due to misconducts in auditing peer industry clients, and 0 otherwise. Equals 1 if the company is audited by domestic or international Big 4 audit firms, and 0 otherwise.
	Difference1 Difference2	The contribution of the review partner to non-overlapping serving firms. The contribution of the engagement partner to non-overlapping serving firms.

5. Empirical results analysis

5.1. Descriptive statistics of signing auditors' serving experience

Table 2 presents the descriptive statistics for the signing auditors' audit-firm serving experiences. The average number of serving experiences across different audit firms for each signing auditor (AuditorExp) is 1.349. Notably, the review partners (AuditorExp1) demonstrate tenure in up to 5 distinct audit firms, in contrast to the maximum of 4 for the engagement partners (AuditorExp2). The average number of serving experiences for the review partners is 1.616, surpassing the engagement partners' average number of serving experiences of 1.185, indicating a broader spectrum of professional exposure among the review partners.

The maximum number of non-overlapping serving experiences within an audit team is 4, with a maximum of 5 collective serving firms, culminating in a maximum *Difference* value of 0.8. The average heterogeneity in team working experience (*Difference*) is 0.239, suggesting that 23.9 % of the serving experiences between a pair of signing auditors do not overlap.

Variables	Mean	SD	Min.	Median	Max.
Panel A: Individual auditor					
AuditorExp	1.349	0.752	1.000	1.000	5.000
AuditorExp1	1.616	0.951	1.000	1.000	5.000
AuditorExp2	1.185	0.510	1.000	1.000	4.000
Panel B: Audit team					
Number of Experiences in the Difference Set	0.679	0.941	0.000	0.000	4.000
Number of Experiences in the Union Set	1.796	1.023	1.000	1.000	5.000
Difference	0.239	0.290	0.000	0.000	0.800

Table 2 Descriptive statistics for signing auditors' audit-firm serving experience

5.2. Descriptive statistics of the primary variables

Table 3 reports the descriptive statistics of key variables in the regression model. *LnKAM (raw)* spans from 1 to 6, with a standard deviation of 0.645 and a mean value of 2.041. This reflects notable variation in the number of items included in KAMs among the sample companies. The average of *LnWord (raw)* is 1,046, with a large disparity between the minimum and maximum values. The mean of *LnClear (raw)* is 1.869, indicating prevalent clarity in the attribution of KAMs in the companies' audit reports. These descriptive statistics align with the prior findings (e.g., Lu and Zhang, 2018; Wang and Li, 2019; Chen et al., 2021), underscoring the consistency in KAM disclosure adequacy. The descriptive statistics of the other control variables align with existing research and are not elaborated.

5.3. Regression analysis

Table 4 presents the main regression results for the impact of the heterogeneity of signing auditors' serving experiences on KAM disclosure. The association between *Difference* and KAM disclosure is positive and significant at the 1 % level. Specifically, the coefficients of KAMs disclosed (*LnKAM*), textual length (*LnWord*) and attribution clarity (*LnClear*) are 0.054, 0.061 and 0.045, respectively, which are statistically significant at the 1 % level. In terms of economic significance, when serving experience heterogeneity increases from 0 (complete similarity) to 1 (complete dissimilarity), KAMs disclosed, textual length and attribution clarity increase by 5.4 %, 6.1 % and 4.5 %, respectively.

These findings imply that auditors with diverse serving experiences can use knowledge complementarity and collective intelligence, thus effectively counteracting conventional thinking biases in KAM disclosures. These results support H1b.

5.4. Mechanism analysis

To further analyze the potential mechanisms through which the heterogeneity of auditors' tenure experience influences KAM disclosure, we explore the boundary conditions from two dimensions: the quality of knowledge accumulation and the environment of knowledge integration.

5.4.1. Effects of the quality of knowledge accumulation

As proposed in H2, when the audit quality of a serving firm is higher, auditors can acquire more highquality knowledge from their experience at that firm, thereby providing better resources for team knowledge integration. On the contrary, when the audit quality of a serving firm is poor, auditors may accumulate knowledge of relatively lower quality from their experiences within that firm, which adds little value for team knowledge integration. To test this hypothesis, we define serving experience at domestic or international Big 4 audit firms as high-quality experience. *Biglocal* equals 1 if the non-overlapping serving firms consist of domestic or international Big 4 audit firms, and 0 otherwise. Additionally, drawing from the literature (Francis and Michas, 2013; Huang et al., 2015; Yang et al., 2018), serving experience at firms where peer industry clients

Table 3					
Descriptive	statistics	for	the	key	variables.

Variables	N	Mean	SD	Min.	Median	Max.
LnKAM	12,570	0.659	0.340	0.000	0.693	1.609
LnKAM (Raw)	12,570	2.041	0.645	1.000	2.000	6.000
LnWord	12,570	6.866	0.421	5.670	6.897	8.320
LnWord (Raw)	12,570	1,046.254	438.044	199.000	989.000	5,498.000
LnClear	12,570	1.016	0.288	0.000	1.099	1.792
LnClear (Raw)	12,570	1.869	0.737	0.000	2.000	5.000
Difference	12,570	0.239	0.290	0.000	0.000	0.800
Size	12,570	22.375	1.318	19.812	22.192	28.505
Lev	12,570	0.423	0.197	0.062	0.418	1.003
ROA	12,570	0.034	0.076	-0.451	0.037	0.219
Loss	12,570	0.109	0.312	0.000	0.000	1.000
Growth	12,570	0.166	0.383	-0.668	0.111	3.335
CFO	12,570	0.050	0.066	-0.180	0.050	0.252
AR	12,570	0.129	0.104	0.000	0.108	0.505
CR	12,570	2.320	2.039	0.094	1.671	15.577
INV	12,570	0.134	0.121	0.000	0.107	0.661
SOE	12,570	0.325	0.468	0.000	0.000	1.000
Top1	12,570	33.615	14.253	9.200	31.160	86.010
ListAge	12,570	11.640	8.058	0.830	9.567	29.132
Change	12,570	0.575	0.494	0.000	1.000	1.000
Big4	12,570	0.062	0.242	0.000	0.000	1.000
MAO	12,570	0.033	0.178	0.000	0.000	1.000
Experience	12,570	12.300	5.090	1.000	13.000	23.000
Collaboration	12,570	2.761	2.360	1.000	2.000	12.000
GenderDIFF	12,570	0.446	0.497	0.000	0.000	1.000
EduDIFF	12,570	0.490	0.500	0.000	1.000	1.000
ExpDIFF	12,570	7.627	4.933	0.000	7.000	20.000

have been penalized is defined as low-quality experience. *Misconduct* equals 1 if the non-overlapping serving firms of a signing auditor pair contain low-quality experience, and 0 otherwise.

Table 5 shows that in the subsample with high-quality knowledge accumulation (i.e., Biglocal = 1 or Misconduct = 0), the coefficients of *Difference* are positive and significant at the 5 % level or better, with the exception of those in Column (5) of Panel A. In the subsample with low-quality knowledge accumulation, the coefficients of *Difference* are not significant. These results support H2 that heterogeneity in audit-firm serving experiences substantially bolsters KAM adequacy, predominantly when coupled with high-quality knowledge accumulation during that heterogeneous experience.

5.4.2. Effects of the knowledge integration environment

Next, we examine the impact of the knowledge integration environment. As proposed in H3a and H3b, educational gaps and seniority differences between signing auditors can reinforce the effect of heterogeneous serving experience by facilitating knowledge integration. Additionally, H4 predicts that smaller firms tend to depend more on individual auditors' knowledge and professional acumen for KAM assessments. However, larger firms often utilize more established and standardized systems for KAM evaluation, which may attenuate the benefits of diversity in audit team knowledge.

To empirically test these hypotheses, we first use *EduDIFF* to capture educational differences. *EduDIFF* equals 1 in cases of educational disparity among audit partners, and 0 otherwise. Then, we split *Difference* into *Difference1 and Difference2* according to the contribution of the review partner and engagement partner, respectively, to non-overlapping serving firms. Furthermore, audit firm size is utilized to evaluate the knowl-edge integration environment at the audit-firm level. Specifically, *BigAF* is an indicator that equals 1 for auditors in domestic or international Big 4 audit firms, and 0 otherwise.

Variables (1)	(2)	(3)
LnKAM	LnWord	LnClear
Difference 0.054***	0.061***	0.045***
(3.19)	(2.85)	(2.97)
Size 0.054***	0.069***	0.042***
(10.40)	(10.45)	(10.19)
Lev 0.059	0.085*	0.063*
(1.54)	(1.77)	(1.95)
ROA -0.481***	-0.485***	-0.373***
(-6.52)	(-5.42)	(-5.90)
Loss 0.013	0.022	0.011
(0.86)	(1.19)	(0.85)
$ListAge = -0.002^*$	-0.002	-0.001
(-1.95)	(-1.59)	(-1.08)
CFO	-0.094	-0.121**
(-2.52)	(-1.26)	(-2.31)
<i>Growth</i> 0.042***	0.049***	0.033***
(5.18)	(4.73)	(4.61)
AR 0.225***	0.349***	0.230***
(4.28)	(5.17)	(5.11)
CR	0.001	0.002
(-0.07)	(0.34)	(0.81)
<i>INV</i> 0.045	0.009	-0.033
(0.92)	(0.14)	(-0.73)
<i>Top1</i> -0.001****	-0.001	-0.000
(-2.61)	(-1.58)	(-1.46)
SOE -0.046***	-0.080^{***}	-0.040^{***}
(-3.61)	(-4.91)	(-3.62)
Big4 -0.075***	0.056*	-0.005
(-2.94)	(1.87)	(-0.27)
MAO -0.087***	-0.103****	-0.069***
(-3.56)	(-3.54)	(-3.43)
Change 0.004	0.014**	0.003
(0.75)	(2.00)	(0.52)
<i>Experience</i> -0.004 ^{****}	-0.006^{***}	-0.000
(-2.78)	(-3.19)	(-0.41)
Collaboration -0.001	-0.000	-0.002
(-0.61)	(-0.04)	(-0.94)
GenderDIFF -0.005	-0.003	0.003
(-0.70)	(-0.33)	(0.48)
EduDIFF –0.009	-0.030^{***}	-0.019^{***}
(-1.14)	(-3.02)	(-2.76)
ExpDIFF -0.000	0.000	-0.002*
(-0.33)	(0.03)	(-1.90)
<i>Constant</i> –0.472 ^{****}	5.389***	0.086
(-4.23)	(38.02)	(0.97)
Industry FE Yes	Yes	Yes
Year FE Yes	Yes	Yes
N 12,570	12,570	12,570
$Adj. R^2 0.087$	0.088	0.081

 Table 4

 Heterogeneity of signing auditors' serving experience and KAM disclosure.

Notes: The *t*-statistics shown in parentheses are adjusted for clustering by client. ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively.

Table 5 Effects of the quality	/ of knowledge accumulat	ion.				
Panel A: Knowledge	accumulation quality as ca	uptured by the size of the serv	ing firm			
Variables	LnKAM		LnWord		LnClear	
	(1) $Biglocal = I$	(2) $Biglocal = 0$	(3) $Biglocal = I$	(4) $Biglocal = 0$	(5) Biglocal = I	(6) $Biglocal = 0$
Difference	0.180^{**} (2.09)	0.012 (0.55)	0.328^{***} (2.95)	-0.008 (-0.30)	0.061 (0.87)	0.020 (1.09)
Controls Industry FE Your FF	Yes Yes Ves	Yes Yes Ves	Y es Y es V es	Yes Yes Ves	Yes Yes Ves	Yes Yes Ves
Adj. R ²	1,916 0.098	10,654 0.093	1,916 0.114	10,654 0.099	1,916 0.089	10,654 0.086
Panel B: Knowledge	accumulation quality as ca	ptured by the misconduct of	the serving firm			
Variables	LnKAM		LnWord		LnClear	
	(1) <i>Misconduct</i> = 0	(2) $Misconduct = I$	(3) <i>Misconduct</i> = 0	(4) <i>Misconduct</i> = <i>I</i>	(5) <i>Misconduct</i> = 0	(6) <i>Misconduct</i> = <i>I</i>
Difference	0.062^{***} (3.13)	0.073 (0.89)	0.062** (2.45)	0.129 (1.19)	0.054^{***} (3.07)	0.024 (0.36)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE Year FE	Yes Yes	Y es Y es	Y es Y es	Y es Y es	Yes Yes	Yes Yes
N Adj. R^2	10,994 0.089	1,574 0.091	10,994 0.091	1,574 0.102	10,994 0.085	1,574 0.087
Notes: The <i>t</i> -statistic	cs shown in parentheses a	re adjusted for clustering by	client. ***, ** and * indicate	significance at the 1%, 5% i	and 10% levels, respectively.	

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Panel A of Table 6 shows that the coefficient of *Difference* is more significant in the subsample with educational disparity (EduDIFF = 1).³ This result supports H3a, indicating that cognitive variances between signing auditors bolster audit knowledge integration and circulation, thus enhancing the impact of heterogeneity in serving experience on KAM disclosure adequacy. The results in Panel B of Table 6 reveal that *Difference1* has a positive effect on all KAM disclosure adequacy indices at the 1 % significance level, whereas *Difference2* fails to load. This finding is consistent with H3b that review partners with more diverse experience can effectively integrate knowledge within audit teams and transfer tacit knowledge acquired from various firms to less experienced members, thus improving KAM disclosure adequacy.

In Panel C of Table 6, we use audit firm size to assess the audit-firm-level knowledge integration environment. The results show that for signing auditor pairs in small audit firms, the coefficients of *Difference* are positive and significant at the 5 % level or better. In contrast, this effect disappears in big audit firms. These results are consistent with H4 that smaller firms offer a better environment for the knowledge integration of signing auditors with different serving experiences.

5.5. Robustness test

5.5.1. Alternative measurement of key explanatory variables

In the previous analyses, we measure the heterogeneity of signing auditors' serving experiences without considering the characteristics of each serving experience. Next, we deepen our analyses by further examining the signing auditors' tenure at their serving firms, the scale of their projects across firms and the chronological order of their serving experiences.

(1) Tenure and project scale

The accumulation of knowledge and experience increases with the duration of service and project scale (Ashton, 1991; Zhang and Xu, 2014). Therefore, we construct an indicator, $Diff_{Tenure}$, measured as the tenure at non-overlapping serving firms as a proportion of the auditors' total years of professional practice. Considering that auditors may accumulate more professional skills and experience as they audit larger projects (Song and Yu, 2018), we also construct an indicator considering the scale of the auditors' projects. As audit fees are closely related to project scale, complexity, risk and the time and effort required, we use the proportion of each auditor's cumulative audit fees at non-overlapping serving firms to the total cumulative audit fees in their professional practice as an indicator, $Diff_{ProjectScale}$, to account for project scale:

$$Diff_{Tenure} = \frac{\text{Auditor1's diverse serving tenure}}{\text{Auditor1's total serving tenure}} + \frac{\text{Auditor2's diverse serving tenure}}{\text{Audior2's total serving tenure}}$$
(3)
$$Diff_{Projectscale} = \frac{\text{Auditor1's accumulated audit fees from diverse audit firms}}{\text{Auditor1's accumulated audit fees from overall serving experience}}$$
$$+ \frac{\text{Auditor2's accumulated audit fees from diverse audit firm}}{\text{Auditor2's accumulated audit fees from overall serving experience}}$$
(4)

(2) Career development

Given the dynamic nature of knowledge accumulation, the accrual of tacit knowledge has a temporal dimension. Specially, recently accumulated knowledge tends to supersede and overshadow previous knowledge accumulation (Song et al., 2011; Tang et al., 2020). Additionally, within the self-reinforcing cycle of knowledge, auditors continually enhance their capability to apply and reconstitute knowledge (Carlile and Rebentisch, 2003; Wei et al., 2017; Tang et al., 2020). Thus, recent serving experiences, often more aligned with

³ Readers are cautioned to interpret these results prudently, as heterogeneity in serving experiences among auditor partners with identical education levels still influences the adequacy of KAM disclosure.

Table 6 Effects of the knowled	dge integration environmer	at.				
Panel A: Educational	gaps among audit team					
Variables	LnKAM		LnWord		LnClear	
	(1) <i>EduDIFF</i> = 1	(2) <i>EduDIFF</i> = 0	(3) <i>EduDIFF</i> = 1	(4) $EduDIFF = 0$	(5) <i>EduDIFF</i> = 1	(6) $EduDIFF = 0$
Difference	0.058^{**} (2.50)	0.053^{**} (2.34)	0.089^{***} (3.14)	0.035 (1.22)	0.054*** (2.69)	0.035* (1.77)
Controls Industry FE Year FE	Yes Yes Yes	Y es Y es Y es	Yes Yes Yes	Y es Y es Y es	Yes Yes Yes	Yes Yes Yes
N $Adj. R^2$ Panel B: Seniority diff	6,163 0.090 erences among audit team	6,407 0.094	6,163 0.092	6,407 0.095	6,163 0.083	6,407 0.084
Variables	(1) LnKAM		(2) LnWord		(3) LnClear	
Difference1 Difference2		0.048^{***} (3.25) 0.013 (1.18)		0.049^{***} (3.26) -0.004 (-0.43)		$\begin{array}{c} 0.047^{***} \\ (3.08) \\ 0.008 \\ 0.074) \end{array}$
Controls Industry FE Year FE N Adj. R ²	Yes Yes Yes	12,570 0.087	Yes Yes Yes	12,570 0.089	Yes Yes Yes	12,570 0.081
p-value P-value Panel C: Audit firm si	ize – Diljerencez	0.030		0.001		0.018
Variables	$\frac{LnKAM}{(1)}$ BigAF = 0	(2) $BigAF = 1$	$\frac{LnWord}{(3)}$ BigAF = 0	(4) $BigAF = 1$	$\frac{LnClear}{(5)}$ BigAF = 0	(6) BigAF = 1
Difference	0.076^{***} (3.11)	-0.002 (-0.09)	0.060^{**} (2.05)	-0.024 (-0.77)	0.050^{**} (2.09)	-0.010 (-0.58)
Controls Industry FE Year FE	Yes Yes Yes	Y _{cs} Yes Ycs	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes	Yes Yes Yes
N Adj. R^2	6,089 0.105	6,481 0.087	6,089 0.113	6,481 0.082	6,089 0.089	6,481 0.087
Notes: The <i>t</i> -statistics	shown in parentheses are	adjusted for clustering by c	lient. ***, ** and * indicate	significance at the 1%, 5% a	nd 10% levels, respectively.	

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current policy shifts, deepen auditors' knowledge comprehension. Consequently, for an auditor's career development, tacit knowledge gained from recent serving experiences is probably more effective in augmenting individual professional competencies and fostering internal knowledge integration within audit teams.

We assign weights to audit team serving experiences based on the chronological order of those experiences: a weight of 1 for experiences within the previous 5 years, 2/3 for those within the previous 5 to 10 years and 1/3 for those over 10 years old (Pittman et al., 2022). The new index, *Diff_{Time}*, reflects the chronologically weighted heterogeneity of the auditors' serving experiences.

Additionally, untabulated analysis results reveal that in the non-overlapping experiences, serving experiences within the previous 5 years comprise 50.8 %, those within the previous 5 to 10 years constitute 35.61 % and those over 10 years old represent just 13.59 %. In terms of the chronological order of differentiated serving experiences, 15.46 % occurred within the previous 5 years, 30.78 % within the previous 5 to 10 years before. The results in Table 7 demonstrate that our main results hold even when we account for the auditors' service duration, their project scales and the chronological order of their experiences.

5.5.2. Controlling for the impact of signing auditors' total number of serving experiences

Our main findings may be confounded by the extent of the signing auditors' total serving experiences. Auditors with broader serving experiences are likely to exhibit greater heterogeneity in their experiences. Furthermore, experienced auditors tend to possess higher capabilities, which may manifest in more comprehensive KAM disclosures. To address this issue, we incorporate the total count of serving experiences of the signing auditor partners (*TotalExp*) as a fixed effect in the baseline regression model. Table 8 shows that with the exception of the Column (1) results, the core explanatory variable *Difference* loads positively and significant at the 10 % level or better. These results suggest that our primary findings are not exclusively driven by the influence of signing auditors' total serving experiences.

5.5.3. Endogeneity concerns

Our analysis may be subject to endogeneity arising from sample selection bias: audit firms are likely to assign more experienced and diverse audit teams to clients with higher business complexity and risk, which in turn may have a higher incidence of KAMs. To alleviate potential endogeneity concerns, we use propensity score matching (PSM) and the Heckman two-stage model.

In the first stage of PSM, we create a dummy variable for high serving experience heterogeneity (*HighDiff*) based on the annual median of *Difference* and regress it against all of the control variables in Model (1) to compute the *Pscore* values. Next, each sample with high serving experience heterogeneity is nearest-neighbor matched by the *Pscore*, with the common support and without replacement, using a caliper distance of 0.05. Panel A of Table 9 reports the results of the pre- and post-matching balance tests. The results indicate that the differences in most of the variables become non-significant post-matching, thus supporting the effectiveness of PSM. In the second stage of PSM, the regression is re-conducted with the matched sample. As presented in Panel B of Table 9, the coefficients of the core explanatory variable *Difference* remain positive and significant at the 1 % level, suggesting that the primary conclusions are not materially altered.

We also conduct a Heckman two-stage test. Table 10 reports the results, which are consistent with the PSM results. Overall, the results demonstrate that our main findings are not driven by sample self-selection bias.

5.5.4. Alternative sample

The descriptive statistics presented previously reveal that more than half of the signing audit teams work entirely within their firms (i.e., *Difference* = 0), thus exhibiting homogenous serving experiences. Theoretically, the heterogeneity of signing auditors' serving experiences constructed in this study may not explain the variance in KAM disclosure in such a homogeneous sample. To avoid potential regression distortions from including too many observations with a *Difference* value of 0, we retain only those observations in which the signing auditors exhibit diversity in serving experiences (i.e., *Difference* > 0) for the robustness testing. Table 11 reports the results of this alternative sample. The results show that the coefficient of *Difference* is positive and significant at the 1 % level across all measures. These findings further confirm that heterogeneity in signing auditors' serving experiences the adequacy of KAM disclosure.

Panel A: Considering audito	rs' tenure		
Variables	(1) LnKAM	(2) LnWord	(3) LnClear
Diff _{Tenure}	0.046 ^{**} (2.48)	0.006 (0.27)	0.033 ^{**} (1.98)
Controls	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Ν	12,570	12,570	12,570
Adj. R^2	0.086	0.087	0.080
Panel B: Considering audito	rs' project scale		
Variables	(1)	(2)	(3)
	LnKAM	LnWord	LnClear
Diff _{Project scale}	0.033***	0.025*	0.025**
	(2.92)	(1.76)	(2.50)
Controls	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Ν	12,570	12,570	12,570
Adj. R^2	0.086	0.087	0.080
Panel C: Considering the ch	ronological order of auditors' experiences		
Variables	(1)	(2)	(3)
	LnKAM	LnWord	LnClear
Diff _{Time}	0.094***	0.085**	0.071***
	(3.14)	(2.30)	(2.65)
Controls	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Ν	12,570	12,570	12,570
$Adj. R^2$	0.086	0.088	0.081

Table 7		
Considering the characteristics	of audit-firm	serving experiences.

Notes: The *t*-statistics shown in parentheses are adjusted for clustering by client. ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively.

Table 8
Controlling for the impact of signing auditors' total number of serving experiences.

Variables	(1)	(2)	(3)
	LnKAM	LnWord	LnClear
Difference	0.037	0.122***	0.047*
	(1.24)	(3.18)	(1.80)
Controls	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
TotalExp FE	Yes	Yes	Yes
N	12,570	12,570	12,570
Adj. R^2	0.089	0.096	0.084

Notes: The *t*-statistics shown in parentheses are adjusted for clustering by client. ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively.

Table 9		
Results	of	PSM.

Panel A: PSM p	re- and post-mat	ching balance to	ests					
Variables	Pre-matchin	ng			Post-match	ing		
	Treated	Control	%Bias	<i>p</i> -values	Treated	Control	%Bias	<i>p</i> -values
Size	22.332	22.407	-5.80	0.00	22.361	22.365	-0.40	0.89
Lev	0.418	0.428	-5.10	0.01	0.423	0.424	-0.60	0.83
ROA	0.037	0.032	7.10	0.00	0.035	0.035	0.30	0.91
Loss	0.097	0.118	-7.00	0.00	0.105	0.105	0.10	0.97
Growth	0.173	0.161	3.10	0.09	0.174	0.169	1.40	0.60
CFO	0.051	0.050	1.40	0.44	0.049	0.050	-1.40	0.59
AR	0.129	0.128	0.60	0.74	0.129	0.129	-0.20	0.94
CR	2.351	2.296	2.70	0.13	2.291	2.300	-0.40	0.88
INV	0.134	0.134	-0.20	0.93	0.134	0.135	-0.90	0.73
SOE	0.317	0.331	-3.10	0.09	0.330	0.330	-0.20	0.95
Top1	33.552	33.663	-0.80	0.67	33.631	33.718	-0.60	0.82
ListAge	11.247	11.933	-8.50	0.00	11.471	11.577	-1.30	0.61
Change	0.576	0.574	0.50	0.77	0.575	0.572	0.60	0.81
Big4	0.021	0.092	-31.40	0.00	0.032	0.018	6.00	0.00
MAO	0.031	0.034	-1.90	0.30	0.032	0.030	0.90	0.73
Experience	15.046	10.288	107.10	0.00	13.245	14.455	-27.20	0.00
Collaboration	2.873	2.680	8.20	0.00	2.992	3.087	-4.00	0.16
GenderDIFF	0.444	0.447	-0.60	0.72	0.454	0.464	-2.00	0.46
EduDIFF	0.496	0.486	1.90	0.28	0.505	0.514	-1.80	0.49
ExpDIFF	10.253	5.701	103.30	0.00	8.012	8.989	-22.2	0.00
Panel B: Second-	stage results of	using the PSM	sample					
Variables		(1)			(2)			(3)
		Ln	KAM		LnWor	d		LnClear
Difference		0.0)56***		0.077**	*		0.050^{***}
			(2.88)		(3.03	5)		(2.91)
Controls		Yes			Yes	/		Yes
Industry FE		Yes			Yes		Yes	
Year FE		Ye	s		Yes			Yes
Ν			5,596		5,59	6		5,596
Adj. R^2			0.086		0.09	1		0.080

Notes: The *t*-statistics shown in parentheses are adjusted for clustering by client. ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively.

6. Economic consequences analysis

The above results suggest that greater heterogeneity in auditors' serving experiences is correlated with more comprehensive KAM disclosure. Building upon this, we further explore whether audit teams with more heterogeneous auditor serving experiences, after sufficiently identifying and addressing risk points in financial reporting, can enhance audit quality and accounting information quality by increasing audit efforts. Specifically, we examine the economic consequences from the dimensions of audit report delays, the issuance of modified audit opinions, the occurrence of restatement and financial misconduct and market reactions to earnings.

We first explore the impact of audit team serving experience heterogeneity on audit input and audit quality. Following the literature (Liu et al., 2017; Yan et al., 2020; Li and Liang, 2023), we use the natural logarithm of audit delay days (*Delay*) and modified audit opinions (*MAO*) as proxies for audit input and audit quality. Columns (1) and (2) of Table 12 show that the coefficients of *Difference* are positive and significant at the 5 % level or better, indicating that serving experience heterogeneity increases audit effort and improves audit quality.

Next, we use the occurrence of financial misconduct (*Misconduct*) and restatements (*Restate*) to capture accounting information quality (Pittman et al., 2022). *Misconduct* (or *Restate*) equals 1, if audited clients experience financial misconduct (or restatement) in subsequent years, and 0 otherwise. Columns (3) and (4) of Table 12 show that the coefficients of *Difference* are negative and significant at the 10 % level or better, sug-

Table 10		
Results of the Heckman	two-stage test.	

Variables	First stage	Second stage		
	(1)	(2)	(3)	(4)
	HighDiff	LnKAM	LnWord	LnClear
Difference		0.056***	0.064***	0.046***
55		(3.31)	(3.00)	(3.06)
Size	0.041***	0.048***	0.059****	0.038***
	(3.29)	(8.69)	(8.46)	(8.70)
Loss	-0.086*	0.023	0.038**	0.018
	(-1.96)	(1.50)	(2.01)	(1.34)
Growth	0.014	0.040^{***}	0.045***	0.031***
	(0.42)	(4.91)	(4.40)	(4.40)
CFO	-0.072	-0.146^{**}	-0.080	-0.114^{**}
	(-0.35)	(-2.37)	(-1.07)	(-2.18)
INV	-0.106	0.058	0.029	-0.025
	(-0.79)	(1.18)	(0.47)	(-0.54)
SOE	0.066**	-0.055^{***}	-0.095^{***}	-0.046^{***}
	(1.97)	(-4.22)	(-5.62)	(-4.15)
Top1	0.001	-0.001^{***}	-0.001*	-0.000*
	(0.60)	(-2.88)	(-1.91)	(-1.66)
ListAge	-0.009^{***}	-0.000	0.000	0.000
	(-4.28)	(-0.39)	(0.24)	(0.06)
Change	0.118***	-0.010	-0.008	-0.007
	(4.64)	(-1.26)	(-0.79)	(-1.07)
Big4	-1.001^{***}	0.071	0.284^{***}	0.094**
	(-14.17)	(1.21)	(3.95)	(2.03)
MAO	0.161**	-0.106^{***}	-0.133***	-0.082***
	(2.17)	(-4.23)	(-4.41)	(-3.98)
Experience	0.141***	-0.022***	-0.034^{***}	-0.013**
*	(49.88)	(-3.30)	(-4.06)	(-2.36)
Lev		0.061	0.089*	0.065**
		(1.61)	(1.85)	(2.00)
ROA		-0.482^{***}	-0.487^{***}	-0.373***
		(-6.55)	(-5.46)	(-5.92)
AR		0.223***	0.347***	0.229***
		(4.26)	(5.14)	(5.09)
CR		-0.000	0.001	0.002
		(-0.04)	(0.39)	(0.83)
Collaboration		-0.001	0.000	-0.001
		(-0.44)	(0.17)	(-0.81)
GenderDIFF		-0.005	-0.003	0.003
		(-0.71)	(-0.35)	(0.48)
EduDIFF		-0.008	-0.029^{***}	-0.018***
		(-1.08)	(-2.95)	(-2.71)
ExpDIFF		-0.000	0.000	-0.002*
		(-0.26)	(0.11)	(-1.84)
IMR		-0.188***	-0.293****	-0.127**
		(-2.78)	(-3.47)	(-2.33)
Constant	-3.146***	0.061	6.223****	0.447**
	(-9.85)	(0.28)	(22.38)	(2.55)
Industry FF	Ves	Ves	Ves	Vec
Year FF	Ves	Ves	Ves	Vec
N	12 567	12 567	12 567	10 567
Pseudo $R^2 Adi R^2$	0 203	0.088	0.090	0.082
	0.200	0.000	0.020	5.002

Notes: The *t/z*-statistics shown in parentheses are adjusted for clustering by client. ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively.

Variables	(1)	(2)	(3)
	LnKAM	LnWord	LnClear
Difference	0.179***	0.414***	0.136***
	(3.38)	(6.04)	(2.95)
Controls	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Ν	5,319	5,319	5,319
Adj. R^2	0.079	0.085	0.071

Table 11 Results of the alternative sample.

Notes: The *t*-statistics shown in parentheses are adjusted for clustering by client. ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively.

 Table 12

 Economic consequences.

Variables	(1)	(2)	(3)	(4)	(5)
	Delay	MAO	Misconduct	Restate	CAR
Difference	0.015**	0.728***	-0.684***	-0.150*	0.007**
	(2.05)	(2.61)	(-3.35)	(-1.68)	(2.47)
SUE					0.002^{***}
					(2.82)
SUE × Difference					0.003*
					(1.65)
Controls	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Ν	12,568	12,570	12,284	12,567	10,799
Adj. $R^2/Pseudo R^2$	0.127	0.268	0.118	0.089	0.047

Notes: The t/z-statistics shown in parentheses are adjusted for clustering by client. ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively.

gesting that divergence in signing auditors' serving experiences reduces the likelihood of clients' financial restatements and violations, thereby enhancing accounting information quality.

Lastly, we use an event study to capture the market reaction to earnings information (Wang et al., 2018; Zhang et al., 2019). The cumulative abnormal returns (*CAR*) around the audit report disclosure date (i.e., event date) are calculated using the market model over a 3-day window. The estimation period is [-150, -30] days, requiring at least 100 trading days of data. Additionally, unexpected earnings (*SUE*) are derived by standardizing annual earnings changes (Basu et al., 2010). The incremental impact of serving experience heterogeneity on earnings response coefficients is captured by an interaction term, *SUE* × *Difference*, in the model (Teoh and Wong, 1993). The client size (*Size*), price-to-book ratio (*PB*), return on equity (*ROE*), market value of equity (*LnMV*), stock beta (*Beta*), ownership structure (*SOE*), whether audited by an international Big 4 firm (*Big4*) and industry (*Industry*) and year (*Year*) fixed effects are also included. Column (5) of Table 12 shows that the coefficient of *SUE* is positive and significant at the 1 % level, and the interaction term *SUE* × *Difference* is positive and significant at the 10% level. This finding indicates that audit teams whose auditors have heterogeneous serving experiences can help enhance the informativeness of accounting information.

7. Conclusions

In this study, we provide novel empirical evidence on the factors influencing KAM disclosure. We find that signing auditors with more heterogeneous audit-firm serving experiences exhibit more adequate KAM disclo-

sure. Mechanism analysis reveals that the quality of knowledge accumulated from heterogeneous serving experiences and the knowledge integration environment at both the team and firm levels significantly influence the impact of serving experience heterogeneity. Specifically, the increase in KAM disclosure adequacy is more salient when auditors accumulate higher-quality knowledge through heterogeneous serving experiences, when audit teams exhibit educational gaps between members, when review partners have heterogeneous experiences and when audit firms are smaller. Economic consequence tests indicate that signing auditors with greater serving experience heterogeneity can enhance audit quality through more audit input, significantly reduce the probability of restatements and financial misconducts and ultimately enhance the informativeness of accounting information. In other words, such audit teams can improve accounting information quality by thoroughly identifying and addressing potential risks in financial reporting.

We extend the literature on KAM disclosure through a novel investigation of how audit team composition affects the adequacy of such disclosure. Our findings offer valuable implications for practice. In the realm of integrated audit firm management, human resource management is pivotal for audit firms' internal governance. Managers need to consider the proper allocation of human resources from the perspective of auditor team composition. By leveraging differentiated serving experiences within audit teams, they can adjust member configurations, enhance communication and cooperation among team members, better harness their teams' collective intelligence and improve internal governance mechanisms and quality management systems. Regulatory bodies are encouraged to encourage audit teams to embrace diverse decision-making frameworks. This shift will aid audit firms in transitioning from a growth-centric to a strength-based approach and promote the healthy development of capital markets.

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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Does the integration between litigation and supervision discipline financial misstatement?

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ABSTRACT

This paper explores the positive governance effects of the Procuratorate's Public Interest Litigation System in China, which combines the powers of litigation and administrative supervision, on the quality of information disclosure by listed state-owned enterprises. We report several findings. (1) The likelihood that listed state-owned enterprises would issue financial restatements and participate in financial fraud decreased significantly in areas selected for pilot implementation. (2) The governance effect is stronger in regulated industries than in unregulated industries. After the pilot implementation, the agency costs decreased, and the increase in legal litigation risks related to false statements faced by enterprises played a deterrent effect. (3) The significance of the above results is stronger when a company's external and internal governance are weaker. This study provides both new evidence of the effectiveness of the integrated governance mechanism and inspiration for future efforts to widely implement this mechanism in the capital market.

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1. Introduction

The recent prevalence of financial scandals has brought modern corporate governance mechanisms to the forefront of public attention. Identifying the critical flaws in modern corporate governance is crucial for determining whether a fresh start is needed or whether existing practices can be repaired and improved. This issue is not only a central focus of recent academic research but also a key concern of policymakers. Both investors and regulatory supervisors are actively striving to enhance corporate governance practices (Filatotchev and Nakajima, 2010).

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Corporate governance mechanisms are vital for addressing agency problems, which encompass internal challenges related to managerial opportunism, stakeholder goal misalignment and management incentive distortions. To address these challenges, internal corporate governance mechanisms such as external stakeholders, board oversight and compensation incentives have been developed (Shleifer and Vishny, 1986; Jensen and Murphy, 1990; Hermalin and Weisbach, 1998; Fang, 2012). In addition, academics and regulators have praised external governance mechanisms such as legal frameworks, the managerial labor market, regulatory oversight, institutional investors and auditing (Hart, 1983; La et al., 1998; Ashbaugh and Warfield, 2003; Shen et al., 2004; Chen and Gao, 2005; Lee and Park, 2009).

While the literature often concentrates on individual corporate governance mechanisms in isolation, in reality, these mechanisms are interconnected, and different mechanisms may have substitutive or complementary effects (Misangyi and Acharya, 2014). The overall efficacy of corporate governance hinges on a combination of mechanisms that play various roles in curbing managerial misconduct (Rediker and Seth, 1995).

Efficient governance often requires a combination of enforcement approaches and involves both private and public mechanisms (Hutton et al., 2022). Such combinations are achieved through collaboration between public enforcement, such as through citizen lawsuits, non-profit organizations, industry self-regulation and the U.S. Securities and Exchange Commission (SEC), and private enforcement by shareholders, institutional investors and bank creditors (Langpap and Shimshack, 2010; Glaum et al., 2018; Hutton et al., 2022; Choy et al., 2023; Gopalan et al., 2023). In theory, both public and private governance mechanisms have strengths and weaknesses.

For example, although public enforcement can deter and prevent misconduct by public firms by imposing harsh criminal, financial and reputational penalties, it often is constrained by factors such as limited resources, internal and external information asymmetry, inadequate incentives to encourage enforcement by public officials and regulatory capture. Although private enforcement has comparatively stronger motivation to participate in corporate governance, it typically involves trade-offs between costs and benefits, free-riding behavior and an inability to impose severe punishments for violations. Therefore, the effectiveness of a single mechanism of corporate governance is often limited.

In the realm of public enforcement, although independent and specialized institutions such as the SEC effectively exert oversight, a broader regulatory approach that integrates various mechanisms may be more beneficial for enhancing the effectiveness of governance (Jackson and Roe, 2009). Regulatory bodies such as the British Financial Services Authority, the Australian Securities & Investments Commission and the China Securities Investor Services Center have successfully integrated market and administrative governance forces to achieve notable advancements in investor protection practices. The literature presents conflicting views on the advantages of integrated supervision (e.g., Čihák and Podpiera, 2006); accordingly, whether integrated regulation is more effective than a singular governance mechanism remains unclear. Building upon this research topic, the current study explores an integrative mechanism that inherently involves the interaction between litigation and administrative supervision, specifically focusing on the Procuratorate's Public Interest Litigation System in China and its impact on governance outcomes.

Within the framework of the Procuratorate's Public Interest Litigation System, procuratorates play a supervisory role through activities such as issuing procuratorial suggestions, initiating public interest litigation, prompting administrative departments to fulfill their obligations and rectifying administrative misconduct. This system is intended to encourage proactive administrative enforcement while bridging the gaps created when administrative agencies fail to carry out their responsibilities. By directly engaging in public interest litigation, procuratorates establish a dynamic interplay between legal and administrative oversight. This ongoing process of integration, which encompasses goal alignment and functional coordination at various levels, fosters optimally effective governance through the collaborative efforts of procuratorates and administrative bodies.

The Procuratorate's Public Interest Litigation System plays a crucial role in safeguarding state-owned assets, with a focus on supervising state-owned enterprises. The enforcement of its supervision encompasses a range of activities, including monitoring preferential government policies, subsidies, tax compliance, internal control practices and accounting information quality within state-owned enterprises. Mechanistically, the system's governance effects are exerted through several key pathways.

First, the system deters managerial misconduct through the issuance of Legal Risk Alert Letters by procuratorates to caution companies about the legality of their actions. Second, the system targets cases involving illegal action or inaction by administrative agencies in the public interest domain, where a lack of clarity regarding litigation subjects often results in insufficient legal supervision of illegal administrative actions. In such instances, procuratorates intervene to initiate administrative public interest litigation against administrative departments, enhancing the proactiveness of administrative enforcement and bolstering external supervisory mechanisms. Third, the combined impact of legal deterrence by procuratorates and improved administrative oversight helps curb internal opportunistic behaviors, such as tunneling, within state-owned enterprises, thereby reducing agency costs. The reduction in harmful acts against state-owned assets reduces state-owned enterprises' need to commit financial fraud to conceal illicit activities, in turn lowering the risks of financial distortion and fraud within these enterprises. The implementation of the Procuratorate's Public Interest Litigation System is anticipated to substantially enhance the quality of financial information quality released by state-owned enterprises, resulting in fewer instances of financial restatement and fraud.

The current study investigates the impact of a pilot implementation of the Procuratorate's Public Interest Litigation System in 73 cities across 13 provinces in China from 2015 to 2017. Using a difference-in-differences (DID) model, this study evaluates changes in the quality of financial information provided by listed state-owned enterprises in the pilot areas to assess the governance effects of this mechanism that integrates litigation with supervision. The findings indicate a significant decrease in the occurrence of financial restatement and fraud by state-owned public firms within the pilot areas.

Moreover, the study findings highlight that the governance effect is more pronounced in industries under the system's supervision than in other industries. The enhancement of information quality can be attributed to the amplified deterrence of litigation risks and mitigation of agency costs by the system. A heterogeneity analysis demonstrates that the positive impact of this integrated mechanism is pronounced in samples with weak external governance mechanisms such as low audit quality and institutional investor shareholding. This finding suggests the existence of substitution relationships between the integrative mechanism and other external governance structures. Additionally, the study reveals that the effectiveness of the system is accentuated in samples with poor environmental, social and governance (ESG) performance. This finding underscores the system's capacity to bolster governance in scenarios where internal mechanisms are lacking or inadequate.

In summary, this research provides empirical evidence demonstrating the positive governance effects of an integrated mechanism involving both litigation and supervision. By shedding light on the factors influencing information disclosure quality and governance mechanisms, this study advances our understanding of how integrative governance mechanisms can enhance transparency and reliability in corporate practices.

Furthermore, this study contributes to the literature by exploring the factors that influence information disclosure quality. Financial restatements can have detrimental effects on both short-term and long-term market reactions (Dechow et al., 1996; Palmrose et al., 2004), leading to costly legal disputes and compensation obligations (Palmrose and Scholz, 2004), increased capital costs (Graham et al., 2008) and an increased probability of management turnover (Desai et al., 2006). Given the significant economic implications of financial restatement and fraud, it is crucial to understand the factors that impact disclosure quality. Other studies investigate the influences of various factors, such as the shareholding structure, board composition, audit committees, external audits, executive attributes and analyst behavior (Beasley, 1996; Abbott et al., 2004; Farber, 2005; Cheng and Farber, 2008; Chen et al., 2015), on financial restatement. In contrast, this paper examines whether an integrated governance mechanism, namely the Procuratorate's Public Interest Litigation System, can enhance information disclosure quality. By focusing on the governance effects of this unique mechanism, this study extends the current understanding of the determinants of information disclosure quality.

Moreover, the current study has significant practical implications for governmental bodies by offering insights to enhance the efficacy of the Procuratorate's Public Interest Litigation System. Initially designed to target public concerns such as environmental conservation, food and drug safety and the safeguarding of state-owned assets, during its pilot phase, the system aimed to tackle issues related to the tragedy of the commons (Hardin, 1968) and collective action dilemmas (Olson, 1971). The current research advocates that policymakers consider expanding the jurisdiction of the Procuratorate's Public Interest Litigation System to encompass the capital market, thereby safeguarding the interests of minority shareholders in the future.

The rest of the paper is organized as follows. Section 2 introduces the institutional background and relevant literature and presents the hypotheses. Section 3 describes the research design and methodology. Section 4 reports the empirical results. Section 5 discusses additional tests, and Section 6 concludes the paper.

2. Literature review and hypothesis development

2.1. Institutional background: The Procuratorate's Public Interest Litigation System and state-owned asset protection

On 1 July 2015, the 15th meeting of the 12th National People's Congress Standing Committee granted authorization to 13 provinces in China, including Beijing, to commence a two-year pilot program involving the Procuratorate's Public Interest Litigation System. This initiative resulted in the coordination of 87 municipal procuratorates and 759 county procuratorates to execute the pilot program.¹ Subsequently, on 27 June 2017, during the 28th meeting of the 12th National People's Congress Standing Committee, the Procuratorate's Public Interest Litigation System was officially incorporated into the Civil Procedure Law and the Administrative Procedure Law, marking its transition from a pilot implementation to formal nationwide implementation.

In the Procuratorate's Public Interest Litigation System, procuratorates are designated as exclusive prosecutors authorized to initiate litigation with a primary focus on addressing public interest issues such as the safeguarding of state-owned assets, environmental protection and resource conservation. By enabling public interest litigation, this system provides a crucial legal mechanism to counterbalance the limitations of administrative oversight, thus compelling governmental bodies to fulfill their obligations. Consequently, this system enables a comprehensive approach that integrates both legal and administrative supervision (Jiang, 2015).

Initially, discussions on the theoretical foundations and practical applicability of the system's design and procedures were prevalent in the realms of administration and law (Jiang, 2015; Zhu, 2015; Liu, 2018). Despite extensive theoretical debates, further empirical research on the system is necessary. Recent studies by Zhang et al. (2022) and Chen et al. (2020) delve into the governance implications of the system in terms of environmental protection, revealing its positive impacts such as fostering green innovation and reducing industrial wastewater discharge in pilot cities.

In the realm of state-owned asset protection, procuratorates in the pilot areas handled 1,583 cases concerning the safeguarding of state-owned assets between 2015 and 2017. Through litigation, the procuratorates successfully recovered over 8.9 billion yuan in direct economic losses, with illegal entities or individuals being obligated to compensate losses surpassing 300 million yuan. Following the formal nationwide implementation of the system in July 2017, until its conclusion in 2020, the procuratorates handled 42,413 public interest litigation cases regarding the protection of state-owned assets. These cases led to the recovery of state-owned assets amounting to over 12.5 billion yuan.² After years of practical application, the initial effectiveness of the Procuratorate's Public Interest Litigation System in preserving state-owned assets has been demonstrated.

Enterprises, particularly state-owned enterprises, play a pivotal role in China's economy. The substantial assets held by state-owned enterprises and their dominant presence in key industries underscore their significant control of and influence on economic development. To effectively safeguard state-owned assets, the Procuratorate's Public Interest Litigation System must closely monitor state-owned enterprises and their governance practices.

Because of the transition from a planned economy to market-oriented reforms, state-owned enterprises in China have historically operated under two distinct governance models, namely administrative governance and economic governance; this is often referred to as the administrative–economic governance model. The appointment, incentives and oversight of senior executives within state-owned enterprises are subject to considerable government intervention (Li et al., 2021) and are directly supervised by the State-owned Assets Supervision and Administration Commission. Consequently, as the administrative body responsible for over-

¹ https://www.scio.gov.cn/xwfbh/qyxwfbh/document/1557150/1557150.htm.

² https://www.spp.gov.cn/xwfbh/wsfbt/202012/t20201217_489171.shtml#3.

seeing state-owned enterprises, the Commission is also subject to judicial oversight by procuratorates. For example, procuratorates have the authority to initiate litigation against the Commission in instances where the Commission neglects its duties in monitoring state-owned enterprises, resulting in the loss of state assets.

The dual mechanisms of administrative supervision by the Commission and judicial oversight by the Procuratorate's Public Interest Litigation System enable the achievement of positive governance outcomes for stateowned enterprises. Empirical studies demonstrate that the system significantly enhances the merger premiums of state-owned enterprises by enhancing their internal governance practices and promoting transparency in information disclosure. This contributes to the preservation of state-owned assets (Bu et al., 2022).

2.2. State-owned asset protection and information disclosure quality

As the Chinese economy has developed, the stakeholders and information users of state-owned enterprises have evolved from primarily comprising the State-owned Assets Supervision and Administration Commission during the planned economy era to a more diverse group in the current market economy era. This shift has raised corporate governance and information disclosure standards within state-owned enterprises. A prevalent issue in China's state-owned enterprises is the concept of "dominance of one share" (Zeng and Chen, 2006), which can limit the influence of minority shareholders in corporate governance. This situation can make it easier for majority shareholders and managers to engage in activities such as tunneling (Li et al., 2004), ultimately resulting in the loss of state-owned assets.

One key method of tunneling involves the manipulation of financial information, wherein deceptive accounting practices act as a shield (Bertrand et al., 2002). Studies show that financial fraud, profit inflation, the dissemination of false information and other illicit behaviors are major contributors to the erosion of stateowned assets (Ma and Han, 2003). There exists a strong positive correlation between the extent of tunneling by majority shareholders and information disclosure violations within companies (Qu and Cai, 2007). Such activities are often accomplished by reducing accounting transparency to facilitate the transfer of benefits (Chen and Xu, 2019).

Therefore, it can be inferred that stricter supervision and more effective protection of state-owned assets may reduce both detrimental behaviors that harm state-owned assets and the motivation to engage in financial fraud to conceal illegal activities. Research indicates that various mechanisms designed to safeguard state-owned assets confer additional benefits in terms of enhancing the quality of accounting information. Measures such as government audits, party organization oversight and central inspections not only protect state-owned assets but also have a positive impact on information governance within state-owned enterprises (Goh and Li, 2011; Li and Wu, 2013; Sun and Guo, 2018; Zheng et al., 2020; He and Hu, 2022; Wang et al., 2022).

Given the governance role of the Procuratorate's Public Interest Litigation System in safeguarding stateowned assets, it is plausible that this system could also yield spillover effects, thus enhancing the quality of information disclosed by state-owned enterprises.

2.3. The Procuratorate's Public Interest Litigation System and information disclosure quality in state-owned enterprises

The Procuratorate's Public Interest Litigation System was implemented with the aim of addressing the limitations of administrative supervision. This system is expected to deter misconduct, enhance administrative oversight, improve corporate governance and reduce the likelihood that insiders will resort to financial fraud to conceal illegal activities, thereby lowering the incidence of financial restatement and fraud.

From a legal perspective, the Procuratorate's Public Interest Litigation System serves to protect public interests (Liu, 2018). It empowers procuratorates to initiate litigation against actions that harm state-owned assets, creating a robust pre-judicial deterrent. Although the system is fairly new, its importance has grown significantly in recent years, and it is recognized as one of the key functions of procuratorates alongside criminal, civil and administrative prosecution.³ Public interest litigation has become a crucial responsibility of

³ https://www.spp.gov.cn/spp/zdgz/202002/t20200228_455449.shtml.

procuratorates, allowing them to expand their supervisory scope by establishing specialized units such as the Public Interest Litigation Procuratorate.⁴ This enables procuratorates to allocate more resources to cases that may previously have been overlooked, thus significantly enhancing their oversight capabilities.

Additionally, procuratorates can proactively issue legal risk alert letters to companies to remind them of the importance of compliance. These alerts not only target companies directly involved in cases but also those with potential vulnerabilities that require attention. Under the threat of litigation posed by judicial deterrence, state-owned enterprises with questionable information disclosure practices may face heightened legal risks in the future, which could tarnish their reputation. This exposure to public scrutiny can attract attention from various stakeholders, including the media, analysts, institutional investors, and society at large, acting as a form of oversight of enterprises' financial disclosure practices and increasing the potential consequences of non-compliance with information disclosure regulations.

Furthermore, procuratorates not only collaborate with local government departments, such as the Stateowned Assets Supervision and Administration Commission, tax bureaus, audit bureaus and finance bureaus, when handling cases but also engage with regulatory authorities, such as the China Securities Regulatory Commission, stock exchanges and the Security Investor Service Center.⁵ This multi-faceted approach enables procuratorates to leverage their expertise and enforcement capabilities effectively. Judicial interventions often necessitate the involvement of forensic accountants to investigate a company's financial information thoroughly and to establish a comprehensive chain of evidence. This audit process, which encompasses various aspects such as accounting records and internal controls, is a means of governance influence on information disclosure practices.

Early research by Wang et al. (2008) demonstrates that listed companies, especially those under local government control, tend to curb their earnings management behavior when confronted with judicial litigation. Practical instances further illustrate the impact of procuratorial actions, such as a case in April 2019 involving the People's Procuratorate of Daowai district in Harbin city, Heilongjiang province. While performing its routine duties, the procuratorate uncovered irregularities in tax declarations across multiple companies, prompting a judicial investigation. The procuratorate identified lapses in the tax bureau's oversight responsibilities, leading to state-owned asset losses. Subsequently, the procuratorate issued recommendations to the tax bureau to fulfill its obligations. A professional audit team was engaged to scrutinize tax declaration forms and financial statements, conduct on-site inspections and uncover illicit activities such as profit shifting and tax evasion. Companies were urged to promptly rectify false financial statements to ensure data accuracy. This case spurred the tax bureau to initiate a district-wide comprehensive tax recovery effort, which reclaimed over 50 million yuan in unpaid taxes and created a ripple effect across the region.⁶ In 2019, the Shanghai Financial Court integrated the Procuratorate's Public Interest Litigation System into the securities sector, underscoring the expanding scope and impact of the relevant mechanisms in enhancing governance within the security domain.⁷

Moreover, the Procuratorate's Public Interest Litigation System assumes a critical supervisory role when the primary supervisory departments of state-owned enterprises fail to fulfill their obligations. As per legal protocol, procuratorates handle public interest litigation in three distinct stages: case filing, pre-litigation procedures and litigation procedures. The pre-litigation phase is particularly important in public interest litigation. In instances where state-owned enterprises suffer harm, procuratorates must first prompt state-owned asset supervisory departments to discharge their responsibilities before commencing formal legal action, thereby transitioning from legal oversight to administrative enforcement. Subsequently, the procuratorates will formally initiate legal proceedings against cases involving state-owned asset losses. In such cases, administrative departments and procuratorates collaborate to establish a seamless mechanism that links administrative enforcement and litigation efforts, thus fostering information exchange and sharing. Throughout this process, procuratorates enlist the expertise of key personnel from administrative departments such as finance bureaus, audit bureaus and tax bureaus to aid in information gathering and professional consultation. By con-

⁴ https://www.spp.gov.cn/zdgz/202302/t20230218_602525.shtml.

⁵ https://www.spp.gov.cn/spp/llyj/202107/t20210726_524801.shtml.

⁶ https://www.spp.gov.cn//xwfbh/dxal/202211/t20221107_592001.shtml.

⁷ https://www.isc.com.cn/html/ztlte2/20190906/864.html.

ducting on-site investigations and implementing various measures, the procuratorates streamline their efforts to safeguard state-owned assets. The pre-litigation and litigation procedures bolster the compliance of administrative supervision and law enforcement and compel administrative agencies to proactively rectify their actions.

One important pathway that leads to the depletion of state-owned assets involves the manipulation of financial information to facilitate insider trading and the illicit misappropriation of assets. Against the backdrop of reinforced legal deterrence and administrative oversight, a comprehensive approach effectively curtails insiders' malfeasance and reduces the need to engage in financial malpractice to mask unlawful conduct. Because most managers of state-owned enterprises are appointed by the government, their career advancement and political considerations hold paramount importance for senior executives in these entities.

Annually, the Central Organization Department delegates the Audit Office to conduct economic responsibility audits of state-owned enterprise leaders and to swiftly address behaviors that jeopardize state-owned assets (Chu and Fang, 2016). In cases where irregularities surface, senior executives may be subjected to salary reductions or termination or may be passed over for political advancement; these potential penalties motivate a sense of caution in their decision-making processes. This reinforced legal and administrative oversight thus serves as a robust check on the conduct of senior executives within state-owned enterprises by increasing the likelihood of exposure of and repercussions for their transgressions. This oversight fosters enhanced corporate governance, diminishes agency costs and effectively curbs insider misconduct in state-owned enterprises. As a result, executives' motivation to engage in financial fraud to conceal illicit activities is diminished, leading to a decline in financial malfeasance.

In summary, we expect to find that the pilot implementation of the Procuratorate's Public Interest Litigation System generated an information governance effect. Considering the availability of data, we choose public state-owned enterprises as the research subjects and propose the following hypothesis:

H1: The likelihood of financial restatement and financial fraud by public state-owned enterprises decreased significantly after the implementation of the Procuratorate's Public Interest Litigation System in pilot areas.

3. Data collection and research methodology

3.1. Research methodology

The Procuratorate's Public Interest Litigation System was piloted in 73 cities in 13 provinces of China from 2015 to 2017. The specific pilot areas are listed in Table 1.

To examine the impact of the Procuratorate's Public Interest Litigation System on financial restatement and financial fraud by state-owned public firms, we construct the following regression model:

$$Logit(Restate or Fraud) = \alpha_0 + \alpha_1 \times Treat + \alpha_2 \times Post + \alpha_3 \times Treat \times Post + Controls + Industry + \varepsilon$$
(1)

where *Restate* and *Fraud* are the dependent variables. With reference to the literature (Dechow et al., 2010; He and Fang, 2021), *Restate* is an indicator variable equal to one if the company issues a financial restatement, and zero otherwise. *Fraud* is an indicator variable equal to one if the company commits financial fraud, and zero otherwise. *Treat* is an indicator variable equal to one if the company is located in a pilot city, and zero otherwise. The coefficient α_1 represents the difference between the treatment group and the control group. *Post* represents the implementation time of the pilot program; specifically, it is an indicator variable equal to one during the pilot implementation period (2015–2017) and zero before pilot implementation (2012–2014). The coefficient α_2 controls for common time trends. The coefficient α_3 is the net effect of interest. We also include industry-fixed effects in model (1). If the pilot implementation of the integrated governance mechanism reduces the likelihood of financial restatement and financial fraud, we expect α_3 to be significant and negative.

Additionally, drawing from previous studies (Cheng, 2006; Gao and Zhang, 2008; He and Fang, 2021), we include the following control variables: (1) company characteristics, namely firm size (*Lnta*), the market-to-book ratio (*MB*), ownership concentration (*Ownership*) and years listed (*Age*); (2) financial indicators, namely leverage (*Lev*), the inventory-to-total-assets ratio (*Invr*), the accounts receivable-to-total-assets ratio (*Recr*), the quick ratio (*Quick*), asset turnover (*Aturn*), return on assets (*ROA*) and the sales growth rate (*Salegrowth*); and (3) other control variables, namely mergers and acquisitions (*M&A*), refinancing (*SEO*), cross-listing

not chief of the Provalutorate of Pacific Diaganon Systems				
13 Provinces/Autonomous regions/ Municipalities	73 Pilot cities			
Beijing	Beijing			
Anhui	Bengbu, Chuzhou, Fuyang, Hefei, Lu'an, Wuhu, Suzhou, Xuancheng			
Fujian	Fuzhou, Longyan, Nanping, Quanzhou, Sanming			
Gansu	Baiyin, Jiayuguan, Jiuquan, Lanzhou, Longnan, Qingyang, Tianshui, Zhangye			
Guangdong	Guangzhou, Qingyuan, Shantou, Shaoguan, Shenzhen, Zhaoqing			
Guizhou	Guiyang, Liupanshui			
Hubei	Huanggang, Huangshi, Jingmen, Jingzhou, Shiyan, Suizhou, Wuhan, Xianning, Xiaogan, Yichang			
Jilin	Baicheng, Baishan, Jilin, Siping, Tonghua, Changchun			
Jiangsu	Changzhou, Nanjing, Suzhou, Taizhou, Wuxi, Xuzhou, Yancheng			
Inner Mongolia	Baotou, Chifeng, Ordos, Hohhot, Hulunbeier			
Shandong	Dezhou, Liaocheng, Linyi, Qingdao, Weifang, Yantai			
Shanxi	Baoji, Hanzhong, Xi'an, Xianyang, Yulin			
Yunnan	Kunming, Lincang, Pu'er, Qujing			

 Table 1

 Pilot Cities of the Procuratorate's Public Interest Litigation System.

(*BH*), marketization (*Mindex*), audit opinion (*MAO*), audit quality (*Big10*) and audit tenure (*Tenure*). The definitions of the variables are presented in Table 2.

3.2. Sample selection and descriptive statistics

The sample period spans three years before, the year of and two years after the implementation of the pilot phase of the Procuratorate's Public Interest Litigation System; accordingly, data on Chinese listed stateowned enterprises from 2012 to 2017 are selected. Subsequently, certain observations were excluded based on the following criteria: (1) financial companies, (2) pure B-share companies, (3) Special Treatment companies and (4) samples with missing data on relevant variables. The final number of firm-year observations is 5684. For this study, the financial data of listed state-owned enterprises are obtained from the China Stock Market & Accounting Research (CSMAR) database. To control for the influence of outliers, we winsorize all of the continuous variables at the 1 % level and cluster standard errors at the company level in all of the regressions.

Table 3 presents the descriptive statistics. The average value of *Restate* during the sample period is 0.078, indicating that 7.8 % of the sample involved financial restatement. The average value of *Fraud* is 0.055, indicating that 5.5 % of the sample engaged in financial fraud. The mean value of *Treat* is 0.378, suggesting that 37.8 % of the sample belongs to the treatment group. The mean value of *Post* is 0.505, indicating that 50.5 % of the sample corresponds to the period after the implementation of the pilot phase.

The sample is further divided into four subsamples, which are compared with respect to financial restatement and financial fraud. The results are shown in Table 4. Panel A reveals that in non-pilot areas (*Treat* = 0), the mean values of *Restate* and *Fraud* before pilot implementation are 0.086 and 0.057, respectively. After pilot implementation, the corresponding mean values are 0.082 and 0.060, respectively. *T*-tests and Wilcoxon rank-sum tests reveal no significant differences between the two groups, indicating that the quality of financial information disclosed by listed state-owned enterprises in non-pilot areas does not exhibit a significant time trend from before to after pilot implementation. In pilot areas (*Treat* = 1), the mean values of *Restate* and *Fraud* before pilot implementation are 0.083 and 0.062, respectively. After pilot implementation, the corresponding mean values are 0.048 and 0.033, respectively. The differences between the two groups are significant at the 1 % level, indicating a reduction in financial restatement and fraud in pilot areas following pilot implementation. Similarly, Panel B shows that before pilot implementation (*Post* = 0), there are no significant differences in financial restatements and fraud between listed state-owned enterprises in pilot areas and non-pilot areas. However, the occurrences of financial restatement and fraud in pilot areas are shown to be significantly lower after pilot implementation (*Post* = 1) than those in non-pilot areas, and this difference is significant at the 1 % level.
Variable Category	Variable	Definition
Dependent Variables	Restate Fraud	An indicator variable equal to one if the company issues a financial restatement, and zero otherwise. An indicator variable equal to one if the company commits financial fraud, and zero otherwise.
Independent	Treat	An indicator variable equal to one if the company is located in a pilot city, and zero otherwise.
Variables	Post	An indicator variable equal to one during the pilot implementation period (2015–2017) and zero before pilot implementation (2012–2014).
Control Variables	Lnta	Natural logarithm of the market value of a company at the end of the year.
	Lev	Total liabilities divided by total assets at the end of the current year.
	Invr	Net inventory divided by total assets.
	Recr	Net accounts receivable divided by total assets.
	Quick	(Current assets – net inventories)/current liabilities.
	Aturn	Sales revenue divided by total assets.
	ROA	Net income before extraordinary items, scaled by the beginning balance of total assets.
	Salegrowth	(Current sales revenue - sales revenue of last period) / sales revenue of last period
	MB	Market capitalization divided by the total equity for common shareholders at the end of the current year.
	M&A	An indicator variable equal to one if the company has a merger or acquisition event, and zero otherwise.
	SEO	An indicator variable equal to one if the company refinances, and zero otherwise.
	ВН	An indicator variable equal to one if the company issues B or H shares at the same time, and zero otherwise.
	Ownership	Percentage of shares held by controlling shareholders.
	Age	Natural logarithm of the number of years the company has been listed.
	MAO	An indicator variable equal to one if the company's annual audit report is a non-standard audit report, and zero otherwise
	Big10	An indicator variable equal to one if the company's auditor is one of the top 10 auditing firms, and zero otherwise.
	Tenure	Natural logarithm of audit tenure.
	Mindex	Marketization index according to the Fangang Marketization Index.

Table 3	
Descriptive	Statistics.

Variable	N	Mean	Standard Error	P25	Median	P75
Restate	5684	0.078	0.268	0	0	0
Fraud	5684	0.055	0.228	0	0	0
Treat	5684	0.378	0.485	0	0	1
Post	5684	0.505	0.500	0	1	1
Lnta	5684	22.74	1.387	21.77	22.58	23.62
Lev	5684	0.520	0.207	0.366	0.531	0.678
Invr	5684	0.158	0.156	0.050	0.116	0.203
Recr	5684	0.091	0.098	0.018	0.055	0.134
Quick	5684	1.230	1.407	0.534	0.868	1.383
Aturn	5684	0.643	0.474	0.321	0.527	0.814
ROA	5684	0.034	0.048	0.011	0.033	0.058
Salegrowth	5684	0.133	0.499	-0.063	0.055	0.188
MB	5684	3.276	3.788	1.485	2.255	3.604
M&A	5684	0.476	0.499	0	0	1
SEO	5684	0.101	0.301	0	0	0
BH	5684	0.122	0.328	0	0	0
Ownership	5684	0.386	0.158	0.261	0.375	0.503
Age	5684	2.634	0.519	2.485	2.773	2.996
MAO	5684	0.032	0.177	0	0	0
Big10	5684	0.544	0.498	0	1	1
Tenure	5684	7.064	5.542	3	6	9
Mindex	5684	0.668	0.298	0.444	0.778	0.889

Note: P25 = 25th percentile, P75 = 75th percentile.

Panel A: Comparison	n of cities befo	re and after pilo	ot implementa	tion				
Variable: Restate	Post = 0		Post = 1		Mean	T-test	Wilcoxon test ⁸	
Mean Medi		Medium	Mean Medium		Difference	T-value	Z-value	
Treat = 0	0.086	0	0.082	0	0.004	0.514	0.514	
Treat = 1	0.083	0	0.048	0	0.035	3.201***	3.194***	
Variable: Fraud	Post = 0		Post = 1		Mean	T-test	Wilcoxon test9	
	Mean Medium Mean		Mean	Medium	Difference	T-value	Z-value	
Treat = 0	0.057	0	0.060	0	-0.003	-0.446	-0.446	
Treat = 1	0.062	0	0.033	0	0.029	3.106***	3.100***	
Panel B: Comparison	n of non-pilot a	and pilot cities						
Variable: Restate	Treat = 0		Treat = 1		Mean	T-test	Wilcoxon test ¹⁰	
	Mean	Medium	Mean	Medium	Difference	T-value	Z-value	
Post = 0	0.086	0	0.083	0	0.003	0.302	0.302	
Post = 1	0.082	0	0.048	0	0.034	3.290***	3.284***	
Variable: Fraud	Treat = 0		Treat = 1	Treat = 1		T-test	Wilcoxon test ¹¹	
	Mean	Medium	Mean	Medium	Difference	T-value	Z-value	
Post = 0	0.057	0	0.062	0	-0.005	-0.551	-0.551	
Post = 1	0.060	0	0.033	0	0.027	3.173***	3.168***	

Table 4			
Comparison	of Means	Between	Subgroups.

⁸Null hypothesis H0: Restate (Post = 0) = Restate (Post = 1).

⁹Null hypothesis H0: *Fraud* (Post = 0) = *Fraud* (Post = 1).

¹⁰Null hypothesis H0: Restate (Treat = 0) = Restate (Treat = 1).

¹¹Null hypothesis H0: *Fraud* (Treat = 0) = *Fraud* (Treat = 1).

Note: *** p < 0.01, ** p < 0.05 (two-tailed).

4. Empirical results and analysis

4.1. Multiple regression results

Table 5 presents the results of multiple regression analysis. Columns (1) and (2) report the regression results without including control variables. The coefficients of *Treat*Post* on *Restate* and *Fraud* are -0.511 and -0.722, respectively, and both are significant at the 5 % level. Columns (3) and (4) report the regression results when we include the control variables. The coefficients of *Treat*Post* on *Restate* and *Fraud* are -0.596 and -0.778, which are significant at the 5 % and 1 % levels, respectively. These results indicate a significant decrease in the likelihood of financial restatement and fraud in listed state-owned enterprises in pilot areas after pilot implementation, demonstrating that the system indeed has a governance effect on accounting information disclosure.

4.2. Robustness tests

4.2.1. Parallel test

To conduct the parallel test, we include the time-specific dummy variables Post (-3), Post (-2), Post (-1), Post (0), Post (1) and Post (2), along with the respective interaction terms with Treat, in the regression. Specifically, Post (-3) is an indicator variable equal to one in the year 2012, and zero otherwise. This pattern continues for subsequent years. Table 6 reports the regression results of the parallel test, with columns (1) and (2) representing the regressions for Restate and Fraud, respectively.

The coefficients of *Treat***Post* (-3), *Treat***Post* (-2) and *Treat***Post* (-1), which represent the period before pilot implementation, are not statistically significant. In the year of pilot implementation, i.e., 2015, the coefficient of *Treat***Post* (0) is also not significant, indicating that the governance effect of the system

Table 5 Regression Results.

Variable	(1) Restate	(2) Fraud	(3) Restate	(4) Fraud
Treat* Dost	0.511**	0.722**	0.506**	0.779***
Treat TOSt	(-2.098)	(-2.479)	(-2, 383)	(-2.608)
Treat	-0.017	0.099	0.091	0.180
	(-0.091)	(0.461)	(0.478)	(0.824)
Post	-0.070	0.060	-0.004	0.096
	(-0.516)	(0.383)	(-0.024)	(0.563)
Lnta			-0.089	-0.049
			(-1.282)	(-0.636)
Lev			1.233**	1.025*
			(2.293)	(1.701)
Invr			-0.832	-1.063
			(-1.386)	(-1.537)
Recr			0.043	1.287
			(0.050)	(1.539)
Quick			-0.034	-0.051
			(-0.455)	(-0.673)
Aturn			-0.022	-0.139
			(-0.110)	(-0.650)
ROA			-2.868*	-2.436
<i></i>			(-1.850)	(-1.343)
Salegrowth			0.165*	0.12/
			(1.869)	(1.235)
MB			-0.034	-0.039
1404			(-1.983)	(-2.106)
M&A			0.050	0.018
SEO			(0.454)	(0.131)
SEU			(0.205)	(0.207)
RН			0.639*	(0.307)
DII			(-0.039)	(1320)
Ownershin			(-1.771) -0.954	(-1.520)
Ownership			(-1.574)	(-1, 188)
<i>Α α ρ</i>			0.030	0.113
nge			(0.190)	(0.637)
MAO			0 548*	0.880***
			(1.910)	(2.840)
Big10			-0.348**	-0.517^{***}
			(-2.238)	(-2.910)
Tenure			-0.012	-0.028
			(-0.789)	(-1.636)
Mindex			-0.410	-0.082
			(-1.494)	(-0.253)
Constant	-0.969^{***}	-1.676^{***}	1.252	-0.338
	(-3.618)	(-4.693)	(0.884)	(-0.217)
Industry FE	YES	YES	YES	YES
Pseudo R^2	0.026	0.031	0.063	0.072
Ν	5684	5684	5684	5684

did not immediately manifest. This could be because pilot implementation occurred in the second half of 2015, suggesting a certain lag in the policy effect. However, the coefficients of *Treat*Post (1)* and *Treat*Post (2)*, which represent the two years following pilot implementation, are negative and significant (See Figs. 1 and 2).

Variable	(1)	(2)
	Restate	Fraud
Treat * Post (-3)	0.358	0.494*
	(1.557)	(1.873)
Treat * Post (-2)	0.015	0.074
	(0.063)	(0.258)
Treat * Post (-1)	-0.266	-0.297
	(-0.924)	(-0.805)
Treat * Post (0)	-0.258	-0.420
	(-0.987)	(-1.314)
Treat * Post (1)	-0.935**	-1.236***
	(-2.508)	(-2.590)
Treat * Post (2)	-0.596*	-0.457
	(-1.820)	(-1.283)
Post (-3)	0.125	0.084
	(0.590)	(0.339)
Post (-2)	0.162	0.072
	(0.781)	(0.297)
Post (-1)	-0.111	-0.272
	(-0.516)	(-1.086)
Post(0)	0.149	0.119
	(0.835)	(0.604)
Post (1)	-0.022	-0.001
	(-0.155)	(-0.008)
Constant	0.733	-0.974
	(0.498)	(-0.605)
Controls	YES	YES
Industry FE	YES	YES
Pseudo R^2	0.068	0.080
Ν	5684	5684

Table 6 Parallel Test Results.

Notes: *Treat* and *Post* (2) are omitted because of covariance. *** significant at the 1% level, ** significant at the 5% level, * significant at the 10% level.

4.2.2. Fixed effects

To mitigate the influences of disparities in economic development among different cities and inherent differences in company characteristics on the results, we separately add city fixed effects and firm fixed effects and re-estimate model (1). The regression results are shown in Table 7, where columns (1) and (2) control for city fixed effects and columns (3) and (4) control for firm fixed effects. The regression coefficients of *Treat*Post* are consistently negative.

4.2.3. Sample Adjustment

The pilot implementation period was from May 2015 to June 2017, with neither 2015 nor 2017 being complete fiscal years. To ensure a cleaner research sample, we delete the samples in either 2015 or 2017 and reestimate model (1). The results presented in Table 8, columns (1) to (4), show that our results remain robust. Furthermore, as China's direct-controlled municipalities enjoy substantial advantages in terms of governance, economic development, policy innovation, and international influence, we follow Bu et al. (2022) and exclude samples from these municipalities. As shown in Table 8, columns (5) to (6), our results remain robust.

4.2.4. Propensity score matching (PSM)–DID model

As the selection of pilot cities is exogenous, to further alleviate endogeneity concerns, this study uses a PSM–DID model; specifically, taking *Treat* as the dependent variable, we select all of the control variables from model (1) as the covariates. Using a logit regression to obtain propensity scores, we use a 1:1 nearest neighbor matching method (with replacement) to obtain a final sample of 1,912 firm-year observations for



Fig. 2. Parallel test of Fraud.

both non-pilot and pilot samples. In Table 9, PSM is shown to reduce the imbalance between the treatment and control groups. Table 10 reports the regression results based on the PSM matching sample, showing that our main results hold.

4.2.5. Placebo test

To further mitigate endogeneity concerns, we conduct a placebo test. After setting a random time variable, $Post_r$, and randomly assigning a pilot time to each company while maintaining a proportion of $Post_r$ in the sample consistent with that of Post, we regress model (1) using $Post_r$. We extract and save the coefficients and standard errors of $Treat*Post_r$ and calculate the T-statistic. We conduct 1000 placebo regressions on model (1) to obtain 1000 T-statistics. The density plots shown in Figs. 3 and 4 reveal that the coefficients of $Treat*Post_r$ approximately follow a normal distribution around 0. The results of the placebo tests suggest that our main results are not driven by unobservable factors.

4.2.6. Changing the measurement of the dependent variable

To increase the robustness of our results, we additionally measure the accounting information quality using accrual earnings management. Referring to Ball and Shivakumar (2006, 2008), we estimate accrual earnings management using the following regression:

Variable	(1)	(2)	(3)	(4)
	Restate	Fraud	Restate	Fraud
Treat*Post	-0.693**	-0.953^{***}	-0.356*	-0.483^{**}
	(-2.446)	(-2.770)	(-1.849)	(-2.122)
Treat	13.919***	13.203***	-0.296	-0.454
	(10.826)	(9.737)	(-0.971)	(-1.333)
Post	0.002	0.109	0.104	0.225
	(0.013)	(0.524)	(0.689)	(1.296)
Constant	-13.076^{***}	-12.910^{***}	-19.099	-13.751***
	(-6.398)	(-5.492)	(-0.024)	(-3.019)
Controls	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES
City FE	YES	YES	NO	NO
Firm FE	NO	NO	YES	YES
Pseudo R^2	0.146	0.185	0.205	0.223
N	4402	4176	1195	926

Addition	of	City	Fixed	Effects	and	Firm	Fixed	Effects	to	Model ((1)).

$$ACC = \alpha_{j0} + \alpha_{j1} \times \Delta Sales + \alpha_{j2} \times PPE + \alpha_{j3} \times CFO + \alpha_{j4} \times DCFO + \alpha_{j5} \times DCFO \times CFO + \varepsilon$$
(2)

where ACC represents the total accrual of the company, CFO is the cash flow from operations, $\Delta Sales$ denotes the change in sales revenue and PPE represents the book value of fixed assets. All of these variables are standardized by the total assets at the beginning of the period. DCFO takes a value of one when CFO is < 0, and zero otherwise. The absolute value of ACC, denoted as |ACC|, measures the degree of accrual earnings management. We use |ACC| as the dependent variable and incorporate it into model (1) to examine the impact of the Procuratorate's Public Interest Litigation System on the accrual earnings management of listed stateowned enterprises. As shown in Table 11, the coefficients of Treat*Post are negative and significant at the 5% level, suggesting that system implementation significantly reduced the degree of accrual earnings management of listed state-owned enterprises, thus demonstrating a governance effect on accounting information disclosure.

Table 8	
Sample	Adjustment.

Variable	Deleted samp	les from 2015	Deleted samples from 2017		Excluded samples from direct-controlled municipalities		
	(1) Restate	(2) Fraud	(3) Restate	(4) Fraud	(5) Restate	(6) Frau	d
Treat*Post	-0.861**	0.861** -0.956**	-0.556**	-0.842***		-0.759^{***}	-0.934***
	(-2.530)	(-2.432)	(-2.220)	(-2.754)		(-2.841)	(-2.916)
Treat	0.091	0.186	0.102	0.191		0.131	0.260
	(0.475)	(0.848)	(0.531)	(0.868)		(0.636)	(1.113)
Post	-0.026	0.088	0.023	0.108		-0.013	0.091
	(-0.163)	(0.472)	(0.148)	(0.604)		(-0.086)	(0.494)
Constant	1.342	0.266	1.354	-0.594		1.397	-0.541
	(0.890)	(0.162)	(0.888)	(-0.363)		(0.907)	(-0.316)
Controls	YES	YES	YES	YES	YES	YES	
Industry FE	YES	YES	YES	YES	YES	YES	
Pseudo R^2	0.065	0.077	0.063	0.071		0.066	0.079
N	4732	4732	4718	4718		4736	4736

Note: *** significant at the 1% level, ** significant at the 5% level, * significant at the 10% level.

Table 7

Table 9 Imbalance Between the Treatment and Control Groups after PSM.

Variable	(1)	(2)	Mean Difference	T-test		
	$Treat = 0 \ (N = 1912)$	$Treat = 1 \ (N = 1912)$				
	Mean	Mean	(1) - (2)	T-value	$p > \mid t \mid$	
Lnta	22.746	22.761	-0.015	-0.321	0.748	
Lev	0.505	0.508	-0.003	-0.444	0.657	
Invr	0.164	0.160	0.004	0.793	0.428	
Recr	0.095	0.096	-0.001	-0.036	0.972	
Quick	1.293	1.234	0.059	1.333	0.183	
Aturn	0.643	0.649	-0.006	-0.395	0.693	
ROA	0.038	0.036	0.002	0.810	0.418	
Salegrowth	0.139	0.137	0.002	0.133	0.895	
MB	3.056	2.876	0.18	2.032**	0.042	
M&A	0.485	0.473	0.012	0.712	0.477	
SEO	0.096	0.100	-0.004	-0.489	0.625	
BH	0.125	0.126	-0.001	-0.049	0.961	
Ownership	0.386	0.388	-0.002	-0.236	0.813	
Age	2.598	2.607	-0.009	-0.507	0.612	
MAO	0.020	0.024	-0.004	-0.883	0.378	
Big10	0.549	0.554	-0.005	-0.293	0.770	
Tenure	6.792	6.771	0.021	0.118	0.906	
Mindex	0.686	0.685	0.001	0.105	0.917	

Regression on the PSM-DID	Model.	
Variable	(1)	(2)
	Restate	Fraud
Treat*Post	-0.667**	-0.768**
	(-2.258)	(-2.278)
Treat	0.131	0.154
	(0.609)	(0.647)
Post	0.042	0.072
Constant	(0.214)	(0.337)
Constant	0.762	0.562
	(0.458)	(0.308)
Controls	YES	YES
Industry FE	YES	YES
Pseudo R^2	0.070	0.083
N	3824	3824

Note: *** significant at the 1% level, ** significant at the 5% level, * significant at the 10% level.

5. Additional tests

5.1. The impact mechanism

Table 10

First, given the resource constraints imposed by regulatory authorities, if the Procuratorate's Public Interest Litigation System significantly constrains the opportunistic behavior of state-owned enterprises, the effects of these constraints should be more pronounced in key regulated industries than in other industries. The key areas targeted for regulation mainly include environmental and resource protection, food and drug safety, state-owned asset protection and state-owned lands using rights transfers. Therefore, we identify listed state-owned enterprises in the following industries as belonging to key regulated industries: the mining indus-



Fig. 3. 1000 placebo regressions on Restate.



Fig. 4. 1000 placebo regressions on Fraud.

Table 11 Changing the Measurement of the Dependent Variable.

Variable	(1)	(2)	(3)
	DA	DA	DA
Treat*Post	-0.004^{**}	-0.004^{**}	-0.003^{**}
	(-2.334)	(-2.259)	(-2.061)
Treat	0.003	0.066****	0.005^{**}
	(1.602)	(9.021)	(2.027)
Post	-0.001	-0.000	0.002
	(-0.712)	(-0.328)	(1.188)
Constant	0.036**	0.031**	0.055
	(2.478)	(2.169)	(1.100)
Controls	YES	YES	YES
Industry FE	YES	YES	YES
City FE	NO	YES	NO
Firm FE	NO	NO	YES
Adj. R^2	0.107	0.168	0.064
N	5609	5596	5609

try, petroleum, chemical, plastic, and rubber manufacturing industry, metal and non-metal manufacturing industry, machinery, equipment and instrument manufacturing industry, food and beverage manufacturing industry, pharmaceutical and biological product manufacturing industry, wholesale and retail trade industry and real estate industry. Specifically, we classify samples as belonging to key regulated or non-key regulated industries and show the results of the subsample regression in Table 12. It can be seen that the coefficient of *Treat*Post* is significant for the key regulated subsample but not significant for the non-key regulated subsample, indicating that the system has a more pronounced effect on improving information disclosure quality in key regulated vs. non-key regulated industries.

Second, according to the theoretical analysis, the deterrence effect of the system mainly stems from the initiation of public interest litigation. Therefore, we examine firms' litigation risk mechanism. We use litigation data from the CSMAR and East Money databases to construct an indicator variable, *Misrepresentation*, as a measure of litigation risk. Specifically, if listed state-owned enterprises are involved in misrepresentation litigation, *Misrepresentation* is equal to one; otherwise, it is equal to zero. The regression results are shown in columns (1) and (2) of Table 13. When only the industry fixed effects are controlled, as in column (1), the coefficient of *Treat*Post* is not statistically significant. When both the industry and city fixed effects are controlled, as in column (2), the coefficient of *Treat*Post* is positive and significant at the 5 % level, which indicates that pilot implementation increases the litigation risk faced by listed state-owned enterprises, thus significantly raising the probability of misrepresentation litigation and leading some problematic state-owned enterprises to become the focus of regulation.

Lastly, the governance effect of the system may also stem from its ability to constrain the opportunistic behavior of state-owned enterprises' top executives. Therefore, we examine this mechanism from the perspective of agency costs. Referring to prior research (Luo et al., 2011; Chu and Fang, 2016), we use top executives' excess perquisites to measure agency costs:

$$\frac{Perk_{i,t}}{Assets_{i,t-1}} = \beta_0 + \beta_1 \times \frac{1}{Assets_{i,t-1}} + \beta_2 \times \frac{\Delta Sale_{i,t}}{Assets_{i,t-1}} + \beta_3 \times \frac{PPE_{i,t}}{Assets_{i,t-1}} + \beta_4 \times \frac{INV_{i,t}}{Assets_{i,t-1}} + \beta_5 \times LnEmployee_{i,t} + \varepsilon_{i,t}$$
(3)

where $Perk_{i,t}$ represents the management expenses minus managers' compensation, $Assets_{i,t-1}$ denotes the total assets at the end of the previous year, $\Delta Sale_{i,t}$ indicates the change in sales revenue, $PPE_{i,t}$ represents the book value of fixed assets, $INV_{i,t}$ represents the total inventory at the end of the year and $LnEmployee_{i,t}$ is the natural logarithm of the total number of employees. We use model (3) to estimate the normal level of top exec-

Table 12

Subsample Analysis of Key regulated and Non-Key Regulated Industries.

Variable	Restate				Fraud	
	(1)		(2)		(3)	(4)
	Non-key regulated in	ndustries	Key regulated indus	stries	Non-key regulated industries	Key regulated industries
Treat*Post		-0.441	-0.0	634*	-0.514	-0.920^{**}
		(-1.170)	(-1.	918)	(-1.181)	(-2.313)
Treat		0.151	-0	.008	0.022	0.235
		(0.519)	(-0.	031)	(0.062)	(0.873)
Post		-0.238	0	.162	-0.140	0.238
		(-1.009)	(0.	875)	(-0.519)	(1.079)
Constant		0.887	-0	.424	-1.317	-1.665
		(0.395)	(-0.	212)	(-0.505)	(-0.768)
Diff			0.193	3***		0.406**
Controls	YES		YES		YES	YES
Industry	YES		YES		YES	YES
Pseudo R^2		0.093	0	0.058	0.111	0.066
Ν		2268	2	3416	2268	3416

Note: *** significant at the 1% level, ** significant at the 5% level, * significant at the 10% level.

				-		
Variable	(1)	(2)	(3)	(4)	(5)	(6)
	Misrepresentation	Misrepresentation	UnPerk	UnPerk	Оссиру	Оссиру
Treat*Post	0.485	4.063**	-0.026*	-0.012	-0.001	-0.006**
	(0.358)	(2.031)	(-1.812)	(-0.882)	(-0.250)	(-2.496)
Treat	-0.588	-6.825	0.008	0.124*	-0.002	-0.182***
	(-0.509)	(-1.521)	(0.418)	(1.846)	(-0.639)	(-20.085)
Post	0.963	1.077	-0.089***	-0.087***	0.002	0.004**
	(1.143)	(0.655)	(-8.448)	(-8.411)	(1.169)	(2.162)
Constant	-13.925**	3.556	1.649***	1.753***	-0.036	-0.046
	(-2.094)	(0.294)	(8.666)	(10.024)	(-1.320)	(-1.563)
Controls	YES	YES	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES	YES
City FE	NO	YES	NO	YES	NO	YES
Adj. R^2	0.203	0.501	0.257	0.348	0.127	0.204
N	2498	540	5684	5671	5684	5671

Mechanism of the Impact of the Procuratorate's Public Interest Litigation System on Accounting Information Disclosure.

utives' perquisites. Top executives' excess perquisites, represented by $UnPerk_{i,t}$, are defined as the difference between the actual level and estimated normal level of top executives' perquisites. Finally, we use $UnPerk_{i,t}$ as the dependent variable and regress it into model (1), and the results are shown in columns (3) and (4) of Table 13. In column (3), only the industry fixed effects are controlled, and the coefficient of *Treat*Post* is negative and significant at the 10 % level, indicating that pilot implementation reduces the excess perquisites of top executives of listed state-owned enterprises, thus lowering agency costs.

Referencing Wang and Xiao (2005), we also measure agency costs using the fund occupation of related parties, which is represented by $Occupy_{i,t}$ and calculated as the net amount of funds occupied by related parties divided by the company's total assets at the end of the year. Finally, we use $Occupy_{i,t}$ as the dependent variable and regress it into model (1), and the results are shown in columns (5) and (6) of Table 13. In column (5), only the industry fixed effects are controlled, and the coefficient of *Treat*Post* is not statistically significant. In column (6), both the industry and city fixed effects are controlled, and the coefficient of *Treat*Post* is negative and significant at the 5 % level, indicating that pilot implementation reduces the fund occupation by related parties in state-owned enterprises. Overall, despite weak evidence, these research findings suggest that the Procuratorate's Public Interest Litigation System indeed has reduced misconduct by managers of listed state-owned enterprises, thus alleviating agency problems and improving corporate governance.

5.2. Cross-sectional tests

5.2.1. External governance mechanisms

As institutional investors and auditors serve as crucial information intermediaries and external governance mechanisms, do they affect the relationship between the Procuratorate's Public Interest Litigation System and accounting quality?

Institutional investors play a crucial role as information intermediaries in the capital market. Research suggests that in a given company, the proportion of institutional investor shareholding is positively associated with the strength of the investors' external supervisory governance role within the company (Cheng, 2006). Institutional investors play a vital role in mitigating information asymmetry, leading to higher information efficiency within a company. Consequently, the positive impact of the Procuratorate's Public Interest Litigation System on accounting quality in listed state-owned enterprises may be diminished when institutional investor shareholding is high.

Table 13

Variable	Institutiona	al investor share	holding		Audit qualit	у		
	Restate		Fraud		Restate		Fraud	
	(1) Low	(2) High	(3) Low	(4) High	(5) Low	(6) High	(7) Low	(8) High
Treat*Post	-0.814^{**} (-2.442)	-0.316 (-0.799)	-0.908^{**} (-2.370)	-0.555 (-1.033)	-1.053^{***} (-2.773)	-0.114 (-0.347)	-1.026^{**} (-2.388)	-0.525
Treat	0.228 (0.961)	-0.074 (-0.252)	0.309 (1.131)	-0.008 (-0.025)	0.168 (0.638)	-0.085 (-0.305)	0.109 (0.379)	0.154
Post	-0.023	0.123 (0.497)	0.139 (0.617)	0.108 (0.358)	0.171 (0.881)	-0.177	0.048	0.217
Constant	-0.712 (-0.422)	3.321 (1.459)	-2.251 (-1.194)	1.951 (0.775)	0.539 (0.259)	-0.017 (-0.008)	-1.173 (-0.486)	-1.996 (-0.824)
Diff		-0.498***		-0.353***		-0.939***		-0.501***
Controls	YES	YES	YES	YES	YES	YES	YES	YES
Pseudo R^2	9 ES 0.075	9 ES 0.067	9 ES 0.090	9 ES 0.072	9 ES 0.067	9 ES 0.070	9 ES 0.079	YES 0.074
N	2841	2843	2841	2843	2590	3094	2590	3094

Table 14 Cross-Sectional Tests: External Governance Mechanisms.

Generally, independent auditors can enhance accounting disclosure quality (Watts and Zimmerman, 1983). Compared with their lower-quality counterparts, high-quality auditors can better identify and monitor profit manipulation, fraud and misconduct and thus play an important role in external governance. When the external audit quality is lower, the need for the Procuratorate's Public Interest Litigation System as a compensatory governance mechanism is greater, and the system's incremental positive effect on accounting quality may be higher. Therefore, we expect the governance effect of the integrated mechanism to be stronger on listed stateowned enterprises with lower audit quality.

We conduct cross-sectional tests and show the results in Table 14. The coefficient of *Treat*Post* is negative and significant only in the subsample with low institutional investor shareholding and low audit quality. These results show that the relationship between the Procuratorate's Public Interest Litigation System and accounting quality is stronger in companies with weaker external governance, suggesting a substitution effect between the integrated mechanism and other external governance mechanisms.

5.2.2. Internal governance mechanisms

ESG performance serves as a critical benchmark for assessing the internal governance performance of companies, as it reflects how they integrate environmental, social responsibility and corporate governance considerations into their business operations. A higher ESG rating typically signifies a company with a stronger governance framework and fewer non-systemic risks (Sassen et al., 2016; Gillan et al., 2021; He et al., 2022). Listed state-owned enterprises with a low ESG rating tend to rely on the Procuratorate's Public Interest Litigation System to compensate for internal weakness; therefore, we expect that the incremental governance impact of the integrated mechanism on the quality of disclosure by listed state-owned enterprises is more pronounced for enterprises with lower ESG ratings.

We conduct cross-sectional tests and show the results in Table 15. Specifically, the ESG rating is obtained from the Huazheng Index (Fang and Hu, 2023). In Table 15, the coefficient of *Treat*Post* is negative and significant only in the subsample with low ESG ratings. These results suggest that the correlation between the Procuratorate's Public Interest Litigation System and accounting quality is stronger in listed state-owned enterprises with weaker internal governance.

Variable	ESG rating			
	Restate		Fraud	
	(1)	(2)	(3)	(4)
	Low	High	Low	High
Treat*Post	-0.748^{**}	-0.240	-1.019^{***}	-0.432
	(-2.350)	(-0.546)	(-2.646)	(-0.855)
Treat	0.120	0.154	0.255	0.157
	(0.518)	(0.452)	(0.956)	(0.410)
Post	-0.044	0.125	0.072	0.194
	(-0.250)	(0.428)	(0.349)	(0.551)
Constant	-1.435	3.896	-4.568**	4.610
	(-0.800)	(1.372)	(-2.154)	(1.364)
Diff		-0.508***		-0.587**
Controls	YES	YES	YES	YES
Industry	YES	YES	YES	YES
Pseudo R^2	0.062	0.127	0.079	0.119
Ν	3343	2261	3343	2261

Table 15 Cross-Sectional Tests: Internal Governance Mechanism.

6. Conclusion

Corporate governance scandals erode not only shareholders' wealth but also investors' confidence and thus ultimately impede capital market development, with far-reaching economic ramifications. Some crucial imperatives to address these problems have emerged, namely addressing agency problems, mitigating opportunistic behavior (e.g., financial fraud) and safeguarding shareholders' rights. Different from prior research, which predominantly scrutinizes individual corporate governance mechanisms, the current study scrutinizes the Procuratorate's Public Interest Litigation System, which fuses litigation and administrative oversight. This system is centered on safeguarding public interests and state-owned assets in China; this is a novel focal point of analysis in the current study, which aims to unravel the spillover governance effects of the system on accounting information disclosure by listed state-owned enterprises. By examining the interplay between this integrated governance framework and the disclosure practices of state-owned enterprises, this research unveils the potential for the Procuratorate's Public Interest Litigation System to enhance governance effects within the corporate sphere. The current study thus sheds light on the efficacy of this unique governance mechanism in terms of bolstering investors' confidence and upholding the integrity of the capital market.

This study finds that compared with their counterparts in non-pilot regions, listed state-owned enterprises in pilot regions experienced a significant reduction in the probability of financial restatement and financial fraud following pilot implementation. Further analysis reveals that the governance effects are pronounced in key regulated industries. Additionally, the increased risk of litigation related to misrepresentation after pilot implementation is found to have a deterrent effect. Further analysis shows that the Procuratorate's Public Interest Litigation System enables an improved disclosure environment by constraining top executives' excess perquisites and the fund occupation of related parties. Cross-sectional tests demonstrate that the aforementioned relationships are stronger when state-owned enterprises are exposed to weaker external governance, i.e., when the levels of institutional investor ownership and audit quality are lower, indicating a substitutive relationship between the integrated mechanism and other external governance mechanisms. Additionally, the governance effect is stronger in state-owned enterprises with worse internal governance (i.e., ESG) performance, suggesting an increased demand for enhanced supervision by the system.

With this study, we further explore the efficacy of integrated governance mechanisms, broaden the spectrum of factors known to influence the quality of information disclosure and provide empirical substantiation of the expansion of the Procuratorate's Public Interest Litigation System's supervisory purview within the capital market. Acting under procuratorates that spearhead oversight initiatives and initiate public interest litigation to instigate corrective actions within administrative departments, this integrated governance framework enables superior autonomy and efficacy compared with standalone administrative supervision.

For policymakers, the current pilot phase of the Procuratorate's Public Interest Litigation System is circumscribed by its supervisory ambit. However, the current study shows that the system can yield governance outcomes pertaining to accounting information disclosure. Given the pivotal foundational role of information quality in the integrity of the capital market, this finding should encourage policymakers to actively explore the potential use of public interest litigation within the securities domain. Within the Chinese capital market landscape, extant integrated governance mechanisms currently encompass entities such as the China Securities Investor Services Center (ISC). Notably, representative securities litigation orchestrated by the ISC has demonstrated preliminary governance efficacy, and the Procuratorate's Public Interest Litigation System is expected to emerge as a valuable extension of the ISC in the near future. By preemptively thwarting insider trading, market manipulation and other illicit activities through proactive vigilance, fortified oversight throughout the process, judicial redress post facto and collaborations with diverse stakeholders, such as the China Securities Regulatory Commission (CSRC), stock exchanges and others, a collective effort can be marshaled to safeguard minority shareholders' interests and propel capital market advancement.

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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Compliance management and investment efficiency in state-owned enterprises: Evidence from China



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ABSTRACT

Drawing on the implementation of the compliance management guidelines issued by China's SASACs, we construct a quasi-natural experiment to examine the impact of the implementation of these guidelines on the investment efficiency of SOEs. The investment efficiency of SOEs is significantly improved after the implementation of the guidelines. The impact is more pronounced on SOEs with significant financing constraints, high financing requirements and intense competition in the product market. We also find that the guidelines improve efficiency investment by reducing management's risk appetite, mitigating the Type I agency problems and enhancing the level of internal control. The conclusions indicate that compliance management is an important strategy for enhancing the investment efficiency of SOEs.

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1. Introduction

Globally, listed firms face serious problems with inefficient investments (Goodman et al., 2014; Otto and Volpin, 2018). Research on this problem focuses on financial constraints (McLean et al., 2012; Zhang et al., 2017), internal control (Li et al., 2011; Fang and Jin, 2013), accounting information quality (Chen et al., 2011; Yuan and Rao, 2018) and other related factors. In firms, risk management is integrated throughout the entire investment process, which consists of investment project evaluation, decision-making, plan implementation and post-implementation evaluation. Studies show that policy risk (Shen et al., 2012) and technology risk (Shantia et al., 2021) influence the investment behavior of firms. However, although compliance risk management is an essential component of corporate risk management, the impact of compliance management on investment efficiency is rarely studied.

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For a long time, the development of SOEs in China has been plagued by problems such as low efficiency (Opie et al., 2019), lack of ownership accountability (Li et al., 2023) and political interference (Chen et al., 2011b). Under the influence of soft budget constraints and other factors (Chen and Chen, 2014), SOEs face more serious inefficient investment issues than non-SOEs (Chen and Xie, 2011; Liu et al., 2015). This results in asset loss and value decline, which seriously hamper the development of SOEs. The Chinese government has promoted the mixed ownership reform of SOEs (Fu et al., 2008; Chen et al., 2012; Xue et al., 2018), because deficiencies in internal control, such as weak compliance awareness, lead to unequal competition and fraud (Hou and Moore, 2010; Hass et al., 2019), which seriously restrict the development of SOEs. As international competition is increasingly manifested in disputes over rules and laws, compliance issues have recently emerged as an important factor in the numerous anti-monopoly investigations and sanctions against Chinese firms operating globally. Therefore, it is necessary to integrate compliance management requirements into firms' internal control processes and to encourage firms to conduct diverse investment activities in compliance with the law and as safeguards against major risks. Most of the literature on internal control and investment efficiency focuses on the impact of the disclosure of internal control defects on the effectiveness of internal control and investment efficiency (Li et al., 2011; Zhang and Liu, 2015). Obviously, studying the impact of internal control effectiveness on investment efficiency is not enough. Furthermore, it does not provide a comprehensive understanding of the relationship between internal control mechanisms and investment efficiency. Drawing on the compliance management guidelines issued by the central and local State-owned Assets Supervision and Administration Commissions (SASACs), we not only examine the influence of internal governance on investment efficiency in detail, enriching the literature on SOEs' investment behavior, but also offer empirical evidence that can support the development of a compliance management system for SOEs.

With regard to the construction of a compliance management system, the Chinese government has systematically implemented compliance management guidelines for establishing compliance management systems that align with international standards. This initiative aims to promote the high-quality development of firms in China. On 9 November 2018, the SASAC of the State Council issued and implemented the "Central Enterprise Compliance Management Guidelines." The local SASACs have successively issued and implemented compliance management guidelines that are applicable to the local SOEs under their jurisdiction. These guidelines explicitly require subordinate SOEs to systematically implement a compliance management system and to integrate compliance management into the entire investment process before, during and after events. The implementation of these guidelines offers an external event suitable for assessing the influence of compliance management on the investment efficiency of SOEs. Consequently, we investigate whether the guidelines have a positive impact on the investment behavior of SOEs and the mechanisms through which the guidelines impact investment efficiency.

Theoretically, there are three channels through which the guidelines can impact investment efficiency. First, compliance management guidelines systematically encourage SOEs to conduct organized compliance management activities, including system formulation, risk identification, compliance review, risk response, risk assessment, evaluation and compliance training. Second, the guidelines clearly require SOEs to establish a dedicated compliance management department to oversee their compliance efforts. Furthermore, SOEs need to establish a compliance risk identification and early warning system, a compliance review system and a compliance accountability assessment system. These systems significantly enhance the compliance awareness and management capabilities of SOEs. Third, in terms of corporate investment, the guidelines require strict implementation of decision-making approval procedures, thus standardizing the asset transactions and bidding activities of SOEs. The guidelines require SOEs to strictly implement a decision-making system where major decisions, important appointments and removals, arrangements of significant projects and the use of substantial funds must be determined through collective discussions. SOEs need to detail decision-making processes and authorities at all levels to ensure the legality and compliance of investment decisions. Furthermore, the guidelines require SOEs to pay particular attention to compliance risks associated with major decisions, major contracts and the control of large amounts of funds to prevent the diffusion of risks. Based on the above discussion, we predict that implementing the guidelines effectively encourages SOEs to enhance their compliance management systems, thereby improving their investment performance and reducing inefficient investments.

Drawing on the 2018 "Central Enterprise Compliance Management Guidelines" issued by the SASAC of the State Council and the subsequent compliance management guidelines issued by local SASACs, we conduct

a quasi-natural experiment. We collect data from listed Chinese non-financial SOEs for the 2015–2022 period and examine the impact of the implementation of compliance management guidelines on the investment efficiency of the relative SOEs using a staggered difference-in-differences (DID) model. We observe a significant improvement in the investment efficiency of the pilot firms following the implementation of the guidelines. A cross-sectional analysis reveals that in SOEs facing severe financing constraints, high financing demand and intense competition in the product market, the impact of the implementation of the guidelines on investment efficiency is more pronounced than in other firms. The mechanism analysis shows that the guidelines improve investment efficiency by reducing management's risk preference, alleviating Type I agency problems and enhancing the level of internal control. Further analysis shows that compliance management can simultaneously alleviate the over-investment and under-investment activities of SOEs.

Our research makes four potential contributions. First, inefficient investment is common in listed firms globally (Chen et al., 2011b; Choi et al., 2020). Most of the literature on investment efficiency, however, is related to financing constraints, internal control and the quality of accounting information. Most studies of internal control and compliance management examine the impact of internal control on investment efficiency from the perspective of internal control defects (Li et al., 2011; Zhang and Liu, 2015) but do not consider the specific influence of compliance management on investment efficiency. Based on the quasi-natural experiment of the compliance management guidelines issued by SASACs, we analyze the impact of compliance management of internal governance on investment efficiency but also provides empirical evidence that can support the development of compliance management guidelines. Furthermore, we find that compliance management is an effective strategy to enhance investment efficiency. Our findings offer guidance to listed firms in emerging markets seeking to enhance their corporate governance mechanisms and mitigate financial risks.

Second, the literature on risk management focuses on traditional risk management theory (Gahin, 1967; Cummins, 1976), financial risk management theory (Sharpe, 1964; Ullrich, 1992), internal control theory (Scott, 1976; McMullen et al., 1996) and enterprise risk management theory (Allayannis and Ofek, 2001). It also covers credit risks (Yu, 2003; Mapper, 2004; Guillen et al., 2007; Xiong et al., 2009), foreign exchange risks (Allayannis and Ofek, 2001; Graham and Rogers, 2002; Lin et al., 2008; Guo, 2012) and compliance risks in financial firms (Zhang and Wu, 2009). Through the quasi-natural experiment of the implementation of compliance management guidelines in China, we extend research on the economic consequences of risk management to compliance risk management in non-financial firms. This study explores the relationship between compliance management and the investment efficiency of SOEs. Our research complements existing studies on risk management, but offers a unique Chinese perspective and empirical findings on global compliance risk management.

Third, research on the governance of SOEs focuses on SOE reform (Liu et al., 2012), mixed ownership (Chen et al., 2012; Xue et al., 2018), resource allocation efficiency (Huang et al., 2017; Li and Yang, 2018), external oversight (Wang and Qi, 2016) and executive incentives (Liu et al., 2010; Luo et al., 2018). Our research revolves around the internal governance reform of compliance management of SOEs, enriching the literature on the governance of SOEs. Furthermore, the issue of inefficient investment by SOEs is not unique to China; it is prevalent in countries with emerging markets (O'Toole et al., 2016; Svigir and Vasicek, 2016). In addition, constructing a compliance management system and enhancing compliance awareness among SOEs are crucial elements of governance reform in countries with emerging markets and weak legal environments. Our conclusions not only have implications for China's attempts to deepen the reform of compliance management and improve the investment performance of SOEs but also provide insights for other countries with emerging markets seeking to enhance the development of compliance management systems and increase the value of listed firms.

2. Background, theoretical analysis and hypothesis development

SOEs are an integral part of the Chinese national economy. Under the multiple constraints of laws and regulations such as the "Company Law of the People's Republic of China" and the "State-owned Assets of Enterprises Law of the People's Republic of China," SOEs need to enhance their risk prevention system and adhere to compliance management standards. In 2015, the SASAC of the State Council issued the "Opin-

ions on Comprehensively Promoting the Law-based Governance Construction of SOEs," which explicitly outlines the objective of establishing a law-based governance framework for SOEs characterized by comprehensive governance, operational compliance, standardized management and integrity.

In 2016, the SASAC of the State Council issued the "Notice on Pilot Construction of Compliance Management System for Some Central Enterprises," designating China Mobile Communications Corporation, China National Petroleum Corporation, China Merchants Group, Dongfang Electric Corporation and China Railway Group as the pilot corporations for constructing compliance management systems.

In 2018, the SASAC of the State Council issued the "Central Enterprise Compliance Management Guidelines" with the aim of effectively preventing and controlling compliance risks. These guidelines systematically guide central enterprises, which controlled by the SASAC of the State Council, in conducting organized and planned management activities, including formulating systems, identifying risks, conducting compliance reviews, responding to risks, assessing risks and evaluating and providing compliance training. In addition, the SASAC has compiled a series of compliance guidelines for key areas such as anti-monopoly, export control and anti-commercial bribery. These guidelines provide strong support for the reform and development of central enterprises. In the same year, the SASAC issued the "Implementation Measures for Accountability for Illegal Operation and Investment of Central Enterprises," which clarifies the scope, standards, responsibilities, accountability and working procedures for illegal operations and investments by central enterprises.

Since 2019, the SASAC has successively issued a series of policy documents to guide enterprises in their accountability for illegal operations and investments. Since then, local SASACs have implemented compliance management guidelines that are suitable for local SOEs. In 2022, the SASAC of the State Council issued the "Measures for the Compliance Management of Central Enterprises." Compared with the "Central Enterprise Compliance Management Guidelines," the new measures emphasize stricter constraints. As a result, the construction of the compliance management system for SOEs has entered a crucial phase. It is of great practical importance to test the outcomes of the new compliance management system.

As compliance management guidelines are the foundation of comprehensive risk management, we believe that implementing them significantly enhances the compliance management of the relative SOEs, and thus effectively reduce compliance risk and further improve investment efficiency through the following channels.

First, compliance management guidelines compel firms to apply their corporate investment compliance risk identification and early warning system before making a decision and to implement a compliance review system after making a decision. This helps to constrain the risk preferences of SOEs. The guidelines clearly indicate that the decision-making system for major issues, important appointments and removals, arrangement of significant projects and the use of large funds must be determined through collective discussions. This should be considered the key aspect of compliance management. The guidelines target management personnel as the key focus of compliance management and aim to strengthen compliance in overseas investment and operations.

The guidelines require SOEs to systematically analyze the possibility, impact and potential consequences of risks. They must comprehensively address the compliance risks present in their operation and management activities and establish a compliance risk identification and early warning system. The "arrogant" hypothesis, supported by management irrationality theory (Roll, 1986; Li et al., 2019), suggests that overconfidence leads management to overestimate revenue, underestimate risks and make risky investment decisions. A compliance risk identification and early warning system requires firms' evaluations of investment projects to include compliance reviews of the investment projects. This ensures that management conducts a comprehensive feasibility analysis of investment projects that can effectively identify potential risks in the projects, thereby improving the quality of investment decision-making and the efficiency of SOEs' resource allocation.

Furthermore, the guidelines require SOEs to consider compliance reviews as a necessary part of the operation and management of major contracts and major projects. Relevant departments should make suggestions to modify non-compliant content. All decisions should undergo compliance review before implementation. If there is a compliance issue with an investment decision made by the firm's management, the compliance review system can promptly and effectively rectify the error in judgment. Therefore, establishing and enhancing a compliance risk assessment and identification system and a compliance review system for investment projects raises the private costs of managing SOEs that face higher risks. As management's revenue does not increase due to the higher compliance risks, the management of such SOEs may reassess the expected utility of risky projects and further reduce their risk preference (Chen et al., 2022). According to senior management echelon theory, management's risk preference affects a firm's investment decision-making (Hambrick and Mason, 1984). SOEs with compliance management systems will opt for high-quality projects that meet compliance requirements, reduce investment in inferior projects and increase investment in high-quality projects, which will enhance the investment efficiency of firms (Yao et al., 2020).

Second, compliance management guidelines can effectively alleviate the Type I agency problem by enhancing the investment decision-making assessment and accountability system. According to modern enterprise theory, the inconsistent interests of management and owners lead to the Type I agency problem (Jensen and Meckling, 2000). Management without strong supervision tends to underestimate the risks and uncertainties of investment projects and deviate from the rational investment track, which leads to inefficient investment (Faccio et al., 2011). As SOEs do not have traditional owners, it is difficult to effectively monitor senior management, further exacerbating this agency problem (Liu and Shi, 2010). Accordingly, the management of SOEs may make investment decisions that not aim to maximize the value of enterprises to achieve private interests or to establish a "business empire," leading to inefficient investments (Jensen, 1986; Shleifer and Vishny, 1989). The guidelines require compliance management to be part of the annual comprehensive assessment of department heads and affiliated firms. The guidelines require SOEs to refine their assessment indicators and strengthen compliance assessment and evaluation.

Furthermore, the guidelines require SOEs to strengthen accountability for violations, specify the scope of responsibilities for violations, refine the standards for punishment and enhance the punishment system for violations. All levels of SOEs' senior managers are under the jurisdiction of the Organization Department of the Communist Party of China (CPC) and receive the same benefits as government officials at their respective levels (Yang et al., 2013). Therefore, managers of SOEs tend to engage in political pandering as they pursue positions and advance their official careers, leading to the formation of a political lock-in effect (Wang et al., 2014). For the senior managers of SOEs, political promotion, as a hidden incentive, can weaken the link between incentive assessment and enterprise profits (Chen et al., 2009; Yu et al., 2016). After the implementation of the guidelines, senior managers of SOEs will limit their behavior to comply with assessment requirements to advance their career development and maximize their interests. This will effectively prevent illegal or self-interested behavior by management in the firm's investment activities. Under the more stringent postevent assessment and accountability system, senior managers' awareness of responsibility and risk is enhanced. This improvement will lead to more cautious investment decisions. Thus, compliance management guidelines are effective investment incentives.

Third, compliance management guidelines clarify the responsibilities of the board of directors, the board of supervisors and managers in compliance management. They further refine the division of compliance management responsibilities among business departments, compliance departments and supervision departments. This helps to improve the internal control system by establishing a compliance management organizational structure.

The guidelines help SOEs to establish a three-level compliance management organizational structure: governance, management and execution. At the governance level, the compliance management responsibilities of the board of directors, the board of supervisors and managers are clarified. At the management level, the guidelines require the establishment of a compliance committee. This committee is co-located with the leading group on the rule of law (agency responsible for promoting the rule of law in SOEs) or the risk control committee. Its responsibilities include taking charge of the organization, leadership and coordination of compliance management. At the execution level, the guidelines require the establishment of "three lines of defense" for compliance management. The business department serves as the "first line of defense" and is responsible for daily compliance risk management in relevant areas. The "second line of defense" is primarily the legal department, which serves as a specialized unit for compliance management. This department is chiefly accountable for establishing the compliance management system and conducting daily compliance tasks in coordination with other departments within the organization. The internal audit department and discipline inspection department typically function as the "third line of defense," overseeing and assessing the effectiveness of the compliance management system.

In the organizational structure of compliance management, the governance, management and execution levels form a coordinated, multi-dimensional approach to managing compliance risks. The enhancement of

the internal control system facilitates organized and high-quality information exchange. As one of the elements of internal control, accurate and timely information exchange can alleviate the information asymmetry between the parties involved in a company contract (Li et al., 2011; Fang and Jin, 2013). Internal control is a process that provides reasonable assurance of the authenticity and reliability of financial reports. Strengthening compliance management further enhances the internal control of SOEs. High-quality internal control helps to improve the quality of financial reports (Doyle et al., 2007a; Doyle et al., 2007b) and enables investors to better understand the profitability and growth opportunities of a firm. Effective prevention and control of compliance risks can significantly reduce the uncertainty surrounding future operational decisions and the demands of external investors for capital costs and risk compensation. Thus, a compliance risk control system reduces the excessive financing costs that result from adverse selection and moral hazard and alleviates financing constraints (McLean et al., 2012; Zhang et al., 2017; Choi et al., 2020), thereby enhancing the investment efficiency of SOEs.

A graphical representation of the above analysis is shown in Fig. 1, based on which we propose the following hypothesis.

H1: The implementation of compliance management guidelines effectively improves the investment efficiency of the relative SOEs.

3. Data and methodology

3.1. Data and sample

We construct our sample using all Chinese A-share listed SOEs for the 2015–2022 period. We remove all observations that (1) are from the financial industry, (2) have special treatment (ST and *ST) or particular transfer (PT) status and (3) contain missing values or abnormal values. We collect financial data and corporate



Fig. 1. Theoretical framework.

characteristic data from the China Stock Market and Accounting Research Database (CSMAR) and internal control index data from the DIB Internal Control and Risk Management Database. We obtain a final sample of 7,764 annual observations from 1,306 firms. We winsorize all of the continuous variables at the 1 % and 99 % levels for the full sample period to avoid the influence of extreme values.

3.2. Variable construction

3.2.1. Measures of investment efficiency

Following Richardson (2006), we estimate the following model to calculate the investment efficiency of enterprises:

$$Inv_{it} = \alpha_0 + \alpha_1 Growth_{it-1} + \alpha_2 Lev_{it-1} + \alpha_3 Cash_{it-1} + \alpha_4 Age_{it-1} + \alpha_5 Size_{it-1} + \alpha_6 Ret_{it-1} + \alpha_7 Inv_{it-1} + \sum Industry + \sum Year + \varepsilon_{it}$$

$$(1)$$

where the dependent variable is *Inv. Inv* equals the sum of cash paid for fixed investments, intangible assets and other long-term assets and the cash paid to obtain subsidiaries and other business units, minus the net amount of cash received from the disposal of fixed assets, intangible assets and other long-term assets, the net amount of cash received from the disposal of subsidiaries and other business units, the depreciation of fixed assets, the amortization of intangible assets and the amortization of long-term deferred expenses for firm *i* in year *t*, divided by the total assets of firm *i* in year *t*-1. *Growth* is the Tobin's q of firm *i* in year *t*-1, which is measured by market value divided by total assets. *Lev* is the asset–liability ratio for firm *i* in year *t*-1. *Cash* equals net cash derived from business activities divided by the total assets of firm *i* at the beginning of year *t*-1. *Age* equals the number of years firm *i* has been listed as of year *t*-1. *Size* equals the natural logarithm of the total assets of firm *i* in year *t*-1. *Ret* equals the annual stock return considering the reinvestment of cash dividends of firm *i* in year *t*-1. \sum *Industry* is an industry dummy, which uses two-digit numbers to define manufacturing industries beginning with "C" and one-digit numbers for other industries, following the 2012 Industry Standards of the China Securities Regulatory Commission. \sum *Year* is a year dummy. We use the value of residual ε to measure the investment efficiency of firms. A high absolute value indicates inefficient investment.

3.2.2. Measures of the implementation of compliance management guidelines

We regard the implementation of compliance management guidelines for SOEs as exogenous policy shocks and estimate a staggered DID model. The independent variable is *Compliance*, which equals 1 if a firm is affected by the guidelines and 0 otherwise. To select firms that are subject to compliance management guidelines, we make judgments based on the actual controller of firms. If the actual controller of a sample firm is a certain SASAC and this SASAC issues and implements compliance management guidelines during the sample period, the firm is considered to be affected by compliance management guidelines. Following Lu et al. (2018), we use the implementation dates of compliance management guidelines are considered to be effective from that current year. If the guidelines are implemented during the second half of a year, the guidelines are considered to be effective as of the subsequent year. We manually collect compliance management guidelines issued by all levels of SASACs. The specific implementation times of the compliance management guidelines of all levels of SASACs and the effective time of those guidelines are given in Appendix A.

3.2.3. Control variables

The control variables used in the regression analysis are drawn from Huang and Huang (2022), who identify the characteristics related to investment efficiency. Our control variables include the natural logarithm of years since establishment as of year t-1 (LnAge), the natural logarithm of total assets in year t-1 (Size), net cash from business activities divided by total assets at the beginning of year t-1 (Cash), debt-to-asset ratio in year t-1 (Lev), Tobin's q in year t-1 (Tobinq) and the annual stock return considering the reinvestment of cash dividends in year t-1 (Ros). The characteristic of shareholders, boards and directors includes the largest shareholder ratio in year t-1 (TopI), the shareholding ratio of institutional investors in year t-1 (Insti*hold*), whether the chairperson of the board and the CEO are the same person in year t-1 (*Dual*), the natural logarithm of the number of board members in year t-1 (*Bsize*) and the proportion of independent directors in year t-1 (*Outdir*). In addition, we control for firm and year fixed effects.

3.3. Empirical model

We study the impact of the compliance management guidelines implemented by SASACs on SOEs. Following Beck et al. (2010) and Chen et al. (2012), we estimate the following staggered DID model to test our hypothesis:

$$Ineinv_{it} = \beta_{0} + \beta_{1}Compliance_{it} + \beta_{2}Age_{it-1} + \beta_{3}Size_{it-1} + \beta_{4}Cash_{it-1} + \beta_{5}Lev_{it-1} + \beta_{6}Tobinq_{it-1} + \beta_{7}Ros_{it-1} + \beta_{8}Top1_{it-1} + \beta_{9}Instihold_{it-1} + \beta_{10}Dual_{it-1} + \beta_{11}Bsize_{it-1} + \beta_{12}Outdir_{it-1} + \mu_{it} + \varphi_{it} + \varepsilon_{it}$$
(2)

where *Ineinv* represents investment efficiency as calculated by Richardson (2006). μ represents firm fixed effects, φ represents year fixed effects and ε represents the residual. A negative coefficient on β_1 is consistent with improvements in investment efficiency after compliance with management guidelines. Detailed definitions of the variables are given in Appendix B.

3.4. Summary statistics

Table 1 reports the descriptive statistics of all of the variables. The mean value of *Compliance* is 0.237, indicating that approximately 24 % of the observations are subject to the implementation of compliance management guidelines. The mean value of *LnAge* is 3.056. The mean value of *Size* is 22.967. The mean value of *Cash* is 0.052. The mean value of *Lev* is 0.497. The mean value of *Tobinq* is 2.087. The mean value of *Ros* is 0.124. The mean value of *Top1* is 0.384, indicating that, on average, the largest shareholder controls approximately 38.4 % of the shares in an SOE. The mean value of *Instihold* is 0.576, indicating that, on average, 57.6 % of the shares of an SOE are held by institutional investors. The mean value of *Dual* is 0.108, indicating that for 10.8 % of the observations, the chairman of the board and CEO are the same person. The mean value of *Bsize* is 2.186. The mean value of *Outdir* is 0.372.

Table 2 presents the correlation coefficient matrix for the main variables, with the Pearson correlation coefficient results at the bottom left and the Spearman correlation coefficient results at the top right. The correlations between *Lev* and *Size*, *Tobinq* and *Size*, *Instihold* and *Size*, *Instihold* and *Top1*, and *Outdir* and *Bsize* are relatively high. Therefore, we perform VIF multicollinearity analysis, and the results show that all of the variables have VIF coefficients less than 10, indicating that there is no multicollinearity problem.

Table 1

Summary Statistics. This table shows the investment efficiency, whether observations for Chinese listed non-financial SOEs during the 2015–2022 period affected by compliance management guidelines and the descriptive statistics of the control variables.

Variable	Ν	Mean	S.D.	Min	Median	Max
Ineinv	7,764	0.030	0.036	0.000	0.019	0.213
Compliance	7,764	0.237	0.425	0.000	0.000	1.000
LnAge	7,764	3.056	0.258	2.197	3.091	3.584
Size	7,764	22.967	1.409	20.211	22.833	27.075
Cash	7,764	0.052	0.075	-0.184	0.052	0.280
Lev	7,764	0.497	0.200	0.078	0.504	0.915
Tobing	7,764	2.087	1.439	0.820	1.595	9.105
Ros	7,764	0.124	0.434	-0.506	0.037	1.785
Top1	7,764	0.384	0.152	0.113	0.367	0.761
Instihold	7,764	0.576	0.177	0.167	0.581	0.931
Dual	7,764	0.108	0.311	0.000	0.000	1.000
Bsize	7,764	2.186	0.195	1.609	2.197	2.708
Outdir	7,764	0.372	0.055	0.308	0.353	0.571

coefficients a	re at the top	right. ***, **	and $*$ denote	significance	at the 1 %, 5	% and 10 %	i levels, respec	ctively.					
	Ineinv	Compliance	LnAge	Size	Cash	Lev	Tobinq	TopI	Ros	Instihold	Dual	Bsize	Outdir
Ineinv		-0.127 * * *	-0.147^{***}	-0.178^{***}	0.103^{***}	-0.108^{***}	0.237^{***}	-0.016	0.139^{***}	0.002	0.024**	-0.008	-0.023^{**}
Compliance	-0.114^{***}		0.213^{***}	0.126^{***}	0.036^{***}	0.000	-0.122^{***}	0.042^{***}	0.042^{***}	0.069^{***}	-0.046^{***}	-0.031^{***}	0.036***
LnAge	-0.092^{***}	0.197^{***}		0.033^{***}	-0.010	0.052^{***}	-0.153^{***}	-0.174^{***}	-0.050^{***}	-0.158^{***}	-0.013	-0.025^{**}	-0.013
Size	-0.201^{***}	0.132^{***}	-0.021*		0.118^{***}	0.461^{***}	-0.606^{***}	0.256^{***}	0.011	0.444 ***	-0.056^{***}	0.194^{***}	0.109^{***}
Cash	0.059^{***}	0.041^{***}	-0.014	0.106^{***}		-0.164^{***}	0.035^{***}	0.137^{***}	0.086^{***}	0.229^{***}	-0.015	0.111^{***}	-0.022*
Lev	-0.095^{***}	0.002	0.058^{***}	0.446^{***}	-0.164^{***}		-0.422***	0.014	0.009	0.032^{***}	0.002	0.058^{***}	0.047***
Tobinq	0.313^{***}	-0.081^{***}	-0.092^{***}	-0.471^{***}	0.053^{***}	-0.356^{***}		-0.148^{***}	0.229^{***}	-0.109^{***}	0.039^{***}	-0.058^{***}	-0.060^{***}
TopI	-0.026^{**}	0.038^{***}	-0.190^{***}	0.270^{***}	0.135^{***}	0.012	-0.117^{***}		0.013	0.659^{***}	-0.079***	-0.004	0.069***
Ros	0.177^{***}	0.025^{**}	-0.049^{***}	-0.000	0.069^{***}	0.010	0.305^{***}	0.007		0.045^{***}	0.012	0.021*	-0.002
Instihold	-0.018	0.075^{***}	-0.177***	0.461^{***}	0.211^{***}	0.035^{***}	-0.070^{***}	0.662^{***}	0.048^{***}		-0.096^{***}	0.140^{***}	0.063^{***}
Dual	0.016	-0.046^{***}	-0.006	-0.051^{***}	-0.014	0.005	0.014	-0.080^{***}	0.008	-0.102^{***}		-0.101^{***}	0.074^{***}
Bsize	-0.041^{***}	-0.030^{***}	-0.018	0.192^{***}	0.095***	0.061^{***}	-0.081^{***}	-0.005	0.006	0.142^{***}	-0.095^{***}		-0.413^{***}
Outdir	-0.011	0.044^{***}	-0.024**	0.134***	-0.018	0.055***	-0.021*	0.078***	0.006	0.052***	0.069***	-0.450***	

Table 2 Correlation Matrix. This table shows the correlation coefficient matrix among the variables. The Pearson correlation coefficients are at the bottom left and the Spearman correlation 3 In addition, we find significant and positive correlations between *Ineinv* and *LnAge*, *Ineinv* and *Size*, *Ineinv* and *Lev*, and *Ineinv* and *Instihold*. There are significant and negative correlations between *Ineinv* and *Cash*, *Ineinv* and *Growth*, *Ineinv* and *Ros*, and *Ineinv* and *Dual*. The Pearson correlation coefficient and Spearman correlation coefficients of *Ineinv* and *Compliance* are -0.114 and -0.127, respectively, and both are significant at the 1 % level, giving preliminarily support to our hypothesis.

4. Empirical results

4.1. Parallel trend test

Satisfying the parallel trend test is a prerequisite for a DID model. Callaway and Sant' Anna (2021), Sun and Abraham (2021) and Baker et al. (2022) point out that if the processing effects of different experimental groups are different in scale or dynamic and different in magnitude, the parallel trend test using the traditional dynamic effect model may give biased results in a staggered DID model. Following Sun and Abraham (2021), we conduct the following dynamic effect test of the interactive weight estimation model to investigate whether the parallel trend hypothesis is satisfied:

$$Ineinv_{it} = \gamma_0 + \gamma_1 D_{it}^{-4} + \gamma_2 D_{it}^{-3} + \gamma_3 D_{it}^{-2} + \gamma_4 D_{it}^{-1} + \gamma_5 D_{it}^{+1} + \gamma_6 D_{it}^{+2} + \gamma_7 D_{it}^{+3} + \varphi_{it} + \varepsilon_{it}$$
(3)

where we are interested in the coefficients of D_{ii}^{-4} to D_{ii}^{+3} , which are weighted by the size of the different experimental subsamples, divided by the sample size of all experimental groups. We define the year the compliance management guidelines were implemented as the base year. D_{ii}^{-j} is equal to 1 if the observation is *j* periods before the implementation of compliance management guidelines and 0 otherwise. D_{ii}^{+j} is equal to 1 if the observation is *j* periods after the implementation of compliance management guidelines and 0 otherwise.

Fig. 2 shows the results of the dynamic effect test. The coefficients of D_{it}^{-4} , D_{it}^{-3} , D_{it}^{-2} and D_{it}^{-1} are not significantly different from 0 at the 10 % level. The coefficient of D_{it}^{+3} is significant and negative. This result not only satisfies the parallel trend assumption but also preliminarily supports our hypothesis that the implementation of compliance management guidelines improves the investment efficiency of SOEs.



Fig. 2. Dynamic Effect Test.

4.2. Baseline regression

Table 3 presents the association between the implementation of compliance management guidelines (*Compliance*) and investment efficiency (*Ineinv*). Column (1) shows a univariate test that contains only the independent variable *Compliance*, column (2) shows the results that include all of the control variables and column (3) shows the test results that include the control variables, year fixed effects and firm fixed effects. All of the regression coefficients for *Compliance* remain negative across all columns at the 1 % level. The results in column (3) show that *Ineinv* decreases by 23.16 % (0.0044/0.019) after the implementation of compliance management guidelines. Our results also show that firms' age and size can affect their investment efficiency. Incremental growth opportunities and profitability reduce the investment efficiency of firms. Our findings further suggest that the implementation of compliance management guidelines significantly improves the investment efficiency of the relative SOEs.

Table 3

Implementation of Compliance Management Guidelines and Investment Efficiency. This table presents the effects of the implementation of compliance management guidelines on investment efficiency for a sample of Chinese A-share listed SOEs during the 2015–2022 period. The dependent variable Ineinv is investment efficiency in year t, as defined by Richardson (2006). The independent variable Compliance indicates whether a firm is subject to compliance management guidelines. Detailed variable definitions are given in Appendix B. All of the regressions include firm and year fixed effects. The robust t-statistics are clustered at the firm level and reported in parentheses. ***, ** and * denote significance at the 1 %, 5 % and 10 % levels, respectively.

	(1)	(2)	(3)
Variable	Univariate Test	Control Variable	Fixed Effect
Compliance	-0.0097***	-0.0065***	-0.0044***
1	(-9.97)	(-6.51)	(-3.05)
LnAge		-0.0071***	-0.0402**
		(-3.57)	(-2.49)
Size		-0.0033***	-0.0060***
		(-6.25)	(-3.02)
Cash		0.0285***	0.0089
		(3.94)	(1.28)
Lev		0.0100***	0.0027
		(3.31)	(0.35)
Tobinq		0.0057***	0.0075***
		(9.29)	(7.75)
Top1		-0.0026	0.0006
		(-0.57)	(0.06)
Ros		0.0083***	0.0064***
		(7.69)	(4.70)
Instihold		0.0093**	0.0015
		(2.15)	(0.18)
Dual		0.0005	-0.0000
		(0.31)	(-0.01)
Bsize		-0.0029	-0.0072
		(-0.99)	(-1.19)
Outdir		0.0011	0.0183
		(0.12)	(1.19)
_cons	0.0324***	0.1119***	0.2826***
	(49.12)	(7.45)	(4.16)
Year FE	No	No	Yes
Firm FE	No	No	Yes
Ν	7.764	7.764	7.673
Adj_R ²	0.013	0.126	0.254

4.3. Cross-sectional analysis

We perform a cross-sectional analysis to examine the association between the implementation of compliance management guidelines and investment efficiency, controlling for financing constraints, financing needs and market competition. To do this, we divide the sample into subsamples of high and low levels of financing constraints, financing needs and market competition.

4.3.1. Financing constraints and financing needs

Problems in internal governance and serious information asymmetry restrict the external financing capacity of firms (Chen et al., 2011a; Choi et al., 2020). Thus, for firms with higher financing constraints, the implementation of the compliance management guidelines can play a greater marginal role and have a more significant effect on investment efficiency than for firms without such constraints. In contrast, firms with low financing constraints often have a better internal governance environment, and the implementation of the guidelines may have a limited effect on investment efficiency. Following Hadlock and Pierce (2010), we use the Size-Age index (SA) to measure financing constraints. The index measures the financing constraints of firms considering both age and size. The smaller the index value, the greater the financing constraints the firm faces. We divide our sample into high and low financing constraints subsamples using the median SA index in the year before the implementation of guidelines. In addition, we use the cash adequacy ratio (*Fin_need*) to measure the financing needs of firms, following Sun et al. (2016).

Tables 4 shows that the implementation of compliance management guidelines promotes investment efficiency in firms with high financing constraints and financing needs, but the effects are weaker for firms with low financing constraints and financing needs. For the high financing constraints and financing needs subsamples, the coefficients of *Compliance* are, respectively, -0.0049 and -0.0044, and both are significant at the 5 % level. The results show that the implementation of compliance management guidelines has a stronger effect in promoting investment efficiency in SOEs facing high financing constraints and high financing needs than in their counterparts.

4.3.2. Product market competition

Market competition encourages SOEs to strengthen internal management and improve enterprise efficiency (Kong et al., 2014). However, market competition also aggravates the innovation and bankruptcy risks of firms and affects their operations (Hou and Robinson, 2006). In China's emerging and transitional market, product market competition has a negative governance effect, which may intensify the agency problem between managers and shareholders (Chen and Xu, 2011) and induce compliance risk. We use the Herfind-

Table 4

Cross-sectional Analysis of Financing Constraints and Financing Needs. This table presents the effects of the implementation of compliance management guidelines on investment efficiency for a sample of Chinese A-share listed SOEs during the 2015–2022 period. The sample is divided into high and low firm-level financing constraints (*SA*) subsamples and high and low financing needs (*Fin_need*) subsamples, based on the median values in the year before the implementation of guidelines. The dependent variable is *Ineinv*. The independent variable is *Compliance*. Detailed variable definitions are given in Appendix B. All of the regressions include firm and year fixed effects. The robust *t*-statistics clustered by firm are reported in parentheses. ***, ** and * denote significance at the 1 %, 5 % and 10 % levels, respectively.

Variable	(1) High finai	ncing constraints	(2) Low finance	cing constraints	(3) High fir	nancing needs	(4) Low fina	ancing needs
Compliance		-0.0049** (-2.24)		-0.0027 (-1.42)		-0.0044^{**} (-2.49)		-0.0035 (-1.46)
Control variables	Yes	~ /	Yes	~ /	Yes		Yes	,
Year FE Firm FE	Yes Yes		Yes Yes		Yes Yes		Yes Yes	
N Adj_R ²		3,819 0.224		3,799 0.315		3,667 0.308		3,666 0.254
Difference test <i>p</i> -value				$\begin{array}{c} -0.002\\ 0.142\end{array}$				-0.001 0.296

ahl-Hirschman index (*HHI*) as a measure of product market competition. A high *HHI* value indicates low market competition.

Table 5 reveals that the implementation of compliance management guidelines promotes investment efficiency in firms facing high product market competition, but the effects are weaker for firms facing low product market competition. For the high product market competition subsample, the coefficient of *Compliance* is -0.0076, which is significant at the 1 % level. Thus, the implementation of compliance management guidelines has a more significant impact on the investment efficiency of SOEs with high product market competition than on those with low product market competition.

4.4. Mechanism analysis

Based on our hypothesis, we predict that the implementation of compliance management guidelines will improve the investment efficiency of SOEs by reducing management's risk appetite, mitigating the Type I agency problem and enhancing the level of internal control. Accordingly, we conduct the following mechanism analysis.

4.4.1. Management's risk appetite

According to executive echelon theory, management's risk preferences affect the investment decisions of firms (Hambrick and Mason, 1984). A management team with a high-risk appetite is likely to make high-risk decisions about operations and investments (Chen et al., 2022). However, compliance management guide-lines increase the private costs of risky decisions by strengthening enterprises' decision-making assessment and accountability mechanisms. The influence of management's risk preferences is thus reduced, and firms can make more prudent investment decisions and improve investment efficiency. We use the difference between

Table 5

Cross-sectional Analysis of Product Market Competition. This table presents the effect of the implementation of compliance management guidelines on the investment efficiency of Chinese A-share listed SOEs during the 2015–2022 period. The sample is divided into high and low product market competition subsamples based on the media industry-level Herfindahl–Hirschman index (*HHI*) ranking in the year before the implementation of the guidelines. The dependent variable is *Ineinv*. The independent variable is *Compliance*. Detailed variable definitions are given in Appendix B. All of the regressions include firm and year fixed effects. The robust *t*-statistics clustered at the firm level are reported in parentheses. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

Variable	(1) High n compet	narket tition	(2) Low comp market	petition in the
Compliance		-0.0076***		-0.0018
		(-3.37)		(-0.89)
Control variable	Yes		Yes	
Year FE	Yes		Yes	
Firm FE	Yes		Yes	
Ν		3,788		3,722
Adj_R ²		0.243		0.284
Difference test				0.006***
<i>p</i> -value				0.000

current assets and current liabilities, divided by total assets (*Risk*) to measure management's risk appetite, following Chen et al. (2022). A high value of *Risk* indicates a low tolerance for risk.

Columns (1)–(3) in Table 6 present the results of the mediation analysis using management's risk appetite. The results in column (1) reveal that there is a significant and negative relationship between the implementation of compliance guidelines (*Compliance*) and management's risk appetite (*Risk*). Column (2) shows that a higher *Risk* value is correlated with a lower *Ineinv* value at the 5 % level. In addition, we rerun the baseline regression using a subsample of observations in which *Risk* is not null in column (3). These results suggest that the implementation of compliance guidelines reduces management's risk appetite, which in turn promotes investment efficiency by reducing over-investment.

Table 6

Mechanism Test. This table presents the analysis of the mediating roles of management's risk appetite, Type I agency problems and internal control on the relationship between the implementation of compliance management guidelines and investment efficiency for a sample of Chinese A-share listed SOEs during the 2015–2022 period. The dependent variables in columns (1), (4) and (7) are *Risk*, *Acost* and *InConl*, respectively. *Risk* is measured by the difference between current assets and current liabilities, divided by total assets, following Chen et al. (2022). *Acost* is measured by the sum of management expenses and sales expenses divided by operating revenue. *InConl* is measured by the natural logarithm of the internal control index value obtained from the DIB internal control and risk management database. The dependent variable in columns (2), (3), (5), (6), (8) and (9) is *Ineinv*. The independent variable is *Compliance* and the mediation variables are *Risk*, *Acost* and *InConl*. Detailed variable definitions are given in Appendix B. All of the regressions include firm and year fixed effects. The robust *t*-statistics clustered at the firm level are reported in parentheses. ***, ** and * denote significance at the 1 %, 5 % and 10 % levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Variable	MV:Risk	Ineinv	Ineinv	MV:Acost	Ineinv	Ineinv	MV:InConl	Ineinv	Ineinv
Compliance	0.0102**	-0.0043***	-0.0044***	-0.0078**	-0.0043***	-0.0045***	0.1118**	-0.0044***	-0.0046***
-	(2.00)	(-2.95)	(-3.05)	(-2.35)	(-3.02)	(-3.15)	(2.37)	(-3.08)	(-3.15)
MV		-0.0135**			0.0232**			-0.0010*	
		(-2.06)			(2.06)			(-1.96)	
LnAge	-0.0523	-0.0409 **	-0.0402 **	-0.0870 **	-0.0373 **	-0.0394 **	0.8646	-0.0404 **	-0.0412**
	(-0.91)	(-2.52)	(-2.49)	(-2.22)	(-2.34)	(-2.47)	(1.50)	(-2.49)	(-2.53)
Size	0.0002	-0.0060***	-0.0060***	-0.0135^{**}	-0.0064***	-0.0067***	0.0911	-0.0057***	-0.0058***
	(0.02)	(-3.00)	(-3.02)	(-2.42)	(-3.25)	(-3.37)	(1.10)	(-2.86)	(-2.90)
Cash	0.0422*	0.0095	0.0089	-0.0672 ***	0.0113*	0.0097	-0.0828	0.0090	0.0091
	(1.76)	(1.35)	(1.28)	(-4.17)	(1.72)	(1.50)	(-0.35)	(1.30)	(1.30)
Lev	-0.4559***	-0.0035	0.0027	0.0036	0.0058	0.0059	-1.1221***	0.0022	0.0033
	(-14.50)	(-0.42)	(0.35)	(0.18)	(0.76)	(0.77)	(-3.56)	(0.28)	(0.43)
Tobinq	0.0061**	0.0076***	0.0075***	-0.0000	0.0078***	0.0078***	0.0243	0.0075***	0.0075***
	(2.23)	(7.88)	(7.75)	(-0.00)	(8.20)	(8.14)	(1.14)	(7.75)	(7.72)
Top1	0.0705*	0.0016	0.0006	-0.0048	-0.0033	-0.0034	0.4088	0.0001	-0.0003
	(1.78)	(0.15)	(0.06)	(-0.22)	(-0.36)	(-0.37)	(0.98)	(0.01)	(-0.03)
Ros	0.0044	0.0065***	0.0064***	-0.0057***	0.0063***	0.0062***	0.0561	0.0066***	0.0066***
	(1.16)	(4.75)	(4.70)	(-3.16)	(4.71)	(4.61)	(1.50)	(4.82)	(4.78)
Instihold	0.0595**	0.0023	0.0015	-0.0298*	0.0043	0.0036	0.3870	0.0019	0.0015
	(2.04)	(0.27)	(0.18)	(-1.76)	(0.51)	(0.43)	(1.39)	(0.22)	(0.18)
Dual	0.0067	0.0001	-0.0000	0.0017	-0.0003	-0.0002	-0.0344	-0.0002	-0.0002
	(1.14)	(0.04)	(-0.01)	(0.49)	(-0.15)	(-0.13)	(-0.52)	(-0.14)	(-0.12)
Bsize	0.0168	-0.0070	-0.0072	0.0089	-0.0107*	-0.0105*	-0.2983	-0.0078	-0.0075
	(0.87)	(-1.16)	(-1.19)	(0.73)	(-1.81)	(-1.77)	(-1.22)	(-1.30)	(-1.25)
Outdir	0.0749	0.0193	0.0183	0.0493	0.0073	0.0084	-0.5909	0.0178	0.0184
	(1.60)	(1.25)	(1.19)	(1.64)	(0.49)	(0.57)	(-1.07)	(1.16)	(1.20)
_cons	0.3846	0.2878***	0.2826***	0.6900***	0.2872***	0.3032***	2.5193	0.2831***	0.2806***
	(1.43)	(4.20)	(4.16)	(4.19)	(4.28)	(4.52)	(0.92)	(4.14)	(4.08)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Ν	7,673	7,673	7,673	7,415	7,415	7,415	7,625	7,625	7,625
Adj_R^2	0.858	0.255	0.254	0.796	0.266	0.265	0.224	0.256	0.256

4.4.2. Type I agency problem

In firms with severe agency problems, managers can easily make decisions that are conducive to their private interests rather than the maximization of the enterprise's value. High-risk, aggressive investment plans eventually lead to a decrease in the firm's investment efficiency and even the loss of state-owned assets (Li and Yu, 2012; Liu and Ye, 2013). The compliance management guidelines require the inclusion of compliance management in the annual comprehensive assessments of managers of departments and affiliated firms and the enhancement of punishments for non-compliance, to effectively suppress the non-compliant or self-interested behavior of managers in their roles as a "political person" in the firms' investment activities. Reducing the agency problem encourages managers to make more prudent investment decisions; thus, compliance management guidelines are effective investment incentives. We use the sum of management expenses and sales expenses divided by operating revenue (Acost) to measure the level of Type I agency problems in a firm. A high value of Acost indicates a high agency cost.

Columns (4)–(6) in Table 6 show the results of the mediation analysis for Type I agency problems. The results in column (4) reveal that there is a significant and negative relationship between the implementation of guidelines (*Compliance*) and the cost of Type I agency problems (*Acost*). Column (5) shows that a higher *Acost* is positively correlated with a higher *Ineinv* and significant at the 5 % level. In addition, we rerun the baseline regression using a subsample of observations in which *Acost* is not null in column (6). These results suggest that the implementation of compliance management guidelines significantly reduces the agency costs of SOEs, and thus improves their investment efficiency.

4.4.3. Internal control

The implementation of compliance management guidelines achieves multi-dimensional coordination among firms' governance, management and execution levels in the area of compliance risk by constructing a compliance management organizational structure. The strengthening of compliance management further improves SOEs' internal control procedures. The mitigation of uncertainty regarding future operation decisions can reduce the excess financing costs caused by adverse selection and moral hazard, and thus further improve the investment efficiency of SOEs. We use the natural logarithm of the internal control index obtained from the DIB internal control database (*InConl*) to measure firms' internal control.

Columns (7)–(9) in Table 6 show the results of the mediation analysis for internal control. The results in column (7) reveal that there is a significant and positive relationship between the implementation of guidelines (*Compliance*) and internal control (*InConl*). Column (8) shows that a higher *InConl* is correlated with a lower *Ineinv* at the 10 % level. In addition, we rerun the baseline regression on a subsample of observations in which *InConl* is not null in column (9). These results suggest that the implementation of compliance management guidelines significantly improves the internal control of SOEs, and thus improves their investment efficiency.

5. Robustness checks

5.1. Alternative measures of investment efficiency

In our baseline regression, the absolute residual value calculated using Richardson's (2006) model is used to measure investment efficiency. We also use the following alternative measures of investment efficiency. (1) Divide the sample into low investment efficiency and high investment efficiency subsamples using the median absolute value of the residuals in Richardson's (2006) model. (2) Following Biddle et al. (2009), we treat enterprise investment as a function of enterprise growth opportunity and construct a liner regression between enterprise investment and growth opportunity. Thus, we divide the absolute value of the residual of Model 4 into low investment efficiency and high investment efficiency subsamples and use the price-to-book ratio as a proxy for firms' growth opportunity. (3) Chen et al. (2011a) improve the measures in Biddle et al. (2009). Chen et al. (2011a) believe that different directions of corporate sales revenue change rate have different impacts on enterprises' optimal investment level. We add a directions of sales revenue change rate dummy in Model 5. We divide the absolute value of the residual from Model 5 into low investment efficiency and high investment efficiency subsamples, following Chen et al. (2011a). (4) We divide the absolute value of the residuals from Model 6 into low investment efficiency and high investment efficiency subsamples, following Chen et al. (2012). (5)

We divide the absolute value of the residuals from Model 7 into low investment efficiency and high investment efficiency subsamples, following Choi et al. (2020).

$$Inv_{it} = \beta_0 + \beta_1 Growth_opp_{it-1} + \varepsilon_{it}$$

$$\tag{4}$$

$$Inv_{it} = \beta_0 + \beta_1 Growth_opp_{it-1} + \beta_2 NEG_{it-1} + \beta_3 NEG_{it-1} \times Growth_opp_{it-1} + \varepsilon_{it}$$

$$\tag{5}$$

$$Inv_{it} = \beta_0 + \beta_1 Growth_opp_{it-1} + \beta_2 Cash_{it-1} + \alpha_i + \alpha_t + \alpha_{ct} + \alpha_{lt} + \varepsilon_{it}$$

$$\tag{6}$$

$$Inv_{it} = \beta_0 + \beta_1 Growth_opp_{it-1} + \beta_2 Cash_{it-1} + \beta_3 Growth_asset_{it-1} + \beta_4 Inv_{it-1} + \alpha_i + \alpha_t + \varepsilon_{it}$$
(7)

where the dependent variable in Models 4 to 7 is *Inv. Growth_opp* is firms' growth opportunity, measured by the price-to-book ratio in Model 4 and by the sales revenue growth rate in Model 5. *NEG* is a dummy that equals 1 if the sales revenue growth rate is positive and 0 otherwise in Model 5. *Growth_opp* in Models 6 and 7 is measured by Tobin's q. *Cash* is measured by net cash from business activities divided by total assets. *Growth_asset* is measured by the total asset growth rate. We control fir firm fixed effects, year fixed effects, region-year fixed effects and industry-year fixed effects in Model 6. We control for firm fixed effects and year fixed effects in Model 7.

Table 7 shows the results using these alternative measures of investment efficiency. The coefficients of *Compliance* remain significant and negative, supporting the robustness of our conclusions.

5.2. Placebo tests

To eliminate errors caused by deviations in sample selection, we conduct the following two placebo tests. (1) We define a new independent variable *Randomdid*. *Randomdid* is a dummy equal to 1 if an observation has been randomly assigned to an "experimental group" that is the same size as the sample used in the baseline regression and 0 otherwise. Then we rerun the baseline regression using *Randomdid*. We repeat the above steps 500 times. (2) We treat the policy shock as occurring 2 years before the actual implementation of the compliance management guidelines and define a new independent variable *Fake*. Fig. 3 shows the results of the placebo test using 500 random samples. The dotted coordinate point in the figure is the intersection of the coefficients of *Compliance* and the 10 % level. The virtual samples generally present a normal distribution with means equal to 0, and the majority of the *p*-values are greater than 0. Most coefficients of *Compliance* are not significant at the 10 % level. Column (1) in Table 8 shows the results of the correlation between *Fake* and

Table 7

Alternative Measures of Investment Efficiency. This table presents the results of the analyses of the effect of the implementation of compliance management guidelines on investment efficiency for a sample of Chinese A-share listed SOEs during the 2015–2022 period. The dependent variable in column (1) is Ineinv_group, which equals 1 for the low investment efficiency group and 0 otherwise, following Richardson (2006). The dependent variable in column (2) is Ineinv_Biddle, which equals 1 for the low investment efficiency group and 0 otherwise, following Biddle et al. (2009). The dependent variable in column (3) is Ineinv_Chen, which equals 1 for the low investment efficiency group and 0 otherwise, following Chen et al. (2011a). The dependent variable in column (4) is Ineinv_McLean, which equals 1 for the low investment efficiency group and 0 otherwise, following McLean et al. (2012). The dependent variable in column (5) is Ineinv_Choi, which equals 1 for the low investment efficiency group and 0 otherwise, following McLean et al. (2012). The dependent variable in column (5) is Ineinv_Choi, which equals 1 for the low investment efficiency group and 0 otherwise, following Choi et al. (2020). The independent variable is Compliance. Detailed variable definitions are given in Appendix B. All of the regressions include firm and year fixed effects. The robust t-statistics clustered at the firm level are reported in parentheses. ***, ** and * denote significance at the 1 %, 5 % and 10 % levels, respectively.

	(1)	(2)	(3)	(4)	(5)
Variable	Ineinv_group	Ineinv_Biddle	Ineinv_Chen	Ineinv_McLean	Ineinv_Choi
Compliance	-0.0568***	-0.0456**	-0.0358*	-0.0433**	-0.0675***
	(-2.70)	(-2.27)	(-1.88)	(-2.01)	(-3.06)
Control variable	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes
Ν	7,673	7,763	7,764	7,644	7,054
Adj_R ²	0.153	0.027	0.024	0.172	0.190

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Fig. 3. Results of 500 random sample placebo tests.

Ineinv. The coefficient of *Fake* is not statistically or economically significant, indicating that the results of our baseline regression are not due to sample selection bias.

5.3. Test excluding observations from just before the implementation

In the baseline regression, we treat the implementation of the compliance management guidelines in the second half of a year as implementation in the subsequent year. However, our parallel trend test shows that implementation in the second half of a year has some impact on investment efficiency in the current year. Accordingly,

we drop observations from just in the policy year whose implantation was in the second half of the year mainly to prevent definitional bias for policy year from affecting the results of the study, following Chen et al. (2022). Column (2) in Table 8 shows that the re-regressed coefficient of *Compliance* becomes -0.0050, which is significant at the 1% level. This result further illustrates the robustness of our baseline regression results.

5.4. Additional fixed effects

We control for firm and year fixed effects in the baseline regression. As some SOEs change their industries and headquarters locations during the sample period, we rerun the regression with region fixed effects and industry fixed effects. Columns (3) and (4) of Table 8 show that our baseline results remain robust after including region fixed effects and industry fixed effects.

5.5. Identification in the year the guidance is implemented

We define an alternative independent variable by substituting the year the compliance management guidelines are implemented for the year the guidelines are issued. In this sample, the compliance management guidelines of Hunan Province, Mianyang Municipality, Heilongjiang Province, Hainan Province and Jiangxi Province SASACs, which were implemented between 1 June 2022 and 31 December 2022, are included in

Table 8 Other Robustnk share listed SC <i>Compliance</i> . Tl regression in cc (6) excludes fir statistics clustel	ess Checks. ⁷ DEs during t he regression blumn (4) in rms in the 2(red at the fit	This table presents the results of the the 2015-2022 period. The depender in column (2) excludes observatio cludes additional region fixed effects. 016 pilot implementation. Detailed it level are reported in parentheses	effect of the in th variable is <i>l</i> ins from just <i>l</i> The regression variable defini t. ***, ** and	nplementation <i>Ineinv.</i> The inc before the imp n in column (5 tions are give * denote signi	of compliance ma lependent variabl lementation. The) uses observation a in Appendix B. ficance at the 1 %	anagement guidelines on investment e in column (1) is <i>Fake</i> . The indepe : regression in column (3) includes & is from the year the guidelines are im All of the regressions include firm o, 5% and 10% levels, respectively.	efficiency for a sample of C andent variable in columns additional industry fixed eff plemented. The regression i and year fixed effects. The	innese A- $(2)-(6)$ is sets. The sets to column robust t -
Variable 2 A	1) : Years in Advance	(2) Excluding Observations Just Bef Implementation	ore the In Ef) dustry Fixed fects	(4) Region Fixed Effects	(5) Identification in the Year of Imple the Guidance	(6) mentation of Without the 2 Firms	016 Pilot
Compliance			-0.0050^{***} (-3.00)	-0.0045^{**} (-3.11	* _0.0043***	* (-0.0040*** (-2.76)	.0044*** (-3.04)
Fake	0.00 (0.6	08 53)	r		- -		×	r.
Control Y variable	l es	Yes	Y	Sc	Yes	Yes	Yes	
Year FE Y	ſes	Yes	Y	SS	Yes	Yes	Yes	
Firm FE Y	se les	Yes	Y	SS	Yes	Yes	Yes	
Province FE N Industry FE N	40 70	No No	ŻΫ	o es	Yes No	No No	No	
N Adj_R ²	7,6 0.2	73 53	7,155 0.254	7,67.0.25	3 7,675 9 0.251		7,673 0.254	7,624 0.254

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the identification of variable *Compliance*. Column (5) of Table 8 shows that the coefficient of *Compliance* is -0.0040, which is significant at the 1 % level. The result further illustrates the robustness of the baseline regression results.

5.6. Deleting the 2016 pilot firms

In March 2016, the SASAC of the State Council selected China Mobile Communications Cooperation, China National Petroleum Corporation, China Merchants Group, Dongfang Electric Corporation and China Railway Group to carry out pilot compliance management system construction. We exclude the listed firms controlled by the above five corporations from a robustness test sample. The listed firms involved in the pilot project are given in Appendix C. Column (6) in Table 8 shows the results of the baseline regression using the sample that excludes the pilot firms. The coefficient of *Compliance* is -0.0044 and is significant at the 1 % level. Thus, our results remain robust after excluding the firms involved in the pilot implementation in 2016.

5.7. Propensity score matching

To reduce the influence of the differences between firms in the experimental and control groups on the results, we rerun the regression using propensity score matched samples. Specifically, the control variables are used for 1:2 nearest neighbor matching. Table 9 shows the regression results using propensity score matched samples. We use samples supporting shared assumption in Column (1), samples with weights other than 0 in Column (2) and weighted samples in Column (3). These three samples are constructed in the procedure of propensity score matching. We use all of them in the regressions to robust our conclusions. The coefficients of *Compliance* are statistically and economically significant at the 1 % level. The consistent results illustrate the robustness of the baseline regression results.

6. Further discussion

Inefficient investment can be divided into over-investment and under-investment. Our baseline regression confirms that the implementation of compliance management guidelines can significantly improve the investment efficiency of SOEs. In this section, we discuss whether these guidelines alleviate both over-investment and under-investment.

Using the residuals of Model 1, we assign residuals greater than 0 to the over-investment group, and those less than 0 to the underinvestment group. To make the results easier to understand, the absolute value of the model residual is still taken. Table 10 shows the results of the baseline regression using the over-investment and under-investment subsamples. The coefficients of *Compliance* are -0.0041 and -0.0030 and are significant at the 10 % and 5 % levels, respectively. The difference between the coefficients is not significant. These results

Table 9

Propensity Score Matching. This table presents the effect of the implementation of compliance management guidelines on investment efficiency for a sample of Chinese A-share listed SOEs during the 2015-2022 period. The dependent variable is *Ineinv*. The independent variable is *Compliance*. The sample in column (1) uses observations supporting shared assumption. The sample in column (2) uses observations with weights other than 0. The sample in column (3) uses a weighted sample. Detailed variable definitions are given in Appendix B. All of the regressions include firm and year fixed effects. The robust *t*-statistics clustered by firm are reported in parentheses. ***, ** and * denote significance at the 1 %, 5 % and 10 % levels, respectively.

	(1) Sample Supporting Shared Assumption	(2) Sample with V	Veights Other Than 0	(3) Weighted Sample
Compliance	-0.0044***		-0.0052***	-0.0057***
	(-3.03)		(-2.97)	(-2.77)
Control variable	Yes	Yes		Yes
Year FE	Yes	Yes		Yes
Firm FE	Yes	Yes		Yes
Ν	7,655		5,716	11,775
Adj_R ²	0.254		0.251	0.343

Table 10

Impact of Compliance Guidelines on Under-investment and Over-investment. This table presents the results of the analyses of the effect of the implementation of compliance management guidelines on investment efficiency for a sample of Chinese A-share listed SOEs during the 2015–2022 period. The baseline sample is divided into over-investment and underinvestment subsamples based on the residual of Model 1. The regression in column (1) uses the over-investment subsample. The regression in column (2) uses the under-investment subsample. The dependent variable is *Ineinv*. The independent variable is *Compliance*. Detailed variable definitions are given in Appendix B. All of the regressions include firm and year fixed effects. The robust *t*-statistics clustered at the firm level are reported in parentheses. ***, ** and * denote significance at the 1 %, 5 % and 10 % levels, respectively.

	(1)	(2)
	Over-investment	Under-investment
Compliance	-0.0041*	-0.0030**
*	(-1.95)	(-2.34)
LnAge	-0.0069*	-0.0058***
	(-1.84)	(-2.94)
Size	-0.0046^{***}	-0.0027***
	(-5.36)	(-4.88)
Cash	0.0653***	0.0078
	(5.96)	(0.91)
Lev	0.0057	0.0092***
	(1.11)	(2.88)
Tobinq	0.0032***	0.0066***
	(3.32)	(8.75)
Top1	-0.0038	-0.0001
	(-0.54)	(-0.02)
Ros	0.0095***	0.0076***
	(3.62)	(5.33)
Instihold	0.0155**	0.0030
	(2.25)	(0.64)
Dual	0.0036	-0.0008
	(1.44)	(-0.56)
Bsize	0.0017	-0.0051*
	(0.36)	(-1.78)
Outdir	0.0124	-0.0016
	(0.69)	(-0.18)
_cons	0.1316***	0.0979***
	(5.10)	(6.79)
Year FE	Yes	Yes
Firm FE	Yes	Yes
Ν	3.205	4.559
Adj_R ²	0.074	0.226
Difference test	-0.001	
p-value	0.12	

suggest that the implementation of compliance management guidelines can simultaneously alleviate overinvestment and under-investment by SOEs. However, the underlying mechanisms are different. For overinvestment, compliance management guidelines reduce management's risk preference and the agency problem. In contrast, compliance management guidelines may alleviate under-investment by improving resource allocation efficiency (Yao et al., 2020) and reducing corporate soft constraints (Chen and Chen, 2014).

7. Conclusion

We use a sample of Chinese A-share listed SOEs for the 2015–2022 period to analyze the impact of the compliance management guidelines implemented by SASACs on the investment efficiency of SOEs using a staggered DID model. The results show that the compliance management guidelines significantly improve the investment efficiency of SOEs. The effect is stronger in firms with severe financing constraints, high financing needs and high product market competition than in their counterparts. Implementing compliance management guidelines can improve investment efficiency by reducing management's risk appetite, alleviating Type I agency problems and improving the internal control of firms. In addition, implementing compliance management guidelines simultaneously eases over-investment and under-investment.

We expand research on the impact of compliance risk control on investment efficiency from the perspective of corporate micro-governance. We explore compliance management as a potential incentive for efficient investment through its effects on risk preference, agency problems and internal control. The results provide preliminary insight into the key institutional measures that SOEs can use to effectively reduce material risks. Inadequate information disclosure and high information asymmetry are common problems in emerging markets. The construction of compliance management systems is an important governance reform in developing countries with weak legal environments. We supplement relevant research on the factors contributing to investment efficiency from the perspective of compliance management, which not only has value for deepening the reform of compliance management of SOEs in China but also offers important insights for other developing countries seeking to establish risk management systems and enhance the value creation ability of listed firms.

CRediT authorship contribution statement

Dengjin Zheng: Conceptualization, Funding acquisition, Supervision and Project administration. **Yan Xu:** Writing – original draft, Writing – review & editing, Visualization, Validation, Formal analysis, Methodology. **Yangyang Wenren:** Writing – original draft, Writing – review & editing and Visualization.

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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.

Appendix A.

Table A1

Schedule of implementation of state-owned enterprise compliance management guidelines by different levels of SASACs (2018–2022).²

Promulgation Authority	File Name (in Chinese)	Implementation Time	Recognition Year
SASAC of the State Council	《中央企业合规管理指引 (试 行) 》	November 9, 2018	2019
SASAC of Beijing Municipality Government	《市管企业合规管理工作实施方 案》	December 26, 2018	Judging with different batches of pilot ^①
SASAC of Shanghai Municipality Government	《上海市国资委监管企业合规管 理指引(试行)》	January 21, 2019	2019
SASAC of Chongqing Municipality Government	《重庆市市属国有企业合规管理指引(试行)》	November 1, 2019	2020
Jiangsu Provincial Government SASAC	《省属企业合规管理指引(试行)》	November 8, 2019	2020
	File News (in Chinese)	In the sector of	
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Promulgation Authority	File Name (in Chinese)	Implementation Recognition Year Time	
Shandong Provincial Government SASAC	《省属企业合规管理指引》	December 13, 20 2019)20
SASAC of Inner Mongolia Autonomous Region	《关于建立企业合规管理体系的指导意见》	January 7, 2020 20)20
Guangdong Provincial Government SASAC	《广东省省属企业合规管理指引》	March 3, 2020 20.)20
Shaanxi Provincial Government	《陕西省省属企业合规管理指引 (试行)》	April 9, 2020 20.)20
SASAC of Yancheng Municipality Government	《市属企业合规管理指引(试行)》	May 14, 2020 20.)20
SASAC of Altai Territory	《阿勒泰地区直属企业合规管理 指引(试行)》	July 10, 2020 20.)21
Shanxi Provincial Government	《山西省省属企业合规管理指引 (试行)》	July 14, 2020 20.)21
SASAC of Meizhou Municipality Government	《梅州市市属企业合规管理指引 (试行)》	August 28, 2020 20)21
SASAC of Qingdao Municipality Government	《青岛市国资委监管企业合规管理指引(试行)》	September 4, 20.)21
SASAC of Suzhou Municipality Government	《苏州市市属企业合规管理指引 (试行)》	November 2, 20.)21
SASAC of Guangzhou Municipality Government	《广州市市属企业合规管理指引	December 1, 20.)21
SASAC of Xuzhou Municipality Government	《市属企业合规管理指引(试行)》	December 8, 20.)21
Guizhou Provincial Government	《贵州省国资委监管企业合规经营管理指引》	December 29, 20.)21
SASAC of Tianjin Municipality	《天津市国资委监管企业合规管理指引(试行)》	December 30, 20.)21
SASAC of Chengdu Municipality Government	《成都市属国有企业合规管理指	December 31, 20.)21
Hubei Provincial Government	《湖北省出资企业合规管理指引 (试行)》	February 7, 20.)21
Sichuan Provincial Government	《四川省省属企业合规管理指引	March 19, 2021 20.)21
SASAC of Dalian Municipality Government	《大连市国资委监管企业合规管理指引(试行)》	May 28, 2021 20.)21
Yunnan Provincial Government	《云南省省属企业合规管理指引(试行)》	June 15, 2021 20.)21
SASAC of Fuzhou Municipality Government	《福州市国资委所出资企业合规 管理指引(试行)》	July 29, 2021 20.)22
SASAC of Weihai Municipality Government	《威海市市属国有企业合规管理指引》	October 15, 20.)22
Anhui Provincial Government	《安徽省省属企业合规管理指引 (试行)》	November 25, 20.)22
SASAC of Nanjing Municipality Government	《南京市市属企业合规管理指引 (试行)》	December 2, 20.)22
SASAC of Henan Municipality Government	《河南省省管企业合规管理指引》	December 14, 20 2021)22

(continued)

Promulgation Authority	File Name (in Chinese)	Implementation Recognition Year Time	
SASAC of Shijiazhuang	《石家庄市国资委监管企业合规	December 16,	2022
Municipality Government	管理指引(试行)》	2021	
SASAC of Bozhou Municipality	《亳州市市属企业合规管理指引	February 14,	2022
Government	(试行)》	2022	
SASAC of Ningxia Hui	《宁夏回族自治区属国有企业合	March 30, 2022	2022
Autonomous Region	规管理指引》		
Zhejiang Provincial Government	《浙江省省属企业合规管理指引	April 10, 2022	2022
SASAC	(试行)》		
SASAC of Huzhou Municipality	《湖州市市属企业合规管理指引	June 16, 2022	2022
Government	(试行)》		

(continued)

① The implementation of compliance management guidelines of SOEs in Beijing Municipality included three batches: The first batch involved BAIC Group (北汽集团), Beijing Enterprises Group Company Limited (北控集团), Beijing Construction Engineering Group (北京建工集团), Beijing Tourism Group (首旅集团) and BOE Technology Group Co., Ltd. (京东方集团), which started in 2018. The second batch involved Shougang Group (首纲集团), Beijing Infrastructure Investment Co., Ltd. (京东方集团), Beijing Energy Holding Co., Ltd. (京 能集团), Beijing Capital Group (首纲集团), Beijing State-owned Asset Management Co., Ltd. (北京国资公司), Beijing Electronics Holding Co., Ltd. (北京电控), Beijing Tongrentang Group (同仁堂集团), BBMG Corporation (金隅集团), Beijing ShoKai Group (首开集 团), Beijing Uni-Construction Group (住总集团), Beijing Xianglong Capital Management Company Limited (祥龙公司) and Beijing Capital Agribusiness and Foods Group (首农食品集团), which started in 2020. The remaining SOEs controlled by SASAC of Beijing Municipality Government started their compliance management system construction in 2021.

²Compliance management guidelines implemented by SASACs of Hainan Province, Heilongjiang Province, Hunan Province, Jiangxi Province and other municipalities are issued later than June 30, 2022 or have not been issued at the completion of our article, so we don't list them in the appendix.

Appendix B.

Table B1

Variable Definit	ions.
Variable	Definitions
Dependent Vari	able
Ineinv	Investment efficiency calculated by Richardson (2006), measured by the absolute value of the residual error of model (1).
Ineinv_group	Divide into two groups of low investment efficiency and high investment efficiency by the median absolute value of Richardson (2006) model's residuals. <i>Ineinv_group</i> equals 1 if divided into low investment efficiency group and 0 otherwise.
Ineinv_Biddle	Investment efficiency calculated by Biddle et al. (2009), divide into two groups of low investment efficiency and high investment efficiency by the median absolute value of model's residuals. <i>Ineinv_Biddle</i> equals 1 if divided into low investment efficiency group and 0 otherwise.
Ineinv_Chen	Investment efficiency calculated by Chen et al. (2011), divide into two groups of low investment efficiency and high investment efficiency by the median absolute value of model's residuals. <i>Ineinv_Chen</i> equals 1 if divided into low investment efficiency group and 0 otherwise.
Ineinv_McLean	Investment efficiency calculated by McLean et al. (2012), divide into two groups of low investment efficiency and high investment efficiency by the median absolute value of model's residuals. <i>Ineinv_Chen</i> equals 1 if divided into low investment efficiency group and 0 otherwise.

(continued)	
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Variable	Definitions
Ineinv_Choi	Investment efficiency calculated by Choi et al. (2020), divide into two groups of low investment efficiency and high investment efficiency by the median absolute value of model's residuals. <i>Ineinv_Chen</i> equals 1 if divided into low investment efficiency group and 0 otherwise.
Independent Va	riable
Compliance	Dummy equals 1 if the firm is affected by compliance management guidelines and 0 otherwise.
Randomdid	Dummy equals 1 if samples belong to "experimental groups" which select the same number of as the baseline regression through random sampling and 0 otherwise.
Fake	Dummy equals 1 if current year of samples are after the two years before implementation of compliance management guidelines and 0 otherwise.
Control Variabl	e
LnAge	The firm age, measured by the natural logarithm of years of establishment.
Size	The firm size, measured by the natural logarithm of the total assets.
Cash	Net cash amount from business activities divided by total asset at beginning period.
Lev	Debt-to-asset ratio, measured by total liabilities divided by total asset.
Tobinq	Tobin's q, measured by market value divided by total asset.
Ros	The annual stock return considering cash dividends reinvestment.
Top1	The shareholding ratio of the largest shareholder.
Instihold	The shareholding ratio of institution investors.
Dual	Dummy equals 1 if the chairman of board and general manager are integrated and 0 otherwise.
Bsize	The size of board, measured by the natural logarithm of the number of board members.
Outdir	The proportion of independent directors on the Board.
Other Variable	
SA	Financing constraints calculated by Hadlock and Pierce (2010), measured by the following model:
	$SA = -0.737 * Size + 0.043 * Size^2 - 0.040 * Age$
	where <i>Size</i> is the natural logarithm of the total assets, <i>Age</i> is the natural logarithm of years of establishment.
Fin_need	Financing needs calculated by Sun et al. (2016), measured by net cash amount from business activities divided by the sum of cash paid for purchasing fixed assets, intangible assets and other long-term assets and cash paid for distributing dividend, profits or paying interests.
HHI	Herfindahl-Hirschman index, measured by the following model: $HHI = \sum \left(\frac{Sales_i}{\sum Sales_i}\right)^2$
	where <i>Sales</i> is prime operating revenue of firm <i>i</i> . $\sum Sales$ is the sum of prime operating revenue of all the firms in the industry
Risk	Management's risk appetite, measured by the difference between current assets and current liabilities, divided by total assets.
Acost	Type I agency cost, measured by the sum of management expenses and sales expenses divided by operating revenue.
InConl	Level of internal control, measured by the natural logarithm of internal control index obtained from DIB internal control and risk management database.

Appendix C.

Table C1	
List of Listed Firms Involved in	Compliance Management Pilot in 2016.
Pilot Central Enterprises in	Subordinate Listed Firms and Stock Codes
2016	
China Mobile Communications Cooperation	China Mobile Limited (600941)
China National Petroleum Corporation	PetroChina Company Limited (601857)
China Merchants Group	China Merchants Port Group Co., Ltd (001872)China Merchants Expressway Network and Technology Holdings Co., Ltd. (001965)China Merchants Shekou Industrial Zone Holdings Co., Ltd. (001979)China Merchants Energy Shipping Co., Ltd (601872)
Dongfang Electric Corporation	Dongfang Electric Co., Ltd. (600875)
China Railway Group	China Railway Special Cargo Logistics Co., Ltd (001213)China Railway
	Hi-tech Industry Co., Ltd.
	(600528)
	China Railway Group Limited (601390)

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Implicit regulation in M&As: Evidence from voluntary earnouts in China

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ABSTRACT

Earnout provisions ("earnouts" hereafter) provide for contingent payments in M&A agreements and play a role in reducing information asymmetry. However, in China, earnouts are not solely driven by negotiations between acquirers and targets but are also related to regulatory preference. The CSRC amended the M&A regulation in 2014, deregulating mandatory earnouts while retaining the approval system. Leveraging on this context, we explore whether regulators implement implicit regulation by encouraging the usage of voluntary earnouts, and the economic consequences of such action. Our results show that earnouts are more likely to be included in an M&A contract when the deal requires CSRC approval. M&As that involve earnouts are also more likely to obtain regulatory approval and in a shorter time. These findings suggest that regulators may still prefer earnouts even after deregulation. In addition, we find that the association between voluntary earnouts and acquirers' postacquisition performance is negative when the M&A deal requires regulatory approval, suggesting that voluntary earnouts influenced by regulatory preference can potentially have a negative impact. Further analyses indicate that this impact can be alleviated by comment letters and market monitoring. Our findings provide regulators with insights into the effects of the regulatory reform in the M&A market. © 2024 Sun Yat-sen University. Production and hosting by Elsevier B.V. This

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1. Introduction

Based on negotiations between acquirers and targets, earnouts provide for contingent payments and reduce information asymmetry in established mergers and acquisitions (M&A) markets (Datar et al., 2001; Cain

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et al., 2011; Barbopoulos and Sudarsanam, 2012; Cadman et al., 2014). Evidence indicates that earnouts are included in 4 % to 18 % of international M&A contracts (Kohers and Ang, 2000; Cain et al., 2011; Bates et al., 2018). However, earnouts usage is more widespread in China, and regulatory preference provides a likely reason for this. China mandated earnouts in most M&A deals up to 2014 when it deregulated these requirements.¹ However, more than 60 % of M&A deals continue to include earnouts after 2014, especially those requiring regulatory approval, far outpacing the global norm. This suggests that in China's M&A market, earnouts usage is likely to be influenced by regulatory preferences in addition to buyer–seller negotiation. However, the phenomenon is underexplored in the literature, and thus we aim to fill this gap with our study.

The literature on government regulation suggests that government intervention can rectify market failures through the more efficient allocation of resources and by maximizing social welfare (Keynes, 1936; MacAvoy, 1970). In China, regulatory actions can manifest in both explicit and implicit forms. Explicit regulation involves legislation, rules, and other regulations, while implicit regulation operates through unwritten norms and relationships. Implicit regulation can, however, be triggered by transitions in explicit regulation. Whenever government regulations shift, whether in terms of weakening or strengthening, regulators are likely to adhere to the earlier regulation and implement implicit regulation. In expectation of this, firms have incentives to cater to the regulator's preferences (Chen et al., 2008). In this paper, we investigate whether implicit regulation affects the usage of earnouts and its economic consequences.

China offers a unique setting to examine our research question. First, earnouts in China have been voluntary since the deregulation of mandatory earnouts in 2014, allowing us to observe the variations in earnouts usage and analyze their determinants. Second, despite this deregulation, many M&A deals still need approval from the M&A and Restructuring Committee of the China Securities Regulatory Commission (CSRC), which provides us with the opportunity to explore how regulators can affect earnouts through regulatory approval. If M&A approvals include implicit regulation, we expect regulators to have a preference for earnouts, which will be manifested in regulatory decisions such as the M&A approval rate and timeliness. In addition, when designing deal contracts, the acquirers and the targets can consider both market factors and regulatory preferences, as evident in the use of voluntary earnouts when the deal requires regulatory approval.

Our results are consistent with our predictions. We find that earnouts are more likely to be included in an M&A contract when the deal needs approval from the regulator. M&A deals with earnouts are also more likely to obtain regulatory approval and also within a shorter time. Both these findings suggest that regulators still have a preference for earnouts even after the deregulation. In addition, we find that the association between voluntary earnouts and acquirers' post-acquisition performance is negative when the M&A deal requires regulatory approval, suggesting the potential negative impact of voluntary earnouts that are influenced by regulatory preference. Further analyses indicate that this negative impact can be alleviated by comment letters from regulators and other market-based mechanisms.

Our study makes the following contributions to the literature. First, our findings contribute to research into the impact of regulation. The literature identifies a balance between market forces and regulation, showing that while regulation can alleviate market failures it may also introduce compliance costs and hinder market competition (Stigler, 1971; Spierings, 1990; Tollison and Wagner, 1991). Regarding the regulation of M&A activities, previous literature mainly examines the effects of explicit regulations (Clougherty and Zhang, 2021; Li et al., 2022). Our study leverages voluntary earnouts to examine the role and economic impact of implicit regulation in China's M&A approval processes. Second, our findings add to the literature on the determinants and economic consequences of earnouts. Studies highlight that information asymmetry is a key driver behind the signing of earnouts in M&A deals, and that earnouts are more likely when the target firm is smaller, unlisted or in a different industry than the acquirer and when acquirers have lower earnings quality or financial constraints (Kohers and Ang, 2000; Datar et al., 2001; Cain et al., 2011; Cadman et al., 2014; Allee and Wangerin, 2018; Bates et al., 2018). However, by utilizing China's unique setting, we find that regulatory approval, in addition to market factors, can influence the use of earnouts. We also find a negative correlation between voluntary earnouts and M&A performance when regulatory approval is required, sug-

¹ Please refer to the "Guidelines for Major Asset Restructuring of Listed Companies" launched by the China Securities Regulatory Commission (CSRC). The details of the regulatory requirements are discussed in Section 2.1.

gesting that voluntary earnouts may be ineffective under regulatory approval. This can inform the academic debate on the role of earnouts in China's M&A market (Hou et al., 2015; Pan et al., 2017; Li et al., 2020; Liu et al., 2021). Third, our findings provide insights into the changes in regulatory roles under the registration system. Even after the deregulation of mandatory earnouts, we find that M&A approval can potentially influence market behaviors through implicit regulation. Thus, during capital market reforms, both the direct effects of explicit regulation and indirect effects through implicit regulation should be considered.

The remainder of this paper is structured as follows. In Section 2, we review the institutional background and the literature and develop our hypotheses. In Section 3, we introduce the research design. In Section 4, we explore the implicit regulation related to earnouts by examining the relationship between regulatory approval and voluntary earnouts. In Section 5, we examine the impact of voluntary earnouts under regulatory approval on M&A performance, and further assess the role of comment letters and market monitoring. Section 6 concludes this paper.

2. Institutional background and literature review

2.1. Institutional background

The CSRC launched its "Guidelines for Major Asset Restructuring of Listed Companies" ("the guidelines" hereafter) in 2008, which signified a new era in the regulatory supervision of M&A activities among listed firms in China.² This mandate requires listed companies to provide earnings forecasts for target firms at the time of acquisition and report realized earnings after acquisition. Furthermore, if valuation methods are based on future earnings expectations, such as the discounted cash flow (DCF) model, the M&A contract should include earnouts that clearly state how the target controlling shareholder will compensate listed firms' shareholders if the actual earnings of target firms fall short of their expectations.³ Around 75 % of M&A deals rely on the DCF model for valuation,⁴ so the majority of M&A deals in China are required to include earnouts. The 2008 guidelines also indicate that almost all of these deals should obtain approval from the CSRC.

The guidelines received criticism from the capital market for creating significant hurdles to the completion of M&A deals. Thus, in October 2014, the CSRC amended them and relaxed its regulation. The amendments aim to simplify pre-event regulatory approval but strengthen post-event regulatory supervision. The two most significant changes regarding earnouts and regulatory approval are as follows. First, the mandatory requirements for earnouts were removed. Except for deals involving related-party transactions, the acquirer and target can negotiate whether to include earnouts in the contract. Second, although the regulatory approval system was retained, the regulator relaxed the criteria for M&A deals requiring review and approval from the CSRC, and only deals involving stock purchase and backdoor listing need to be submitted. Table 1 illustrates the situation before and after the 2014 amendments.

However, in practice the majority of M&A deals after the deregulation of mandatory earnouts in 2014 continue to voluntarily include earnouts. Thus, this deregulation event, in conjunction with the M&A approval system, provides an ideal setting for exploring implicit regulation in the M&A market.

² The 2008 guidelines provide a clear definition of major asset restructuring for listed companies' M&A deals, which occurs if any of the following thresholds are met: (1) The target value exceeds 50% of the acquiring company's total assets for the last fiscal year. (2) The target's revenue surpasses 50% of the acquiring company's total operating income for the last fiscal year. (3) The net value of the target is over 50% of the acquiring company's net assets at year-end, and the transaction value is more than 50 million RMB. In this paper, we use "M&A deals" to refer to M&As involving major asset restructuring.

³ An earnout provision commonly entails the target company committing to achieving specific operational performance targets within a few years (typically 1 to 3 years) following the acquisition. In China's M&A market, earnouts are generally one-way, which means that if the target fails to meet its performance commitments, compensation needs to be provided to the shareholders of the acquiring company. In developed markets, however, earnouts are usually bi-directional, i.e., the consideration may be discounted (awarded) if the target falls below (exceeds) its performance commitments.

⁴ This number is based on M&A deals conducted between 2008 and 2014.

EarnoutsMostly MandatoryMostly VoluntaryRegulatory ApprovalAll types of transactionsOnly stock purchase and backdoor listing of		Pre-2014	Post-2014
	Earnouts	Mostly Mandatory	Mostly Voluntary
	Regulatory Approval	All types of transactions	Only stock purchase and backdoor listing deals

This table illustrates the changes before and after the 2014 amendments of the "Guidelines for Major Asset Restructuring of Listed Companies."

2.2. Literature review

Government regulation can be either explicit or implicit. Explicit regulation is enforced through written rules while implicit regulation typically arises from unwritten tacit agreements. For instance, in the IPO market, setting an upper price-to-earnings (P/E) ratio limit for IPO shares is a form of implicit regulation.⁵ Zhang et al. (2020) provide evidence that this implicit regulation of IPO pricing leads to a significant deviation between the initial offering price and the equilibrium price, resulting in a price bubble for IPO shares. In a sample period without window guidance, IPO pricing behavior in China closely resembles that of mature markets (Hu et al., 2019). Chen et al. (2008) investigate the impact of implicit regulation on IPO quota allocation across provinces in China. In addition, the CSRC implicitly takes the occurrences of scandals in a province into consideration when allocating IPO quotas, and thus local governments have an incentive to avoid scandals so they can obtain the IPO quota, while investors incorporate related information into their trading decisions. Regulatory approval also incentivizes companies to engage in rent-seeking behavior, as this can increase their chances of approval and expedite the review process, either by hiring intermediaries with political connections or by attracting venture capital (Li and Liu, 2012; Zeng et al., 2016). These actions can also be viewed as implicit agreements between market participants and regulators.

We argue that implicit regulation also occurs in the M&A market, through the regulatory preference for voluntary earnouts. Acquiring regulatory approval and review time are factors that significantly influence transaction efficiency for both the acquirer and the target. Therefore, when an M&A deal requires regulatory approval, the decision to include earnouts in a contract is influenced not only by characteristics of the deal such as valuation risk, but also by regulatory preferences. Despite the deregulation of mandatory earnouts after 2014, regulators may still have a preference for earnouts due to regulatory inertia, leading to higher approval rates and shorter processing time.

Therefore, if implicit regulation does occur, it represents an "invisible handshake" concerning earnouts between regulators and M&A parties. This leads to our hypotheses 1a and 1b:

H1a. Ceteris paribus, an M&A contract including earnouts is more likely when regulatory approval is required than when it is not.

H1b. *Ceteris paribus*, M&A deals with earnouts are more likely to gain regulatory approval and in a shorter time than those without earnouts.

3. Research design

3.1. Data and sample selection

Our sample consists of M&A deals from 2014 to 2021. We require the acquirer to be a listed company in a non-financial sector and to voluntarily engage in earnouts. We obtain M&A-related characteristics from the Wind database and firm-level financial data from the China Stock Market & Accounting Research Database

⁵ The IPO P/E regulation has experienced multiple regime changes. Before 2009, to prevent overly high issuance prices, the CSRC implemented an implicit window guidance, capping the P/E ratio for new stock offerings at a maximum of 30. In June 2009, the CSRC removed this guidance, shifting to a market-based approach for setting issuance prices. In June 2014, regulators implemented implicit regulation again, which caps the P/E ratio at around 23.

Sample Construction.	
M&As involving non-financial listed companies as acquirers from 2014 to 2021	1695
Minus: Observations requiring mandatory earnouts	506
Minus: Observations with missing values of regression variables	348
Final regression sample	841

This table shows the sample selection procedure. Our initial sample consists of 1695 M&A deals from 2014 to 2021. After applying the requirements of non-financial listed acquirers, voluntary earnouts and non-missing regression variables, our final sample includes 841 observations.

(CSMAR). Table 2 outlines the sample selection procedure. Our final sample includes 841 observations. All continuous variables are winsorized at the 1st and 99th percentiles to mitigate the effect of outliers.

3.2. Models and variable definition

Table 2

H1a predicts that *ceteris paribus*, the likelihood of including earnouts is higher when M&A deals require regulatory approval. We use the following logit model to test H1a:

$$Logit(Earnout = 1) = \beta_0 + \beta_1 Regulation + \beta_2 Controls + YearFE + IndFE + \varepsilon$$
(1)

where *Earnouts* is an indicator variable that equals one if the M&A contract includes earnouts and zero otherwise, and *Regulation* is an indicator variable that equals one if the M&A activity requires regulatory approval and zero otherwise.

H1b proposes that *ceteris paribus*, M&A deals including earnouts are more likely to be approved by regulators and in a shorter time. We estimate the following models to test H1b:

$$Logit(Pass = 1) = \beta_0 + \beta_1 Earnout + \beta_2 Controls + YearFE + IndFE + \varepsilon$$
⁽²⁾

$$RegTime = \beta_0 + \beta_1 Earnout + \beta_2 Controls + YearFE + IndFE + \varepsilon$$
(3)

where *Pass* is an indicator equal to one if an M&A deal obtains regulatory approval and zero otherwise; *RegTime* is the time taken in the regulatory approval process, calculated as the number of days from the date regulatory review begins to the approval date divided by 30; and *Earnouts* is an indicator variable equal to one if an M&A deal includes earnouts and zero otherwise.

We control for both firm-level and M&A deal-level characteristics following previous literature (Li et al., 2020; Li et al., 2022). Firm-level control variables include firm size (*Size*), debt ratio (*Lev*), ownership of the largest shareholder (*LargestHolder*), return on equity (*ROE*), whether a state-owned enterprise (*SOE*), earnings per share (*EPS*), listing board (*Board*) and duality of CEO and chairman roles (*Dual*). M&A deal characteristics include percentage of ownership acquired (*Share*), evaluation value-added ratio (*EvaRatio*), the relative size of the deal (*MergerSize*), whether it is a related-party transaction (*RS*), whether it involves a backdoor listing (*BackDoor*), payment method (*PayShare*) and whether the target entity is a non-listed company (*TargetNo*). We also incorporate industry- and year-fixed effects into all regression models. Detailed variable definitions are given in Appendix A.

4. Empirical results

4.1. Descriptive statistics

Table 3 presents the sample distribution and descriptive statistics for the key variables. Panel A gives the sample distribution across different values of *Earnouts* and *Regulation*, and shows that approximately 68 % of M&A deals in our sample require regulatory approval and that around 67 % include earnouts. Panel B of Table 3 presents the summary statistics of the regression variables. The mean value of *Pass* is 0.887, indicating that the approval rate for M&A deals is 88.7 %. The mean value of *RegTime* is 4.291, indicating that the average duration of regulatory approval is around 4.3 months. However, the duration varies significantly, ranging

Panel A Sample Distributio	n					
		Earnouts = 0	Ed	arnouts = 1		
Regulation = 0		156		117		273
Regulation = 1		123		445		568
		279		562		841
Panel B Summary Statistics						
Variable	Ν	Mean	Standard deviation	Median	Min	Max
Pass(Regulation = 1)	435	0.887	0.317	1.000	0.000	1.000
RegTime(Regulation = 1)	435	4.291	2.295	3.767	0.433	17.87
Earnouts(Regulation = 1)	435	0.772	0.420	1.000	0.000	1.000
Earnouts	841	0.668	0.471	1.000	0.000	1.000
Size	841	21.951	1.257	21.782	18.972	25.863
Lev	841	0.454	0.213	0.444	0.067	0.985
Top1	841	32.483	14.252	30.080	9.970	72.150
ROE	841	0.039	0.171	0.053	-1.132	0.474
SOE	841	0.271	0.445	0.000	0.000	1.000
EPS	841	0.279	0.476	0.209	-1.604	2.784
Board	841	0.251	0.434	0.000	0.000	1.000
Dual	841	0.325	0.469	0.000	0.000	1.000
Share	841	90.576	19.512	100.000	13.540	100.000
EvaRatio	841	5.121	7.657	2.348	0.000	48.696
MergerSize	841	0.307	0.736	0.090	0.002	5.377
RS	841	0.307	0.461	0.000	0.000	1.000
BackDoor	841	0.055	0.228	0.000	0.000	1.000
PayShare	841	0.228	0.420	0.000	0.000	1.000
TargetNo	841	0.935	0.247	1.000	0.000	1.000

Table 3 Sample Distribution and Summary Statistics.

This table provides the sample distribution and summary statistics for the key variables. Panel A presents the sample distribution. Panel B presents the summary statistics of the variables. Our final sample includes 841 M&A deals from 2014 to 2021.

from 0.4 months to 17.8 months. This highlights the pivotal role regulators play in the M&A market. The mean value of *Earnouts* (when *Regulation* = 1) is 0.772, indicating that 77.2 % of M&A activities include earnouts in their contracts when regulatory approval is required, which is higher than the percentage of M&A activities including earnouts in the overall sample. Other variables are distributed within reasonable ranges.

4.2. Regulatory approval and voluntary earnouts

4.2.1. Hypothesis 1a

H1a predicts that earnouts are more likely in M&A deals that require regulatory approval. We first test this hypothesis using the univariate test. As shown in Panel A of Table 4, when M&A deals require regulatory approval (Regulation = 1), the mean value of Earnouts is 0.783, which is significantly higher than the value when regulatory approval is not required (Regulation = 0) and is thus consistent with H1a.

The first column of Panel B in Table 5 reports the results of Model (1). The dependent variable is the indicator of including earnouts in M&A contracts (*Earnouts*), while the independent variable is whether the M&A deal requires regulatory approval (*Regulation*). The coefficient of *Regulation* is 2.014, which is positive and statistically significant at the 1 % level, indicating a higher likelihood of including earnouts when M&A deals require regulatory approval. All else being equal, in economic terms the likelihood of signing earnouts in M&A deals that require regulatory approval is approximately 7.5 times that of deals that do not require approval ($e^{2.014}$), which is consistent with H1a.

An alternative explanation of our results is that regulatory preference is fully aligned with the market. Regulators may only prefer earnouts when the deal brings shareholders more risk and uncertainty. To address this

Panel A Univariate Tes	t				
	Regulation =	1	Regulation = 0		MeanDiff
Earnouts	568	0.783	273	0.429	0.355***
Panel B Regression of V	Voluntary				
Earnouts on Regulatory	y Approval				
		(1)	(2)		(3)
		Earnouts	Earno	outs	Earnouts
Regulation		2.014***	2.294	4***	2.899***
		(11.146)	(6.4	55)	(8.816)
EvaRatio			0.	051	0.079^{***}
			(1.5	584)	(3.173)
Method			2.55	7***	2.556^{***}
			(6.7	/05)	(9.598)
CrossProv			0.	162	1.191***
			(1.0	92)	(3.368)
<i>EvaRatio</i> × <i>Regulation</i>					-0.055^{**}
					(-2.396)
Method×Regulation					0.328
					(0.453)
CrossProv×Regulation					-1.661***
					(-3.865)
Control		Yes	Yes		Yes
Year Fixed Effects		Yes	Yes		Yes
Industry Fixed Effects		Yes	Yes		Yes
N		841		841	841
Pseudo R^2		0.284	0.	388	0.402

 Table 4

 Regulatory Approval Requirement and Voluntary Earnouts.

This table reports the results on the association between whether an M&A deal requires regulatory approval and voluntary earnouts usage. Panel A presents the univariate tests. Panel B reports the regression results. z-statistics are included in parentheses. *, ** and *** indicate statistical significance at the 10 %, 5 % and 1 % level, respectively.

concern, we add control variables for measuring M&A risk into Column (2).⁶ As shown in the table, the coefficients on *EvaRatio*, *Method* and *CrossProv* are all positive, suggesting that as the degree of risk increases earnouts are more likely to be included in M&A contracts. After controlling for M&A risk, the coefficient for *Regulation* remains positive and significant, further supporting H1a. Additionally, we introduce interaction terms between *EvaRatio*, *Method*, *CrossProv* and *Regulation* in the regression model. The results in Column (3) of Panel B in Table 4 indicate that after including these terms, the coefficients for *EvaRatio*, *Method* and *CrossProv* are all positive. However, the coefficients for the interaction terms *EvaRatio* × *Regulation* and *CrossProv* × *Regulation* are both significantly negative at the 1 % level. These findings suggest that after considering M&A risks, regulatory approval has an incremental effect on the decision to sign earnouts and partially substitutes for the effect of the market.

4.2.2. Hypothesis 1b

If implicit regulation on earnouts does occur, we expect to observe a higher likelihood of regulatory approval and in a shorter time for M&A deals with earnouts, as H1b proposes. To test this hypothesis, we include both M&A deals that obtain regulatory approval and those that do not in our regression sample. Columns (1) and (2) of Table 5 present the empirical results. The dependent variables are whether the deal

⁶ Following the literature (Kohers and Ang, 2000; Datar et al., 2001; Cain et al., 2011; Bates et al., 2018; Sun and Liu, 2022), we use the M&A evaluation value-added ratio (*EvaRatio*), evaluation method (*Method* is coded as 1 when the DCF model is used for M&A valuation, and 0 otherwise) and cross-provincial acquisitions (*CrossProv* is coded as 1 for cross-provincial M&A activities, and 0 otherwise) to measure market-driven risks. A higher M&A evaluation value-added ratio, the use of the DCF model for valuation and cross-provincial acquisitions indicate greater M&A risk.

	(1)	(2)	(3)	(4)
	Pass	RegTime	Pass	RegTime
Earnouts	0.732***	-0.355*		
	(2.748)	(-1.908)		
Earnouts_Resid			0.783*	-0.312
			(1.758)	(-1.737)
Control	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes
N	435	435	435	435
Pseudo/Adj. R^2	0.121	0.170	0.122	0.169

Table 5					
Voluntary	Earnouts	and	Regulatory	Approval	

This table reports the regression results on the association between voluntary earnouts and regulatory approval. The dependent variables in Columns (1) and (2) are whether the deal obtained approval (*Pass*) and the time taken for approval (*RegTime*), respectively. z-statistics or t-statistics are included in parentheses. *, ** and *** indicate statistical significance at the 10 %, 5 % and 1 % level, respectively.

obtained approval (*Pass*) and the time taken to obtain approval (*RegTime*), as in Columns (1) and (2), respectively, while the main independent variable is the indicator of including earnouts in M&A contracts (*Earnouts*). In Column (1), the coefficient for Earnouts is 0.732, and thus positive and significant at the 1% level, while in Column (2) it is -0.355, and thus negative and significant at the 10% level. This indicates that voluntary earnouts are associated with a higher likelihood of regulatory approval and a shorter time for regulatory review. Economically, the odds of obtaining regulatory approval for M&As with earnouts are 2.08 times the odds for those without. Including earnouts also shortens the approval process by 35.5% on average, which translates into a 1.5-month decrease in approval time, considering the sample's average approval duration of 4.3 months. These findings therefore support H1b.

Our findings thus far suggest that earnouts can increase the likelihood of regulatory approval and shorten the approval process. However, these results will also be affected by the degree of regulator alignment and market mechanisms, and thus the higher approval rate may reflect regulators' preference for high-quality deals. To address any issues arising from unobservable factors that may influence both the use of earnouts and regulatory behavior, we regress the likelihood of including earnouts in M&A contracts on a series of M&A deal-level characteristics using samples that do not require regulatory approval.⁷ We then obtain a predicted earnouts likelihood value under market-driven negotiation. The difference between the actual and the predicted values of *Earnouts* then gives the residual value of earnouts (*Earnouts_Resid*), which captures the use of earnouts that is unexplained by market factors. Finally, we replace *Earnouts* in Models (2) and (3) with *Earnouts_Resid*. The results are reported in Columns (3) and (4) of Table 5. The coefficient of *Earnouts_Resid* is significantly positive in Column (3), and negative and close to being significant in Column (4). This indicates that after considering the effect of market factors on earnouts, regulators continue to exhibit a preference for them, thereby ruling out the alternative explanation that regulatory preferences solely mirror market preferences.

The results for H1a and H1b indicate that M&As requiring regulatory approval are more likely to include earnouts, and that those with earnouts are more likely to gain regulatory approval and in a shorter period. These findings together support our argument that despite the removal of mandatory requirements for earnouts, implicit regulation may still be evident in the M&A regulatory approval process.

Next, we conduct a series of additional robustness checks on the empirical results regarding H1b. If regulators aim to reduce M&A risk through earnout agreements, they may have a preference for earnouts that can more effectively signal the quality of M&A transactions. Therefore, we further examine the relationship between earnout characteristics and regulatory approval. First, we consider the size of earnouts. If the performance level committed through earnouts is too high to achieve, the M&A deal will damage the performance of listed firms (Wang and Fan, 2017). Therefore, regulators may prefer a moderate performance commitment. In

⁷ In the estimation model, we include the M&A deal-level characteristics of *Share*, *MergerSize*, *RS*, *BackDoor*, *PayShare* and *TargetNo* and the M&A risk variables *EvaRatio*, *Method* and *CrossProv*.

Columns (1) and (2) of Table 6, we include *EarnoutsRelSize*, which equals the total level of performance committed divided by the total transaction value, into the regression. The coefficient on *EarnoutsRelSize* is significantly negative in Column (1) and significantly positive in Column (2). Combined with the coefficient on *Earnouts*, this indicates that while regulators have a preference for voluntary earnouts, they exercise caution regarding high performance commitments.

Second, previous studies show that the incentive effect of a performance commitment with both reward and compensation agreements (two-way earnouts) is more significant than with only compensation agreements (one-way earnouts) (Rao et al., 2018). In Columns (3) and (4), we include *Earnouts_Twoway* and *Earnouts_O-neway*, indicating two-way and one-way earnouts. Their coefficients are all significantly positive or significantly negative, indicating that regulators prefer any earnout to no earnouts. However, they have a stronger preference for two-way earnouts. The likelihood of M&A activities with two-way earnouts obtaining regulatory approval is 2.2 times greater than of those with one-way earnouts, and the average regulatory time is shortened by 1.09 months. In summary, regulators have a stronger preference for high-quality earnouts, which aligns with their efforts to enhance the efficiency of the M&A market and protect investors through implicit regulation.

Next, to further address the endogenous nature of earnouts usage, we conduct the following empirical analyses. First, we examine whether our results hold after requiring a covariate balance between the treatment and

Robustness Checks.				
Panel A Earnouts Characteristic	cs and Regulatory Approval			
	(1) Pass	(2) RegTime	(3) Pass	(4) RegTime
EarnoutsRelSize	-1.751***	1.190**		
Farnouts	(-2.636) 1 388***	(2.438) -0.777****		
Lamouis	(3 134)	(-3, 633)		
Earnouts_Twoway	(0.12.)	(2.022)	1.451****	-0.582*
Earnouts_Oneway			(3.871) 0.656** (2.393)	(-1.920) -0.327* (-1.799)
Control	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes
N	435	435	435	435
Pseudo/Adj. R^2	0.128	0.173	0.128	0.169
Panel B Entropy Balancing				
		(1)		(2)
		Pass		RegTime
Earnouts		0.773		-0.838***
		(1.390)		(-2.838)
Control		Yes		Yes
Year Fixed Effects		Yes		Yes
Industry Fixed Effects		Yes		Yes
N		435		435
Panel C Oster Test				
	(1)	(2)		(3)
Parameter Assumption	1.3 R ; $\delta = 1$	2.2 <i>R</i>	$\beta; \delta = 1$	$R; \beta = 0$
Estimation	(1)"True" β Bound [-0.4195, -0.3554]	(2) <i>"</i> [—0	True" β Bound 0.8236, -0.3554]	(3) $\delta - 4.0549$

Table 6 Robustness Checks

This table presents the robustness test results on the association between earnouts usage and regulatory approval. Panel A explores the variations in earnout characteristics. Panel B shows results using an entropy balanced sample. Panel C addresses omitted variable bias using Oster's approach. z-statistics or t-statistics are included in parentheses. *, ** and *** indicate statistical significance at the 10 %, 5 % and 1 % level, respectively.

the control sample. We take an entropy balancing approach and require a covariate balance of variables at the M&A characteristic level across the sample with earnouts and the control sample (Hainmueller, 2012). As shown in Panel B of Table 6, the coefficients of *Earnouts* are consistent with those in Table 5. Second, we conduct robustness tests using the method proposed by Oster (2019) to address omitted variable bias. If unobserved omitted variables are present in the model, consistent estimates of the true coefficients can be obtained using the estimator $\beta^* = \beta^*(R_{max}, \delta)$.⁸ Following Oster (2019), we apply the following two methods for our robustness tests: (a) we set δ to 1 and R_{max} to 1.3 times or 2.2 times the current regression fit, and if $\beta^* = \beta^*(R_{max}, \delta)$ falls within the 99 % confidence interval of the estimated parameters, then the results pass the robustness test; and (b) we set R_{max} to 1 times the current regression fit and calculate the value of δ that makes $\beta = 0$, and if the value of δ is greater than 1 or less than 0, then the results are robust. Panel C of Table 6 shows our results. Columns (1) and (2) display the results of using the first method, and the estimated interval of $\beta^* = \beta^* (R_{max}, \delta)$ falls within the 99 % confidence interval [-0.0904, 0.1935], indicating that unobserved variables, which are of equal importance to those observed (including fixed effects), are highly unlikely to render β ineffective or reverse it to positive. Column (3) presents the results of using the second method. The value of δ is -4.0549 and thus less than 0, and implies that the coefficient adjusted for omitted variables should be greater than that obtained from the previous regression, which confirms the robustness of our findings.

5. Additional tests

5.1. Regulatory approval, voluntary earnouts and post-M&A performance

The literature suggests that market-driven earnouts can mitigate valuation risks, reduce information asymmetry, and enhance the performance of the target companies (Pan et al., 2017; Rao et al., 2018). However, Choi (2017) finds that earnouts do not always serve as a sufficient signal of high-quality M&A, as low-quality targets can offer identical earnouts to high-quality targets. Thus acquirers will find it difficult to discern target quality through earnouts. The use of earnouts can then distort resource allocation. Therefore, given the prevalence of earnouts use in China's M&A market, the effect of earnouts should be examined, as this could be influenced by regulatory approval.

To investigate the impact on post-M&A performance of voluntary earnouts under the influence of regulatory approval, we estimate the following regression:

$$TobinQ = \beta_0 + \beta_1 Earnouts + \beta_2 Regulation + \beta_3 Earnouts \times Regulation + \beta_4 Controls + YearFE + IndFE + \varepsilon$$
(4)

where *TobinQ* is the firm value of the acquiring firm in the year following the completion of the M&A deal; *Earnouts* is an indicator variable that equals one if the M&A contract includes earnouts and zero otherwise; *Regulation* is an indicator variable that equals one if the M&A deal requires regulatory approval and zero otherwise; and *Earnouts* \times *Regulation* is the interaction term of *Earnouts* and *Regulation*, which takes a value of 1 when voluntary earnouts could potentially be influenced by regulatory approval.

We focus on the coefficient of the interaction term *Earnouts* × *Regulation* (β_3). A significantly positive value for β_3 indicates that voluntary earnouts have a significant positive impact on the *TobinQ* of the acquiring firm when regulatory approval is required for the M&A activity. Conversely, if β_3 is significantly negative, it suggests that voluntary earnouts lead to worse M&A performance when regulatory approval is required.

Columns (1) to (3) in Table 7 report the results of Model (4). The results in Column (1) indicate that the coefficient of *Earnouts* \times *Regulation* is negative and significant at the 10 % level, suggesting that the use of voluntary earnouts is associated with poorer performance when regulatory approval is required. Additionally, the coefficient of *Regulation* is not significant, indicating that the requirement for regulatory approval for M&A

⁸ This estimator requires setting two parameters: R_{max} and δ . Here, δ represents the selection proportionality, which measures the strength of the relationship between observable variables and the variable of interest compared with the relationship between unobservable omitted variables and the variables of interest. R_{max} represents the maximum goodness of fit of the regression equation if unobservable omitted variables could be observed. In recent years, this method has been widely used in international finance and accounting literature (Call et al., 2018; Green et al., 2019; Cohen et al., 2020).

activities does not necessarily imply better or worse performance. Columns (2) and (3) present the results on the association between earnouts usage and performance for observations requiring regulatory approval and those that do not, respectively. The coefficient of *Earnouts* in Column (2) is negative but not statistically significant, while in Column (3) it is negative and significant at the 1 % level. These results suggest the potential negative consequences of voluntary earnouts under the influence of regulatory approval.

Endogeneity may also affect these results, as M&A activities that include earnouts under the influence of regulatory approval may inherently have higher valuation risks, and thus lead to the observed poorer post-M&A performance. To mitigate for potential endogeneity issues, we replace *Earnouts* in Model (4) with *Earnouts_Resid* (calculated as described in Section 4.2.2) and reexamine the model. *Earnouts_Resid* represents the proportion of earnouts that remains unexplained by market factors, which serves as a proxy variable for earnouts usage influenced by regulatory approval. The results in Columns (4) to (6) of Table 7 confirm those in Columns (1) to (3).

Thus, our results together indicate that implicit regulation in regulatory approval processes may be a plausible explanation for the negative correlation between voluntary earnouts and M&A performance in China. Other studies argue that when information asymmetry or valuation gaps in M&A transactions are minimal or can be mitigated through pre-deal due diligence and discussions, excluding earnouts from M&A contracts is preferable (Datar et al., 2001; Choi, 2017). However, due to both market factors and regulatory preference, earnouts are overused in China, which increases the difficulty of distinguishing good from bad targets and the likelihood of acquiring low-quality targets (Akerlof, 1970; Wang and Fan, 2017). Firms may also over-rely on earnouts at the expense of thorough due diligence, thus increasing post-acquisition risk. Although the regulator's preference is intended to reduce information asymmetry and protect shareholders, it could undermine the effectiveness of voluntary earnouts and adversely affect firm value.

To check the robustness of the findings presented in Table 7, we use an alternative variable, (ZScore),⁹ which captures the distress risk of the acquirer. As Table 8 indicates, we continue to find a value-destroying effect of earnouts influenced by regulatory preference.

5.2. The role of comment letters and market monitoring

The results presented in Section 5.1 indicate that voluntary earnouts are negatively associated with post-M&A performance when regulatory approval is required. Next, we investigate whether the negative effect of voluntary earnouts influenced by regulatory preference can be mitigated by comment letters and market monitoring.

5.2.1. Comment letters

The regulatory process became more visible to the public in 2014 and regulators more frequently sent comment letters. Both these letters and the responses from listed firms are then disclosed. Previous studies find that comment letters from the CSRC before regulatory approval and those from stock exchanges after acquisition both have a positive impact on post-acquisition performance (Li et al., 2019; Sun and Liu, 2022). Therefore, we conduct a heterogeneity analysis of comment letters and their influence on the relation between voluntary earnouts and M&A performance. We construct two dummy variables, $CSRC_Comment$ and $Exchange_Com$ ment, to indicate whether the CSRC/stock exchange provides comment letters during the approval process or after acquisition. We then include $Earnouts \times Regulation \times CSRC_Comment$, $Earnouts \times Regula$ $tion \times Exchange_Comment$, and other relevant interaction terms in Model (4). As Table 9 indicates,¹⁰ the

⁹ According to Altman (1968), ZScore = 1.2X1 + 1.4X2 + 3.3X3 + 0.6X4 + 0.999X5, where X1 represents working capital/total assets, X2 represents retained earnings/total assets, X3 represents earnings before interest and taxes/total assets, X4 represents market value of equity/book value of total liabilities and X5 represents sales/total assets. A lower *ZScore* indicates a higher risk of financial distress for the company.

¹⁰ In the regression model shown in Column (1) of Table 9, the interaction term *Earnout* × *CSRC_Comment* is not included as the CSRC can only raise questions (*CSRC_Comment* =1) when the M&A activity requires regulatory approval (*Regulation* = 1). Therefore, the values of *Earnout*×*CSRC_Comment* and *Earnout*×*Regulation*×*CSRC_Comment* are identical. When both are included in the regression simultaneously, the coefficient estimate for the interaction term *Earnout*×*CSRC_Comment* is automatically absorbed and omitted due to redundancy.

	(1)	(2)	(3)	(4)	(5)	(6)
	Full Sample	$\begin{array}{l} Regulation \\ = 0 \end{array}$	Regulation = 1	Full Sample	$\begin{array}{l} Regulation \\ = 0 \end{array}$	Regulation = 1
	TobinQ	TobinQ	TobinQ	TobinQ	TobinQ	TobinQ
Earnouts $ imes$ Regulation	-0.464*					
	(-1.766)					
Earnouts	-0.468*	-0.282	-0.991^{***}			
	(-1.818)	(-1.718)	(-3.822)			
Earnouts Resid \times Regulation	· · · · ·	· /	· · · ·	-0.793^{**}		
_ 3				(-2.768)		
Earnouts Resid				-0.096	-0.038	-0.809***
Lanto ano_reota				(-0.581)	(-0.244)	(-4.205)
Regulation	0.183			-0.117	(()
Teginarion	(0.697)			(-0.870)		
Diff in Coefficients (p-value)	(01057)		0.015	(01070)		0.006
Control	Yes	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
N	841	273	568	841	273	568
Adi. R^2	0.321	0.405	0.320	0.318	0.401	0.313

Table 7					
Regulatory Approval,	Voluntary	Earnouts	and	Post-M&A	Performance.

This table presents the multivariate OLS results of post-acquisition performance. In Columns (1)-(3), we include *Earnouts, Regulation* and their interactions to examine the impact of earnouts under regulation approval on M&A performance, while in Columns (4)-(6) we replace *Earnouts* with *Earnouts_Resid*. Columns (1) and (4) report the regression results for the full sample, and Columns (2)-(3) or (5)-(6) report the regression results for the subsample requiring regulatory approval (Columns 3 and 6) and those without such requirement (Columns 2 and 5). t-statistics are included in parentheses. *, ** and *** indicate statistical significance at the 10 %, 5 % and 1 % level, respectively.

Table 8 Robustness Checks: Alternative Measure of Post-M&A Performance.

	(1)	(2)	(3)	(4)	(5)	(6)
	Full	Regulation	Regulation	Full	Regulation	Regulation
	Sample	= 0	= 1	Sample	= 0	= 1
	ZScore	ZScore	ZScore	ZScore	ZScore	ZScore
Earnouts × Regulation	-1.495**					
	(-2.299)					
Earnouts	-0.411	0.167	-2.217^{***}			
	(-0.806)	(0.542)	(-5.288)			
Earnouts_Resid × Regulation				-2.066^{***}		
				(-3.674)		
Earnouts_Resid				-0.042	0.169	-2.160^{***}
				(-0.265)	(0.557)	(-4.282)
Regulation	0.067			-0.721*		
	(0.104)			(-2.088)		
Diff in Coefficients (p-value)				0.000		0.000
Control	Yes	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
N	726	224	502	726	224	502
Adj. R ²	0.304	0.476	0.276	0.306	0.475	0.276

This table presents the results of robustness checks for Table 8. The dependent variable is the distress risk of the acquirer (*ZScore*). t-statistics are included in parentheses. *, ** and *** indicate statistical significance at the 10 %, 5 %, and 1 % level, respectively.

Table 9 The Role of Comment Letters.

	(1)	(2)
	CSRC's comment letters <i>TobinQ</i>	Stock exchanges' comment letters <i>TobinQ</i>
<i>Earnouts</i> × <i>Regulation</i> × <i>CSRC_Comment/Exchange_Comment</i>	0.516***	0.859**
	(3.559)	(2.425)
Earnouts \times Regulation	-0.597^{**}	-0.624^{**}
	(-2.158)	(-2.247)
Earnouts × Exchange_Comment		-0.004
		(-0.011)
<i>Regulation</i> × <i>CSRC_Comment</i> / <i>Exchange_Comment</i>	-0.742^{***}	-1.319**
	(-3.348)	(-2.832)
Earnouts	-0.472*	-0.496*
	(-1.785)	(-1.894)
Regulation	0.418	0.508
	(1.490)	(1.713)
CSRC_Comment/Exchange_Comment	-0.179	0.366
	(-0.849)	(1.098)
Control	Yes	Yes
Firm Fixed Effects	Yes	Yes
Industry Fixed Effects	Yes	Yes
N	841	841
Adj. R ²	0.328	0.324

This table reports the multivariate OLS results of post-acquisition performance. We further include two dummy variables— *CSRC_Comment* (whether the CSRC issues comment letters during the approval process) and *Exchange_Comment* (whether the stock exchange issues comment letters post-acquisition)—and their full interactions with *Earnouts* and *Regulation* in the regressions. t-statistics are included in parentheses. *, ** and *** indicate statistical significance at the 10 %, 5 % and 1 % level, respectively.

regression coefficients of *Earnouts* × *Regulation* are significantly negative in both columns and the coefficients of the three-way interaction terms, *Earnouts* × *Regulation* × *CSRC_Comment/Exchange_Comment*, are both significantly positive at least at the 5 % level. These results suggest that while voluntary earnouts negatively correlate with M&A performance when regulatory approval is needed, comment letters can mitigate this negative impact. This highlights the value of regulators' attempts to enhance information disclosure, especially after deal completion.

5.2.2. Market monitoring

Regulators attempt to leverage various market forces to monitor listed companies, to reinforce the role of the market in resource allocation, and encourage the adoption of a registration-based IPO system. Based on the finding in the prior literature that investment banks and financial analysts play significant monitoring roles (Chen et al., 2015; Bradley et al., 2017), in this section we investigate the effects of investment banks and financial analysts on the negative impact of earnouts influenced by regulatory preference. If investment banks and financial analysts facilitate information transmission from listed firms to the capital market, the market can better identify target firm quality through earnouts and therefore mitigate the negative impact of earnouts under regulatory influence.

Column (1) of Table 10 presents the heterogeneity results regarding investment banks' reputations. *AdvRep* is coded as 1 if the investment bank advising the M&A deal is among the top ten brokerage firms, and 0 otherwise. Columns (2) and (3) tabulate the heterogeneity results for the role of analyst monitoring. *Ana* is set to 1 if the number of analysts covering the acquirer is greater than the sample median and zero otherwise, while *Report* equals 1 if the number of analyst reports about the acquirer is greater than the sample median and zero otherwise. In all three columns, we observe significant and positive coefficients on the three-way interactions, suggesting that reputable investment banks and financial analysts mitigate the negative association between earnouts influenced by regulators and post-acquisition performance. This finding supports the argument that market-based mechanisms alleviate the unintended consequences of regulatory approval.

Table 10		
The Role	of Market	Monitoring.

	(1)	(2)	(3)
	Advisor's Reputation	Analyst Following	Analyst Reports
	TobinQ	TobinQ	TobinQ
Earnouts × Regulation × AdvRep/Ana/Report	1.370*	0.861*	0.808*
	(1.768)	(1.758)	(1.894)
Earnouts × Regulation	-0.970*	-0.861*	-0.849*
	(-2.090)	(-1.797)	(-1.957)
Earnouts imes AdvRep Ana Report	-0.930	-0.366	-0.287
	(-1.622)	(-0.965)	(-0.752)
Regulation × AdvRep/Ana/Report	-0.542	-0.417	-0.482
	(-0.995)	(-0.983)	(-1.490)
Earnouts	-0.160	-0.289	-0.320
	(-1.015)	(-0.704)	(-0.845)
Regulation	0.418	0.375	0.416
	(0.933)	(0.913)	(1.141)
AdvisorRep/Ana/Report	0.486	0.076	0.116
	(1.315)	(0.233)	(0.370)
Control	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes
N	841	841	841
Adj. <i>R</i> ²	0.325	0.320	0.320

This table reports the multivariate OLS results of post-acquisition performance. We further include three dummy variables—*AdvRep* (whether the investment bank consulting the deal is reputable), *Ana* (whether analyst following is high) and *Report* (whether the number of analyst reports is high)—and their full interactions with *Earnouts* and *Regulation* in the regressions. t-statistics are included in parentheses. *, ** and *** indicate statistical significance at the 10 %, 5 % and 1 % level, respectively.

6. Conclusion

In this study, we investigate the causes and consequences of earnouts in China's M&A market and present evidence suggesting that these earnouts originate not only from market factors but also from implicit regulation. Based on a sample of M&A deals after the deregulation of mandatory earnouts in 2014, we find that deals requiring CSRC approval are more likely to include voluntary earnouts and those with voluntary earnouts are more likely to obtain regulatory approval and also in a shorter time. This suggests a persistent regulatory preference for earnouts even after the deregulation. We also reveal a negative correlation between voluntary earnouts and post-acquisition performance when the M&A deal requires regulatory approval, indicating the unintended negative impact of regulatory-influenced voluntary earnouts. However, we find that this negative effect can be mitigated through comment letters and external monitoring from information intermediaries.

Our study provides various policy implications. First, we find that regulatory inertia remains after explicit regulation is relaxed and brings unintended consequences. Regulators should thus consider both the direct and indirect effects of regulatory policies. Second, our study suggests that in the M&A market, information disclosure enhances M&A contract effectiveness, which highlights the importance of the tradeoff between regulation and marketization in China. Finally, the parties in M&A deals should prioritize the gathering and sharing of information pre-transaction, rather than simply using earnouts to reduce information asymmetry and valuation uncertainties.

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 definition

Variable	Definition
Key Variables	
Earnouts	An indicator variable that equals one if an M&A deal includes earnouts, and zero otherwise.
Regulation	An indicator variable that equals one if an M&A deal requires regulatory approval, and zero otherwise.
Pass	An indicator variable that equals one if an M&A deal obtains regulatory approval, and zero otherwise.
RegTime	The time taken in the regulatory approval process, calculated as the number of days from the start of the review process to the approval date divided by 30.
Control Variabl	les
Firm-level chard	acteristics
Size	The natural logarithm of total assets of the acquirer.
Lev	The ratio of total liabilities to total assets of the acquirer.
Largest Holder	Stock ownership of the largest shareholder of the acquirer.
ROE	Net income to equity of the acquirer.
SOE	An indicator variable that equals one if the acquirer is a state-owned enterprise, and zero otherwise.
EPS	Earnings per share of the acquirer.
Board	An indicator variable that equals one if the acquirer is listed on the Growth Enterprise Market, and zero otherwise.
Dual	An indicator variable that equals one if the acquirer's CEO also assumes the role of chairman, and zero otherwise.
Deal-level chard	acteristics
Share	The percentage of ownership acquired.
EvaRatio	Evaluation value-added ratio, calculated as (valuation – book value)/book value.
MergerSize	The relative size of the transaction, calculated as the total transaction value/total assets of the acquirer.
RS	An indicator variable that equals one for related-party acquisition, and zero otherwise.
BackDoor	An indicator variable that equals one for backdoor listing, and zero otherwise.
PayShare	An indicator variable that equals one for stock payment, and zero otherwise.
TargetNo	An indicator variable that equals one if the target firm is unlisted, and zero otherwise.

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Rumors and price efficiency in stock market: An empirical study of rumor verification on investor Interactive platforms

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ABSTRACT

Using rumor verification data from investor interactive platforms, we investigate the effect of stock market rumors on price efficiency. We find favorable rumors are positively correlated with stock price synchronicity, while unfavorable rumors are negatively correlated with stock price synchronicity. Both favorable and unfavorable rumors are positively correlated with stock mispricing levels, and stock price crash risk. Mechanism tests reveal that favorable rumors about industry leaders have industry spillover effects. The effect of rumors on mispricing levels and stock price crash risk are more pronounced when there are more retail investors. Further analysis shows stronger detrimental impacts of rumors on price efficiency for small-cap companies, companies with low information transparency and companies with low institutional ownership.

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1. Introduction

Rumors, defined as "an unverified account or explanation of events" (Peterson and Gist, 1951, p159), constitute a pivotal informal channel for information in stock markets. Although rumors are often unattributed or unconfirmed, investors tend to adopt a "better safe than sorry" attitude, epitomized by the adage "Buy on the rumors, sell on the news." A large number of studies document the significant stock market impact of rumors (Lloyd-Davies and Canes, 1978; Zhao et al., 2010; Ahern and Sosyura, 2015). In recent years, with the rapid development of the Internet and new media technology, rumors are disseminated through social media networks in a multipoint and multidirectional fashion, leading to the rumor mill phenomenon.

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Furthermore, the open sharing and rapid dissemination features of the Internet enable even individuals without professional expertise and social influence to spread rumors on platforms such as stock forums, Weibo or WeChat, potentially triggering drastic market fluctuations. In China's stock market, there is no shortage of rumor-mongering via social media, with participants including retail investors, market manipulators, We-Media¹ and insiders of listed companies posting anonymously on online forums. For instance, in one false information case reported by the China Securities Regulatory Commission (CSRC), the chairman of a listed company instructed the secretary to post rumors about the company's restructuring on the Eastmoney stock forum, which was followed by a clarifying announcement from the company regarding these rumors.²

Rumors take various forms, especially in recent years. For example, numerous so-called "stock market short essays" internet posts³ have emerged covering information ranging from corporate events to industry themes and from individual stocks to macro policies, often containing a large amount of subjective and exaggerated valuation analysis. Such rumors, replete with easily embellished soft information, pose significant challenges for ordinary investors seeking to discern value relevance and are thus a focal point of regulatory rectification efforts.

The core characteristics of a rumor is its unverified nature (DiFonzo and Bordia, 2007). On the one hand, rumors may contain truthful information if they are based on insiders leaking sensitive details or analyses by stock market gurus. On the other hand, rumors may consist of noise if they are spread by investors, We-Media accounts and company insiders driven by irrational motives such as emotional venting and entertainment or by opportunistic motives to manipulate the market. Van Bommel (2003) points out that rumors primarily exist in the form of vague information that is a mix of truth and lies. The vague nature of rumors often has industry-wide effects. Take the common phenomenon of "riding the hotspots" in the stock market as an example: interest in a single hot topic may spread through an entire industry sector or a rumor about macro policies can impact the stock prices of multiple related companies. Consequently, rumors can cause multiple stocks within the same industry to experience severe concurrent price rises or falls, making it difficult to isolate firm-specific information.

In China's stock market, where there is a high number of retail investors and a speculative atmosphere is prevalent, investors often follow rumors indiscriminately, and thus even false rumors can have significant effects on stock trading. Even when a rumor contains true information, distortion can occur over multiple transmissions. When rumors are predominantly noise and investors blindly speculate, stock prices can severely deviate from the true value of the assets. A stock price's reaction to rumors exhibits emotionally abnormal fluctuations; when rumors are confirmed or debunked, the market often fails to return to rationality promptly. Driven by irrational factors such as expectation biases, negative biases and confirmation bias, investors engage in risk-averse behaviors such as closing positions or selling off, exerting tremendous downward pressure on stock prices and rapidly increasing the risk of a stock price crash.

We collect rumor verification data from investor interactive platforms including Shanghai Stock Exchange e-Interaction and Shenzhen Stock Exchange Interactive Easy to study the impact of rumors on stock market price efficiency. The rumor verification data on these interactive platforms reflect the information needs of investors, and the rumors of interest to investors are more likely to influence their trading decisions than other rumors. The interactive platforms are operated and supervised by the exchanges, and listed companies have no right to delete or edit the content initiated by investors. Thus, they provide a more complete presentation of stock market rumors than other sources.

Our results show that the number of corporate rumors is significantly and positively correlated with stock price synchronicity. Favorable rumors significantly increase stock price synchronicity, whereas unfavorable rumors significantly decrease it, indicating that favorable rumors lead to stock price co-movement at the market and industry levels, whereas unfavorable rumors cause idiosyncratic fluctuations in the stock price. At the same time, both favorable and unfavorable rumors significantly increase the level of mispricing and stock price crash risk, indicating that rumors distort price discovery and damage price efficiency in the stock market.

 $^{^{1}}$ "We-Media" refers to individuals or organizations who utilize social media, blogs, video websites, and other channels for information dissemination and content creation.

² http://www.csrc.gov.cn/csrc/c100200/c1000418/content.shtml.

³ http://www.news.cn/2023-07/17/c_1212245081.htm.

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Mechanism tests reveal that, on the one hand, although leading companies have a lower probability of being involved in rumors, when industry leaders are embroiled in them, the likelihood of favorable rumors occurring in other companies within the same industry is higher and the impact of favorable rumors on stock price synchronicity is stronger than if the rumors are about companies that are not industry leaders.

On the other hand, from the perspective of trend-following investors, when a company has a large number of retail investors, the adverse effects of rumors on mispricing and stock price crash risk are more pronounced than when there are a small number of retail investors. Moreover, our heterogeneity analysis based on asymmetric company information indicates that rumors have a more significant negative effect on price efficiency for companies that are smaller, less transparent and with a lower proportion of institutional ownership than for their counterparts. Tests of the market reaction to rumors find that rumors lead to an inflated stock price, but a significant reversal occurs in the short term, further demonstrating that rumors only introduce shortterm irrational fluctuations in stock prices and do not facilitate the revelation of true information.

The main contributions of this study are as follows. First, it enriches research on the economic consequences of stock market rumors. We analyze the impact of rumors on stock market price efficiency from an informational perspective. Rumors, as a special form of information, are extensively produced (Lei et al., 2016), and information is a core factor in the asset pricing process. By examining the impact of rumors on stock price synchronicity, mispricing and stock price crash risk, this study demonstrates that stock market rumors damage the pricing efficiency of China's stock market. Our findings are consistent with the conclusions of Peng and Tang (2019). Focusing on the value relevance of accounting earnings, Peng and Tang (2019) find that rumors distract investors' limited attention and raise doubts about the quality of corporate information disclosure, leading investors to reduce the weight of accounting earnings in their decision-making information set. We analyze multiple aspects of price efficiency, including the incorporation of firm-specific information into stock prices, the deviation of stock prices from fundamental value and the risk of significant stock price declines, providing comprehensive empirical evidence for the negative impact of rumors on stock market price discovery and capital allocation efficiency. Our findings regarding the relationship between rumors and stock price synchronicity are inconsistent with those of Cai et al. (2023). Cai et al. (2023) find that rumored firms have lower stock price synchronicity than do firms without rumors, suggesting that rumors incite investor emotions. Cai et al. (2023) mainly focus on the quantity of rumors rather than their content (favorable or unfavorable orientation), and their data are drawn from companies' clarification announcements. Our study detects heterogeneous effects of favorable and unfavorable rumors on stock price synchronicity: favorable rumors increase stock price synchronicity, whereas unfavorable rumors decrease it. We draw our rumor data from investors' rumor verifications on investor interactive platforms. Clarification announcements are issued by listed companies, and management may selectively respond to stock market rumors. In particular, they may focus on clarifying unfavorable rumors to eliminate negative market reactions. In contrast, the data on investors' rumor verification platforms reflect investors' information needs, especially those of ordinary investors, which are closely related to investors' trading decisions. The rumor sample in this study contains a high proportion of favorable rumors, hence we find that rumors, overall, exhibit a significant positive correlation with stock price synchronicity.

Second, this study enriches research on the factors influencing stock market price efficiency. Asset pricing is the core function of the stock market and the basis for the efficient allocation of resources. The stock market is essentially an information market, and the process of price discovery is the process of information being gradually revealed through trading. The producers, intermediaries and users of information, as well as the trading mechanisms, all significantly influence the price discovery process in stock markets. Research shows that listed companies (Jin and Myers, 2006; Xu and Xu, 2015), analysts (Zhu et al., 2007; Xu et al., 2012), media (You and Wu, 2012; Kim et al., 2014), investors (Daniel et al., 1998; Kumar and Lee, 2006) and short sellers (Miller, 1977; Hong and Stein, 2003) all have important effects on stock market price efficiency. We focus on a special form of information in the market, i.e., rumors. The sources of rumors are difficult to identify and a large number of participants are involved in the diffusion process. Rumors are commonly used by market manipulators as a manipulation tactic, and uninformed investors often engage in herd trading based on rumors. With the development of social media, the rapid spread of rumors can trigger "enthusiastic public attention" (Huberman and Regev, 2001, p387). This study provides empirical evidence of the negative stock market effects of rumors from the perspective of price efficiency. The rest of the paper is organized as follows. The second section offers a theoretical analysis and hypothesis development. The third section outlines the research design. The fourth section gives the empirical test results. The fifth section presents the research conclusions.

2. Theoretical analysis and hypothesis development

2.1. Theoretical analysis

Information is the core element of the price discovery process for assets, guiding the market to allocate resources. Under the efficient market hypothesis, all relevant information is revealed in stock prices in a timely manner. Information can pertain to three levels: market level, industry level and firm level (Roll, 1988; You, 2017). However, due to factors such as information costs, transaction costs and investors' bounded rationality, stock prices cannot reveal all value-relevant information in a timely manner. Therefore, a completely efficient market does not exist (Grossman and Stiglitz, 1980; Hirshleifer and Teoh, 2003). When stock prices contain limited company-specific information and more generally reflect market and industry-level information, they exhibit co-movement with market- and industry-level average returns. Furthermore, micro-market structure theory indicates that asset prices only partially reveal the true value of assets, with equilibrium prices containing noise (Grossman and Stiglitz, 1980). Value-relevant information helps stock prices reflect a company's fundamental value, while noise distracts investors and interferes with their trading decisions, causing stock prices to deviate from the fundamental value of the company. In this process, rumors exert a significant impact on investors' expectations, emotions and risk attitudes. The dissemination of rumors and related stock price volatility further exacerbate the transmission of irrational sentiments among uninformed investors. Investors experience significant emotional fluctuations in instances of frustrated expectations, thereby heightening stock price crash risk.

We select three indicators to depict price efficiency: stock price synchronicity, mispricing and stock price crash risk. First, stock price synchronicity reflects the information content of stock prices, including firm-specific information and industry/market-wide macro information. Most studies find that stock price synchronicity negatively correlates with price efficiency (Morck et al., 2000; Hutton et al., 2009). However, some argue that stock price synchronicity is positively related to price efficiency (Wang et al., 2009), as high synchronicity implies less noise trading when fluctuations in individual stocks are mainly noise-driven. Thus, stock price synchronicity measures how much of the variation in individual stock returns can be explained by industry/market-wide returns. Further tests are needed to examine whether the information in rumors consists of noise. Second, mispricing reflects the deviation of stock prices from fundamental value. If rumors increase mispricing, it can be inferred that the industry/market-wide information incorporated into stock prices has low relevance to companies' fundamental value, indicating that rumors largely act as noise. Finally, analyzing how rumors influence investors' risk attitudes helps to clarify the role of rumors in price discovery. If rumors exacerbate investors' irrational biases, the likelihood of stock price crashes will significantly increase, further proving that rumors distort stock market pricing mechanisms.

Information asymmetry has a strong effect on price efficiency. Studies consistently find a significant positive correlation between information asymmetry and stock price synchronicity, mispricing and the risk of stock price collapse (Hutton et al., 2009; Xu and Xu, 2015; Bian et al., 2022). Moreover, research reveals significant correlations among these variables. Durnev et al. (2003) find that stocks with lower stock price synchronicity contain more future earnings-related information in their prices, indicating a negative relationship between stock price synchronicity and price efficiency. Jin and Myers (2006) find that higher crash frequencies are associated with higher stock price synchronicity. Zhang et al. (2019) find a significant positive correlation between stock price overvaluation and stock price crash risk. These variables reflect price efficiency from three aspects, with different emphases but close associations.

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2.2. Hypothesis development

Investors may obtain corporate information from various channels, including company disclosures, media reports, analyst research and "grapevine" rumors transmitted by friends, family or social media networks. Unconfirmed information in the stock market fits with the definition of rumors used in communication and social psychology studies. Rumors are unverified or of unknown origin (Schmidt, 2020) and often arise in uncertain situations (DiFonzo and Bordia, 2007). The risky nature of stock markets makes them a breeding ground for rumors. In China's stock market, with its large number of retail investors and a strong speculative atmosphere, coupled with the rapid development of the Internet and new media, rumors have become a severe problem, disrupting market order and aggregating market risks. The phenomenon of speculation on hot topics is closely related to rumors. Rumors related to economic and industrial policies have a wide-reaching impact,⁴ and rumors concerning products, raw materials and leading companies can spill over to multiple companies in the industry chain.⁵ Vague rumors often lead uninformed investors to engage in shadow-chasing speculation.⁶ Although rumors may contain some truth, they manifest more like noise due to their mixing of truth with lies; such noise often diffuses across supply chains, industries, conceptual sectors and even the entire market. The core factor influencing stock price synchronicity is the extent to which stock prices reflect company-specific information. The generation and spread of rumors are influenced by industries and market factors, thus significantly affecting the integration of company-specific information into stock prices. Thus, our first hypothesis is as follows.

H1: Corporate rumors have a significant impact on stock price synchronicity.

The information in rumors is diverse, and market participants engage in the creation and spread of rumors for various motives. DiFonzo and Bordia (2007) summarize three main motives for participation in rumor dissemination: the fact-finding motive, which involves using informal channels to obtain information to alleviate the anxiety due to feeling a lack of control; the relationship-enhancing motive, which involves sharing rumors to improve one's social network; and the self-enhancement motive, which involves actively spreading rumors that are consistent with one's beliefs, opinions, attitudes and expectations. On the one hand, informed traders may pass on some or all of their private information on social media platforms out of a desire to show off or gain Internet influence (Chen et al., 2014). Such rumors often have informative content, but this may become distorted or falsified through continuous transmission. On the other hand, regardless of whether they possess private information, market manipulators might spread rumors or stimulate existing ones to evolve and spread further, thereby inducing investors to engage in herd trading and affecting market transactions (Allen and Gale, 1992).

Van Bommel (2003) points out that when market manipulation motives are dominant, rumors often consist of a mixture of truth and lies. In addition, when significant fluctuations occur in stock trading, uninformed investors observe the anomalies but fail to promptly obtain relevant information from reliable sources. Accordingly, they assume the existence of information suppression or the leakage of insider information and, driven by anxiety, distrust and other emotions, they may post on Internet discussion sites out of factfinding motive. These kinds of rumors are primarily speculative in nature.

The above analysis suggests that although rumors may contain some truth, the amount of true information is limited. Furthermore, the "distortion and strange loop" phenomenon leads to the continuous evolution of rumors (Guo, 2011, p88), ultimately causing them to overall act as noise. Uninformed investors with bounded

⁴ The Chinese government has implemented a series of policies for classifying garbage since 2017. Companies in the related industry have been subject to rumors about topics such as garbage treatment projects, technology and the production of related equipment.

⁵ The price of hexafluorophosphate, a raw material for lithium batteries, has increased, and related rumors about production capacity and prices have emerged in connection with many listed companies such as Do-Fluoride (002407), China Mineral Resources (002738) and Tianji Shares (002759).

⁶ Rumors circulated in 2017 that "Tesla's Shanghai factory must form a joint venture with a Chinese company"; Shanghai Electric (601727) and Shanghai Lingang (600848) were mentioned in the related speculations.

rationality may mistakenly treat noise as value-relevant information and trade on it (Black, 1986). Thus, rumors generally act as noise, increasing the deviation of stock prices from the company's fundamental value. Accordingly, our second hypothesis is as follows.

H2: Corporate rumors are positively related to the degree of stock price deviation from fundamental values.

Although the reliability of rumors cannot be guaranteed, they still have a significant impact on the market transactions of stocks, and a company's ability to clarify rumors is limited (Zhao et al., 2010; Liu and Zhang, 2012; Jia et al., 2014). Behavioral finance theory points out that investors are boundedly rational and often exhibit behavioral biases in investment decisions (Daniel et al., 1998). They overestimate the reliability of the information they hold, including hearsay, and overreact to rumors (Ahern and Sosyura, 2015). At the same time, rumors divert investors' attention and cause investors to question whether a company has undisclosed matters (Peng and Tang, 2019), leading to an underreaction to the company's disclosures. Finally, Lei et al. (2016), using behavioral experimental evidence, find that even completely false information can affect investors' emotions and thus affect their risk attitudes and decisions. In particular, rumors that involve hot concepts or themes are more likely than other rumors to be favored and pursued by investors. In summary, most investors hold an irrational "better to believe than not" attitude toward rumors, often engaging in herd trading based on rumors. When a company is the subject of favorable rumors, investors' expectations of the company's fundamentals and prospects are raised. If there is subsequently no substantial positive evidence or the favorable rumors are debunked, expectation disconfirmation will trigger panic, anger and other negative emotions among investors, leading them to sell off the stock. When a company is the subject of unfavorable rumors, due to negative bias in individual decision-making, investors believe that the company has hidden negative information, and even if the company denies it, investors may maintain a skeptical attitude and sell the stock to avoid risk. In summary, the emergence of rumors intensifies stock price crash risk, further distorting the stock market's pricing mechanism. Thus, our third hypothesis is as follows.

H3: The number of corporate rumors is positively related to stock price crash risk.

3. Research design

3.1. Sample selection and data source

Our research sample consists of all A-share companies listed on the SSE or SZSE from 2017 Q1 to 2020 Q4, excluding financial and ST companies. We use rumor data from the "Rumor Verification" column of Eastmoney.com, which originates from the Q&A sections of Shanghai Stock Exchange e-Interaction and Shenzhen Stock Exchange Interactive Easy. These are official platforms on which investors interact with listed companies and seek confirmation of rumors from the relevant companies. Questioners often use phrases such as "rumor has it," "it is said," and "online rumors" to refer to rumors with unclear sources. We take the texts of the questions as our rumor sample, with the day of the question being considered the day the rumor is active. The final sample of rumors contains 33,913 rumors, 25,386 of which are favorable (74.86 %), about 3,545 companies. The media report data are from the CNRDS database and include rumors published in online financial news and financial newspapers. Other data are from the CSMAR database. In the empirical tests, observations with missing variable values are excluded and all of the continuous variables are winsorized at the 1st and 99th percentiles.

3.2. Definition and calculation of main variables

3.2.1. Rumor variables

The main dependent variables are $Rumor_{i,q}$, $Rpos_{i,q}$ and $Rneg_{i,q}$, which represent the number of rumors, the number of favorable rumors and the number of unfavorable rumors about firm *i* in quarter *q*, respectively. Referring to the classification of rumors by Zhao et al. (2010), a rumor is defined as favorable when it contains information that may positively affect the company's performance, operations, dividend distribution, etc. Otherwise, the rumor is considered unfavorable. For example, company orders, M&As and high dividends

are favorable rumors, while performance declines, share reductions and legal disputes are unfavorable rumors. We label each rumor as favorable or unfavorable using a machine learning method. Specifically, we convert the words in the rumor text into word vectors using Word2Vec. Word2Vec is a deep learning algorithm based on the neural networks proposed by Mikolov et al. (2013). It transforms individual words in a text into vectors in a single high-dimensional space through training and transforms the processing of the text into operations of word vectors accordingly. Then we classify each rumor as favorable or unfavorable using a support vector machine model and construct a word-list as a supplemental classification procedure. We list 10 typical examples of favorable and unfavorable rumors in the Appendix.

3.2.2. Stock price synchronicity

Following Durnev et al. (2003) and Hou and Ye (2008), R^2 is the coefficient of determination in the estimation of Model (1). Then Model (2) is used to logarithmize R^2 to obtain the stock price synchronicity index (SYN) for firm *i* in quarter *q*. A higher value of SYN indicates that a lower amount of firm-specific information is incorporated into the stock price.

$$R_{i,t,q} = \beta_0 + \beta_1 R_{m,t,q} + \beta_2 R_{ind,t,q} + \epsilon \tag{1}$$

$$SYN_{i,q} = Ln\left(\frac{R^2}{1-R^2}\right) \tag{2}$$

where $R_{i,t,q}$ is the return for firm *i* on day *t* of quarter *q*, $R_{m,t,q}$ is the market return on day *t* of quarter *q* and $R_{ind,t,q}$ is the value-weighted industry return on day *t* of quarter *q* excluding firm, where industry classifications are based on the CSRC 2012 standards.

3.2.3. Mispricing

Two methods are used to measure the degree of deviation between the stock price and the company's fundamental value. First, following Hertzel and Li (2010) and You and Wu (2012), Model (3) is regressed by industry and by quarter to generate multiple estimated values of $\hat{\beta}$, then the average value of $\hat{\beta}$ for each indus-

try and quarter is calculated. We predict the fundamental value of firm i(V) using β and each firm's accounting data. Finally, based on Model (4), the mispricing index *Mispl* for firm i in quarter q is constructed as follows:

$$LnM_{i,q} = \beta_0 + \beta_1 B_{i,q} + \beta_2 Ln(NI)_{i,q}^+ + \beta_3 I_{(<0)} Ln(NI)_{i,q}^+ + \beta_4 Lev_{i,q} + \epsilon$$
(3)

$$Misp_{i,q} = Ln\left(\frac{M}{V}\right) \tag{4}$$

where *M* is the firm market value; *B* is the book value of total assets; (NI) + is the absolute value of net income; I(<0) is a dummy variable that takes the value of 1 when net income (NI) is negative and 0 otherwise; and *Lev* is the debt-to-assets ratio.

Second, following Zhang and Zhu (2014), Model (5) is regressed by industry and by quarter, where *Tobin's* Q represents the valuation of the listed company, *Size* is the natural logarithm of total assets, *Lev* is the debtto-assets ratio, *ROA* is the return on total assets and the regression residual $\tilde{\varepsilon}$ represents the part of the company's market valuation that deviates from its intrinsic value. The regression residual $\tilde{\varepsilon}$ is standardized to obtain the asset mispricing index *Misp2* for firm *i* in quarter *q*.

$$Tobin'sQ = \beta_0 + \beta_1 Size_{i,q} + \beta_2 Lev_{i,q} + \beta_3 ROA_{i,q} + \epsilon$$
(5)

3.2.4. Stock price crash risk

Following Kim et al. (2011), two indicators are constructed to measure the stock price crash risk index for firm *i* in quarter *q*: the stock negative return skewness ($NCSKEW_{i,q}$) and the down-to-up volatility measure ($DUVOL_{i,q}$). First, Model (6) is regressed using daily return data of the market and individual stocks to obtain residuals, which measure the probability of a stock price crash for firm *i*.

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$$R_{i,t,q} = \beta_0 + \beta_1 R_{m,t-2,q} + \beta_2 R_{m,t-1,q} + \beta_3 R_{m,t,q} + \beta_4 R_{m,t+1,q} + \beta_5 R_{m,t+2,q} + \varepsilon$$
(6)

where $R_{i,t,q}$ is the daily return of stock *i* on day *t* of quarter *q*, $R_{m,t,q}$ is the market return on day *t* of quarter *q* and the residual ε represents the degree to which the daily return of stock *i* deviates from the market return. The more negative and the smaller the value of ε , the greater the probability of a crash for stock *i*. Taking the logarithm of $\varepsilon + I$, we obtain the idiosyncratic return $W_{i,q}$ for stock *i* in quarter *q*, which is then used in Model (7) to calculate the stock negative return skewness (*NCSKEW*).

$$NCSKEW_{i,q} = -\left[n(n-1)^{\frac{3}{2}} \sum W_{i,q}^{3}\right] / \left[(n-1)(n-2)\left(\sum W_{i,q}^{3}\right)^{\frac{3}{2}}\right]$$
(7)

where n is the number of trading days for stock i in quarter q. The larger the value of *NCSKEW*, the greater the risk of a stock price crash.

Next, *DUVOL* is calculated using Model (8). Days when the idiosyncratic return $W_{i,q}$ for stock *i* in quarter *q* is less than its quarterly average are defined as down days, and days when $W_{i,q}$ is greater than its quarterly average are defined as up days. The standard deviations of the idiosyncratic returns $W_{i,q}$ on down days and up days are separately calculated to obtain downward volatility $(\sum_{down} W_{i,q}^2)$ and upward volatility $(\sum_{up} W_{i,q}^2)$, respectively. n_d is the number of down days, and n_u is the number of up days. The larger the value of *DUVOL*, the greater the risk of a stock price crash for stock *i* in quarter *q*.

$$DUVOL_{i,q} = ln \frac{(n_u - 1)\sum_{down} W_{i,q}^2}{(n_d - 1)\sum_{up} W_{i,q}^2}$$
(8)

3.3. Model

Model (9) serves as the main test model to examine the relationship between corporate rumors and stock market price efficiency.

$$PriceInefficiency_{i,q} = \beta_0 + \beta_1 Rumor_{i,t} (Rpos_{i,t}/Rneg_{i,t}) + \beta_2 CV_{i,t} + \beta_3 Ind + \beta_4 Year + \varepsilon$$
(9)

The dependent variable *PriceInefficency*_{*i*,*q*} is an inverse indicator for measuring the price efficiency of firm *i*, and a larger value for the proxies for *PriceInefficency*_{*i*,*q*} implies lower price efficiency in the stock market. The proxies include (1) the stock price synchronicity index (*SYN*); (2) the level of stock mispricing (*MISP1* and *MISP2*); and (3) stock price crash risk (*NCSKEW* and *DUVOL*). The explanatory variables are the total number of rumors (*Rumor*), the total number of favorable rumors (*Rpos*) and the total number of unfavorable rumors (*Rneg*) for firm *i* in quarter *q*. The model controls for other information events of the company, including the total number (*Media_num*) and the average tone (*Media_sent*) of media reports, as well as the total number (*Ann_num*) and the average tone (*Company announcements*) is calculated by dividing the difference between positive and negative media reports (company announcements) by the total number of media reports (company announcements) by the market-adjusted excess returns on announcement days; if the excess return is greater than 0, the announcement tone is deemed positive; if the excess return is less than 0, the announcement tone is deemed negative; and if the excess return is greater tone to 0, the announcement tone is deemed neutral.

The other control variables are corporate size (*Size*, the natural logarithm of total assets), debt-to-assets ratio (*Lev*), return on total assets (*ROA*, net profit/total asset balance), revenue growth rate (*Growth*), valuation level (*TobinQ*, total market value/book value), average stock return rate (*AvgRet*, the average of daily returns for the quarter), stock return volatility (*Volat*, the natural logarithm of the standard deviation of daily returns for the quarter), turnover rate (*Turnover*, the average of daily turnover rates for the quarter), proportion of shares held by the largest shareholder (*Top1*), concentration of ownership (*Herf5*, the sum of the squares of the proportions of shares held by the top five shareholders), size of the board of directors (*Board*, the natural logarithm of the number of board members), proportion of independent directors (*Indep*, the proportion of independent directors on the board), institutional shareholding ratio (*InstHold*), analyst following

(*Analysts*, the natural logarithm of 1 plus the number of analysts following the company), state-owned enterprise dummy variable (*SOE*) and the natural logarithm of the number of years since the company's listing (*Age*). The model also controls for industry (*Ind*) and year (*Year*) fixed effects, with standard errors clustered by firm.

4. Empirical results

Table 1

Descriptive Statistics

4.1. Descriptive statistics

Table 1 reports the descriptive statistical results of the main variables. The average number of quarterly rumors (*Rumor*) is 0.568, and the average number of favorable quarterly rumors (*Rpos*) is 0.432, which is consistent with the findings of Zhao et al. (2010) and indicates that the stock market is dominated by favorable rumors (76 %). The standard deviations of the rumor indicators are also large, indicating that there are significant differences in the number of rumors about different companies. In comparison, the number of media reports and the number of company announcements are much higher than the number of rumors, indicating that rumors, as a form of gossip, are not the main sources of information in the stock market. We use the investor verification data from the interactive platforms as proxies for rumors often give the impression of being everywhere, that is the consequence of rumors being widespread. We replace the explanatory variables, i.e., the number of favorable and unfavorable company rumors (*Rpos*, *Rneg*), with dummy variables indicating whether favorable or unfavorable company rumors appear in the quarter (*Drpos*, *Drneg*) in a robustness test.

	Ν	Mean	Std. Dev.	Min	Median	Max
SYN	50,662	-0.654	1.032	-4.012	-0.541	1.347
MISP1	47,988	0.029	0.361	-0.549	-0.041	1.286
MISP2	50,609	-0.041	0.833	-1.260	-0.218	4.026
NCSKEW	49,897	-0.386	0.791	-5.943	-0.372	5.852
DUVOL	49,897	-0.284	0.493	-2.823	-0.299	2.826
Rumor	50,742	0.568	1.228	0.000	0.000	7.000
Rpos	50,742	0.432	1.015	0.000	0.000	6.000
Rneg	50,742	0.126	0.401	0.000	0.000	2.000
Media	50,742	3.417	1.233	0.000	3.367	6.937
Msent	50,742	0.169	0.337	-0.786	0.188	1.000
Ann	50,742	1.361	1.623	0.000	0.000	4.357
Asent	50,742	-0.026	0.386	-1.000	0.000	1.000
Size	50,738	22.208	1.333	19.833	22.045	26.244
Lev	50,742	0.404	0.198	0.056	0.394	0.865
ROA	50,742	0.028	0.038	-0.114	0.021	0.157
Growth	46,959	0.164	0.487	-0.668	0.091	3.151
TobinQ	50,742	1.905	1.108	0.839	1.569	7.339
AvgRet	50,742	0.001	0.006	-0.010	-0.000	0.047
Volat	50,742	-3.682	0.422	-4.647	-3.681	-2.047
Turnover	50,742	2.915	3.653	0.162	1.626	21.318
Top1	50,742	33.770	14.490	8.598	31.607	73.186
Herf5	50,742	0.157	0.110	0.016	0.129	0.546
Board	50,736	2.110	0.196	1.609	2.197	2.639
Indep	50,736	0.378	0.054	0.333	0.364	0.571
Inst_hold	50,742	0.418	0.250	0.003	0.431	0.903
Analysts	50,742	1.316	1.238	0.000	1.099	3.871
SOE	50,742	0.304	0.460	0.000	0	1
Age	50,742	2.101	0.909	0.000	2.197	3.332

4.2. Corporate rumors and stock price synchronicity

The regression of the quarterly company data in Model (9), with stock price synchronicity as the dependent variable, examines the relationship between the number of corporate rumors (*Rumor*), the number of favorable rumors (*Rpos*) and the number of unfavorable rumors (*Rneg*) and stock price synchronicity (*SYN*). The results are presented in Table 2. The regression coefficients for the number of corporate rumors (*Rumor*) and the number of favorable rumors (*Rpos*) are significant and positive, while the regression coefficient for the number of unfavorable rumors (*Rneg*) is significant and negative. These results show that it is mainly favorable rumors promote the co-movement of stock prices, which may be closely related to the common practice of hitching on to and speculating on hot topics in the stock market. Unfavorable rumors, in contrast, are firm-specific and positively related to heterogeneous fluctuations in stock prices.

Additionally, the number of media reports (*Media*) is significantly and negatively correlated with stock price synchronicity. The number of company announcements (*Ann*) shows no significant correlation with stock price synchronicity, while the tone of announcements (*Ann*) is significantly and negatively correlated with tone, indicating that company announcements (*Asent*) is significantly and negatively correlated with stock price synchronicity, while the tone of analysts release firm-specific information to the market. The proportion of institutional investor holdings (*InstHold*) is significantly and negatively correlated with stock price synchronicity, while the number of analysts following the company (*Analysts*) is significantly and positively correlated with stock price synchronicity. This demonstrates that various information intermediaries in the market have a heterogeneous impact on stock price synchronicity. Huang and Guo (2014) find that negative media coverage helps to reduce stock price synchronicity, while results of our regression show that a positive tone in media reports is significantly and positively correlated with stock price synchronicity. Positive media coverage may lead to excessive market enthusiasm for a company and its industry peers, exacerbating the co-movement of stock prices. Analysts may also bring market attention to the entire industry, affecting stock price synchronicity in a similar manner. However, given their information into stock prices.

4.3. Corporate rumors and stock mispricing

Stock price synchronicity reflects the extent to which individual stock returns are explained by industry and market-level returns. We find that favorable rumors reduce the amount of firm-specific information in stock prices, while unfavorable rumors increase it. We then further test the impact of rumors on price discovery by using the level of mispricing as the dependent variable for the regression in Model (9). Two mispricing variables, *MISP1* and *MISP2*, are calculated using two methods. The results are shown in Table 3. The regression coefficients for the number of corporate rumors (*Rumor*), the number of favorable rumors (*Rpos*) and the number of unfavorable rumors (*Rneg*) are all significant and positive, indicating that both favorable and unfavorable rumors hinder price discovery in the stock market. Stock market rumors as a whole act as noise, and investors are unable to effectively discern the information in rumors, leading uninformed investors to blindly follow them. Thus, rumors are a kind of friction in the price formation process, exacerbating the deviation of company stock prices from fundamental values.

Barber and Odean (2008) find that stocks covered by the media attract investor attention, resulting in abnormally high trading volumes and returns. The test results show that the number of media reports is significantly and positively correlated with the level of mispricing, suggesting that in China's stock market, media reports also have this spotlight effect. Moreover, media may be paid to conduct biased reporting on companies, and media bias may stir up investors' emotions and lead to pricing errors (Shao et al., 2015). The regression coefficient for the number of company announcements (*Ann*) is significant and negative when *MISP2* is the dependent variable, indicating that company announcements provide value-related information to the market to some extent. However, the regression coefficient for the tone of announcements (*Asent*) is significant and positive, suggesting that favorable announcements may lead to stock prices being too high relative to fundamental values, which could be due to strategic disclosure by companies (Xu et al., 2021) or market overreactions to company announcements.

	SYN	SYN	SYN
	(1)	(2)	(3)
Rumor	0.009^{**}		
	(2.020)		
Rpos		0.018^{***}	
		(3.584)	
Rneg			-0.033^{***}
			(-2.713)
Media	-0.077^{***}	-0.077^{***}	-0.076^{***}
	(-11.439)	(-11.486)	(-11.248)
Msent	0.176	0.176	0.175
	(12.243)	(12.229)	(12.172)
Ann	0.004	0.004	0.004
	(0.886)	(0.903)	(0.900)
Asent	-0.021*	-0.021*	-0.022
~.	(-1.925)	(-1.906)	(-1.998)
Size	0.156	0.155	0.160
•	(13.450)	(13.435)	(13.802)
Lev	-0.472	-0.472	-0.478
	(-9.414)	(-9.409)	(-9.523)
ROA	-0.179	-0.174	-0.176
<i>a</i> 1	(-0.9'/4)	(-0.949)	(-0.959)
Growth	-0.0/4	-0.0/4	-0.0/4
TobinQ	(-6.253)	(-6.233)	(-6.211)
	-0.051	-0.051	-0.051
1	(-3.473)	(-3.401)	(-3.423)
AvgKet	-51.438	-51.551	-51.682
Valatilita	(-28.809)	(-28.830)	(-28.945)
volatility	-0.007	-0.008	-0.002
Turnovar	(-2.803) 0.030***	(-2.943)	(-2.008)
1 иновет	-0.030	(2828)	(8.436)
Tonl	(-8.097)	(-0.828)	(-0.450)
1001	(3,290)	(3,290)	(3 327)
Harf5	0.829***	0.825***	0.853***
110135	(-3,219)	(-3, 205)	(-3, 311)
Roard	0.090*	0.089*	(-5.511)
bouru	(1,733)	(1.728)	(1.700)
Inden	0 401**	0.402**	0.393**
interp	(2.370)	(2.378)	(2.321)
Inst Hold	-0.302***	-0.300****	-0.305***
	(-7, 175)	(-7, 149)	(-7.251)
Analysts	0.040***	0.040****	0.040***
	(5.284)	(5.297)	(5.265)
SOE	0.241***	0.242***	0.239***
	(11.230)	(11.238)	(11.149)
Age	-0.020	-0.021	-0.019
-	(-1.482)	(-1.536)	(-1.393)
Cons	-4.670****	-4.663***	-4.721***
	(-15.731)	(-15.725)	(-15.936)
Ind & Year	Yes	Yes	Yes
N	16 022	16 022	16 022
$\Lambda_{d}; P^2$	40,932	40,932	40,932
Auj. K	0.1/8	0.1/9	0.179

 Table 2

 Corporate Rumors and Stock Price Synchronicity.

Note: *, ** and *** indicate statistical significance at the 10 %, 5 % and 1 % levels, respectively (two-tailed). The t-statistics are given in parentheses below the coefficient estimates. Standard errors are clustered by firm. The same notation applies to the regressions in other tables unless otherwise noted.

	MISP1	MISP1	MISP1	MISP2	MISP2	MISP2
	(1)	(2)	(3)	(4)	(5)	(6)
Rumor	0.006^{***}			0.007^{***}		
	(6.424)			(4.052)		
Rpos		0.007^{***}			0.009^{***}	
		(6.797)	***		(4.449)	**
Rneg			0.009***			0.011***
	0 01 5 ***	0.010***	(3.657)	0.0 00 ***	0.0 00 ***	(2.306)
Media	0.017	0.018	0.018	0.022	0.022	0.022
	(11.337)	(11.423)	(11.465)	(8.306)	(8.358)	(8.397)
Msent	0.002	0.001	0.002	0.006	0.006	0.006
1	(0.599)	(0.527)	(0.649)	(1.148)	(1.102)	(1.1/6)
Ann	-0.001	-0.001	-0.001	-0.006	-0.006	-0.006
Agont	(-1.009)	(-0.982)	(-1.03/)	(-3./45)	(-3.725)	(-3./63)
Asent	(2.577)	(2.552)	0.005	(2, 228)	0.008	(2, 274)
Size	(2.377)	(2.333)	(2.470)	(2.338)	(2.328)	(2.274)
Size	(17, 269)	(17.495)	(17,524)	(52, 025)	0.203	(52,005)
Lan	(17.500)	(17.403) 0.141***	(17.324) 0.140***	(35.055)	(33.087)	(33.093)
Lev	(11.068)	(11 027)	(10.082)	-0.119	-0.119	-0.120
POI	(11.000)	(11.057) 0.244***	(10.962)	(-3.380)	(-3.404)	(-3.426) 2 201***
KOA	-0.343	-0.344	-0.348	-2.200	-2.280	(21.730)
Growth	(-7.072)	0.000***	0.000***	(-21.717)	(-21.700)	(-21.750)
Growin	(-3.476)	(-3, 437)	(-3, 533)	(0.283)	(0.312)	(0.245)
TohinO	0.295***	0.295***	0.295***	0.783***	0 784***	0.783***
1001112	(66 410)	(66442)	(66 259)	(171,114)	(171,078)	(170.827)
AvaRet	$2 140^{***}$	2 089***	2 185***	_5 829***	_5 892***	_5 778***
nogiai	(7 414)	(7, 254)	(7 523)	(-13.059)	(-13, 194)	(-12944)
Volat	0.058***	0.058***	0.059***	0.032***	0.032***	0.034***
,	(13 347)	(13 336)	(13 641)	(4 406)	(4 400)	(4 686)
Turnover	-0.003***	-0.003***	-0.002***	-0.007***	-0.007***	-0.007***
	(-3.585)	(-3.581)	(-3.192)	(-6.019)	(-6.034)	(-5.756)
Top1	-0.001**	-0.001**	-0.001**	-0.002^{**}	-0.002^{**}	-0.002^{**}
1	(-2.101)	(-2.089)	(-2.085)	(-2.520)	(-2.512)	(-2.509)
Herf5	0.073	0.072	0.070	0.138	0.137	0.134
v	(1.192)	(1.170)	(1.130)	(1.364)	(1.351)	(1.319)
Board	0.014	0.014	0.014	0.007	0.006	0.007
	(1.148)	(1.130)	(1.154)	(0.335)	(0.322)	(0.338)
Indep	0.079*	0.079*	0.078*	-0.008	-0.008	-0.009
	(1.828)	(1.817)	(1.803)	(-0.107)	(-0.114)	(-0.126)
Inst Hold	0.064^{***}	0.064^{***}	0.063***	0.067^{***}	0.067^{***}	0.066^{***}
	(6.647)	(6.638)	(6.531)	(4.156)	(4.158)	(4.071)
Analysts	0.023***	0.023***	0.023***	0.001	0.001	0.001
	(11.865)	(11.864)	(11.819)	(0.452)	(0.455)	(0.423)
SOE	-0.007	-0.007	-0.007	-0.010	-0.010	-0.010
	(-1.260)	(-1.291)	(-1.313)	(-1.210)	(-1.230)	(-1.251)
Age	0.013***	0.013****	0.013****	-0.005	-0.005	-0.005
	(3.961)	(3.955)	(4.122)	(-0.949)	(-0.961)	(-0.836)
Cons	-2.074^{***}	-2.078^{***}	-2.082^{***}	-7.869^{***}	-7.873^{***}	-7.879^{***}
	(-20.434)	(-20.512)	(-20.501)	(-63.228)	(-63.299)	(-63.235)
Ind & Year	Yes	Yes	Yes	Yes	Yes	Yes
Ν	46 668	46 668	46 668	46 825	46 825	46 825
Adi. R^2	0.827	0.827	0.827	0 894	0 894	0 894
	0.027	0.027	0.027	0.07 .	0.05 .	0.091

4.4. Corporate rumors and stock price crash risk

Investors make trades based on rumors. When favorable rumors about a company emerge, the stock is chased by investors and its price inflated; when unfavorable rumors occur, investors rush to sell, leading to a sharp decline in the stock price. When investors realize that the actual situation of the company is not as good as expected, or when unfavorable rumors are clarified, the market does not return to rationality but sells off stocks due to negative expectation bias and negative bias, significantly increasing the downward pressure on stock prices and increasing the risk of a significant drop in stock price. We use stock price crash risk as the dependent variable in the regression in Model (9), with stock price crash risk calculated using two methods, *NCKEW* and *DUVOL*. As shown in Table 4, the regression coefficients for the number of corporate rumors (*Rumor*), the number of favorable rumors (*Rpos*) and the number of unfavorable rumors increase stock price crash risk. Most research focuses on the impact of information suppression on stock price crash risk (Hutton et al., 2009; Sun et al., 2017), but investors' emotional fluctuations are also an important factor in stock price crash risk, and we find that rumors, through expectation effects, stimulate irrational investor behavior, further demonstrating the negative impact of stock market rumors on price efficiency.

4.5. Mechanism analysis

4.5.1. Mechanism analysis of stock price synchronicity: Industry spillover effect of favorable rumors

The hyping of hot trends has become a major problem in China's stock market and is the focus of regulatory authorities. A hot topic or concept can often ignite an entire industry chain, causing the stock prices of companies in the industry chain to surge collectively. Rumors and speculative activities are closely related. On the one hand, investors driven by wishful thinking (Allport and Postman, 1947) or market manipulation motives (Van Bommel, 2003) may actively create rumors. The emergence of online forums has significantly reduced the cost of information dissemination, and misleading information spread by ordinary investors can be widely disseminated and cause abnormal fluctuations in stock prices (Aggarwal and Wu, 2006). On the other hand, when corporate rumors appear in the market, investors use interactive platforms to seek confirmation from the listed company, and ambiguous or inaccurate company responses, especially for favorable rumors, can condone or even stimulate the spread of rumors. For example, when blockchain became a market trend, many Internet companies positioned themselves as blockchain concept stocks by disclosing blockchainrelated information on interactive platforms. As a result, their stock prices surged but they also attracted attention and inquiries from the stock exchanges. In fact, these companies did not have substantive technology or business in blockchain; this was typical "catching hotspots" behavior.⁷ Industry-leading companies attract a large amount of market attention, and their business involves multiple upstream and downstream companies. When favorable rumors about industry leaders appear in the stock market, investors may mistakenly speculate that other companies in the industry are also in positive situations, thus favorable rumors spread across the industry. Based on this, we speculate that when there are rumors about industry leaders, the number of rumors about other companies in the same industry will significantly increase, indicating that rumors about industry leaders have industry spillover effects.

Using fundamental leader data from CSMAR, we identify rumors about industry leaders (*Leader*, leading companies are assigned a value of 1, non-leading companies are assigned a value of 0). CSMAR constructs a comprehensive performance score for companies based on indicators in six areas, solvency, operational capability, profitability, growth capability, profit quality and market performance, and selects the top five companies with the highest scores in the industry each quarter as industry leaders. We construct the dummy variable $LdRpos_{i,q}$; if the leading company experiences favorable rumors in quarter q, then for all companies in that industry, $LdRpos_{i,q}$ is assigned a value of 1, and otherwise 0 for quarter q. Leading companies account for 8.01 % of the sample, and 59.78 % of the observations have industry leading companies experienced favorable

⁷ https://www.thepaper.cn/newsDetail_forward_1944407.
Table 4		
Corporate Rumors and S	Stock Price Crash Risk.	

	NCSKEW (1)	NCSKEW (2)	NCSKEW (3)	DUVOL (4)	DUVOL (5)	<i>DUVOL</i> (6)
Rumor	0.015 ^{***} (4.994)			0.009 ^{***} (4.630)		
Rpos		0.012 ^{***} (3.443)			0.008 ^{***} (3.603)	
Rneg			0.050 ^{***} (5.372)			0.026 ^{***} (4.451)
Media	-0.002 (-0.419)	-0.001 (-0.278)	-0.002 (-0.472)	0.002 (0.853)	0.002 (0.972)	0.002 (0.851)
Msent	-0.179^{***} (-16.007)	-0.179^{***} (-16.036)	-0.178^{***} (-15.940)	-0.099*** (-14.519)	-0.099^{***} (-14.552)	-0.099 ^{***} (-14.456)
Ann	0.012***	0.012***	0.012***	0.008***	0.008***	0.008***
Asent	0.018*	0.017*	0.017*	0.009	0.009	0.009
Size	-0.010^{*} (-1.725)	-0.009 (-1.500)	-0.010^{*} (-1.757)	-0.019^{***} (-4.908)	-0.018^{***} (-4.736)	-0.019^{***} (-4.870)
Lev	0.012	0.010	0.012	0.021	0.020	0.021
ROA	0.284^{**} (2.474)	0.285^{**} (2.481)	0.273^{**} (2.374)	0.301**** (4.146)	0.302^{***} (4.160)	0.295***
Growth	0.023^{***} (2.992)	0.023^{***} (3.012)	0.022^{***} (2.891)	0.012^{**} (2.328)	0.012^{**} (2.350)	0.011**
TobinQ	0.040***	0.040^{***} (9.443)	0.039***	0.022*** (7.764)	0.023^{***} (7.810)	0.022***
AvgRet	-45.038^{***} (-34.987)	-45.147^{***} (-35.066)	-44.721^{***} (-34.689)	-39.684^{***} (-45.145)	-39.756^{***} (-45.247)	-39.524 ^{***} (-44.846)
Volat	-0.175^{***} (-12.437)	-0.173^{***} (-12.306)	-0.172^{***} (-12.322)	-0.148^{***} (-16.485)	-0.147^{***} (-16.391)	-0.147***
Turnover	0.037*** (19.622)	0.037*** (19.765)	0.037*** (19.881)	0.021**** (16.414)	0.021**** (16.522)	0.021***
Top1	0.001 (1.037)	0.001 (1.059)	0.001 (1.008)	0.001 (1.060)	0.001 (1.079)	0.001 (1.043)
Herf5	-0.229^{*} (-1.698)	-0.237* (-1.758)	-0.227* (-1.682)	-0.140 (-1.612)	-0.145^{*} (-1.660)	-0.141 (-1.617)
Board	-0.025 (-1.026)	-0.026 (-1.052)	-0.024 (-0.971)	-0.010	-0.011 (-0.666)	-0.010
Indep	0.108 (1.203)	0.106	0.110 (1.219)	0.070 (1.251)	0.069	0.071 (1.253)
Inst Hold	0.022	0.021 (0.935)	0.021 (0.925)	0.023 (1.587)	0.022	0.022
Analysts	0.064 ^{***} (15.501)	0.064 ^{***} (15.483)	0.063***	0.029***	0.029***	0.029 ^{***} (11.405)
SOE	-0.006 (-0.541)	-0.006 (-0.614)	-0.006 (-0.523)	0.009	0.008	0.009
Age	-0.029^{***} (-4.037)	-0.028^{***} (-3.961)	-0.028^{***} (-3.901)	-0.024^{***} (-5.339)	-0.024^{***} (-5.289)	-0.024^{***} (-5.199)
Cons	-0.942^{***} (-6.689)	-0.961^{***} (-6.823)	-0.936^{***} (-6.646)	-0.540^{***} (-5.857)	-0.550^{***} (-5.968)	-0.540****
Ind & Year	Yes	Yes	Yes	Yes	Yes	Yes
N Adj. <i>R</i> ²	46,630 0.075	46,630 0.075	46,630 0.075	46,630 0.124	46,630 0.124	46,630 0.124

$$Rpos_{i,a} = \beta_0 + \beta_1 Leader/LdRpos_{i,a} + \beta_2 CV_{i,a} + \beta_3 Ind + \beta_4 Year + \varepsilon$$
(10)

where the dependent variable (*Rpos*) is the number of favorable rumors for firm *i* in quarter *q*, and the explanatory variables are the dummy variable for the industry leading company (*Leader*) and the dummy variable for the occurrence of good news concerning the industry leading company (*LdRpos*). The control variables are the same as in Model (9). The results are shown in Table 5, columns (1) and (2).

Next, the sample is grouped according to whether there are favorable rumors about the industry leaders, and a subgroup regression analysis is conducted using Model (9). The results are shown in Table 5, columns (3) and (4).

Industry leaders have good corporate governance and information disclosure mechanisms, and their formal information channels are relatively unobstructed, leaving little room for rumors. In addition, industry leaders often perform well both in their operations and in the stock market, thus reducing market manipulators' motivation to engage in hype. Furthermore, industry-leading companies receive extensive market attention, thus rumormongers bear higher reputation risk.

Table 5, column (1) shows that the regression coefficient of the dummy variable for industry leaders (*Leader*) is significant and negative, indicating that there are fewer favorable rumors about industry leaders (*Rpos*) than about other firms. However, as shown in column (2), when there are favorable rumors about industry leaders, there is an increase in favorable rumors about other companies in the same industry. Columns (3) and (4) present the results of the group test based on the dummy variable for whether there are favorable rumors about industry leaders (*LdRpos*). The regression coefficient of favorable rumors (*Rpos*) is significant only in the group where there are favorable rumors about industry leaders (*LdRpos*). The regression coefficient of favorable rumors (*Rpos*) is significant only in the group where there are favorable rumors about industry leaders (*LdRpos* = 1). The research results are consistent with expectations and provide evidence that favorable rumors about industry-leading companies have industry spillover effects.

4.5.2. Mechanism analysis of mispricing and stock price crash risk: From the perspective of trend followers

Aggarwal and Wu (2006) find that information seekers may worsen market efficiency when there are manipulators present. It is generally believed that information seekers contribute to market efficiency by accelerating the incorporation of information into stock prices, but they may also blindly follow rumors or trades, hindering price discovery. Retail investors need to pay higher costs for information acquisition and processing (Blankespoor et al., 2019) and face more severe information asymmetry in trading decisions, so they are more likely to consider rumors as important information supplements. In addition, most retail investors lack the concept of value investment, and speculation and herd trading are prevalent. Rumors are often created and continuously fermented in this process, distorting the price mechanism of the stock market. We measure retail investors' shareholdings by the average shareholdings in the current quarter of the company. When the average shareholdings are lower than the industry-quarter average, it is considered that the company has a higher proportion of retail shareholders (*HighRetail* = 1) and a greater probability of speculative trading based on rumors. Using mispricing indicators (MISP1, MISP2) and stock price crash risk indicators (NCSKEW, DUVOL) as dependent variables, and the number of corporate rumors (Rumor) as an explanatory variable, we rerun Model (9) using groups based on the average number of shares held per household. As shown in Table 6, the positive correlations between rumors and mispricing and stock price crash risk are more significant in samples with a higher proportion of retail investors (HighRetail = 1), and the SUEST tests show significant differences in the coefficients of the groups. The test results indicate that when investors have lower information acquisition and processing capabilities and exhibit more obvious irrational biases in trading, rumors have a stronger negative impact on price efficiency.

4.6. Supplementary tests

4.6.1. Impact of rumors on price efficiency: Heterogeneity analysis on asymmetric information

A good information environment helps to fully integrate firm-specific information into stock prices in a timely manner. When the information disclosed by a company is insufficient, investors find it difficult to dis-

Table 5 Spillover Effects of Favorable Rumors About Industry Leaders.

	Rpos	Rpos	SYN $LdRpos = 0$	SYN LdRpos = 1
	(1)	(2)	(3)	(4)
Leader	-0.059^{***} (-2.650)			
LdRpos	(21020)	0.052***		
Rpos		(5.102)	0.014	0.016***
Media	0.049***	0.046***	(1.631) -0.060^{***}	-0.088 ^{***}
Msent	0.015	(6.247) 0.015	(-6.784) 0.140****	(-11.457) 0.199***
Ann	-0.005	(1.071) -0.007 (1.224)	(6.616) 0.027*** (4.004)	(11.038) -0.010^{**}
Asent	(-0.956) -0.035***	(-1.294) -0.033^{***}	(4.094) -0.028	(-2.118) -0.014
Size	(-3.166) 0.126*** (0.482)	(-2.791) 0.131^{***} (0.260)	(-1.568) 0.121*** (8.212)	(-1.013) 0.170^{***}
Lev	(9.483) -0.196***	-0.231***	(8.213) -0.373***	-0.529***
ROA	(-3.893) -0.352* (-1.920)	(-4.458) -0.355* (-1.842)	(-5.561) 0.391 (1.412)	(-9.880) -0.479^{**}
Growth	(-1.929) -0.017 (-1.522)	(-1.843) -0.020* (-1.745)	(1.412) -0.100^{***} (-6.224)	(-2.248) -0.052^{***}
TobinQ	(-1.522) -0.002 (-0.218)	(-1.743) -0.003 (-0.251)	(-6.324) -0.096^{***} (-7.445)	(-5.581) -0.030^{***}
AvgRet	(-0.218) 4.838*** (2.924)	(-0.331) 5.183 ^{***} (2.065)	(-7.443) -41.177^{***} (-12.487)	(-5.150) -56.979^{***}
Volat	(2.924) 0.279*** (12.502)	(2.965) 0.284 ^{***} (12.120)	(-15.487) -0.160^{***} (-4.784)	-0.021
Turnover	(15.592) 0.055 ^{***} (12.140)	(13.139) 0.056 ^{***} (12.761)	(-4.784) -0.037^{***} (-7.288)	-0.025^{***}
Top1	0.002	0.001	(-7.588) 0.008*** (2.187)	0.005**
Herf5	-0.833***	-0.755***	(3.187) -0.941*** (-2.800)	-0.699** -0.2.460
Board	(-5.522) -0.010 (-0.174)	(-2.991) -0.006 (-0.108)	(-2.890) 0.042 (0.620)	(-2.400) 0.131** (2.415)
Indep	(-0.174) -0.268 (-1.404)	(-0.108) -0.245 (-1.221)	0.342	(2.413) 0.471 ^{***} (2.600)
Inst Hold	(-1.404) -0.195^{***} (-4.688)	(-1.251) -0.211^{***} (-4.839)	(1.317) -0.337^{***} (-6.192)	-0.276^{***}
Analysts	(-4.088) -0.009 (-1.220)	(-4.859) -0.008 (-1.069)	(-0.192) 0.017* (1.729)	0.054***
SOE	(-1.220) -0.061^{****} (-2.580)	-0.067^{***}	(1.729) 0.297^{***} (10.762)	0.207***
Age	(-2.330) 0.094^{***} (7.423)	(-2.703) 0.100^{***} (7.750)	(10.702) -0.021 (-1.213)	-0.015
Cons	(7.423) -1.633^{***} (-5.137)	(7.750) -1.728^{***} (-5.103)	(-1.213) -4.220^{***} (-11.041)	(-1.043) -4.846^{***} (-15.281)
Ind & Year	Yes	Yes	(-11.041) Yes	(-13.281) Yes
N Adj. <i>R</i> ² Difference	46,954 0.100	43,381 0.102	18,891 0.184	28,041 0.184 0.819

Note: The differences in the coefficients are based on *p*-values from seemingly unrelated estimation (SUEST) tests. This is applied to other tests unless otherwise specified.

Table 6			
Subgroup	Analysis	of Retail	Shareholdings.

	MISP1		MISP2		NCSKEW		DUVOL	
	HighRetail = 0	HighRetail = 1						
Rumor	0.005***	0.009***	0.004**	0.012***	0.007	0.021***	0.004	0.014***
	(5.448)	(10.363)	(2.399)	(7.948)	(1.581)	(5.124)	(1.433)	(5.328)
Media	0.018***	0.016***	0.018***	0.028***	-0.009*	0.009*	-0.003	0.009^{***}
	(18.288)	(15.303)	(10.566)	(14.737)	(-1.785)	(1.774)	(-0.833)	(2.771)
Msent	-0.001	0.006*	0.001	0.013**	-0.191***	-0.161***	-0.096***	-0.098^{***}
	(-0.175)	(1.946)	(0.217)	(2.430)	(-12.421)	(-11.093)	(-10.153)	(-11.011)
Ann	0.000	-0.002^{***}	-0.006^{***}	-0.009^{***}	0.014***	0.008**	0.009***	0.006***
	(0.336)	(-3.388)	(-5.323)	(-6.664)	(4.232)	(2.450)	(4.461)	(2.900)
Asent	0.004*	0.004*	0.009*	0.008*	0.035***	-0.001	0.012	0.007
	(1.707)	(1.647)	(1.865)	(1.711)	(2.618)	(-0.069)	(1.447)	(0.889)
Size	0.082***	0.046***	0.296***	0.262***	-0.007	-0.015*	-0.013***	-0.026***
	(58.036)	(26.756)	(117.804)	(83.183)	(-0.951)	(-1.732)	(-2.869)	(-4.960)
Lev	0.168***	0.122***	-0.124***	-0.105^{***}	0.022	0.011	0.025	0.020
	(25.184)	(18.586)	(-10.409)	(-8.713)	(0.630)	(0.346)	(1.172)	(0.982)
ROA	-0.240^{***}	-0.427^{***}	-2.170^{***}	-2.337***	0.553***	-0.049	0.558***	-0.008
	(-8.129)	(-13.682)	(-41.242)	(-40.725)	(3.668)	(-0.312)	(6.053)	(-0.087)
Growth	-0.012***	-0.007^{***}	0.011***	-0.015***	0.019*	0.023**	0.005	0.018**
	(-6.070)	(-2.831)	(2.994)	(-3.462)	(1.887)	(1.982)	(0.841)	(2.538)
TobinQ	0.304***	0.280***	0.785***	0.781***	0.057***	0.029***	0.036***	0.012***
~	(279.779)	(240.994)	(402.937)	(365.487)	(10.188)	(5.083)	(10.382)	(3.387)
AvgRet	3.725***	0.271	-5.642***	-6.472***	-54.979***	-37.300***	-45.535***	-34.864***
0	(11.359)	(0.855)	(-9.635)	(-11.158)	(-31.155)	(-22.381)	(-42.183)	(-34.090)
Volat	0.070^{***}	0.070***	0.043***	0.032***	-0.141***	-0.253***	-0.121***	-0.199***
	(19.131)	(17.361)	(6.590)	(4.304)	(-7.420)	(-12.329)	(-10.447)	(-15.804)
Turnover	-0.011****	-0.001***	-0.018***	-0.005^{***}	0.061***	0.035***	0.035***	0.020***
	(-11.965)	(-2.594)	(-10.998)	(-4.917)	(12.919)	(13.922)	(12.016)	(12.538)
Top1	-0.001****	0.000	-0.002^{***}	-0.000	0.002	0.000	0.001	0.000
	(-5.276)	(1.144)	(-4.384)	(-0.395)	(1.513)	(0.164)	(1.642)	(0.226)
Herf5	0.105***	-0.137***	0.121**	-0.068	-0.336**	-0.125	-0.202^{**}	-0.098
5	(3.425)	(-3.345)	(2.200)	(-0.903)	(-2.139)	(-0.611)	(-2.096)	(-0.782)
Board	0.015**	0.020***	-0.007	0.011	0.026	-0.092^{**}	0.028	-0.063***
	(2.420)	(2.772)	(-0.643)	(0.837)	(0.832)	(-2.528)	(1.488)	(-2.812)
Indep	0.052^{**}	0.081***	-0.064*	0.032	0.212**	-0.009	0.134**	-0.022
	(2.502)	(3.278)	(-1.721)	(0.696)	(1.984)	(-0.072)	(2.044)	(-0.296)
InstHold	0.049***	0.070^{***}	0.027^{***}	0.070^{***}	0.008	0.051*	0.019	0.037**
	(9.001)	(11.848)	(2.797)	(6.435)	(0.275)	(1.738)	(1.107)	(2.029)
Analysts	0.022***	0.024***	-0.001	0.000	0.065***	0.053***	0.030***	0.025***
	(21.806)	(19.633)	(-0.287)	(0.078)	(12.878)	(8.827)	(9.514)	(6.801)
SOE	-0.014^{***}	0.006^{**}	0.001	-0.010*	-0.000	0.001	0.012	0.011
	(-5.614)	(2.033)	(0.205)	(-1.912)	(-0.037)	(0.038)	(1.491)	(1.218)
Age	-0.001	0.029***	-0.020^{***}	0.005	-0.017*	-0.044^{***}	-0.017^{***}	-0.032^{***}
	(-0.437)	(15.707)	(-6.205)	(1.356)	(-1.790)	(-4.750)	(-2.905)	(-5.681)
Cons	-2.192***	-1.631***	-7.803***	-7.714***	-1.119***	-0.911***	-0.739***	-0.385***
	(-61.258)	(-38.339)	(-121.759)	(-98.423)	(-6.094)	(-4.288)	(-6.581)	(-2.952)
Ind & Year	Yes							
Ν	23,833	22,835	24,706	22,119	24,405	22,225	24,405	22.225
Adj. R^2	0.846	0.821	0.899	0.896	0.091	0.066	0.137	0.118
Difference		0.000^{***}		0.000^{***}		0.008^{***}	(0.006***

tinguish between "good" and "bad" companies, and they use market information changes as the basis for evaluating individual stocks (You, 2017). Formal channel information helps investors understand and identify informal channel information. When formal communication channels are unobstructed, investors are less likely to blindly follow rumors in their trading behavior. For companies with a poor information environment, investors' information needs cannot be met, and the fact-finding motive drives them to participate in the spread of rumors (DiFonzo and Bordia, 2007). An opaque information environment also reduces investors' trust in company management. The emergence of rumors strengthens the awareness of uninformed investors of their own information disadvantage and stimulates negative emotions such as anxiety and panic, which then lead investors to develop blind and credulous attitudes toward rumors.

We select three indicators to measure the degree of information asymmetry in companies. First, firm size is closely related to the level of information disclosure. Larger companies generally have more complete information disclosure systems and attract more attention from the market and regulatory authorities than smaller companies. In addition, having an impact on the stock price of large companies requires more funds or holding advantages, so the targets of market speculation are often small-cap stocks. Small-scale companies are more likely to be the subject of rumors and their stock trading is more susceptible to the impact of rumors. Second, the information disclosure evaluation by the Shenzhen Stock Exchange is considered a relatively objective indicator of information transparency. A higher level of information transparency implies a smaller information space for rumors. In addition, institutional investors have greater information and professional advantages, and are less constrained by limited attention. Peng and Tang (2019) find that companies with high institutional ownership are less affected by rumors. Thus, we conduct subgroup analyses based on firm size, information transparency and institutional investor ownership. We create firm size and institutional investor ownership groups based on the industry-quarter median of total assets and institutional shareholding ratio, respectively. For information transparency, we use the method proposed by Xu and Wang (2021), assigning observations of companies that receive an "A" in the Shenzhen Stock Exchange's information disclosure evaluation to the high information transparency subsample, and others to the low information transparency subsample. At the same time, we construct a comprehensive index of stock market price efficiency. Specifically, the stock price synchronicity, mispricing and stock price crash risk indicators are sorted in ascending order, and each indicator is divided into 10 segments, assigned integers from 1 to 10, and the scores of the three indicators are summed and averaged to obtain the price inefficiency index (*PriceInefficeny*_{i,q}). The larger the value of this index, the lower the price efficiency. Using the price inefficiency index (*PriceInefficeny*_{i,q}) as the dependent variable and the number of corporate rumors (*Rumor*) as the explanatory variable, we rerun Model (9) using the subsamples. The test results are shown in Table 7. The SUEST tests show significant differences in the groups' coefficients. For small companies, companies with low information transparency and companies with low institutional ownership, the negative impact of rumors on price efficiency is more significant than for their counterparts.

4.6.2. Stock market reaction to rumors

To further substantiate the negative effects of rumors on pricing mechanisms, we draw on the literature related to rumors and use the event study method to analyze market reactions to rumors. Rumors that are verified by investors on interactive platforms within a week are considered as a single rumor event, and the day when investors ask questions on interactive platforms is considered the event day. The estimation window is set from day [-180, -31] before the event day, and abnormal returns within the event window of [-5, 5] are calculated using the market model. Fig. 1 presents the trends in average abnormal returns (AAR) and average cumulative abnormal returns (ACAR) during the event window. On the day of the rumor event, the focal company's AAR and ACAR significantly increase and then sharply decline, falling below the pre-rumor event day return levels 3 days after the event. The observations are further categorized based on the content of the rumors by first calculating the average tone of rumors for firm i on day t, which is derived by subtracting the number of unfavorable rumors from the number of favorable rumors and dividing by the total number of rumors. Then, the observations are grouped according to average tone, with observations having an average tone greater than 0 being defined as favorable rumors, and those with an average tone less than 0 as unfavorable rumors. Fig. 2 shows the market reaction for the subsamples of favorable and unfavorable rumors. It is observed that for the subsample of favorable rumor events, AAR and ACAR significantly increase on the event day and then quickly fall below the pre-event levels. In the case of unfavorable rumors, the companies' AAR and ACAR significantly decrease on the event day and then rapidly recover to pre-rumor event levels. Overall, rumors have a significant impact on stock prices and there is a clear price reversal effect after the event day. The results are consistent with Ahern and Sosyura (2015) and Jia et al. (2020) and further corroborate that rumors impair the pricing efficiency of stock markets.

Table 7Subgroup Analysis Based on Information Asymmetry.

$\begin{tabular}{ c c c c c c c c c c c c c c c c c c c$		PriceInefficeny						
Big Small High Low High Low Ramor 0.036 ⁺⁺ 0.022 ⁺⁺ 0.026 ⁺⁺ 0.036 ⁺⁺ 0.006 Media 0.015 ⁺ -0.007 0.006 0.024 ⁺⁺ 0.0128 ⁺⁺ 0.017 Media 0.015 ⁺ -0.007 0.006 0.024 ⁺⁺ 0.012 ⁺⁺ 0.012 ⁺⁺ Msent -0.097 ⁺⁺ -0.124 ⁺⁺⁺ -0.216 ⁺⁺⁺ -0.125 ⁺⁺⁺ -0.106 ⁺⁺⁺ -0.168 ⁺⁺⁺ (-3.375) (1.980) (2.199) (3.079) (2.900) (2.544) Asent 0.033 0.043 ⁺ 0.046 0.035 ⁺⁺ 0.026 ⁺⁺ 0.025 ⁺⁺⁺ 0.025 ⁺⁺⁺⁺⁺⁺⁺⁺⁺⁺⁺⁺⁺⁺⁺⁺⁺⁺⁺⁺⁺⁺⁺⁺⁺⁺⁺⁺⁺⁺⁺⁺⁺⁺⁺⁺		Firm Size		Transparency	Transparency		vnership	
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$		Big	Small	High	Low	High	Low	
	Rumor	0.036***	0.072^{***}	0.026**	0.056***	0.031***	0.066***	
		(5.428)	(8.096)	(2.143)	(9.366)	(3.907)	(9.130)	
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	Media	0.015*	-0.007	0.006	0.024***	0.028***	0.007	
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$		(1.775)	(-0.686)	(0.380)	(3.307)	(3.192)	(0.727)	
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	Msent	-0.097***	-0.124***	-0.216***	-0.125***	-0.100^{***}	-0.168***	
$\begin{array}{c c c c c c c c c c c c c c c c c c c $		(-3.267)	(-5.046)	(-4.297)	(-6.070)	(-3.543)	(-6.505)	
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	Ann	0.019***	0.012**	0.021**	0.014***	0.018***	0.015**	
Asent 0.033 0.044* 0.046 0.035* 0.075*** 0.005 Size 0.434* (1.927) (1.237) (1.855) (2.903) (0.242) Size 0.0321 (0.172) (15.012) (27.101) (24.947) (17.997) Lee -0.095 -0.186** -0.224**- -0.107** -0.067 -0.216*** ROA -2.876*** -1.884*** -2.937*** -2.342*** -2.750*** -2.211*** Growth -0.081** -0.036* -0.015*** -0.043** -0.019 (-4.343) (-1.841) (-2.959) (-2.940) (-4.387) (-0.019 TobinQ 0.792*** 0.681*** 0.690*** 0.725*** -110.541** -100.350*** (-36.081) (-32.119) (-22.228) (-42.693) (-35.03) (-33.020) Volat -0.044 -0.242** 0.124* -0.032 -0.032 -0.022 (-1.294) (-6.579) (2.205) (-8.276) (-0.033 (0.11* 0.043**		(3.375)	(1.980)	(2.199)	(3.079)	(2.900)	(2.544)	
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	Asent	0.033	0.043*	0.046	0.035*	0.075***	0.005	
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$		(1.343)	(1.927)	(1.237)	(1.855)	(2.903)	(0.242)	
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	Size	0.432***	0.003	0 319***	0 298***	0 323***	0 269***	
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	5120	(30, 321)	(0.172)	(15.012)	(27, 101)	(24 947)	(17, 997)	
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	Lev	-0.095	-0.186***	-0.202*	-0.107^{**}	-0.067	-0.216^{***}	
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	Lev	(-1.537)	(-3,189)	(-1.808)	(-2, 309)	(-1.084)	(-3.665)	
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	POI	(-1.557) 2 876***	(-5.109) 1 994***	(-1.000) 2 027***	(-2.309) 2 242***	(-1.00+) 2 750***	(-3.003)	
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	KOA	-2.870	-1.004	-2.937	-2.342	-2.750	-2.211	
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	Crowth	(-9.833)	(-7.132)	(-0.557)	(-10.773)	(-9.032)	(-8.200)	
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	Growin	-0.081	-0.030°	-0.105	-0.043	-0.082	-0.019	
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	T 1: 0	(-4.344)	(-1.841)	(-2.939)	(-2.940)	(-4.38/)	(-0.940)	
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	TobinQ	0.792	0.681	0.690	0.792	0./13	0.832	
$\begin{array}{c c c c c c c c c c c c c c c c c c c $		(69.4/3)	(69.290)	(47.313)	(93.910)	(/4.53/)	(/5.946)	
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	AvgRet	-111.301	-98.032	-115.225	-102.501	-110.541	-100.350	
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$		(-36.081)	(-32.119)	(-22.238)	(-42.693)	(-35.503)	(-33.020)	
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	Volat	-0.044	-0.242	0.124	-0.226	-0.032	-0.282	
$\begin{array}{cccccccccccccccccccccccccccccccccccc$		(-1.294)	(-6.579)	(2.205)	(-8.276)	(-0.955)	(-7.819)	
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	Turnover	0.069	0.017	0.034	0.033	0.011*	0.044	
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$		(9.417)	(3.614)	(3.339)	(8.048)	(1.757)	(8.939)	
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	Top1	-0.001	0.003	-0.004	0.001	-0.002	0.005**	
$\begin{array}{cccccccccccccccccccccccccccccccccccc$		(-0.639)	(1.484)	(-1.010)	(0.800)	(-0.974)	(2.006)	
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	Herf5	0.011	-1.023^{***}	0.081	-0.463*	0.104	-1.183^{***}	
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$		(0.037)	(-3.112)	(0.178)	(-1.856)	(0.328)	(-3.027)	
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	Board	0.114^{**}	-0.017	0.140	0.063	0.061	0.065	
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$		(2.099)	(-0.251)	(1.567)	(1.311)	(1.062)	(1.031)	
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	Indep	0.819***	0.246	0.937***	0.751***	0.415^{**}	0.993^{***}	
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$		(4.400)	(1.066)	(3.106)	(4.526)	(2.137)	(4.494)	
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	Inst Hold	0.165^{***}	0.259***	0.275^{***}	0.168^{***}	-0.090	0.216***	
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$		(2.987)	(5.407)	(3.200)	(4.203)	(-0.904)	(2.698)	
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	Analysts	0.229***	0.184^{***}	0.253***	0.182***	0.214***	0.192***	
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	2	(25.374)	(17.088)	(16.532)	(22.922)	(22.350)	(19.008)	
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	SOE	0.078***	0.153***	0.150***	0.117***	0.119***	0.123***	
Age -0.004 0.149^{***} 0.059^{**} 0.028^{**} -0.021 0.08^{***} (-0.217) (8.873) (2.165) (2.121) (-1.319) (4.329) Cons -6.872^{***} 1.651^{***} -3.462^{***} -4.771^{***} -3.788^{***} -4.742^{***} (-19.668) (3.327) (-6.453) (-17.059) (-11.923) (-12.084) Ind & YearYesYesYesYesYesN $23,657$ $22,685$ $8,928$ $37,414$ $23,309$ $23,033$ Adj. R^2 0.372 0.319 0.406 0.305 0.345 0.315 Difference 0.022^{**} 0.054^{**} 0.000^{***}		(3.538)	(5.619)	(3.812)	(6.063)	(5.541)	(4.131)	
(-0.217) (8.873) (2.165) (2.121) (-1.319) (4.329) $Cons$ -6.872^{***} 1.651^{***} -3.462^{***} -4.771^{***} -3.788^{***} -4.742^{***} (-19.668) (3.327) (-6.453) (-17.059) (-11.923) (-12.084) $Ind \& Year$ Yes Yes Yes Yes Yes N $23,657$ $22,685$ $8,928$ $37,414$ $23,309$ $23,033$ Adj. R^2 0.372 0.319 0.406 0.305 0.345 0.315 Difference 0.02^{**} 0.054^{**} 0.000^{***}	Age	-0.004	0.149***	0.059**	0.028**	-0.021	0.081***	
Cons -6.872^{***} 1.651^{***} -3.462^{***} -4.771^{***} -3.788^{***} -4.742^{***} (-19.668) (3.327) (-6.453) (-17.059) (-11.923) (-12.084) Ind & Year Yes Yes Yes Yes Yes Yes Yes N $23,657$ $22,685$ $8,928$ $37,414$ $23,309$ $23,033$ Adj. R^2 0.372 0.319 0.406 0.305 0.345 0.315 Difference 0.022^{**} 0.054^{**} 0.000^{***}	8-	(-0.217)	(8 873)	(2.165)	(2.121)	(-1, 319)	(4 329)	
ConstructionConstructionConstructionConstructionConstruction (-19.668) (3.327) (-6.453) (-17.059) (-11.923) (-12.084) Ind & YearYesYesYesYesYesYesN23,65722,6858,92837,41423,30923,033Adj. R^2 0.3720.3190.4060.3050.3450.315Difference 0.02^{**} 0.054^{*} 0.000^{***}	Cons	-6.872^{***}	1 651***	-3462^{***}	-4 771***	-3 788***	-4742^{***}	
Ind & Year Yes Yes <thyes< th=""> Yes</thyes<>	00110	(-19, 668)	(3 327)	(-6.453)	(-17,059)	(-11, 923)	(-12.084)	
N 23,657 22,685 8,928 37,414 23,309 23,033 Adj. R^2 0.372 0.319 0.406 0.305 0.345 0.315 Difference 0.032^{**} 0.054^* 0.000^{***} 0.000^{***}	Ind & Year	Yes	Yes	Yes	Yes	Yes	Yes	
Adj. R^2 0.372 0.319 0.406 0.305 0.345 0.315 Difference 0.032^{**} 0.054^* 0.000^{***} 0.000^{***}	N	23 657	22 685	8 928	37 414	23 309	23 033	
Difference 0.032^{**} 0.054^{*} 0.000^{***}	Adi. R^2	0 372	0 319	0 406	0 305	0 345	0 315	
	Difference	0.03	32 ^{**}	0.0)54*	0.00	00***	



Fig. 1. Market Responses to Rumors.



Fig. 2. Market Responses to Favorable and Unfavorable Rumors.

4.7. Robustness tests

4.7.1. Propensity score matching

The occurrence of rumors is not random. The characteristics of companies, industries and markets are closely related to the generation and spread of rumors. For instance, the introduction of new industrial policies Table 8 Robustness Test: PSM.

	(1)	(2)	(3)	(4)	(5)	(6)
	SYN	SYN	MISP1	MISP2	NCSKEW	DUVOL
Rpos	0.012 ^{**} (2.213)					
Rneg		-0.040^{***} (-2.755)				
Rumor			0.006 ^{****} (5.917)	0.007 ^{****} (3.941)	0.013 ^{***} (4.337)	0.009 ^{***} (4.527)
Media	-0.076^{***}	-0.073^{***}	0.017 ^{***}	0.015 ^{****}	0.003	0.006*
	(-8.974)	(-6.251)	(9.120)	(4.586)	(0.537)	(1.898)
Msent	0.214 ^{***}	0.217 ^{***}	0.004	0.007	-0.203^{***}	-0.113^{***}
	(10.081)	(6.278)	(1.000)	(1.036)	(-12.895)	(-11.581)
Ann	-0.008*	0.006	-0.001	-0.006^{***}	0.013 ^{***}	0.009 ^{***}
	(-1.710)	(0.862)	(-1.215)	(-3.286)	(4.459)	(4.501)
Asent	0.002	0.015	0.006 ^{**}	0.005	-0.010	-0.006
	(0.092)	(0.589)	(2.364)	(1.058)	(-0.844)	(-0.764)
Size	0.162 ^{***}	0.165 ^{***}	0.067 ^{***}	0.282 ^{***}	-0.009	-0.019^{***}
	(11.948)	(9.219)	(13.881)	(44.614)	(-1.195)	(-3.998)
Lev	-0.411^{***}	-0.374^{***}	0.130 ^{***}	-0.096^{***}	0.032	0.033
	(-7.131)	(-4.482)	(8.931)	(-3.962)	(0.997)	(1.607)
ROA	-0.228	0.237	-0.383 ^{***}	-2.599 ^{****}	0.149	0.251 ^{***}
	(-0.999)	(0.716)	(-7.297)	(-21.430)	(1.050)	(2.747)
Growth	-0.046^{***}	-0.093^{***}	-0.009^{***}	-0.003	0.035 ^{***}	0.020 ^{***}
	(-2.871)	(-4.289)	(-2.866)	(-0.458)	(3.252)	(2.768)
TobinQ	-0.020^{**}	-0.011	0.295 ^{***}	0.787 ^{****}	0.048 ^{***}	0.031 ^{***}
	(-2.002)	(-0.786)	(56.331)	(151.956)	(9.676)	(9.005)
AvgRet	-48.033^{***}	-41.713^{***}	1.871 ^{***}	-5.806^{***}	-34.579^{***}	-32.854 ^{***}
	(-19.748)	(-12.651)	(5.601)	(-10.756)	(-23.623)	(-31.911)
Volat	-0.167^{***}	-0.165^{***}	0.064 ^{***}	0.044^{***}	-0.087^{***}	-0.116^{***}
	(-5.810)	(-3.974)	(11.806)	(4.940)	(-4.872)	(-9.890)
Turnover	-0.024^{***}	-0.023^{***}	-0.002^{**}	-0.006^{***}	0.030^{***}	0.019 ^{***}
	(-6.409)	(-4.038)	(-2.298)	(-4.549)	(15.059)	(13.335)
Top1	0.006 ^{***}	0.005	-0.001*	-0.001	0.001	0.001
	(3.050)	(1.525)	(-1.658)	(-1.516)	(1.047)	(1.103)
Herf_5	-0.940^{***}	-0.837*	0.049	0.047	-0.234	-0.178
	(-3.092)	(-1.856)	(0.695)	(0.410)	(-1.318)	(-1.537)
Board	0.130 ^{**}	0.159 ^{**}	0.017	0.014	-0.012	-0.001
	(2.246)	(2.096)	(1.160)	(0.657)	(-0.399)	(-0.057)
Indep	0.508 ^{***}	0.838 ^{***}	0.087*	-0.008	0.109	0.090
	(2.695)	(3.175)	(1.795)	(-0.111)	(0.986)	(1.238)
InstHold	-0.315 ^{***}	-0.341^{***}	0.066 ^{***}	0.074 ^{***}	0.023	0.034*
	(-6.367)	(-4.751)	(5.737)	(3.919)	(0.822)	(1.872)
Analysts	0.071^{***}	0.068 ^{***}	0.026 ^{***}	0.005	0.063 ^{***}	0.030 ^{***}
	(8.008)	(5.650)	(11.296)	(1.520)	(12.042)	(9.351)
SOE	0.196 ^{***}	0.200 ^{***}	-0.007	-0.019^{**}	-0.022*	-0.008
	(7.994)	(6.116)	(-1.133)	(-2.063)	(-1.672)	(-0.936)
Age	-0.009	0.011	0.013 ^{****}	-0.010	-0.022^{**}	-0.017^{***}
	(-0.534)	(0.497)	(3.548)	(-1.528)	(-2.413)	(-2.833)
Cons	-5.388 ^{***}	-5.707^{***}	-1.988^{***}	-7.743^{***}	-0.722^{***}	-0.515 ^{***}
	(-16.733)	(-13.162)	(-16.181)	(-54.610)	(-4.245)	(-4.457)
Ind & Year	Yes	Yes	Yes	Yes	Yes	Yes
N	21,692	9,300	26,064	26,134	26,066	26,066
Adj. <i>R</i> ²	0.201	0.196	0.831	0.900	0.076	0.123

may lead to an increase in rumors about these policies, which in turn causes the stock prices of companies in one entire industry sector to fluctuate in a consistent manner. To address this, we first apply propensity score matching (PSM) and rerun Model (9). Specifically, as the main test results show that favorable rumors and unfavorable rumors have heterogeneous impacts on stock price synchronicity, we rerun the tests in which the dependent variable is stock price synchronicity using subsamples that are divided into groups based on whether a company is the subject of favorable or unfavorable rumors during the sample period. For tests where the dependent variable is the level of asset mispricing and stock price crash risk, as the main test results show a significant positive correlation with both favorable rumors and unfavorable rumors, the subsamples are divided based on whether a company is the subject of any rumors during the sample period. Then, 1:1 matching without replacement is performed for all of the treatment and control group samples. Using the matched samples, Model (9) is rerun. For stock price synchronicity, the impacts of the number of favorable rumors (*Rpos*) and the number of unfavorable rumors (*Rneg*) are tested separately; for mispricing and stock price crash risk, for simplicity, only the correlations with the total number of rumors (*Rumor*) are examined. The test results are shown in Table 8. In column (1), the regression coefficient for *Rpos* is significant and positive, and the regression coefficient for Rneg is significant and negative; in columns (2)–(6), the regression coefficients for Rumor are significant and positive, consistent with the main test results.

4.7.2. Instrumental variable approach

We construct two instrumental variables. First, the Internet penetration rate in the company's province is selected as the first instrumental variable (IVI), with the data sourced from the China Internet Network Information Center's statistical report. This rate is measured by the proportion of Internet users to the total permanent resident population in each province. The Internet acts as an incubator of rumors (Van Bommel, 2003), especially with the proliferation of social media, where the multi-point and multi-directional spread of rumors causes persuasion bias. That is, when information recipients receive the same information repeatedly, they tend to overestimate its credibility. Users of social media are connected through social networks and are likely to receive the same information, including the same misinformation; this repetition makes receivers overly trust the information (Jia et al., 2020), leading to investors' overreaction to rumors. Therefore, when the Internet penetration rate is higher in the company's location, rumors are more likely to spread through the Internet. Second, we select the natural logarithm of the number of company employees as the second instrumental variable (IV2). A higher number of employees implies more insiders, a higher probability of insider information leakage and a larger information dissemination network. Thus, the number of employees is closely related to the number of rumors associated with the company. A two-stage least squares method is used for the test, with the results presented in Table 9. Column (1) shows the first-stage regression results, where both instrumental variables are significantly and positively correlated with the number of rumors (Rumor), and the F-statistic is 43, exceeding the critical value from a Stock-Yogo weak identification test, thus rejecting the null hypothesis of a weak instrumental variable. The number of rumors (*Rumor*) is regressed against the instrumental variables IV1 and IV2, as well as other control variables, to estimate the fitted values of the number of rumors (*Fitted Rumor*). These fitted values are then used as the explanatory variable in the second stage, with columns (2)-(6) showing the second stage regression results, which are consistent with the main test results.

4.7.3. Alternative explanatory variables

We substitute the explanatory variables of Model (9) with dummy variables indicating whether there are favorable or unfavorable corporate rumors in the quarter (*Drpos*, *Drneg*). The regression results, given in Table 10, show that the results are consistent with the main test results except for the regression coefficient of stock price crash risk on *Drpos*. A possible explanation for the correlation of rumors with stock price crash risk is that investors have a negative bias toward rumor information, reacting more strongly to unfavorable rumors (Jia et al., 2014); thus, unfavorable rumors have a greater impact on stock price crash risk.

4.7.4. Alternative measures of stock price synchronicity

Referring to Chan and Chan (2014), we include lagged terms of industry and market returns (*Rind*_{*t*-*I*,*q*} and $R_{m,t-1,q}$) in Model (1) to calculate the stock price synchronicity index, which is then used as the dependent vari-

Table 9 Robustness Test: Instrumental Variable Approach.

	Rumor	SYN	MISP1	MISP2	NCSKEW	DUVOL
	(1)	(2)	(3)	(4)	(5)	(6)
IV1	0.004***					
	(3.917)					
IV2	0.036**					
	(2.316)					
Fitted Rumor		0.269^{***}	0.269***	0.179^{***}	0.039	0.072*
		(3.069)	(8.504)	(5.696)	(0.558)	(1.685)
Media	0.075***	-0.098***	-0.003	0.008***	-0.004	-0.003
	(7.983)	(-11.951)	(-0.991)	(2.759)	(-0.601)	(-0.734)
Msent	-0.021	0.184***	0.007	0.009*	-0.179***	-0.098***
	(-1.275)	(13.477)	(1.408)	(1.872)	(-16.642)	(-14.690)
Ann	-0.003	0.004	-0.000	-0.006***	0.012***	0.008***
	(-0.516)	(1.265)	(-0.427)	(-5.311)	(5.056)	(5.382)
Asent	-0.051***	-0.008	0.018***	0.017***	0.019*	0.013**
	(-3.668)	(-0.624)	(3.947)	(3.784)	(1.886)	(2.031)
Size	0.168***	0.111****	0.018***	0.250***	-0.015	-0.031***
	(8.572)	(6.037)	(2.702)	(38.211)	(-1.009)	(-3.428)
Lev	-0.293***	-0.410^{***}	0.217***	-0.072***	0.019	0.040**
	(-4.635)	(-10.523)	(15.437)	(-5.165)	(0.629)	(2.085)
ROA	-0.217	-0.148	-0.290****	-2.280***	0 292***	0 314***
	(-0.917)	(-1.065)	(-5.781)	(-45,791)	(2.658)	(4.610)
Growth	0.002	-0.074***	-0.009**	0.002	0.022***	0.011**
0.0.0	(0.145)	(-7.618)	(-2.544)	(0.684)	(2.838)	(2, 365)
TohinO	0.012	-0.051***	0 293***	0.782***	0.039***	0.022***
100002	(1.068)	(-9, 925)	(157,933)	(425 125)	(9,708)	(8 620)
AnoRet	-3.155	-57 130***	3 048***	-6.096***	-44 885***	-39402^{***}
nogiai	(-1, 432)	(-36,566)	(5.425)	(-10.931)	(-36454)	(-51.616)
Volat	0.358***	-0.134***	-0.034^{***}	-0.025**	-0.186***	-0.172^{***}
,	(13.668)	(-3.778)	(-2, 639)	(-1.991)	(-6.624)	(-9, 924)
Turnover	0.068***	-0.047***	-0.021***	-0.019***	0.036***	0.017***
1 41110001	(12.993)	(-7,076)	(-8.665)	(-8,197)	(6 889)	(5 310)
Ton1	0.003	0.006***	-0.002***	-0.002***	0.001	0.001
10/1	(1, 327)	(4 968)	(-4.183)	(-5.805)	(1.135)	(0.977)
Herf5	-1.322^{***}	_0 549***	0 397***	0.360***	_0.215	_0.073
110.35	(-4.113)	(-2, 933)	(5.895)	(5 389)	(-1, 457)	(-0.795)
Roard	_0.057	0.108***	0.029***	0.015	_0.027	_0.009
Doura	(-0.723)	(3 552)	(2 706)	(1 424)	(-1, 131)	(-0.589)
Inden	-0.428	0.503***	0.187***	0.060	0.113	0.093*
macp	(-1, 645)	(4 634)	(4 795)	(1.550)	(1.323)	(1.750)
Inst Hold	_0 230***	_0 237***	0.127***	0 104***	0.030	0.039**
monton	(-4.352)	(-7.161)	(10.640)	(8 785)	(1.152)	$(2 \ 422)$
Analysts	_0.021**	0.043***	0.027***	0.004**	0.064***	0.030***
211101/515	(-2.155)	(8 576)	(14.851)	(2.168)	(16.156)	(12 338)
SOF	_0 104***	0.267***	0.020***	0.007	_0.003	0.015**
SOL	(-3, 434)	(17,715)	(3.682)	(1.271)	(-0.245)	(2.070)
400	0.115***	-0.047^{***}	_0.016***	_0 021***	_0.032***	_0.031***
Age	(7.134)	(-3, 724)	(-3.414)	(_4 595)	(-3, 203)	(-5.076)
Cons	_2 501***	(-3.72+) -4.026***	_1 370 ^{***}	_7 421***	_0.886***	_0.381***
Cons	(-5.031)	(_13 075)	(-13.228)	(-72.158)	(_3 904)	(_2 706)
Ind & Year	(-3.251) Ves	(=13.973) Ves	(=13.220) Ves	(=/2.150) Ves	(-3.904) Ves	(-2.700) Ves
ma a rear	105	105	105	105	105	1 65
Ν	46,338	46,338	46,338	46,338	46,338	46,338
Adj. R^2	0.111	0.089	0.116	0.837	0.074	0.101

able of Model (9). The results show that favorable rumors are significantly and positively correlated with stock price synchronicity, while unfavorable rumors are significantly and negatively correlated with stock price synchronicity, consistent with the main test results (Table 11).

Table 10 Robustness Test Using Alternative Explanatory Variables.

SYN2 SYN2 MISP1 MISP1 MISP2 MISP2 NCSKEW NCSK	W DUVOL DUVOL
(1) (2) (3) (4) (5) (6) (7) (8)	(9) (10)
Drpos 0.045*** 0.014*** 0.018*** 0.013	0.008
(4.066) (6.021) (4.803) (1.512)	(1.418)
$Drneg = -0.040^{**} = 0.010^{***} = 0.016^{***} = 0.016^{***}$	*** 0.031***
(-2.567) (3.230) (2.759) (4.9)	(4.113)
$Media \qquad -0.077^{***} -0.076^{***} 0.018^{***} 0.018^{***} 0.022^{***} 0.022^{***} -0.001 -0$	02 0.003 0.002
(-11.522) (-11.265) (11.441) (11.502) (8.362) (8.391) (-0.210) (-0.210)	(1.061) (0.888)
$Msent \qquad 0.176^{***} \qquad 0.176^{***} \qquad 0.001 \qquad 0.002 \qquad 0.005 \qquad 0.006 \qquad -0.180^{***} \qquad -0.176^{***} \qquad -0.176^{**} \qquad -$	-0.099^{***} -0.099^{***}
(12.206) (12.189) (0.497) (0.620) (1.077) (1.172) (-16.039) (-15.19) (-15.19) (-16.039) (-15.19) (-16.039) (-16.19) (-	(-14.552) (-14.483)
Ann 0.004 0.004 -0.001 -0.001 -0.006 -0.006 0.012 0.01	0.008 0.008
(0.876) (0.892) (-1.027) (-1.027) (-3.760) (-3.758) (4.759) (4.759)	3 9) (4.874) (4.859)
Asent -0.021* -0.022 0.005 0.005 0.008 0.008 0.017* 0.0	7* 0.009 0.009
(-1.916) (-1.995) (2.495) (2.462) (2.298) (2.279) (1.815) (1.315) (1.315)	(1.536) (1.566)
$Size \qquad 0.156 \qquad 0.159 \qquad 0.070 \qquad 0.0284 \qquad 0.284 \qquad -0.008 $	
(13,493) $(13,796)$ $(17,576)$ $(17,583)$ $(53,154)$ $(55,079)$ $(-1,346)$ $(-1,346)$	(-4.559) (-4.806)
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	(12 0.019 0.021)
(-9.399) (-9.320) (11.019) (10.968) (-5.411) (-5.424) (0.325) (0.325) (0.325)	$\begin{array}{cccc} (1.181) & (1.2/9) \\ (1.181) & (1.2/9$
ROA = -0.1/0 = -0.1/7 = -0.345 = -0.348 = -2.287 = -2.291 = 0.282 = 0.2	(4.125) (4.067)
$ \begin{array}{cccc} (-0.900) & (-0.904) & (-7.000) & (-7.701) & (-21.713) & (-21.728) & (2.453)$	(4.125) (4.007)
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	(2, 236) $(2, 270)$
$T_{o}hinO = 0.051^{***} = 0.051^{***} = 0.051^{***} = 0.051^{***} = 0.025^{***} = 0.025^{***} = 0.0724^{***} = 0.0723^{***} = 0.040^{***} = 0.031^{***} = $	(2.330) (2.270)
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	(7.812) (7.697)
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	*** _39 724 *** _39 546 ***
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	$(-45\ 179)$ $(-44\ 863)$
$Volat = -0.069^{***} - 0.062^{***} = 0.058^{***} - 0.060^{***} = 0.033^{***} - 0.034^{***} - 0.171^{***} - 0.17$	-0.146^{***} -0.146^{***}
(-2,966) $(-2,681)$ $(13,406)$ $(13,654)$ $(4,430)$ $(4,686)$ $(-12,186)$ (-12)	(-16, 250) $(-16, 338)$
$Turnover = -0.030^{**} - 0.02^{**} - 0.002^{**} - 0.002^{**} - 0.007^{***} - 0.007^{***} - 0.038^{***} - 0.038^{***} - 0.007^{**} - 0.007$	**** 0.022**** 0.022***
(-8.812) (-8.446) (-3.402) (-3.165) (-5.943) (-5.769) (19.943) (19.943)	(16.712) (16.681)
$Top1 \qquad 0.006^{***} 0.006^{***} -0.001^{**} -0.001^{**} -0.002^{**} -0.002^{**} 0.001 0$	01 0.001 0.001
$(3.273) \qquad (3.326) \qquad (-2.101) \qquad (-2.081) \qquad (-2.526) \qquad (-2.513) \qquad (1.061) \qquad $	(1.084) (1.046)
<i>Herf5</i> -0.821^{***} -0.852^{***} 0.072 0.069 0.137 0.134 -0.242^{*} -0.22^{*}	9* -0.148* -0.142
(-3.191) (-3.307) (1.163) (1.118) (1.353) (1.324) (-1.789) (-1.4)	(-1.700) (-1.630)
Board 0.089* 0.088* 0.014 0.014 0.006 0.007 -0.026 -0	24 -0.011 -0.010
(1.727) (1.704) (1.129) (1.146) (0.321) (0.339) (-1.055) (-0.921)	35) (-0.670) (-0.614)
Indep 0.401^{**} 0.393^{**} 0.078^{*} 0.078^{*} -0.009 -0.009 0.103 0	09 0.067 0.070
(2.370) (2.324) (1.796) (1.796) (-0.127) (-0.124) (1.145) (1	07) (1.194) (1.243)
$InstHold -0.301^{***} -0.305^{***} 0.063^{***} 0.063^{***} 0.065^{***} 0.066^{***} 0.066^{***} 0.019 0$	20 0.021 0.022
(-7.172) (-7.251) (6.580) (6.521) (4.119) (4.075) (0.867) (0.867)	(1.471) (1.507)
Analysts 0.040**** 0.040**** 0.023*** 0.023*** 0.001 0.001 0.063*** 0.06	**** 0.029 ^{***} 0.029 ^{***}
(5.275) (5.273) (11.829) (11.811) (0.420) (0.416) (15.454) (15.454)	54) (11.394) (11.388)
$SOE = 0.242^{***} = 0.240^{***} = -0.007 = -0.007 = -0.010 = -0.010 = -0.007 = -0.$	06 0.008 0.009
$(11.248) \qquad (11.151) \qquad (-1.300) \qquad (-1.323) \qquad (-1.231) \qquad (-1.247) \qquad (-0.647) $	38) (1.182) (1.265)
$Age \qquad -0.021 \qquad -0.019 \qquad 0.013^{***} \qquad 0.013^{***} \qquad -0.005 \qquad -0.005 \qquad -0.028^{***} \qquad -0.028^{**} \qquad -0.028^{*} \qquad -0.028^{**} \qquad -0.028^{**} \qquad -0.028^{*} \qquad -0.0$	$^{***} -0.024^{***} -0.024^{***}$
(-1.535) (-1.394) (4.008) (4.126) (-0.933) (-0.840) (-3.870)	(-5.180) (-5.194)
$Cons \qquad -4.672^{***} -4.717^{***} -2.084^{***} -2.084^{***} -7.880^{***} -7.878^{***} -0.975^{***} -0.94^{*}$	-0.560^{***} -0.544^{***}
$(-15.781) (-15.929) (-20.590) (-20.539) (-63.365) (-63.232) \qquad (-6.918) \qquad (-6.918)$	(-6.074) (-5.902)
Ind & Year Yes Yes Yes Yes Yes Yes Yes Yes	Yes Yes
N 40,932 40,932 40,008 40,008 40,825 40,825 40,030 40	30 46,630 46.630

	(1) <i>SYN</i>	(2) S YN	(3) <i>SYN</i>
Rumor	0.005		
	(1.238)		
Rpos		0.012****	
		(2.807)	
Rneg			-0.034^{***}
			(-3.154)
Media	-0.066^{***}	-0.066^{***}	-0.065^{***}
	(-10.992)	(-11.048)	(-10.810)
Msent	0.140	0.140	0.139
	(10.911)	(10.902)	(10.836)
Ann	0.001	0.001	0.001
	(0.143)	(0.157)	(0.161)
Asent	-0.019*	-0.018*	-0.019*
<i>a</i> .	(-1.870)	(-1.848)	(-1.933)
Size	0.152	0.151	0.155
Y	(14.648)	(14.618)	(14.987)
Lev	-0.441	-0.440	-0.446
DOI	(-9.882)	(-9.8/2)	(-9.986)
ROA	$-0.2/9^{*}$	-0.2/5*	$-0.2/5^{*}$
Count	(-1.688)	(-1.000)	(-1.004)
Growin	-0.067	-0.067	-0.000
Tahin	(-0.304)	(-0.488)	(-0.431)
TobinQ	-0.039	-0.039	-0.038
AngPat	51 207***	(-4.773) 51.373***	(-4.750) 51.540***
Augnei	(-35,181)	(-35,191)	(-35.411)
Volatility	-0.013	-0.015	-0.010
, outurity	(-0.664)	(-0.753)	(-0.497)
Turnover	-0.024***	-0.025****	-0.024^{***}
1 111100001	(-8.342)	(-8.475)	(-8.125)
Top1	0.006***	0.006***	0.006***
	(3.485)	(3.483)	(3.523)
Herf5	-0.774***	-0.770****	-0.794***
5	(-3.358)	(-3.341)	(-3.445)
Board	0.075	0.075	0.073
	(1.607)	(1.605)	(1.573)
Indep	0.332**	0.333**	0.325**
-	(2.175)	(2.185)	(2.130)
InstHold	-0.265^{***}	-0.264***	-0.268^{***}
	(-7.103)	(-7.076)	(-7.171)
Analysts	0.030^{***}	0.030****	0.030^{***}
	(4.499)	(4.511)	(4.486)
SOE	0.212^{***}	0.212***	0.211***
	(11.051)	(11.062)	(10.979)
Age	-0.011	-0.012	-0.010
	(-0.908)	(-0.962)	(-0.838)
Cons	-4.176***	-4.168***	-4.219****
	(-15.755)	(-15.739)	(-15.952)
Ind & Year	Yes	Yes	Yes
Ν	46,899	46,899	46,899
Adi R^2	0.182	0.182	0.182

 Table 11

 Robustness Test Using an Alternative Measure of Stock Price Synchronicity.

5. Conclusion

The stock market has become a breeding ground for rumors due to its inherent uncertainty and information asymmetry, especially with the development of the Internet. Rumors have transitioned from interpersonal "word of mouth" channels to online social media platforms, greatly increasing the scope and speed of their dissemination. During the dissemination process, due to the distortion and strange loop phenomenon, rumors are constantly distorted as they are transmitted (Guo, 2011). Favorable rumors closely related to hot concepts or themes in the stock market are welcomed by investors, often triggering market attention and buying frenzies across the entire industry chain. In this process, We-Media accounts aiming to attract web traffic through sensational reporting, listed companies riding the wave of hot topics, and speculative or manipulative investors all participate in the creation and spread of stock market rumors. Rumors about hot topics in the market and industry are integrated into companies' stock prices, leading to stock price co-movement. However, for most concept stocks, the related concept does not have a substantial impact on the company's business or performance; they serve more as a marketing gimmick for market speculation. Investors overreact to such rumors, causing stock prices to deviate from their intrinsic value. Market manipulators use rumors to drive stock prices to high levels for profit-taking, and when their followers' expectations are disappointed, panic selling occurs, resulting in significant price declines.

We find that unfavorable rumors are more firm-specific than favorable rumors, and they cause heterogeneous fluctuations in stock prices. Whether favorable or unfavorable, rumors are mainly noise, and when investors trade based on rumors, stock prices deviate from their fundamental value, displaying emotional and irrational fluctuations and exacerbating stock price crash risk. Further analyses reveal that favorable rumors about leading companies tend to spread within the industry, as favorable rumors have a spillover effect within the industry. Uninformed investors participating in rumor-driven speculation further worsen the adverse effects of rumors on price efficiency. We find that small-cap stocks, companies with lower transparency and companies with lower institutional ownership are more susceptible to rumor disturbances than their counterparts. Lastly, analyzing market reactions to rumors also confirms that rumors cause significant price volatility. Rumors often accompany illegal activities such as market manipulation and speculative trading, leading to drastic fluctuations in stock prices and the accumulation of market risks, and they ultimately distort resource allocation. Our findings provide empirical evidence that rumors damage the efficiency of stock market pricing.

The governance of rumors is a focal point for regulatory authorities seeking to maintain the informational ecosystem of the stock markets. For investors, regulators should intensify educational efforts, particularly education aimed at correcting the irrational behaviors associated with speculative bandwagoning. For publicly listed companies, there is a need to further refine the mechanisms of information disclosure and pay close attention to informal channels of communication, especially official accounts on social media platforms like Weibo and WeChat, as well as investor interactive platforms, to guard against opportunistic behaviors that seek to capitalize on trending topics. Especially in an era where the Internet can amplify stock market rumors, all market participants need to work to collaboratively foster a clear and orderly online information environment that will promote the high-quality development of stock markets.

Conflict of interest statement

We declare that we have no financial and personal relationships with other people or organizations that can inappropriately influence our work, there is no professional or other personal interest of any nature or kind in any product, service and/or company that could be construed as influencing the position presented in, or the review of, the manuscript entitled "Rumors and price efficiency in stock market: An empirical study of rumor verification on investor Interactive platforms".

CRediT authorship contribution statement

Wenting Zhang: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Validation, Visualization, Writing - original draft, Writing review & editing. Chenxi Wang: Conceptualization,

Data curation, Formal analysis, Investigation, Methodology, Software, Validation, Visualization, Writing - original draft, Writing review & editing.

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Appendix. The following texts are randomly selected from the original rumor verification sample, with 10 favorable rumors and 10 unfavorable rumors.

1. Favorable rumors list

- 1. 2018-01-11 20:16:00 CSG Holding: "There are rumors that Panasonic is cooperating with Tesla on a photovoltaic module project, and CSG is the designated supplier of raw materials. Is this true?" (Shenzhen Stock Exchange Interactive Platform).
- 2. 2018-05-03 12:59:00 Shahe Industrial: "The market is abuzz with rumors that your company is taking control of ARM Holdings, an international semiconductor giant. Can you confirm this?" (Shenzhen Stock Exchange Interactive Platform).
- 2020-07-15 13:59:00 Fengyuan Pharmaceutical: "Hello, company secretary, the company has a stake in Jiangsu Chengxin Pharmaceuticals which is developing NMN-related products. Is this confirmed?" (Shenzhen Stock Exchange Interactive Platform).
- 4. 2019-12-30 13:32:00 Changshan Beiming: "Rumors are circulating that the company is preparing to collaborate with Huawei on its HarmonyOS. Is this the case?" (Shenzhen Stock Exchange Interactive Platform).
- 5. 2019-06-14 14:06:00 Huagong Tech: "Could you please confirm whether your subsidiary, HGTECH, has delivered the first domestic 5G optical module order to Huawei?" (Shenzhen Stock Exchange Interactive Platform).
- 6. 2020-02-17 11:53:53 Kelai Tech: "Hello, company secretary, it's heard that the company plans to introduce strategic investors for the development of the military industry. What stage has this reached? Please speed up the process!" (Shanghai Stock Exchange Interactive Platform).
- 7. 2017-08-24 15:33:00 Wanhua Chemical: "There is word on the internet that your company's PC products have gone into production. Could you please elaborate on the progress of PC, initial production volume, pricing, gross margin, and the expected date for the second phase of production? Thank you!" (Shanghai Stock Exchange Interactive Platform).
- 8. 2020-12-04 08:47:24 Unilumin: "Hello, company secretary, it is said that the Chang'e-5 lunar probe is equipped with electronic products from Unilumin. Is this true? Thank you." (Shanghai Stock Exchange Interactive Platform).
- 9. 2020-06-23 15:35:00 Ningbo Yunsheng: "Rumors suggest that state-owned assets will be invested in the company. Is there any truth to this?" (Shanghai Stock Exchange Interactive Platform).
- 10. 2020-08-21 14:55:53 Hongxing Development: "Media reports suggest that the Qingdao State-owned Assets Supervision and Administration Commission is advancing the mixed-ownership reform of Hongxing Chemical Group, introducing international industrial capital with cutting-edge technology in the electronic ceramics sector. Is this accurate?" (Shanghai Stock Exchange Interactive Platform).

2. Unfavorable rumors list

1. 2021-02-05 15:08:00 TCL Technology: "Hello, company secretary. There is news that TSMC has cut the order for the company's panel IC chips to only 80 % of the original supply. Is this information correct? Does the company have a contingency plan? Thank you." (Shenzhen Stock Exchange Interactive Platform).

- 2. 2019-02-12 14:22:00 Yihua Healthcare: "Are there indeed risks of an RMB 2 billion impairment on the company's goodwill as the internet suggests?" (Shenzhen Stock Exchange Interactive Platform).
- 2021-01-18 16:09:00 Zoomlion: "There are market rumors that the company's annual report will significantly underperform expectations due to a downturn in performance. What is the reason for this?" (Shenzhen Stock Exchange Interactive Platform).
- 4. 2019-07-31 19:39:00 Wasu Media: "Rumors for verification: Is it true that the company has been penalized by the Ministry of Industry and Information Technology for setting up its network?" (Shenzhen Stock Exchange Interactive Platform).
- 5. 2020-12-22 17:52:00 DunAn Environment: "The partners plan has not yet involved stock purchases, and there are rumors that the company is in arrears with salaries. Is it true that employees lack the funds to join the partners' plan?" (Shenzhen Stock Exchange Interactive Platform).
- 6. 2020-12-18 15:29:38 Sunshine Lighting: "There are rumors that the company is undergoing massive layoffs. Can you confirm if this is true?" (Shanghai Stock Exchange Interactive Platform).
- 7. 2018-12-20 15:55:00 Hengrui Medicine: "Is it true that the marketing approval for the monoclonal antibody drug, Carrelizumab, has been suspended? And is it true that there have been cases of hemangiomas as side effects in clinical trials?" (Shanghai Stock Exchange Interactive Platform).
- 8. 2020-01-06 14:43:00 Daheng Science and Technology: "The news mentions that there are irregularities in the major shareholder's purchase of company equity. Can the company clarify this?" (Shanghai Stock Exchange Interactive Platform).
- 9. 2016-04-14 00:00:00 Shuguang Shares: "There are online rumors that your company is involved in a scandal regarding fraud in the new energy vehicle subsidy program. Is this true?" (Shanghai Stock Exchange Interactive Platform).
- 10. 2019-10-30 08:38:00 Huatian Electronics: "The company's largest shareholder is alleged to be involved in a dispute. The company should clarify this situation immediately to prevent unnecessary market speculation and negative impact on the company." (Shanghai Stock Exchange Interactive Platform).

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Sustainability-oriented social responsibility and corporate innovation

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ABSTRACT

This paper empirically examines how sustainability-oriented social responsibility influences corporate innovation quantity and radical innovation from the perspectives of environment- and employee-oriented social responsibility. Both forms of social responsibility are found to contribute significantly to corporate innovation. Corporate environment-oriented responsibility increases innovation by increasing R&D. Employee-oriented responsibility increases innovation by helping firms retain talent; by motivating employees, employeeoriented social responsibility promotes both innovation quantity and radical innovation. Furthermore, both environment- and employee-oriented responsibility can alleviate financing constraints, and the positive effects of environment- and employee-oriented responsibility on radical innovation and innovation quantity, respectively, increase total factor productivity. Following sustainable development theory, this paper analyzes the heterogeneous mechanisms of the influences of environment- and employee-oriented social responsibility on corporate innovation and provides empirical evidence of high-quality, innovation-driven corporate development through social responsibility.

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1. Introduction

Innovation is a means for firms to achieve high long-term performance and an important driver of competitive advantage. Multiple factors, such as corporate social responsibility (CSR; Bocquet et al., 2013; Zhou

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et al., 2020), influence corporate innovation. However, studies have no unified understanding of whether CSR behavior can promote corporate innovation. Some studies argue that CSR can satisfy the needs of internal and external stakeholders, establish friendly relations between a firm and its stakeholders and provide many innovative resources, thus having a positive impact on corporate innovation (Ratajczak and Szutowski, 2016). In contrast, other studies argue that technological innovation projects tend to involve more investment, longer cycles and greater risk and uncertainty than ordinary investment projects. While realizing social benefits, CSR changes corporate resource allocation, crowding out R&D resources and negatively affecting corporate innovation (Mithani, 2017).

The fulfillment of social responsibility and the long-term development goals of firms are intrinsically linked. CSR is a tool for achieving sustainable development (Moon, 2007). Similarly, corporate innovation is aimed at enhancing the market competitiveness and sustainable development of firms. Therefore, the impact of social responsibility on corporate innovation in the face of demand for sustainable development should be investigated. This paper studies the impact of social responsibility on corporate innovation for social responsibility on corporate innovation based on sustainable development theory and further explores the impact on radical innovation. Koberg et al. (2003) define radical innovation as the creation of technological breakthroughs through significant innovations for a product or service market and encompasses technological advances of exceptional importance. Most innovation simply builds on knowledge and technology or modifies functions and practices, but radical innovation, which is the key to wealth creation, involves essential changes (Höyssä and Hysalo, 2009). Radical innovation is more likely to essentially stimulate the production of new technologies, broaden market opportunities, enhance the competitive positions of firms and yield permanent improvements in firm performance and growth (McDermott and O'Connor, 2002).

China provides an ideal experimental setting. Most empirical studies of CSR focus on developed economies (e.g., the United States and European countries). With the growing power and influence of emerging economies, academic interest in CSR in these countries and regions is increasing. As an important emerging market, China has undergone rapid economic expansion, which has brought negative environmental and social consequences. Serious environmental problems such as air and water pollution, the degradation of natural habitats and the wastage of nonrenewable resources are constantly criticized (Shu et al., 2016), and the fading demographic dividend, labor shortages and rising costs are becoming increasingly prominent. However, the mechanisms linking CSR and corporate innovation differ among countries and regions and thus result in ambiguous outcomes. Yang et al. (2019) suggests that the mechanisms underlying the influence of social responsibility on corporate innovation in emerging economies (e.g., China) may differ from those in developed countries.

This paper examines the impact of sustainability-oriented social responsibility on corporate innovation from the perspectives of environment- and employee-oriented social responsibility. The empirical results indicate that both environment- and employee-oriented social responsibility can promote corporate innovation, specifically, innovation quantity and radical innovation. These findings hold after omitted variable issues and the sample selection problem are mitigated, alternative explanations are excluded and exogenous event shocks are considered. Further analysis shows that environment-oriented and employee-oriented CSR affect corporate innovation through heterogeneous mechanisms. Specifically, environment-oriented CSR improves innovation quantity and radical innovation by prompting firms to increase their R&D investment. Employee-oriented social responsibility increases innovation guantity by helping firms retain talent, while contributing to both innovation quantity and radical innovation by motivating talented employees. In addition, both environment- and employee-oriented responsibility can alleviate financing constraints. Finally, an economic consequence test shows that the positive effect of environment-oriented social responsibility on radical innovation increases firms' total factor productivity (TFP). The effect of employee-oriented social responsibility on radical innovation quality ultimately improves firms' TFP as well.

The contributions of our paper are twofold. First, the literature suggests that CSR or environmental, social and governance behavior may affect corporate innovation by improving corporate reputation, alleviating financing constraints and altering corporate investment and risk-taking behavior (Hu et al., 2020; Ko et al., 2020; Yuan et al., 2023), but comparative analyses of the effects of different social responsibilities on corporate innovation are lacking. This paper analyzes the heterogeneous mechanisms by which environment- and employee-oriented social responsibility affect corporate innovation, providing new empiri-

cal data on the relationship between CSR and corporate innovation. Second, this paper considers not only innovation quantity but also radical innovation in the research framework, extending the research on the determinants of corporate innovation. Although radical innovation is closely associated with high risk and uncertainty in firms, it creates technological breakthroughs that lead to new products, create additional business for firms and enhance the organizational ability of firms to cope with turbulent market environments (O'Connor and Ayers, 2005). The literature on radical innovation remains limited, but this paper contributes to the understanding of the drivers of radical innovation.

2. Hypothesis development

Carroll (1979) introduces a pyramid structure to categorize CSR into economic, legal, ethical and philanthropic obligations. Rupp et al. (2013) argue that Carroll's framework is limited because it ignores corporate behavior that favors external stakeholders. In the 1980s, Freeman (1984) introduces the concept of using the relationship between firms and their stakeholders to define CSR. However, various stakeholder groups do not receive equal attention in the academic literature (Akhouri and Chaudhary, 2019), and most studies focus on business interests (Weber, 2008; Rupp et al., 2015). For example, Fairhurst and Greene (2022) investigate CSR from the perspective of shareholders, while Öberseder et al. (2013) examine the consumer perspective.

Based on sustainable development theory, this paper discusses the impact of CSR on two main aspects of corporate innovation: the environment and employees. Over time, sustainability has begun to influence CSR behavior. Sustainability is a deep future-oriented requirement that guides firms to reconsider their CSR strategies from a long-term perspective (Miles et al., 2009). Long-term-oriented strategic decisions can mitigate some negative impacts of social responsibility activities (Wang and Bansal, 2012), thus motivating firms to take a long-term view and removing the constraints of short-term returns (Flammer and Bansal, 2017). Garrett (1968) proposes that firms should not sacrifice the environment for temporary gains in development. Instead, enterprises should assume the obligation of protecting the natural environment to create a harmonious relationship, which is the core concept of sustainable development. Moreover, CSR researchers attach importance to external stakeholders, such as investors and customers, and neglect internal stakeholders, namely employees (Chen and Hung-Baesecke, 2014). Goud (2014) emphasizes the importance of employees in promoting sustainable development. Employees are the most subjectively innovative resource and important carriers of productivity. Their specialized skills create human capital, which generates more sustainable competitive advantages than material resources generate (Huselid, 1995). Thus, environment- and employeeoriented CSR has the long-term dual objectives of improving economic returns and benefiting society, which are in line with the needs and direction of sustainable development.

Corporate innovation is often perceived as a positively external, high-risk and long-term activity and relies on numerous innovation resources, which create high costs and reduce profits in the short term. As a result, under short-term performance and cash flow pressures, firms lack strong willingness to initiate innovation activities. When faced with environmental regulations, firms recognize that the natural environment challenges their development of new resources and capabilities and do their best to minimize or eliminate pollutant emissions and resource consumption in production and operations. Environmental governance measures such as saving energy, reducing emissions and investing in environmental protection can alleviate the public's concerns about a firm's accountability for the natural environment; thus, the firm can gain intangible assets such as legitimacy, reputation and social trust (Turban and Greening, 1997). By responding to environmental challenges, firms can attract the attention of various stakeholders, such as governments, external investors and consumers (Tian et al., 2011). To assuage stakeholders' concerns, resource constraints on innovation may be eased. In addition, firms assuming environment-oriented responsibility should pay close attention to government policies, customers and the public interest, among other external sources of information, which helps promote corporate innovation (García-Piqueres and García-Ramos, 2020).

According to Hart (1995), firms can fulfill their environment-oriented responsibilities through two methods. One method is to address pollution retroactively. For example, firms can use pollution control equipment to identify and dispose of wastewater, waste gas, waste residue and other emissions. The other is to effectively utilize preventive programs; firms can achieve green production through effective clean management, material substitution, recycling or process innovation. Addressing pollution retroactively relies on costly treatment equipment, while preventive programs produce environmentally beneficial products and simultaneously reduce pollution in the production process. Lober (1998) suggests that firms' environmental protection work should focus on pollution prevention and meet environmental requirements by providing innovative products, services or organizations. As Porter and Van der Linde (1995) suggest, innovation induced by pollution prevention reduces emissions below policy-required levels, partially or fully offsetting the costs of emissions fees or shut-down orders due to noncompliance with environmental standards. Pollution prevention requires the sustained development of new technologies for cleaner production to improve formerly resource-intensive and ecologically destructive production methods. In other words, the need to prevent pollution encourages firms to conduct innovation activities, even radical innovation. Radical innovation describes the pursuit of not only an increase in the number of patents but also fundamental change to a firm's production technology, which is highly dependent on large investments and exposed to risk. However, radical innovation outputs offer greater strategic returns once they are successfully developed and applied. For example, radical innovations can create new products and markets, enabling firms to be more competitive in the market (Barba-Aragón and Jiménez-Jiménez, 2020). Overall, while fulfilling their environment-oriented responsibility, firms allocate resources to R&D to scientifically improve resource utilization and reduce the costs of raw materials and waste disposal. In other words, taking environment-oriented responsibility to solve environmental problems is conducive to effective innovation decision-making and prompts firms to conduct more pioneering activities. We propose and empirically test the following hypotheses:

Hypothesis 1a. (H1a). The fulfillment of environment-oriented social responsibility has a positive effect on innovation quantity.

Hypothesis 1b. (H1b). The fulfillment of environment-oriented social responsibility has a positive effect on radical innovation.

Corporate innovation is technological R&D based on the accumulation of knowledge (Nelson, 1982). Bocquet and Mothe (2011) suggest that considering human potential is necessary to assess the relationship between CSR and future innovation. Human capital theory (Schultz, 1961) suggests that the experience, skills and culture of workers make them innovative and creative and important parts of firms' knowledge reserve, from which knowledge can be acquired, digested, transformed and utilized for technological innovation, providing a competitive advantage for the firm (Wright et al., 2001). Human capital is the main source of new ideas and knowledge for firms, influencing the capability for both incremental and radical innovation (Subramaniam and Youndt, 2005). Angle (2000) discusses the interplay between people and innovation, suggesting that attracting and retaining talented employees (Sun et al., 2020; Santos-Jaén et al., 2021) and motivating them to behave innovatively are indispensable for filling a firm's technological gaps (Teixeira and Fortuna, 2004). Although it has become more challenging for managers to retain high-performing employees, fulfilling employee-oriented responsibility can help firms attract, retain and motivate talent. Employeeoriented responsibility improves the reputation and image of a firm, increasing its attractiveness to knowledge workers and helping to retain innovative talent. Albinger and Freeman (2020) find that firms with high social performance have an advantage in attracting and retaining the most qualified employees. Employee-oriented responsibility is associated with a firm creating an environment that attracts employees over the long term (Goud, 2014), preventing the loss of competent employees and avoiding negative impacts on productivity. When employee turnover occurs, employees migrate to competing firms with knowledge and trade secrets gained from their former employers, thus creating a dire situation for the former employer. As stated by Abassi and Hollman (2000), abnormal employee turnover can harm firm performance by reducing innovation and delaying service.

However, given the risk of innovation, innovation projects increase the risk of employee dismissal. Employees are often more willing to invest their time and energy in projects with more stable expectations than risky innovation projects. Firms that fulfill their employee-oriented responsibility can promote employee innovation because they have a high tolerance for early failures and reward long-term successes. In such situations, employees do not incur negative consequences, such as salary reductions or dismissal, due to the failure of innovation projects (Manso, 2011). Employee-oriented responsibility not only favors a quantitative increase in innovation but also involves thorough knowledge creation, that is, radical innovation, because firms that

Table 1 Variable definitions.

Variable	Definition
Innovation	Corporate innovation quantity measured as the natural logarithm of the number of patent applications plus 1.
Radical	Corporate radical innovation measured as the natural logarithm of the number of forward patent citations plus 1.
ECSR	Dummy variable equaling 1 if a listed firm's social responsibility report explicitly discloses environment-related content and 0 otherwise.
HCSR	Dummy variable equaling 1 if a listed firm's social responsibility report explicitly discloses the content related to employee rights and interests and 0 otherwise.
Roa	Net income scaled by total assets
Lev	Book value of total debts divided by the book value of total assets
TobinQ	Sum of market value of equity and net debt scaled by total assets
CFO	Net cash flows from operating activities scaled by total assets
GDP	GDP growth rate of the province where a firm is located
Tech	Fiscal expenditures on science and technology divided by regional fiscal expenditures
Urban	Urban population divided by total regional population

actively fulfill their employee-oriented responsibility create an environment that allows for trial and error and can motivate employees to take risks in innovation. For example, employee-oriented responsibility provides knowledge workers with autonomy through long-term incentive systems such as equity pay (Azoulay et al., 2011), which help to compensate for employees' myopic motivations. As potentially creative individuals, employees are then motivated to break out of their established daily roles and spend their personal time and energy to conceptualize valuable ideas. They work hard to explore and accumulate a large amount of unique and in-depth knowledge, which facilitates the generation of new ideas for radical innovation, thus enriching and deepening the corporate knowledge base. In addition, firms that focus on employee-oriented responsibility often provide a platform for employees to exchange information and inspiration and thus explore and accumulate knowledge with a wider scope and combine, transform and integrate external knowledge with internally generated knowledge, potentially expanding the firm's innovation frontiers (Romer, 1990). We propose and empirically test the following hypotheses:

Hypothesis 2a. (H2a). The fulfillment of employee-oriented social responsibility has a positive effect on the quantity of innovation.

Hypothesis 2b. (*H2b*). The fulfillment of employee-oriented social responsibility has a positive effect on radical innovation.

Descriptive statis	Descriptive statistics.						
Variable	N	Mean	SD	Min	P50	Max	
Innovation	26,141	1.480	1.630	0	1.100	5.700	
Radical	26,141	2.194	2.071	0	2.197	10.982	
ECSR	26,141	0.610	0.490	0	1	1	
HCSR	26,141	0.059	0.235	0	0	1	
Roa	26,141	0.030	0.070	-0.400	0.030	0.210	
Lev	26,141	0.460	0.220	0.050	0.450	1.170	
TobinQ	26,141	2.130	1.450	0.880	1.660	9.500	
CFO	26,141	0	0.120	-0.540	0.020	0.280	
GDP	26,141	9.270	2.720	-2.500	8.300	19.200	
Tech	26,141	0.030	0.020	0	0.030	0.070	
Urban	26,141	0.610	0.140	0.220	0.610	0.940	

Table 2 Descriptive statistics.

Table 3						
Environment-oriented	social	respo	onsibility	and	corporate	innovation

	(1)	(2)	(3)	(4)	(5)	(6)
	Innovation			Radical		
ECSR	0.312***	0.264***	0.254***	0.521***	0.422***	0.436***
	(8.805)	(7.473)	(7.054)	(10.932)	(8.978)	(9.102)
Roa		2.845***	2.748***		3.523***	3.805***
		(13.958)	(12.304)		(15.087)	(14.217)
Lev		0.086	0.128		0.820***	1.085***
		(0.886)	(1.248)		(6.798)	(8.192)
TobinQ		-0.107^{***}	-0.101^{***}		-0.143^{***}	-0.142^{***}
-		(-9.333)	(-8.419)		(-10.084)	(-9.282)
CFO		-0.013	0.031		-0.378^{***}	-0.434^{***}
		(-0.189)	(0.436)		(-4.139)	(-4.364)
GDP			0.018^{***}			0.016*
			(2.654)			(1.649)
Tech			2.960*			-1.971
			(1.792)			(-0.876)
Urban			0.467			2.989^{***}
			(0.998)			(4.675)
Constant	0.227*	0.205	0.175	0.738^{***}	0.304*	-1.650^{***}
	(1.712)	(1.420)	(0.372)	(4.690)	(1.761)	(-2.667)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Province FE	No	No	Yes	Yes	Yes	Yes
N	34,598	31,143	26,141	34,598	31,143	26,141
Adj. R^2	0.218	0.244	0.283	0.242	0.276	0.275

3. Research design

3.1. Sample selection and data sources

Our initial sample comprises Chinese listed firms from 2006 to 2020. We delete observations in the financial industry, observations marked as ST or *ST and observations without sufficient data. The final sample consists of 26,141 firm-year observations. We obtain data from the China Stock Market and Accounting Research Database and Chinese Research Data Services Platform. Moreover, all the continuous variables are winsorized at the 1 % and 99 % levels to eliminate the effects of extreme values.

3.2. Empirical model and variable description

Based on our theoretical analysis, we establish the following regression model to test the comprehensive impact of sustainability-oriented social responsibility on corporate innovation:

$$Y_{i,t+1} = \beta_0 + \beta_1 CSR_{i,t} + \beta_2 Roa_{i,t} + \beta_3 Lev_{i,t} + \beta_4 Tobin Q_{i,t} + \beta_5 CFO_{i,t} + \beta_6 Tech_{i,t} + \beta_7 Urban + \omega + \mu$$

$$+ \eta + \varepsilon$$
(1)

where $Y_{i,t+1}$ is the explained variable, denoting the innovation quantity and radical innovation of firm *i* in year t+1, respectively. $CSR_{i,t}$ represents sustainability-oriented social responsibility, including environmentoriented social responsibility (*ECSR*) and employee-oriented social responsibility (*HCSR*). To eliminate the effect of lags in firms' innovation output, we lag both the explanatory and control variables by one period. The variables ω , μ and η indicate fixed effects for time, industry and region, respectively. The standard errors for each regression are clustered at the firm level. With respect to corporate innovation, we use the number of patent applications to measure innovation quantity. Second, following Dahlin and Behrens (2005), we observe whether a patent has an impact on future technology. The greater the number of forward citations of a patent, the more likely it is that the patent involves significant advanced and groundbreaking research. Such innovation serves as an important catalyst for change and lays the technological foundation for particular fields. Therefore, we use the number of forward patent citations to measure corporate radical innovation.

Following the literature, we control for several firm- and province-level characteristics that may influence corporate innovation. At the firm level, *Roa*, *Lev*, *TobinQ* and *CFO* are included. At the province level, we control for *GDP*, *Tech* and *Urban*. Table 1 provides detailed definitions of the variables.

4. Empirical results and discussion

4.1. Descriptive statistics

The descriptive statistics are presented in Table 2. The minimum and maximum values for *Innovation* are 0 and 5.700, respectively, with a standard deviation of 1.630. The minimum and maximum values for *Radical* are 0 and 10.982, respectively, with a standard deviation of 2.194. Therefore, radical innovation varies more than innovation quantity among Chinese listed firms. The mean values of *ECSR* and *HCSR* are 0.610 and 0.059, respectively, indicating that 61 % and 5.9 % of the firms in the sample observations are concerned with environment- and employee-oriented responsibility, respectively. The descriptive statistics of the control variables are reasonable.

	(1)	(2)	(3)	(4)	(5)	(6)
	Innovation			Radical		
HCSR	0.671***	0.631***	0.648***	1.043***	0.925****	0.936***
	(8.426)	(7.678)	(7.591)	(11.630)	(10.404)	(10.133)
Roa	· · · ·	2.778***	2.783***		3.559***	3.905***
		(14.054)	(12.428)		(15.413)	(14.487)
Lev		0.070	0.128		0.794***	1.100***
		(0.737)	(1.258)		(6.696)	(8.282)
TobinQ		-0.108^{***}	-0.103^{***}		-0.148^{***}	-0.148^{***}
-		(-9.415)	(-8.640)		(-10.252)	(-9.490)
CFO		-0.027	0.024		-0.376^{***}	-0.438^{***}
		(-0.418)	(0.335)		(-4.202)	(-4.439)
GDP			0.019***			0.017*
			(2.743)			(1.778)
Tech			3.790**			-0.688
			(2.288)			(-0.305)
Urban			0.681			3.341***
			(1.445)			(5.176)
Constant	0.015	0.161	-0.536	0.314**	0.164	-2.035^{***}
	(0.110)	(1.136)	(-1.171)	(1.986)	(0.967)	(-3.400)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Province FE	No	No	Yes	Yes	Yes	Yes
N	36,017	32,507	26,201	36,017	32,507	26,201
Adj. R^2	0.225	0.252	0.288	0.246	0.280	0.278

Table 4 Employee-oriented social responsibility and corporate innovation.

Table 5

4.2. Baseline results

Table 3 presents data on the effect of environment-oriented social responsibility on corporate innovation. Columns (1)–(3) show the regression results with innovation quantity as the explained variable. With year and industry fixed effects controlled for, the regression coefficient of *ECSR* (in column (1)) is significant and positive. Subsequently, firm- and region-level characteristics are added to the model, and the regression coefficient of *ECSR* remains significant and positive at the 1 % level, as shown in column (3). Similarly, columns (4)–(6) show the regression results with radical innovation as the explained variable. The regression coefficient of *HCSR* is significant and positive at the 1 % level with all control variables and fixed effects controlled for, as shown in column (6). This result is not only statistically significant but also economically significant. For each standard deviation increase in *ECSR*, *Innovation* increases by 12.45 % (0.490 × 0.254), and *Radical* increases by 21.36 % (0.490 × 0.436). These results confirm the positive effects of environment-oriented social responsibility on innovation quantity and radical innovation, supporting *H1a* and *H1b*, respectively.

Table 4 presents data on the effect of employee-oriented social responsibility on corporate innovation. With *Innovation* or *Radical* as the explained variable, the regression coefficient of *HCSR* is significant and positive at the 1 % level after all variables are controlled for. In terms of economic significance, with each standard deviation increase in *HCSR*, *Innovation* increases by 15.23 % (0.235 × 0.648), and *Radical* increases by 22 % (0.235 × 0.936). Thus, employee-oriented responsibility can promote corporate innovation, both innovation quantity and radical innovation, supporting *H2a* and *H2b*, respectively.

Controlling time trends.					
	(1)	(2)	(3)	(4)	
	Innovation	Radical	Innovation	Radical	
ECSR	0.259***	0.530****			
	(7.360)	(11.243)			
HCSR			0.660****	1.010^{***}	
			(7.751)	(10.572)	
Roa	2.781****	3.450***	2.804***	3.566***	
	(12.559)	(12.734)	(12.635)	(13.064)	
Lev	0.132	1.056***	0.131	1.076***	
	(1.294)	(7.813)	(1.283)	(7.938)	
TobinQ	-0.092***	-0.113***	-0.095****	-0.122***	
~	(-8.518)	(-7.854)	(-8.822)	(-8.322)	
CFO	0.011	-0.381***	0.010	-0.372***	
	(0.148)	(-3.833)	(0.147)	(-3.763)	
GDP	0.010*	-0.032***	0.005	-0.041***	
	(1.863)	(-4.067)	(0.997)	(-5.225)	
Tech	0.601	-11.586***	1.584	-10.085^{***}	
	(0.383)	(-5.414)	(1.005)	(-4.684)	
Urban	0.567	3.302***	0.645	3.442***	
	(1.263)	(5.257)	(1.432)	(5.448)	
Year	0.037***	-0.065^{***}	0.047***	-0.042^{***}	
	(5.985)	(-7.436)	(8.207)	(-5.035)	
Constant	-73.859***	130.133***	-94.838***	82.899***	
	(-6.076)	(7.509)	(-8.348)	(5.074)	
Year FE	No	No	No	No	
Industry FE	Yes	Yes	Yes	Yes	
Province FE	Yes	Yes	Yes	Yes	
N	26,141	26,141	26,201	26,201	
Adj. R^2	0.282	0.234	0.2884	0.2369	

4.3. Robustness checks

4.3.1. Mitigating omitted variable issues

Sustainability-oriented social responsibility and corporate innovation, as firm-level variables, may both be endogenous to the whole firm system. Hence, there is another possible explanation for our results: Firms with better performance may pay closer attention to CSR. Simultaneously, they may also be more capable of conducting innovation activities. The findings of this paper still hold after *Roa* is controlled for in the regression. In addition, we replace the time dummy variable in model (1) with a time trend variable. The results are shown in Table 5. The regression coefficients of *ECSR* and *HCSR* remain significant and positive, excluding the possibility that both CSR and corporate innovation are affected by firm performance simultaneously.

To further test the reliability of the baseline results, we introduce the firm-level control variables scale of assets (*Size*), years listed (*Age*), proportion of shares held by the first largest shareholder (*Top1*) and number of corporate boards (*Indboard*) into model (1) and reregress the model to mitigate potential omitted variable issues. The results of the regression are presented in Table 6. The results show that the main conclusions of this paper hold after the addition of a series of control variables.

	(1)	(2)	(3)	(4)
	Innovation	Radical	Innovation	Radical
ECSR	0.122****	0.077*		
	(3.579)	(1.780)		
HCSR			0.480^{***}	0.370^{***}
			(5.819)	(4.578)
Roa	1.598****	1.277****	1.626***	1.297***
	(7.082)	(4.984)	(7.196)	(5.059)
Lev	-0.107	-0.269**	-0.079	-0.241*
	(-0.993)	(-2.092)	(-0.740)	(-1.868)
TobinQ	0.034**	0.126***	0.030**	0.121***
~	(2.387)	(7.015)	(2.080)	(6.788)
CFO	0.072	-0.354***	0.061	-0.362***
	(0.997)	(-3.730)	(0.851)	(-3.830)
GDP	0.015**	0.014	0.015**	0.014
	(2.077)	(1.411)	(2.166)	(1.467)
Tech	1.666	-4.112*	2.106	-3.864*
	(0.954)	(-1.806)	(1.206)	(-1.699)
Urban	0.742	2.301****	0.908*	2.412***
	(1.522)	(3.669)	(1.866)	(3.840)
Size	0.316***	0.728***	0.303****	0.715***
	(10.999)	(22.917)	(10.730)	(22.481)
Age	-0.050****	-0.026****	-0.051****	-0.027^{***}
÷	(-13.026)	(-6.018)	(-13.354)	(-6.189)
Top1	-0.002	-0.005****	-0.002	-0.005^{***}
*	(-1.455)	(-2.781)	(-1.347)	(-2.720)
Indboard	-0.049	-0.007	-0.045	-0.005
	(-1.315)	(-0.162)	(-1.203)	(-0.105)
Constant	-6.216***	-16.337***	-6.076***	-15.810^{***}
	(-7.904)	(-18.254)	(-7.772)	(-17.625)
Year FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Province FE	No	No	Yes	Yes
Ν	24,253	24,253	24,286	24,286
Adj. R^2	0.331	0.380	0.334	0.382

Table 6 Adding control variables.

4.3.2. Mitigating selection bias

Because disclosure by listed firms is voluntary, a considerable proportion of the values of the core explanatory variables equal 0 in the sample. Thus, sample selection bias may arise if those samples are excluded. This paper uses the Heckman sample selection model to mitigate the potential selection bias as follows:

$$\begin{cases} P(y_{i,t} = 1) = F(\alpha_0 + \alpha_1 Controls_{i,t}) \\ Y_{i,t+1} = \beta_0 + \beta_1 X_{i,t} + \beta_2 Controls_{i,t} + Year + Industry + Province + \varepsilon_{i,t+1}, y_{i,t} = 1 \end{cases}$$
(2)

where $y_{i,t}$ includes the dummy variables *DumECSR* and *DumHCSR*. $F(\cdot)$ denotes a probability distribution function, and a probit model is applied in the first stage. To ensure the estimation efficiency, we introduce a dummy variable, *DumRDI*, indicating the R&D expenditures of listed firms, as a control variable in the first-stage regression. The regression results are presented in Table 7, showing that the coefficients of *ECSR* and *HCSR* are significant and positive, supporting the main findings of this paper.

4.3.3. Excluding alternative explanations

This paper argues that corporate innovation is driven by the fulfillment of environment-oriented social responsibility by firms. Given the practical requirements of sustainable development, firms are subject to increasingly strict environmental regulations. Thus, firms may be forced to conduct innovation activities under the pressure of such environmental regulations (Xu et al., 2022). To rule out this alternative explanation, we

Table 7			
Mitigating	sample	selection	bias

	(1)	(2)	(3)	(4)	(5)	(6)
	DumECSR	Innovation	Radical	DumHCSR	Innovation	Radical
	Step 1	Step 2	Step 2	Step 1	Step 2	Step 2
ECSR		0.264***	0.346***			
		(10.546)	(12.444)			
HCSR					0.495***	0.707^{***}
					(12.177)	(15.593)
Roa	2.343***	3.578***	3.970^{***}	3.528***	3.575***	4.045***
	(12.069)	(18.069)	(18.152)	(6.848)	(18.143)	(18.555)
Lev	0.629***	1.206***	1.454***	0.756***	1.231***	1.493***
	(7.631)	(20.041)	(22.475)	(5.802)	(20.594)	(23.272)
TobinQ	-0.101^{***}	-0.067^{***}	-0.061^{***}	-0.139***	-0.069^{***}	-0.065^{***}
	(-9.542)	(-6.845)	(-5.813)	(-5.230)	(-7.026)	(-6.146)
CFO	-0.025	-0.328^{***}	-0.697^{***}	0.096	-0.332^{***}	-0.718^{***}
	(-0.316)	(-3.505)	(-6.844)	(0.788)	(-3.560)	(-7.085)
GDP	0.013	0.030***	0.021*	-0.020	0.029***	0.023**
	(1.327)	(2.837)	(1.799)	(-1.252)	(2.735)	(2.007)
Tech	6.918***	1.321	1.105	-3.683	2.092	2.214
	(3.553)	(0.742)	(0.549)	(-1.463)	(1.178)	(1.106)
Urban	1.330**	0.986^{**}	3.100***	-1.612*	1.078^{**}	3.371***
	(2.300)	(2.010)	(5.630)	(-1.824)	(2.205)	(6.155)
DumRDI	0.144^{***}			0.109*		
	(3.376)			(1.771)		
Constant	-1.040*	-0.101	-0.270	-0.075	-0.185	-0.629
	(-1.771)	(-0.201)	(-0.474)	(-0.085)	(-0.367)	(-1.106)
IMR		-0.231***	-0.190^{***}		-0.232^{***}	-0.155^{**}
		(-3.32)	(-2.79)		(-3.33)	(-2.30)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes	Yes	Yes
N	25,080	25,081	25,081	24,639	25,141	25,141
Pseudo- R^2	0.238			0.100		

Note: In columns (1) and (2), the numbers in parentheses are *z* values. In columns (3)–(6), the numbers in parentheses are *t* values. *Note*: The asterisks denote the level of statistical significance: *** if p < 0.01, ** if p < 0.05 and * if p < 0.1. See Table 1 for variable definitions.

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	(1)	(2)
	Innovation	Radical
ECSR	0.250***	0.417***
	(6.781)	(8.654)
Subsidy	11.849**	4.604
	(2.547)	(0.998)
Charge	-54.758**	-75.261**
	(-2.321)	(-2.531)
Roa	2.930****	4.083***
	(12.234)	(14.489)
Lev	0.153	1.228***
	(1.412)	(9.012)
TobinQ	-0.101^{***}	-0.121***
~	(-7.700)	(-7.387)
CFO	0.021	-0.469***
	(0.277)	(-4.494)
GDP	0.017**	0.021**
	(2.337)	(2.029)
Tech	2.291	-2.162
	(1.322)	(-0.934)
Urban	0.524	3.485***
	(1.041)	(5.174)
Constant	-0.304	-2.203***
	(-0.627)	(-3.511)
Year FE	Yes	Yes
Industry FE	Yes	Yes
Province FE	Yes	Yes
Ν	24,791	24,791
Adj. R^2	0.276	0.274

Table 8Excluding alternative explanations.

introduce two variables representing environmental regulatory instruments, namely environmental subsidies (*Subsidy*) and sewage charges (*Charge*), which are standardized by firms' total assets. Table 8 presents the regression results, showing that the conclusions of this paper remain valid after the exclusion of the alternative explanation of environmental regulations.

4.3.4. Considering exogenous shocks

There may be reverse causality between sustainability-oriented social responsibility and corporate innovation. For example, innovative firms have more material resources, which can be utilized for CSR. We use exogenous shock events in 2015 to mitigate this endogeneity issue. In addition to voluntary firm behavior, strong government regulation is an important catalyst for environment-oriented social responsibility. After the implementation of the new Environmental Protection Law in 2015, environmental regulations were strengthened, and the cost for firms violating the law increased, thus benefiting the improvement of environmental governance and driving firms to fulfill environment-oriented responsibility. Moreover, the minimum wage is an institutional requirement protecting employees' rights and interests. From 2004 to 2015, the average monthly minimum wage in all regions of the country increased from RMB 430.75 to RMB 1,549.22. We define *Post* as a dummy variable equaling 1 when the year is 2015 or later and 0 otherwise. Year and individual fixed effects are controlled for in a difference-in-differences model. The regression coefficients of *ECSR* × *Post* and *HCSR* × *Post* are significant and positive, as shown in Table 9. These results indicate that these shock events of 2015, that is, the implementation of the new Environmental Protection Law and the minimum wage, drove environment- and employee-oriented CSR, respectively, effectively increasing corporate innovation.

	(1)	(2)
$ECSR \times Post$	0.093***	
	(3.978)	
$HCSR \times Post$		0.241***
		(4.625)
Roa	0.655***	0.660***
	(5.385)	(5.443)
Lev	0.068	0.071
	(0.947)	(0.980)
TobinQ	-0.022^{***}	-0.023***
-	(-3.166)	(-3.202)
CFO	0.099**	0.100**
	(2.125)	(2.145)
GDP	0.016****	0.016***
	(2.583)	(2.592)
Tech	2.122	2.352
	(1.380)	(1.537)
Urban	1.259***	1.319***
	(2.891)	(3.033)
Constant	0.476	0.489
	(1.554)	(1.598)
Year	Yes	Yes
Individual	Yes	Yes
Ν	26,180	26,240
R^2	0.028	0.030

Table 9Considering exogenous event shocks.

Note: The *t* values in parentheses are based on standard errors clustered by firm. The asterisks denote the level of statistical significance: *** if p < 0.01, ** if p < 0.05 and * if p < 0.1. See Table 1 for variable definitions.

4.3.5. Controlling for firm-level fixed effects

To control for firm characteristics that do not vary over time, we control for firm-level fixed effects in the regression. The regression results are shown in Table 10. The results indicate that the main findings of this paper still hold.

4.3.6. Entropy balancing method

The propensity score method may require the deletion of control group observations that cannot be matched, thus discarding part of the sample. Therefore, we adopt the entropy balancing method to address sample selection bias. As Table 11 indicates, the regression coefficients of *ECSR* and *HCSR* remain significant and positive, confirming the robustness of this paper's findings.

4.3.7. Changing the regression model

$$Y_{i,t+1} = \beta_0 + \beta_1 ECSR_{i,t} + \beta_2 HCSR_{i,t} + Controls + \omega + \mu + \eta + \varepsilon$$
(3)

where the variables ECSR and HCSR are simultaneously included in model (3). The results are presented in Table 12. Aligning with the baseline results, the regression coefficients of both ECSR and HCSR are significant and positive at the 1 % level after all variables are controlled for.

4.3.8. Testing whether corporate innovation can also predict sustainability-oriented social responsibility

One possibility challenges the conclusions of this paper. If corporate innovation behavior influences firm decisions to bear sustainability-oriented social responsibility, changes in CSR are endogenous to innovation quantity and radical innovation. Thus, the conclusions observed in this paper are likely to be biased because of this reverse causality. For example, if firms have many eco-friendly technologies, they can efficiently save

Table 10		
Controlling for firm-level	fixed	effects.

	(1)	(2)	(3)	(4)
	Innovation	Radical	Innovation	Radical
ECSR	0.034*	0.119****		
	(1.845)	(4.615)		
HCSR			0.175***	0.207^{***}
			(4.763)	(3.927)
Roa	0.700^{***}	1.471***	0.700***	1.477***
	(5.797)	(8.960)	(5.806)	(9.003)
Lev	0.061	-0.022	0.062	-0.017
	(0.836)	(-0.221)	(0.859)	(-0.169)
TobinQ	-0.021^{***}	0.040****	-0.021***	0.039***
~	(-3.339)	(4.448)	(-3.356)	(4.308)
CFO	0.099**	-0.180^{***}	0.099**	-0.177^{***}
	(2.134)	(-2.732)	(2.140)	(-2.695)
GDP	0.005	-0.046^{***}	0.004	-0.048^{***}
	(1.099)	(-6.199)	(0.945)	(-6.559)
Tech	0.377	-16.022^{***}	0.595	-15.570^{***}
	(0.259)	(-8.637)	(0.411)	(-8.392)
Urban	1.281***	2.299****	1.293****	2.294***
	(3.049)	(4.120)	(3.087)	(4.138)
Constant	-45.235***	184.147***	-46.249***	172.495***
	(-4.327)	(12.380)	(-4.569)	(11.855)
Year	0.023***	-0.091***	0.023***	-0.085^{***}
Firm FE	Yes	Yes	Yes	Yes
Ν	26,176	26,176	26,236	26,236
Adj. R^2	0.023	0.040	0.024	0.040

energy and reduce emissions. Such firms would be willing to assume sustainability-oriented social responsibility. To rule out this possibility, we use model (4) to test whether corporate innovation can also predict sustainability-oriented social responsibility:

$$\Delta CSR_{i,t} = \beta_0 + \beta_1 Innovation_{i,t-1} + \beta_2 Innovation_{i,t-2} + Controls + \omega + \mu + \eta + \varepsilon$$
(4)

where $\Delta CSR_{i,t}$ denotes the change in the CSR of firm *i* in year *t*. The regression results in Table 13 show that neither corporate innovation in year *t*-1 nor in year *t*-2 can predict changes in CSR.

4.3.9. Alternative variable measurement

We change the measurement of the explained variables. Considering the more technical factors and innovation intensity of invention patents, we use the number of patent applications as an alternative measure of the explained variable. The regression results in columns (1) and (2) of Table 14 show that the regression coefficients of *ECSR* and *HCSR* are both significant and positive. In addition, we define the explanatory variable with a continuous evaluation index obtained from Hexun.com. The regression results are presented in columns (3)–(6) of Table 14 and are consistent with the baseline results.

4.3.10. Placebo tests

Finally, we use placebo tests to examine whether unobserved factors cause errors in our findings. Figs. 1 and 2 show the results of placebo tests with environment- and employee-oriented social responsibility, respectively, as the explanatory variable. The t values of the regression coefficients are all centrally distributed around 0, indicating that unobserved factors do not significantly threaten the findings.

5. Further analysis

5.1. Mechanisms

This paper suggests that environment-oriented social responsibility can motivate firms to increase their R&D investment in groundbreaking environmental technologies and scientifically reduce the cost of raw materials and waste treatment. Therefore, we add R&D investment (*RDI*) and its interaction term with *ECSR* to model (1). The variable *RDI* is equal to a firm's R&D investment scaled by its total assets. The regression results are presented in Table 15. In columns (2) and (4), the regression coefficients of *ECSR* × *RDI* are both significant and negative, implying that environment-oriented CSR is conducive to increasing R&D investment, which exerts a positive impact on innovation quantity and radical innovation.

Talent is the core element of corporate innovation. Based on the theoretical analysis, this paper argues that employee-oriented social responsibility can help firms retain and motivate talent, thereby significantly contributing to the enhancement of corporate innovation. We add the variables *Retain* and *Motivate* and their interaction terms with the variable *HCSR* to model (1). The variable *Retain* equals the inverse of the technician turnover rate. The variable *Motivate* equals the number of equity incentives. The regression results for *Retain* and *Motivate* are presented in Tables 16 and 17, respectively. In columns (1) and (3) of Table 16, the regression coefficients of *Retain* are both significant and positive, indicating that retaining talent has a positive effect on innovation quantity and radical innovation. As column (2) shows, the regression coefficient of $HCSR \times Retain$ is significant and negative when the explained variable is innovation quantity, and negative but nonsignificant when the explained variable is radical innovation. Thus, employee-oriented social responsibility increases innovation quantity, rather than radical innovation, by helping firms retain talent and alleviating talent shortages.

	(1)	(2)	(3)	(4)
	Innovation	Radical	Innovation	Radical
ECSR	0.262****	0.372***		
	(7.068)	(8.015)		
HCSR			0.612***	0.869^{***}
			(7.591)	(10.007)
Roa	2.915***	3.608***	4.166***	6.199***
	(10.915)	(11.440)	(5.858)	(8.226)
Lev	0.124	1.165***	0.568**	2.421***
	(1.101)	(8.050)	(2.527)	(9.316)
TobinQ	-0.101***	-0.135***	-0.116***	-0.189***
	(-7.103)	(-7.791)	(-3.607)	(-5.024)
CFO	0.080	-0.379^{***}	-0.190	-0.429
	(0.906)	(-3.150)	(-0.825)	(-1.546)
GDP	0.002	0.013	0.009	-0.006
	(0.174)	(0.931)	(0.459)	(-0.258)
Tech	1.912	-4.193	-0.967	-3.981
	(0.912)	(-1.631)	(-0.254)	(-0.928)
Urban	-0.209	2.959***	2.070*	2.481*
	(-0.335)	(3.668)	(1.902)	(1.954)
Constant	0.686	-1.189	-1.299	-1.086
	(1.138)	(-1.543)	(-1.221)	(-0.922)
Year FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes
Ν	26,141	26,141	26,201	26,201
Adj. R ²	0.291	0.284	0.358	0.398

Table 11 Results of entropy balancing.

In columns (1) and (3) of Table 17, the regression coefficients of *Motivate* are both significant and positive, revealing that motivating talent positively affects innovation quantity and radical innovation. When the explained variable is innovation quantity, as in column (2), or radical innovation, as in column (4), the regression coefficients for $HCSR \times Motivate$ are significant and negative. The results show that firms motivate talented employees through equity incentives in the process of fulfilling employee-oriented social responsibility and encourage these employees to take risks in innovation and long-term perspectives, not only increasing innovation quantity but also effectively stimulating radical innovation.

5.2. Sustainability-oriented social responsibility and corporate finance constraints

Financing constraints are a key factor affecting corporate innovation. We measure financial constraints (FC) with the Kaplan–Zingales index to analyze the impact of sustainability-oriented social responsibility on corporate financing constraints. Studies confirm the effect of financing constraints on corporate innovation (Amore et al., 2013); thus, this paper reports only the effect of sustainability-oriented social responsibility on financing constraints. The results are shown in Table 18, where the regression coefficients of ECSR and HCSR are both significant and negative, with FC_{t+1} as the explained variable. Both environment- and employeeoriented social responsibility can help firms establish a positive social image to gain the favor of external investors and thus obtain more financial resources. Therefore, the fulfillment of sustainability-oriented social responsibility is conducive to alleviating corporate financing constraints.

5.3. Economic consequences

This paper examines the economic consequences of sustainability-oriented social responsibility from the perspective of firms' TFP (TFP), which is of great significance in determining the role of CSR in China's cor-

Changing the regr	Changing the regression model.							
	(1)	(2)	(3)	(4)	(5)	(6)		
	Innovation			Radical				
ECSR	0.254***	0.211***	0.201***	0.432***	0.345***	0.361***		
HCSR	(7.486) 0.600 ^{****}	(6.209) 0.574 ^{***}	(5.790) 0.590 ^{***}	(9.485) 0.919 ^{****}	(7.612) 0.833 ^{****}	(7.784) 0.834 ^{***}		
Roa	(7.678)	(7.082) 2.754 ^{***}	(6.989) 2.659***	(10.548)	(9.560) 3.391***	(9.193) 3.680 ^{***}		
Lev		(13.698) 0.052	(12.093) 0.095		(14.695) 0.771 ^{****}	(13.933) 1.039***		
TohinO		(0.545) -0.104***	(0.937) -0.098***		(6.480) -0.138***	(7.930) -0.138***		
1001112		(-9.120)	(-8.229)		(-9.784)	(-9.007)		
CFO		-0.018	0.028 (0.385)		-0.386^{***}	-0.439^{***}		
GDP		(0.200)	0.018****		(4.255)	0.016*		
Tech			(2.667) 3.340**			(1.666) -1.434		
Urban			(2.014) 0.597 (1.260)			(-0.637) 3.172^{***} (4.030)		
Constant	0.240*	0.228	0.033	0.757^{***}	0.338*	(4.939) -1.850^{***} (-2.975)		
Year FE	Yes	Yes	Yes	Yes	Yes	Yes		
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes		
Province FE	Yes	Yes	Yes	Yes	Yes	Yes		
Ν	34,598	31,143	26,141	34,598	31,143	26,141		
Adj. R^2	0.225	0.251	0.290	0.253	0.285	0.284		

Table 12

Table 13

	(1)	(2)	(3)	(4)
	Innovation		Radical	
L ₁ Innovation	-0.0004		0.001	
-	(-0.121)		(0.445)	
L_2 Innovation	-0.0001		0.0001	
	(-0.023)		(0.077)	
$L_I RI$		-0.001		0.002
		(-0.388)		(1.539)
$L_2 RI$		0.0003		0.001
		(0.153)		(0.610)
Roa	0.274***	0.276****	0.054***	0.049***
	(7.476)	(7.517)	(4.315)	(3.977)
Lev	-0.013	-0.013	-0.000	-0.001
	(-1.435)	(-1.431)	(-0.014)	(-0.377)
TobinQ	0.002	0.002	-0.001	-0.000
	(1.371)	(1.352)	(-1.253)	(-0.580)
CFO	-0.072^{***}	-0.073^{***}	-0.008	-0.008
	(-3.002)	(-3.082)	(-0.831)	(-0.813)
GDP	-0.000	0.000	-0.002*	-0.002*
	(-0.002)	(0.075)	(-1.876)	(-1.921)
Tech	0.149	0.116	0.121	0.121
	(0.390)	(0.306)	(0.598)	(0.606)
Urban	0.056	0.038	0.007	0.003
	(0.675)	(0.464)	(0.174)	(0.086)
Constant	-0.084	-0.069	0.016	0.005
	(-1.004)	(-0.839)	(0.388)	(0.114)
Year FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes
N	23,635	23,997	23,711	24,075
Adj. R ²	0.073	0.073	0.004	0.005

	10010 10								
1	Testing whether	corporate in	novation	predicts	sustainability-	oriented	social	responsibility.	

Note: The *t* values in parentheses are based on standard errors clustered by firm. The asterisks denote the level of statistical significance: *** if p < 0.01, ** if p < 0.05 and * if p < 0.1. See Table 1 for variable definitions.

porate governance and economic environments. In columns (1) and (2) of Table 19, the regression coefficients of ECSR are significant and positive, and the regression coefficient of $ECSR \times Radical$ is significant and positive, suggesting that radical innovation induced by environment-oriented social responsibility is conducive to improving TFP, contributing to the high-quality development of firms. In columns (3) and (4), the regression coefficients of HCSR and $HCSR \times Innovation$ are significant and positive. These results suggest that when firms assume environment-oriented social responsibility, and innovation quantity increases as a result, the TFP of firms can also improve accordingly.

6. Conclusions

The sustainable development of firms is receiving increasing attention in China. Both CSR and corporate innovation are closely related to sustainable development. Taking China's A-share listed firms as a sample, this paper analyzes the effects of sustainability-oriented social responsibility on innovation quantity and radical innovation. Sustainability-oriented social responsibility yields a number of positive economic consequences. First, environment-oriented social responsibility aims to maintain a healthy and balanced environment. Firms that attach importance to environment-oriented social responsibility usually increase their energy efficiency and reduce their material consumption by developing environmentally friendly processes and products, which motivate them to increase their R&D investment and achieve innovative outputs. Second, talent is an indispensable resource for corporate innovation. Firms that assume employee-oriented social respon-

	(1)	(2)	(3)	(4)	(5)	(6)
	Invention	Invention	Innovation	Radical	Innovation	Radical
ECSR	0.225****		0.031***	0.051***		
	(7.582)		(7.887)	(11.368)		
HCSR		0.590^{***}	× /		0.069***	0.139***
		(7.993)			(7.171)	(12.164)
Roa	2.298***	2.328***	2.805***	3.911***	2.724***	3.709***
	(12.368)	(12.457)	(12.605)	(14.711)	(12.403)	(14.179)
Lev	0.296***	0.297***	0.120	1.077***	0.090	0.997***
	(3.569)	(3.585)	(1.179)	(8.136)	(0.889)	(7.616)
TobinQ	-0.063***	-0.065^{***}	-0.104^{***}	-0.147^{***}	-0.107^{***}	-0.152***
-	(-6.347)	(-6.540)	(-8.637)	(-9.505)	(-8.833)	(-9.742)
CFO	-0.095	-0.101*	0.019	-0.447^{***}	0.022	-0.445^{***}
	(-1.622)	(-1.737)	(0.270)	(-4.528)	(0.300)	(-4.526)
GDP	0.017^{***}	0.017^{***}	0.018^{***}	0.017*	0.019***	0.018*
	(3.148)	(3.225)	(2.718)	(1.747)	(2.791)	(1.849)
Tech	3.867***	4.586***	3.352**	-1.350	3.579**	-0.939
	(2.839)	(3.358)	(2.035)	(-0.605)	(2.168)	(-0.421)
Urban	1.038***	1.235***	0.538	3.131***	0.675	3.400***
	(2.744)	(3.232)	(1.151)	(4.885)	(1.433)	(5.296)
Constant	-0.715*	-1.300^{***}	-0.370	-1.784^{***}	-0.468	-1.964^{***}
	(-1.872)	(-3.497)	(-0.817)	(-3.001)	(-1.029)	(-3.307)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes	Yes	Yes
N	26,141	26,201	26,201	26,201	26,201	26,201
Adj. R ²	0.235	0.243	0.286	0.279	0.286	0.283



Fig. 1. Placebo test (environment-oriented social responsibility and corporate innovation).

sibility can retain talent, which is conducive to enhancing innovation quantity. However, firms must mobilize the motivation, participation and commitment of their employees by encouraging them to take a long-term orientation to stimulate innovation. In such situations, employee-oriented social responsibility can promote radical innovation. Moreover, the fulfillment of environment- and employee-oriented responsibility by firms is conducive to mitigating financing constraints and augmenting TFP, thus increasing firm value. Therefore, firms should be fully aware of the importance of fulfilling sustainability-oriented social responsibility and the different mechanisms of environment- and employee-oriented responsibility to improve the positive effects of



Fig. 2. Placebo test (employee-oriented social responsibility and corporate innovation).

Table 15 Environment-oriented social responsibility, R&D investment and corporate innovation.

	(1)	(2)	(3)	(4)	
	Innovation		Radical		
ECSR	0.255****	0.416***	0.437***	0.723***	
	(7.104)	(9.642)	(9.181)	(12.305)	
RDI	1.604	12.424***	2.414	21.666***	
	(0.946)	(7.463)	(1.186)	(9.461)	
$ECSR \times RDI$		-11.209***		-19.943***	
		(-5.639)		(-7.848)	
Roa	2.714***	2.661****	3.756***	3.662***	
	(12.165)	(12.044)	(14.067)	(13.991)	
Lev	0.140	0.197*	1.104****	1.207***	
	(1.362)	(1.947)	(8.317)	(9.336)	
TobinQ	-0.103^{***}	-0.105^{***}	-0.146^{***}	-0.149^{***}	
-	(-8.633)	(-8.860)	(-9.502)	(-10.028)	
CFO	0.033	0.027	-0.431^{***}	-0.441^{***}	
	(0.462)	(0.386)	(-4.363)	(-4.507)	
GDP	0.017^{**}	0.018***	0.015	0.017*	
	(2.556)	(2.733)	(1.546)	(1.768)	
Tech	2.978*	3.174*	-1.911	-1.562	
	(1.806)	(1.932)	(-0.850)	(-0.708)	
Urban	0.437	0.313	2.931****	2.712***	
	(0.934)	(0.669)	(4.583)	(4.279)	
Constant	0.194	0.113	-1.615^{***}	-2.948^{***}	
	(0.413)	(0.237)	(-2.610)	(-4.730)	
Year FE	Yes	Yes	Yes	Yes	
Industry FE	Yes	Yes	Yes	Yes	
Province FE	Yes	Yes	Yes	Yes	
Ν	26,137	26,137	26,137	26,137	
Adj. R^2	0.288	0.294	0.281	0.293	

CSR on innovation quantity and radical innovation. Eventually, exogenous shocks at the policy level can affect CSR behavior. For example, the new Environmental Protection Law and minimum wage have pushed firms to take active responsibility for the environment and their employees, respectively, and indirectly promoted corporate innovation. Government departments should continue to improve the relevant institutional system with regard to environmental protection and the protection of workers' rights and interests at the pol-

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Table 16							
Employee-oriented	social	responsibility.	talent	retention	and	corporate innovation.	

	(1)	(2)	(3)	(4)
	Innovation		Radical	
HCSR	0.667***	0.670***	0.924***	0.954***
	(7.393)	(7.412)	(10.056)	(9.886)
Retain	0.040***	0.041***	0.041***	0.057***
	(17.326)	(18.842)	(11.508)	(15.154)
$HCSR \times Retain$		-0.530**		0.002
		(-2.321)		(0.012)
Roa	3.018****	3.017***	4.143***	4.215****
	(12.691)	(12.689)	(14.872)	(14.860)
Lev	0.129	0.129	1.131****	1.185***
	(1.194)	(1.192)	(8.405)	(8.519)
TobinQ	-0.115^{***}	-0.115^{***}	-0.147^{***}	-0.151^{***}
_	(-9.164)	(-9.158)	(-8.972)	(-9.022)
CFO	0.056	0.056	-0.486^{***}	-0.508^{***}
	(0.716)	(0.720)	(-4.734)	(-4.791)
GDP	0.017^{**}	0.017^{**}	0.015	0.015
	(2.180)	(2.182)	(1.444)	(1.435)
Tech	2.438	2.425	-2.279	-2.377
	(1.323)	(1.316)	(-0.939)	(-0.950)
Urban	0.396	0.394	3.414***	3.588***
	(0.757)	(0.754)	(4.903)	(5.007)
Constant	0.545	0.481	-1.406^{**}	-3.204^{***}
	(1.051)	(0.908)	(-2.110)	(-4.606)
Year FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes
N	23,762	23,762	23,762	23,762
Adj. R^2	0.274	0.274	0.274	0.274

Table 17

Employee-oriented social responsibility, talent motivation and corporate innovation.

	(1)	(2)	(3)	(4)	
	Innovation		Radical		
HCSR	0.628****	0.646***	0.908***	0.925****	
	(7.442)	(7.553)	(9.967)	(9.884)	
Motivate	0.039****	0.043***	0.057***	0.062***	
	(3.451)	(4.745)	(5.433)	(6.780)	
$HCSR \times Motivate$		-0.020*		-0.019*	
		(-1.647)		(-1.723)	
Roa	2.656****	2.650***	3.716***	3.710***	
	(11.944)	(11.961)	(14.032)	(14.030)	
Lev	0.105	0.104	1.065***	1.065^{***}	
	(1.036)	(1.029)	(8.102)	(8.098)	
TobinQ	-0.103^{***}	-0.103^{***}	-0.148^{***}	-0.148^{***}	
	(-8.743)	(-8.739)	(-9.672)	(-9.671)	
CFO	0.033	0.033	-0.424^{***}	-0.425^{***}	
	(0.467)	(0.460)	(-4.319)	(-4.323)	
GDP	0.018^{***}	0.018***	0.016	0.016	
	(2.615)	(2.603)	(1.642)	(1.634)	
Tech	3.644**	3.656**	-0.906	-0.894	
	(2.194)	(2.200)	(-0.400)	(-0.395)	

(continued on next page)

Т	abl	le	17 (continued)
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	(1)	(2)	(3)	(4)	
	Innovation		Radical		
Urban	0.799*	0.789*	3.518***	3.508****	
	(1.709)	(1.686)	(5.457)	(5.445)	
Constant	-0.601	-0.023	-2.132***	-3.141***	
	(-1.323)	(-0.048)	(-3.566)	(-4.975)	
Year FE	Yes	Yes	Yes	Yes	
Industry FE	Yes	Yes	Yes	Yes	
Province FE	Yes	Yes	Yes	Yes	
Ν	26,201	26,201	26,201	26,201	
Adj. R^2	0.295	0.295	0.288	0.288	

Table 18			
Sustainability-oriented	social responsibility	and corporate	financing constraints.

	(1)	(2)
ECSR	-0.137^{***}	
	(-3.824)	
HCSR		-0.210^{***}
		(-3.686)
Roa	-12.752^{***}	-12.797***
	(-28.217)	(-28.335)
Lev	5.600***	5.586***
	(52.982)	(53.012)
TobinQ	0.336***	0.338***
	(15.940)	(16.052)
CFO	-0.401***	-0.406***
	(-3.370)	(-3.402)
GDP	0.024**	0.025**
	(2.498)	(2.531)
Tech	1.288	0.779
	(0.565)	(0.342)
Urban	-0.748	-0.816
	(-1.247)	(-1.360)
Constant	0.396	0.479
	(0.689)	(0.831)
Year FE	Yes	Yes
Industry FE	Yes	Yes
Province FE	Yes	Yes
Ν	24,338	24,372
Adj. R^2	0.489	0.489

Note: The *t* values in parentheses are based on standard errors clustered by firm. The asterisks denote the level of statistical significance: *** if p < 0.01, ** if p < 0.05 and * if p < 0.1. See Table 1 for variable definitions.

icy level. Thus, firms can be guided to actively fulfill environment- and employee-oriented responsibility and thereby realize sustainable development.

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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Table 19 Economic consequences.

$\begin{array}{cccccccccccccccccccccccccccccccccccc$		(1)	(2)	(3)	(4)
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	ECSR	0.314***	0.222****		
$\begin{array}{cccccccccccccccccccccccccccccccccccc$		(12.933)	(5.955)		
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	$ECSR \times Innovation$	· · · · · ·	-0.004		
$ECSR \times Radical$ 0.042^{***} $HCSR$ (3.629) $HCSR \times Innovation$ (6.109) (2.859) $HCSR \times Innovation$ (6.109) (2.859) $HCSR \times Radical$ (-0.010) (-0.010) $Innovation$ 0.009 -0.002 -0.010 $Innovation$ 0.009 0.009 -0.002 -0.003 $Radical$ 0.142^{***} 0.118^{***} 0.33^{**} 0.034^{***} $Radical$ 0.142^{***} 0.118^{***} 0.33^{***} 0.034^{***} Roa 4.121^{***} 4.119^{****} 1.931^{***} 1.931^{***} Roa 4.121^{***} 4.119^{***} 0.313^{**} 0.031^{**} CeV 1.804^{**} 1.787^{**} 0.313^{**} 0.031^{**} CeV 1.674^{**} -0.176^{**} -0.031^{**} -0.031^{**} CFO 0.101^{*} 0.102^{**} 0.228^{***} 0.228^{***} CFO 0.101^{*} 0.102^{**} 0.228^{***} 0.228^{***} CFO 0.101^{*} 0.102^{*			(-0.259)		
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	$ECSR \times Radical$		0.042***		
$\begin{array}{ccccccc} HCSR & & 0.120^{***} & 0.113^{***} \\ & & & & & & & & & & & & & & & & & & $			(3.629)		
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	HCSR		(2122)	0.120***	0.113***
$\begin{array}{cccccccccccccccccccccccccccccccccccc$				(6.109)	(2.859)
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	$HCSR \times Innovation$			()	0.019**
$\begin{array}{c cccc} HCSR \times Radical & & & & & & & & & & & & & & & & & & &$					(2.030)
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	$HCSR \times Radical$				-0.010
$\begin{array}{c cccc} Invotation & 0.009 & 0.009 & -0.002 & -0.003 \\ & (0.759) & (0.681) & (-0.425) & (-0.786) \\ Radical & 0.142^{***} & 0.118^{***} & 0.033^{***} & 0.034^{***} \\ & (17.036) & (11.863) & (10.840) & (10.953) \\ Roa & 4.121^{***} & 4.119^{***} & 1.931^{***} & 1.931^{***} \\ & (17.826) & (17.843) & (20.034) & (20.027) \\ Lev & 1.804^{***} & 1.787^{***} & 0.313^{***} & 0.313^{***} \\ & (21.223) & (21.048) & (9.623) & (9.616) \\ TobinQ & -0.176^{***} & -0.176^{***} & -0.031^{***} & -0.031^{***} \\ & (-15.870) & (-15.915) & (-5.832) & (-5.848) \\ CFO & 0.101^* & 0.102^* & 0.228^{***} & 0.228^{***} \\ & (1.674) & (1.696) & (7.023) & (7.029) \\ GDP & -0.002 & -0.001 & 0.006^{**} & 0.006^{**} \\ & (0.452) & (0.311) & (-1.108) & (-1.108) \\ Urban & -0.573 & -0.502 & 0.437^{***} & 0.431^{***} \\ & (36.783) & (36.730) & (20.034) & (20.027) \\ Year FE & Yes & Yes & Yes & Yes \\ Industry FE & Yes & Yes & Yes & Yes \\ N & 19.613 & 19.613 & 22.431 & 22.431 \\ Adj, R^2 & 0.433 & 0.434 & 0.217 & 0.217 \\ \end{array}$					(-1.131)
Internation(0.759) (0.759)(0.681) (0.681)(-0.425) (-0.786)(-0.786)Radical 0.142^{***} 0.118^{***} 0.033^{***} 0.034^{***} (17.036)(11.863)(10.840)(10.953)Roa 4.121^{***} 4.119^{***} 1.931^{***} 1.931^{***} (17.826)(17.843)(20.027)Lev 1.804^{***} 1.787^{***} 0.313^{***} 0.313^{***} (21.223)(21.048)(9.623)(9.616)TobinQ -0.176^{***} -0.031^{***} -0.031^{***} (1.674)(1.696)(7.023)(7.029)GDP -0.002 -0.001 0.006^{**} 0.006^{**} (-0.313)(-0.260)(2.263)(2.241)Tech 0.544 0.3755 -0.661 -0.661 (1.377)(-1.204)(2.648)(2.609)Urban -0.573 -0.502 0.437^{***} 0.431^{***} (1.377)(-1.204)(2.648)(2.609)Constant(14.873^{***})(14.871^{***}) 1.931^{***} 1.931^{***} (36.783)(36.730)(20.034)(20.027)Year FEYesYesYesYesIndustry FEYesYesYesYesN19.61319.61322.43122.431Adj. R^2 0.4330.4340.21722.431	Innovation	0.009	0.009	-0.002	-0.003
Radical $(.142^{**})$ $(.0.18^{**})$ $(.0.33^{**})$ $(.0.34^{***})$ Roa $(.17.036)$ $(.11.863)$ $(.0.840)$ $(.0.953)$ Roa 4.121^{***} 4.119^{***} 1.931^{***} 1.931^{***} $(.7.826)$ $(.7.843)$ $(.20.034)$ $(.20.027)$ Lev 1.804^{***} 1.787^{***} 0.313^{***} 0.313^{***} $(.21.223)$ $(.21.048)$ $(.9.623)$ $(.9.616)$ TobinQ -0.176^{***} -0.176^{***} -0.031^{***} -0.031^{***} (15.870) (-15.915) (-5.832) (-5.848) CFO 0.101^* 0.102^* 0.228^{***} 0.228^{***} (15.870) (-1.5915) (-5.832) (-5.848) CFO 0.101^* 0.102^* 0.228^{***} 0.228^{***} (16.74) $(.1696)$ (7.023) (7.029) GDP -0.002 -0.001 0.006^{***} 0.006^{***} $(.0.452)$ (0.311) (-1.108) (-1.108) Urban -0.573 -0.502 0.437^{***} 0.431^{***} (1.377) (-1.204) (2.648) (2.0027) Year FEYesYesYesYesIndustry FEYesYesYesYesN 19.613 19.613 22.431 22.431 Adj. R^2 0.433 0.434 0.217 0.217		(0.759)	(0.681)	(-0.425)	(-0.786)
InitialOfferOffer (17.036) (11.863) (10.840) (10.953) Roa 4.121^{***} 4.119^{***} 1.931^{***} 1.931^{***} (17.826) (17.843) (20.034) (20.027) Lev 1.804^{***} 1.787^{***} 0.313^{***} 0.313^{***} (21.223) (21.048) (9.623) (9.616) $TobinQ$ -0.176^{***} -0.031^{***} -0.031^{***} (-15.870) (-15.915) (-5.832) (-5.848) CFO 0.101^* 0.102^* 0.228^{***} 0.228^{***} (-1.5870) (-15.915) (-5.832) (-5.848) CFO 0.101^* 0.102^* 0.228^{***} 0.228^{***} (-1.674) (1.696) (7.023) (7.029) GDP -0.001 0.006^{**} 0.006^{**} (-0.313) (-0.260) (2.263) (2.241) $Tech$ 0.544 0.375 -0.661 -0.661 (0.452) (0.311) (-1.108) (-1.108) $Urban$ -0.573 -0.502 0.437^{**} 0.431^{**} (-1.377) (-1.204) (2.648) (2.0027) Year FEYesYesYesYesIndustry FEYesYesYesYesN $19,613$ $19,613$ $22,431$ $22,431$ Adj, R^2 0.433 0.434 0.217 0.217	Radical	0.142***	0.118***	0.033***	0.034***
Roa (121^{**}) (110^{***}) (193^{***}) (1931^{***}) (17.826) (17.843) (20.034) (20.027) Lev 1.804^{***} 1.787^{***} 0.313^{***} 0.313^{***} (21.223) (21.048) (9.623) (9.616) $TobinQ$ -0.176^{***} -0.031^{***} -0.031^{***} (-15.870) (-15.915) (-5.832) (-5.848) CFO 0.101^{*} 0.102^{*} 0.228^{***} (1.674) (1.696) (7.023) (7.029) GDP -0.002 -0.001 0.006^{**} 0.006^{**} (-0.313) (-0.260) (2.263) (2.241) $Tech$ 0.544 0.375 -0.661 -0.661 (0.452) (0.311) (-1.108) (-1.108) $Urban$ -0.573 -0.502 0.437^{***} 0.431^{***} (-1.377) (-1.204) (2.648) (2.609) Constant 14.873^{***} 14.871^{***} 1.931^{***} 1.931^{***} (36.783) (36.730) (20.034) (20.027) Year FEYesYesYesYesIndustry FEYesYesYesYesN 19.613 19.613 22.431 22.431 Adj, R^2 0.433 0.434 0.217 0.217		(17.036)	(11.863)	(10.840)	(10.953)
InternationInternationInternationInternation (17.826) (17.843) (20.034) (20.027) Lev 1.804^{***} 1.787^{***} 0.313^{***} 0.313^{***} (21.223) (21.048) (9.623) (9.616) TobinQ -0.176^{***} -0.176^{***} -0.031^{***} -0.031^{***} (-15.870) (-15.915) (-5.832) (-5.848) CFO 0.101^{**} 0.102^{**} 0.228^{***} 0.228^{***} (1.674) (1.696) (7.023) (7.029) GDP -0.002 -0.001 0.006^{**} 0.006^{**} (-0.313) (-0.260) (2.263) (2.241) Tech 0.544 0.375 -0.661 -0.661 (0.452) (0.311) (-1.108) (-1.108) Urban -0.573 -0.502 0.437^{***} 0.431^{***} (36.783) (36.730) (20.034) (20.027) Year FEYesYesYesYesIndustry FEYesYesYesYesN 19.613 19.613 22.431 22.431 Adj. R^2 0.433 0.434 0.217 0.217	Roa	4 121***	4 119***	1 931***	1 931***
Lev1.804***1.787***0.313***0.313*** (21.223) (21.048) (9.623) (9.616) $TobinQ$ -0.176^{***} -0.031^{***} -0.031^{***} (-15.870) (-15.915) (-5.832) (-5.848) CFO 0.101^* 0.102^* 0.228^{***} 0.228^{***} (1.674) (1.696) (7.023) (7.029) GDP -0.002 -0.001 0.006^{**} 0.006^{**} (-0.313) (-0.660) (2.263) (2.241) $Tech$ 0.544 0.375 -0.661 -0.661 (0.452) (0.311) (-1.108) (-1.108) $Urban$ -0.573 -0.502 0.437^{***} 0.431^{***} (-1.377) (-1.204) (2.648) (2.009) Constant 14.873^{***} 14.871^{***} 1.931^{***} 1.931^{***} (36.783) (36.730) (20.034) (20.027) Year FEYesYesYesYesIndustry FEYesYesYesYesN $19,613$ $19,613$ $22,431$ $22,431$ Adj. R^2 0.433 0.434 0.217 0.217		(17.826)	(17 843)	(20.034)	(20.027)
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	Lev	1 804***	1 787***	0.313***	0.313***
TobinQ -0.176^{**} -0.176^{**} -0.031^{**} -0.031^{**} CFO 0.101^* 0.102^* 0.228^{***} 0.228^{***} (-15.970) (-15.915) (-5.832) (-5.848) CFO 0.101^* 0.102^* 0.228^{***} 0.228^{***} (-0.31) (1.674) (1.696) (7.023) (7.029) GDP -0.002 -0.001 0.006^{**} 0.006^{**} (-0.313) (-0.260) (2.263) (2.241) Tech 0.544 0.375 -0.661 -0.661 (0.452) (0.311) (-1.108) (-1.108) Urban -0.573 -0.502 0.437^{***} 0.431^{***} (-1.377) (-1.204) (2.648) (2.609) Constant 14.873^{***} 14.871^{***} 1.931^{***} 1.931^{***} (36.783) (36.730) (20.034) (20.027) Year FEYesYesYesYesIndustry FEYesYesYesProvince FEYesYesYesN $19,613$ $19,613$ $22,431$ $22,431$ Adj. R^2 0.433 0.434 0.217 0.217		(21.223)	(21.048)	(9.623)	(9.616)
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	TobinQ	-0.176***	-0.176***	-0.031****	-0.031***
CFO $(10.01)^{\circ}$ $(10.02^{\circ})^{\circ}$ $(2.03^{\circ\circ})^{\circ}$ $(10.02^{\circ})^{\circ}$ $(2.03^{\circ\circ})^{\circ}$ GDP (1.674) (1.696) (7.023) (7.029) GDP -0.002 -0.001 $0.006^{\circ\circ}$ $0.006^{\circ\circ}$ (-0.313) (-0.260) (2.263) (2.241) Tech 0.544 0.375 -0.661 -0.661 (0.452) (0.311) (-1.108) (-1.108) Urban -0.573 -0.502 $0.437^{\ast\circ\circ}$ $0.431^{\ast\circ\circ}$ (-1.377) (-1.204) (2.648) (2.609) Constant (36.783) (36.730) (20.034) (20.027) Year FEYesYesYesYesIndustry FEYesYesYesYesProvince FEYesYesYesYesN $19,613$ $19,613$ $22,431$ $22,431$ Adj. R^2 0.433 0.434 0.217 0.217		(-15870)	(-15, 915)	(-5.832)	(-5.848)
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	CFO	0 101*	0.102*	0.228***	0 228***
GDP (1007) (1007) (1007) (1007) GDP -0.002 -0.001 0.006^{**} 0.006^{**} (-0.313) (-0.260) (2.263) (2.241) $Tech$ 0.544 0.375 -0.661 -0.661 (0.452) (0.311) (-1.108) (-1.108) $Urban$ -0.573 -0.502 0.437^{***} 0.431^{***} (-1.377) (-1.204) (2.648) (2.609) Constant 14.873^{***} 14.871^{***} 1.931^{***} 1.931^{***} (36.783) (36.730) (20.034) (20.027) Year FEYesYesYesYesIndustry FEYesYesYesProvince FEYesYesYesN $19,613$ $19,613$ $22,431$ $22,431$ Adj. R^2 0.433 0.434 0.217 0.217		(1.674)	(1.696)	(7.023)	(7.029)
(-0.313) (-0.260) (2.263) (2.241) Tech 0.544 0.375 -0.661 -0.661 (0.452) (0.311) (-1.108) (-1.108) Urban -0.573 -0.502 0.437^{***} 0.431^{***} (-1.377) (-1.204) (2.648) (2.609) Constant 14.873^{***} 14.871^{***} 1.931^{***} 1.931^{***} (36.783) (36.730) (20.034) (20.027) Year FEYesYesYesYesIndustry FEYesYesYesYesProvince FEYesYesYesYesN $19,613$ $19,613$ $22,431$ $22,431$ Adj. R^2 0.433 0.434 0.217 0.217	GDP	-0.002	-0.001	0.006**	0.006**
Tech (0.137) (-1.06) (-1.06) 0.544 0.375 -0.661 -0.661 (0.452) (0.311) (-1.108) (-1.108) $Urban$ -0.573 -0.502 0.437^{***} 0.431^{***} (-1.377) (-1.204) (2.648) (2.609) Constant 14.873^{***} 14.871^{***} 1.931^{***} 1.931^{***} (36.783) (36.730) (20.034) (20.027) Year FEYesYesYesYesIndustry FEYesYesYesYesProvince FEYesYesYesYesN19,61319,61322,43122,431Adj. R^2 0.433 0.434 0.217 0.217		(-0.313)	(-0.260)	(2.263)	(2.241)
Interface (0.311) (0.312) (0.601) (0.601) (0.452) (0.311) (-1.108) (-1.108) (0.452) (0.311) (-1.108) (-1.108) (-1.377) (-1.204) (2.648) (2.609) Constant (14.873^{***}) 14.871^{***} 1.931^{***} 1.931^{***} (36.783) (36.730) (20.034) (20.027) Year FEYesYesYesYesIndustry FEYesYesYesYesProvince FEYesYesYesYesN19,61319,61322,43122,431Adj. R^2 0.4330.4340.2170.217	Tech	0 544	0.375	-0.661	-0.661
Urban -0.573 -0.502 0.437^{***} 0.431^{***} (-1.377) (-1.204) (2.648) (2.609) Constant 14.873^{***} 14.871^{***} 1.931^{***} 1.931^{***} (36.783) (36.730) (20.034) (20.027) Year FEYesYesYesYesIndustry FEYesYesYesYesProvince FEYesYesYesYesN19,61319,61322,43122,431Adj. R^2 0.4330.4340.2170.217		(0.452)	(0.311)	(-1, 108)	(-1, 108)
Constant (-1.377) (-1.204) (2.648) (2.609) Constant 14.873^{***} 14.871^{***} 1.931^{***} 1.931^{***} (36.783) (36.730) (20.034) (20.027) Year FEYesYesYesYesIndustry FEYesYesYesYesProvince FEYesYesYesYesN19,61319,61322,43122,431Adj. R^2 0.4330.4340.2170.217	Urban	-0.573	-0.502	0 437***	0 431***
Constant (4.873^{***}) (4.871^{***}) (1.931^{***}) (1.931^{***}) (36.783)(36.730)(20.034)(20.027)Year FEYesYesYesYesIndustry FEYesYesYesYesProvince FEYesYesYesYesN19,61319,61322,43122,431Adj. R^2 0.4330.4340.2170.217		(-1, 377)	(-1, 204)	(2.648)	(2,609)
(36.783) (36.730) (20.034) (20.027) Year FE Yes Yes Yes Yes Industry FE Yes Yes Yes Yes Province FE Yes Yes Yes Yes N 19,613 19,613 22,431 22,431 Adj. R ² 0.433 0.434 0.217 0.217	Constant	14 873***	14 871***	1 931***	1 931***
Year FE Yes Yes Yes Yes Yes Industry FE Yes Yes Yes Yes Yes Province FE Yes Yes Yes Yes Yes N 19,613 19,613 22,431 22,431 22,431 Adj. R^2 0.433 0.434 0.217 0.217		(36 783)	(36,730)	(20.034)	(20.027)
Industry FE Yes Yes <t< td=""><td>Year FE</td><td>Yes</td><td>Yes</td><td>Yes</td><td>Yes</td></t<>	Year FE	Yes	Yes	Yes	Yes
Industry I D I Co I Co <thi co<="" th=""> I Co <thi co<="" th=""> I Co</thi></thi>	Industry FE	Ves	Ves	Ves	Yes
N19,61319,61322,43122,431Adj. R^2 0.4330.4340.2170.217	Province FE	Yes	Yes	Yes	Yes
Adj. R^2 0.433 0.434 0.217 0.217	N	19 613	19 613	22,431	22 431
	Adi. R^2	0.433	0.434	0.217	0.217

Note: The *t* values in parentheses are based on standard errors clustered by firm. The asterisks denote the level of statistical significance: *** if p < 0.01, ** if p < 0.05 and * if p < 0.1. See Table 1 for variable definitions.

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