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Earnings seasonality, management earnings forecasts and stock returns

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ABSTRACT

We examine whether management earnings forecasts (MEFs) help reduce the stock return seasonality associated with earnings seasonality around earnings announcements (EAs) in Chinese A-share markets. We find that firms in historically low earnings seasons outperform firms in high earnings seasons by 2.1% around MEFs. Firms in low earnings seasons also have higher trading volume and return volatility than their counterparts around EAs and MEFs. MEFs significantly reduce the ability of historical seasonal earnings rankings to negatively predict announcement returns, volume and volatility around EAs. The reduction effects are stronger when MEFs are voluntary or made closer to EAs. The evidence suggests that MEFs facilitate the correction of investors' tendency to extrapolate earnings seasonality and its resulted stock mispricing.

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1. Introduction

Firm sales often exhibit seasonal variations; operating income and profits are high during peak sales seasons, while income and profits are low during off-peak seasons. Chang et al. (2017) refer to this intra-year cyclical variation in a firm's earnings as *earnings seasonality*, measured using historical average quarterly earnings rankings. As publicly listed firms must disclose their quarterly financial data, market participants can easily obtain information about a firm's historical earnings and draw inferences about its seasonal pattern. Therefore, earnings seasonality is predictable.

According to the efficient market hypothesis, all relevant and predictable information is factored into asset prices and only unexpected information causes asset price movements. However, a growing body of literature shows that some *ex-ante* predictable information can cause systemic price movements and lead to abnormal returns around predictable events or dates (e.g., Barber et al., 2013; Hartzmark and Solomon, 2018; Autore and Jiang, 2019; Hirshleifer et al., 2020).

Chang et al. (2017) examine whether earnings seasonality is properly priced in the U.S. securities market and find that, on average, stocks in historically high earnings seasons earn significantly *higher* returns than stocks in historically low earnings seasons during the months when earnings announcements (EA) are made. The authors attribute this seasonal return predictability to the recency effect among investors, who form earnings' expectations based on those in recent quarters and overlook long-term earnings patterns, such as seasonality.

He et al. (2020) find that earnings seasonality also leads to seasonal return predictability in the Chinese securities market, where individual investors are the main participants. Differing from the U.S. market, however, stock returns of firms during historically high earnings seasons in the Chinese market are significantly *lower* than those in historically low earnings seasons around EA events. The authors suggest that this negative relationship between earnings seasonality and announcement returns stems from investors' representativeness heuristic.

The representativeness heuristic is a cognitive bias that leads people to make predictions or draw inferences based on the similarity of two events in the presence of uncertainty, without sufficient consideration of the unconditional probabilities of these events. One direct manifestation of representativeness bias is the extrapolation of and overreaction to the likelihood of similar events occurring in the future (e.g., Barberis et al., 1998; Ahmed and Safdar, 2017).

He et al. (2020) posit that Chinese investors over-rely on historical, same-quarter earnings when forming earnings expectations due to representativeness bias. Thus, the market expectations for future quarters that have historically shown high earnings are too high and for quarters that have historically shown low earnings are too low, causing stock prices to overreact to earnings seasonality. Such expectation errors are corrected over time, especially after a firm's EA, resulting in cross-sectional return seasonality around EAs that can be negatively predicted by earnings seasonality.

Our study extends this line of research to the setting of management earnings forecasts (MEFs). We study whether Chinese A-share firms exhibit return seasonality when issuing MEFs that is negatively predicted by earnings seasonality, and whether MEFs help to reduce the ability of earnings seasonality to negatively predict the cross-sectional returns around EAs. We also extend research of He et al. (2020) on seasonal return predictability by studying the seasonal predictability of trading volume and return volatility based on earnings seasonality. Furthermore, we show that voluntary MEFs have a stronger reduction effect on the seasonal predictability of returns, volume and volatility around EAs than mandatory MEFs. A similar effect is observed for MEFs made closer to EAs relative to those issued long before EAs.

The MEF regulatory framework was introduced in the Chinese securities market in 1998. The MEF Disclosure Rules stipulate that A-share listed firms must issue timely MEFs (called mandatory disclosures) if there are considerable fluctuations in expected earnings (e.g., an increase or a decrease of more than 50% relative to that of the same reporting period in the previous fiscal year), or if they expect to report a net loss during a reporting period or reverse the net loss of the same reporting period in the previous fiscal year. Firms that do not meet the mandatory disclosure requirement may choose to issue management forecasts voluntarily. In our sample, 38.6% of the EAs are preceded by MEFs and 51.8% of the MEFs are voluntary.

Previous studies (e.g., Hirst et al., 2008; Bozanic et al., 2018) show that MEFs, whether mandatory or voluntary, and other voluntary disclosures help reduce information asymmetry, correct investors' earnings expectation errors and improve pricing efficiency. Hence, we expect MEFs to have a similar effect to that of EAs and partially correct the mispricing of earnings seasonality induced by the representativeness bias, leading to a negative relationship between earnings seasonality and the cross-sectional returns around MEFs.

Our study makes the following four contributions to the literature. First, to the best of our knowledge, this study is the first to document the seasonal predictability of returns associated with earnings seasonality around MEFs. Second, we document novel findings regarding the effects of volume and volatility seasonality related to earnings seasonality around EAs and MEFs in the Chinese stock markets. Third, we show that firms that issue MEFs before EAs exhibit weaker seasonal predictability of returns associated with earnings seasonality around EAs. Fourth, we show that the reduction in predictability is more pronounced for voluntary or timely MEFs. In contrast, other MEF attributes, such as weekend MEF disclosure, mandatory MEFs disclosing bad news and large discrepancies between management forecasted and realized earnings, tend to increase this seasonal return predictability. We attribute these findings to firms selectively disclosing their earnings and sugarcoating their expected performance to reduce the negative market impact of MEFs.

2. Motivation and hypothesis development

2.1. Literature review

MEFs are key information disclosures made by publicly listed firms. An MEF refers to information about prospective earnings issued by a firm's management before a regular EA. Due to its forward-looking nature, MEFs provide timely and essential information for investors to assess firm fundamentals (Luo and Song, 2012; Huang et al., 2018). Research shows that MEFs help to reduce the information asymmetry between firms and investors (Kraft et al., 2014; Bozanic et al., 2018; Beardsley et al., 2021). When a firm's performance is expected to change considerably, MEFs can provide a timely alert to investors (Bao et al., 2019) to avoid substantial stock price volatility.

MEFs influence stock prices and behaviors of market participants, such as analysts and investors. MEFs also affect firms' cost of capital, litigation risk, earnings management and management reputation arising from MEF accuracy and transparency (Guay et al., 2016; Wang and Duan, 2019). For example, Jahn et al. (2019) classify the supplementary information of MEFs into soft and verifiable forecast information and show that when MEFs contain good news, firms prefer to release verifiable information to enhance MEF credibility. Zheng et al. (2015) find that MEFs affect the forecasting behavior of securities analysts and improve the information environment of the capital market. Abernathy et al. (2019) find that issuing MEFs leads to higher audit risk and audit fees, as high-quality MEFs are usually accompanied by a demand for high-quality audit information (Bhandari et al., 2020). All of the above studies suggest that MEFs have important information content.

A growing body of literature shows that predictable information, such as certain dates or firm events, cause systematic and predictable stock price fluctuations. For example, stocks earn positive excess returns during the months when earnings or stock dividends are typically announced (e.g., Barber et al., 2013; Hartzmark and Solomon, 2018; Kim et al., 2021). Among other events, EAs are accompanied by predictably higher returns if the announcements are made immediately before major holidays (Autore and Jiang, 2019) than if the announcements are made on ordinary days. Stocks that are more sensitive to investor mood swings earn higher average returns than their counterparts in seasons when investor mood is predictably high, such as in January or on Fridays (Hirshleifer et al., 2020).

In the EA settings, Chang et al. (2017) find that in the U.S. equity market, investors tend to overweight the previous quarter's earnings when forming their future earnings expectations (i.e., the recency effect), thereby underreacting to earnings seasonality. As earnings before the peak earnings season tend to be low, investors often underestimate peak season earnings. Therefore, EAs tend to be positive "surprises" and lead to firms outperforming their counterparts in the peak earnings season; the reverse is true for firms in the off-peak season.

Contrary to the findings of Chang et al. (2017), He et al. (2020) find a significant and negative relationship between quarterly earnings rankings and announcement returns in the Chinese A-share market—on average, stocks during the off-peak earnings season outperform stocks during the peak earnings season around EAs. The authors suggest that this negative relationship is caused by investors' representativeness bias, which leads them to extrapolate historical same-quarter earnings when forming expectations about future earnings, causing prices to overreact to earnings seasonality. Therefore, the EAs of peak season firms tend to disappoint, whereas those of off-peak season firms tend to exceed expectations, leading to the negative relationship between earnings seasonality and announcement returns.

In settings outside of EAs, research shows that the representativeness heuristic can lead to similar stock market phenomena, such as investors forming sales growth expectations by extrapolating previous sales figures (Ahmed and Safdar, 2017), overvaluation of growth stocks (Piotroski and So, 2012) and overreaction to and subsequent reversal of stock prices (Barberis et al., 1998, 2014).

2.2. Hypothesis development

Extending the work of He et al. (2020), we explore whether return seasonality induced by earnings seasonality also exists for MEFs and whether MEFs help mitigate such return seasonality effects around EAs. As He et al., we hypothesize that Chinese investors subject to the representativeness bias extrapolate historical seasonal earnings and overreact to earnings seasonality, which leads to the overpricing of peak season firms and underpricing of off-peak season firms.

However, if a firm discloses its MEFs before the EA, as MEFs typically contain new and relevant information about prospective earnings that are not in the possession of general investors, we expect MEFs to partially correct investors' expectation errors and result in predictable cross-sectional announcement returns based on earnings seasonality during the MEF period. Thus, we expect stocks of firms in historically low earnings seasons to earn higher MEF announcement returns than stocks of firms in historically high earnings seasons.

Unlike He et al. (2020), we also examine how trading volume or price volatility around EAs varies with earnings seasonality. We explore whether there is a negative relationship between stock trading volume or price volatility and quarterly earnings rankings around EAs and MEFs. The representativeness bias implies an underestimation of firm performance during the off-peak earnings season. Therefore, announced management forecasts or actual earnings are more likely to exceed investor expectations, leading to an increase in trading volume and price volatility. In contrast, during the peak earnings season, announcements tend to be disappointing, thereby discouraging stock purchases.

Furthermore, short sales are highly constrained in the Chinese securities market, especially for individual investors. Therefore, short sales would be limited after investors receive bad news around MEFs or EAs. Individual investors are also subject to the disposition effect and tend to hold onto losing stocks (Wu et al., 2020). Hence, disappointing announcements will decrease trading volume and price volatility. This implies a negative relationship between trading volume or volatility and earnings seasonality around MEFs and EAs.

Therefore, we propose the following hypothesis for firms issuing MEFs related to the seasonal predictability of returns, volume and volatility by earnings seasonality:

H1: *Firms in historically high earnings seasons have lower announcement returns, trading volume and return volatility than firms in historically low earnings seasons around EAs and MEFs.*

H1 applies to firms that issue MEFs before the EA. However, it also applies to general firms, as He et al. (2020) document a negative relationship between earnings seasonality and announcement returns.

We also expect MEFs to reduce seasonal predictability around EAs in H1. In general, MEFs are issued before the EA and inform investors about management's view of prospective earnings and partially corrects investors' expectation errors and mispricing (Ding et al., 2021). Thus, the seasonal predictability of returns, volume and volatility around EAs can be partially realized after the MEF. Consequently, seasonal predictability is expected to decline around the EAs following MEFs. Therefore, we propose the following hypothesis related to the moderating effects of MEFs on the subsequent predictability of earnings seasonality.

H2: *MEFs reduce the seasonal predictability of returns, trading volume and price volatility associated with earnings seasonality around EAs.*

Firms can choose the content, mode, and timing of disclosure (Cai, 2012; Zhang et al., 2012; Xu et al., 2017). We expect certain types of MEFs to exhibit a stronger moderating effect, such as timely or voluntary MEFs. The timeliness of an MEF is measured by its closeness to an EA. Firms can choose when to issue or update their MEFs. The closer the MEF announcement date to the EA, the more relevant and accurate is the information provided by the MEF (Luo and Du, 2014; Hu and Wang, 2015; Huang et al., 2019). Hence, we expect a timely MEF to exert a stronger moderating effect on the return predictability of earnings seasonality around EAs. We propose the following hypothesis related to the moderating effect of timely MEFs.

H3: *MEFs made closer to an EA have a stronger moderating effect on the negative relationship between returns/volume/volatility and earnings seasonality around EAs than MEFs made long before an EA.*

Next, we explore voluntary versus mandatory MEFs. The literature suggests that firms opt for voluntary disclosure for many reasons, such as to reduce information asymmetry, cost of capital and litigation risks or to increase transparency and firm reputation. Therefore, voluntary MEFs tend to contain more useful, accurate and timely information than mandatory MEFs (Hirst et al., 2008; Song et al., 2011; Leuz and Wysocki, 2016; Roychowdhury et al., 2019; Wang et al., 2020).

In contrast, when firms must issue MEFs due to considerable income fluctuations or expected operating losses, management tends to downplay or hide crucial performance information to merely meet the disclosure requirements, which leads to less reliable and accurate performance forecasts (Lu et al., 2017; Cianciaruso and Sridhar, 2018). Therefore, we propose the following hypothesis related to the moderating effect of voluntary versus mandatory MEFs.

H4: *Voluntary MEFs have a stronger moderating effect on the negative relationship between returns/volume/volatility and earnings seasonality around EAs than mandatory MEFs.*

3. Data and variables

3.1. Data

The main sample comprises A-share firms listed on the Shanghai and Shenzhen stock exchanges from Q1 of 2010 to Q4 of 2020. The data are obtained from the China Stock Market and Accounting Research (CSMAR) database. We start from 2010 because MEF data become available on that year. We obtain data on firm financials, stock trading and factor returns from the CSMAR database and apply the following filters: 1) exclude financial firms, 2) exclude firms designated as special treatment (ST) or particular transfer (PT)[1] and 3) require a firm to have at least 20 consecutive quarters of financial statement data preceding the current fiscal year. Last, we restrict the sample to have data for the main dependent, independent and control variables, which result in 49,080 firm-quarter observations. We winsorize all continuous variables at the 1st and 99th percentiles to limit the influence of extreme values. We retain the last MEF for a given quarter to consider the most relevant MEFs for firms that issue more than one MEF.

3.2. Variable definitions

3.2.1. Quarterly earnings rankings

In the Chinese securities market, listed firms usually disclose net profit in an MEF instead of earnings per share (Liu and Lu, 2018). Hence, following He et al. (2020), we use a firm's adjusted net profit in quarterly reports to measure its quarterly earnings.

Following Chang et al. (2017), we measure earnings seasonality using quarterly earnings rankings. We rank the 20 quarterly earnings of the most recent 5 fiscal years (from y-6 to y-1) from lowest to highest (from 1 to 20) for all fiscal years and calculate the average historical earnings ranking for each fiscal quarter (denoted by *EarnRank*). Thus, in the following fiscal year, the fiscal quarter with the lowest (highest) *EarnRank* is considered off-season (peak season) earnings.

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[1] Firms that receive a delisting risk warning are designated as ST and firms that have ceased trading or cleared their prices pending delisting are designated as PT.

3.2.2. Cumulative abnormal returns

We use an event study approach to calculate the cumulative abnormal returns (CAR) over an announcement window to examine announcement returns around MEFs and EAs. Following He et al. (2020), we use the market-adjusted model to calculate the daily abnormal return ($AR_{i,k}$) for firm i on day k, defined as daily stock return ($R_{i,k}$) minus daily market return ($R_{m,k}$) in our main analyses:[2]

$$AR_{i,k} = R_{i,k} - R_{m,k},$$

where market return refers to the returns of the equal-weighted consolidated A-share market portfolio.

The MEF announcement day (t) is the forecast release date if the forecast is released on a trading day, or the first trading day after the release date if it is released on a non-trading day. The EA day is defined analogously. As our focus is on the short-term market response to MEFs or EAs, following He et al. (2020), we use 5 trading days before and after the event day as the announcement window.[3] We calculate CAR during the MEF period (denoted by *CAR-MEF*) and during the EA period (denoted by *CAR-EA*) as follows:

$CAR - MEF = \sum_{k=t-5}^{t+5} AR_{i,k}$, where $t = 0$ for the MEF announcement date, and.

$CAR - EA = \sum_{k=t-5}^{t+5} AR_{i,k}$, where $t = 0$ for the EA announcement date.

3.2.3. Trading volume

Following Jiang et al. (2021), we construct the excess turnover (*TOV*) variable to examine the response of trading volume around MEFs and EAs. Turnover is measured as the daily number of shares traded divided by the number of shares outstanding. *TOV* is measured as the average turnover during the event window (–5, +5) divided by the average daily turnover during the pre-event window (–252, –23), denoted by *TOV-MEF* and *TOV-EA*, respectively.

3.2.4. Price volatility

Following Luo and Du (2014), we calculate the standard deviation of daily returns during the event window (–5, +5) to examine stock price volatility around MEFs and EAs, denoted by *STDEV-MEF* and *STDEV-EA*, respectively.

3.2.5. MEF indicator

We construct an indicator variable, *MEF*, which takes a value of 1 if there is an MEF before the EA in a firm-quarter, and 0 otherwise, to test the effect of MEFs on seasonal return/volume/volatility predictability associated with earnings seasonality.

We construct several other variables to capture different attributes or types of MEFs. *MEF-Voluntary* is an indicator variable that takes a value of 1 for voluntary MEFs and 0 for mandatory MEFs. *MEF-Mand-BNews* is an indicator variable takes a value of 1 if a mandatory MEF discloses bad news and 0 if a mandatory MEF discloses good news. We define bad news as when the lower bound of the MEF is a net loss or more than 50% below the realized earnings in the same quarter of the previous year. *MEF-Weekend* is an indicator variable that takes a value of 1 for MEFs released on a Saturday or Sunday and 0 otherwise.

3.2.6. Time interval between forecasted and realized earnings

We measure the time delay of an MEF using the time interval between a firm's MEF and EA in a given quarter. The interval *INR* is defined as Ln (1 + the number of days between an MEF and an EA); a smaller *INR* value indicates a more timely MEF.

3.2.7. Difference between forecasted and realized earnings

In general, management issues expected earnings as a range of values instead of a point forecast. To measure the sugarcoating of a mandatory MEF containing bad news (*MEF-Mand-BNews* = 1), we measure the

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[2] Our results remain robust when we use CAPM or the Fama–French three-factor model to calculate abnormal returns.

[3] There is no qualitative difference in the results even if we select 2 trading days before and after the event.

difference between the lower bound of management forecasted earnings and realized earnings, scaled by absolute realized earnings (denoted as *Diff-Earn*) as follows:

Diff-Earn = (lower bound of forecasted earnings – realized earnings) ÷ |realized earnings|.

If we hold realized earnings constant, then the more sugarcoating the management forecasted earnings, the greater the earnings gap or *Diff-Earn*.

Following Xu et al. (2014) and He et al. (2020), we use a set of control variables in the panel regressions: stock return in the previous month (*PastRet*), firm size (*Size*), book-to-market ratio (*BM*), leverage (*LEV*), an indicator variable for accounting information quality (*Quality*), an indicator variable for net income loss

Table 1
Variable definitions.

Variable	Definition
EarnRank	Quarterly earnings ranking (definition 1), which is calculated as the average earnings ranking of the same fiscal quarter during the most recent 5 fiscal years from y − 6 to y − 1, where earnings are measured using adjusted net profit.
EarnRank₁	Quarterly earnings ranking (definition 2), which is calculated as the average earnings ranking of the same fiscal quarter during the most recent 5 fiscal years from y − 6 to y − 1, where earnings are measured using adjusted earnings per share.
CAR-MEF (%)	CAR during the MEF period, which is defined as the sum of daily abnormal returns during the MEF event window (−5, +5), where abnormal returns are market adjusted.
CAR-EA (%)	CAR during the EA period, which is defined as the sum of daily abnormal returns during the EA event window (−5, +5), where abnormal returns are market adjusted.
STDEV-MEF (%)	Return volatility during the MEF period, which is calculated as the standard deviation of stock returns during an MEF event window (−5, +5).
STDEV-EA (%)	Return volatility during the EA period, which is calculated as the standard deviation of stock returns during an EA event window (−5, +5).
TOV-MEF	Excess turnover during the MEF period, which is defined the average turnover during the MEF event window (−5, +5) divided by the average daily turnover during the pre-event window (−252, −23), where turnover is calculated as the daily number of shares traded divided by the number of shares outstanding.
TOV-EA	Excess turnover during the EA period, which is defined the average turnover during the EA event window (−5, +5) divided by the average daily turnover during the pre-event window (−252, −23), where turnover is calculated as the daily number of shares traded divided by the number of shares outstanding.
MRet	Monthly stock return in an EA month.
MEF	An indicator variable for MEF, which takes a value of 1 if the firm-quarter contains an MEF before the EA, and 0 otherwise.
MEF-Voluntary	An indicator variable for voluntary MEF, which takes a value of 1 for voluntary MEFs and 0 for mandatory MEFs.
MEF-Weekend	An indicator variable for weekend MEF, which takes a value of 1 if an MEF is released on a Saturday or Sunday, and 0 if it is released on a weekday.
MEF-Mand-BNews	An indicator variable for mandatory MEFs containing bad news, which takes a value of 1 if a mandatory MEF discloses bad news and 0 if a mandatory MEF discloses good news. Bad news means that the lower bound of the MEF is a net loss or more than 50% below the realized earnings in the same quarter of the previous fiscal year.
Diff-Earn	The gap between the lower bound of management forecasted earnings and realized earnings for firms issuing mandatory MEFs disclosing bad news, which is calculated as (the lower bound of forecasted earnings – realized earnings) ÷	realized earnings |.
INR	Natural logarithm of 1 plus the number of days between an MEF and an EA.
BM	Book-to-market ratio, which is calculated as book equity divided by market equity.
PastRet	Monthly stock returns in the preceding month before the MEF or EA.
Size	Firm size, which is calculated as the logarithm of market equity in the preceding month.
Inst	An indicator variable for high institutional holdings, which takes a value of 1 if mutual funds that are among the top 10 shareholders together hold more than 20% of the outstanding shares in the most recent quarter, and 0 otherwise.
Loss	An indicator variable for net earnings loss, which takes a value of 1 if the firm reports negative earnings in the previous fiscal year, and 0 otherwise.
Quality	An indicator variable for accounting information quality, which takes a value of 1 if discretionary accruals measured using the modified Jones model (Dechow et al., 1995) are above the median value, and 0 if they are below the median value.
LEV	Leverage ratio, which is calculated as total liabilities divided by total assets.

(*Loss*) and an indicator variable for high institutional holdings (*Inst*). The accounting variables and *Inst* are based on information from the previous quarter. All of the variables are defined in Table 1.

4. Research design

We adopt three main research methods to explore seasonal return/volume/volatility predictability associated with earnings seasonality: event sorting, calendar-time portfolio factor model regressions and firm-level panel regressions.

First, we sort the MEF and EA events according to *EarnRank* to study how announcement returns/volume/volatility vary with earnings seasonality. Specifically, we divide the MEF and EA sample events into eight groups based on *EarnRank* (lowest = 1 and highest = 8), focusing on firms that issue an MEF before the EA in a given quarter. Next, we calculate the average *CAR*, *TOV* and *STDEV* for each group during the sample period.[4] We test whether the differences between the lowest and highest *EarnRank* groups (low-minus-high) are positive (i.e., whether off-peak season firms outperform peak season firms during MEF and EA periods).

Second, we use the calendar-time portfolios and factor model regressions to explore whether the returns of the calendar-time long-short (e.g., low-minus-high) portfolios can be explained by risk factors. We also test whether the long-short returns differ between firms issuing and not issuing MEFs, and for firms issuing MEFs, differ in terms of MEF timeliness.

Each month, we sort firms issuing EAs into eight groups based on *EarnRank* and calculate the equal-weighted monthly returns (R_p) of each group. The long-short portfolio takes a long position in the lowest *EarnRank* group (off-peak season firms) and a short position in the highest *EarnRank* group (peak season firms). Then, we estimate the *alphas* by fitting the multi-factor models for the long-short returns in the full sample. The factor models used include the Fama and French (1993) three-factor (FF-3), Carhart (1997) four-factor (Carhart-4) and Fama and French (2015) five-factor (FF-5) models:

$$R_p = \alpha + \beta_{MKT}RMRF + \beta_{SMB}SMB + \beta_{HML}HML + \varepsilon; \tag{1}$$

$$R_p = \alpha + \beta_{MKT}RMRF + \beta_{SMB}SMB + \beta_{HML}HML + \beta_{UMD}UMD + \varepsilon \tag{2}$$

$$R_p = \alpha + \beta_{MKT}RMRF + \beta_{SMB}SMB + \beta_{HML}HML + \beta_{RMW}RMW + \beta_{CMA}CMA + \varepsilon. \tag{3}$$

In Eqs. (1)–(3), R_p is the monthly return of the long-short portfolio, and *RMRF*, *SMB*, *HML*, *UMD*, *RMW* and *CMA* denote monthly returns on the market, size, value, momentum, profitability and investment factors, respectively. All of the factors are based on Chinese A-share markets and their returns are obtained from the CSMAR database.

The third method is the firm-level panel ordinary least squares (OLS) regression model, which is used to test the moderating effects of MEFs, timely and voluntary MEFs and the effects of other types of MEFs or MEF attributes on the seasonality effects of returns/volume/volatility around EAs. Panel regressions allow us to control for various firm and stock attributes as well as time and industry fixed effects. The key independent variables are the interaction terms between *EarnRank* and *MEF* (or its type/attribute). The regression model is as follows:

$$Y = \beta_1 EarnRank + \beta_2 EarnRank \times X + \beta_3 X + \gamma' Controls + Year \times Qtr\,FEs + Industry\,FEs + \varepsilon, \tag{4}$$

where the dependent variable *Y* is *CAR-EA*, *TOV-EA* or *STDEV-EA*. The key independent variables are *EarnRank*, an MEF type or attribute measure *X* and the interaction term between *EarnRank* and *X*. The MEF-based measures include *MEF*, *INR*, *MEF-Voluntary*, *MEF-Weekend*, *MEF-Mand-BNews* and *Diff-Earn*. The control variables (Controls) include *PastRet*, *Size*, *BM*, *LEV*, *Quality*, *Loss* and *Inst*. All of the control variables are measured in the previous quarter relative to earnings in a given quarter. Industry (Industry FEs) and quarterly time (Year × Qtr FEs) fixed effects are included in all regressions. Standard errors are adjusted for clustering at the firm level. All of the variables are defined in Table 1.

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[4] The results remain qualitatively similar if we use value-weighted means.

Table 2
Descriptive statistics.

Variable	N	Mean	Std. Dev	25th	Median	75th
EarnRank	49,080	10.487	3.093	8.400	10.600	12.600
CAR-MEF	18,945	0.911	0.163	–2.910	–1.013	3.004
CAR-EA	49,080	0.862	0.145	–3.100	–0.947	3.803
TOV-MEF	18,945	1.012	1.492	0.166	1.044	1.513
TOV-EA	49,080	0.931	2.035	0.082	0.493	1.464
STDEV-MEF	18,945	2.847	2.886	1.377	2.152	3.835
STDEV-EA	49,080	2.899	2.308	1.603	2.360	3.681
MRet	49,080	0.011	0.147	–0.078	–0.009	0.076
MEF	49,080	0.386	0.530	0	0	1
MEF-Voluntary	18,945	0.518	0.237	0	1	1
MEF-Weekend	18,945	0.213	0.418	0	0	1
MEF-Mand-BNews	9,140	0.618	0.331	0	1	1
Diff-Earn	5,649	1.113	0.114	0.118	1.603	2.166
INR	18,945	3.841	0.919	2.876	4.015	4.648
PastRet	49,080	0.017	0.140	–0.061	0.012	0.077
Size	49,080	15.736	0.958	15.065	15.580	16.258
BM	49,080	0.634	0.268	0.426	0.627	0.843
LEV	49,080	0.450	0.239	0.285	0.442	0.596
Loss	49,080	0.114	0.317	0	0	0
Quality	49,080	0.500	0.500	0	1	1
Inst	49,080	0.008	0.087	0	0	0

Note: The variables CAR-MEF, CAR-EA, STDEV-MEF and STDEV-EA are in percentage (%).

5. Empirical results

5.1. Descriptive statistics

Table 2 reports the descriptive statistics of all of the variables. For the MEF sample, CAR-MEF, TOV-MEF and STDEV-MEF in the 5 trading days before and after the MEF are 0.911%, 1.012 and 2.847%, respectively. For the full sample (with and without MEFs), during the same window before and after the EAs, the mean CAR-EA is 0.862%, the mean TOV-EA is 0.931 and the mean STDEV-EA is 2.899%.

EarnRank has a mean of 10.487 and a median of 10.600, as it is based on rankings from 1 to 20. MEF has a mean of 0.386, which indicates that 38.6% of the firm-quarters issue MEFs before the EA. MEF-Voluntary has a mean of 0.518, which indicates that 51.8% of the firms in the MEF sample issue voluntary MEFs. INR has a mean of 3.841, which suggests that the last MEF is typically issued roughly 45 days ($=e^{3.841} - 1$) before an EA.[5]

MEF-Weekend has a mean of 0.213, which indicates that 21.3% of the firms in the MEF sample issue MEFs on weekends. MEF-Mand-BNews has a mean of 0.618, which indicates that 61.8% of the mandatory MEFs contain bad news. Diff-Earn has a mean of 1.113, which suggests that, on average, management issues overly optimistic forecasts when issuing mandatory MEFs disclosing bad news (i.e., they sugarcoat bad news).[6]

5.2. Event sorting and regression analysis

5.2.1. Event sorting based on earnings seasonality

We first conduct a simple sorting of the MEF and EA events, focusing on firms issuing MEFs before the EA in each quarter to test H1, which predicts a negative relationship between announcement returns/volume/

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[5] Many MEFs are released in January, whereas Q1 EAs are typically released in April, which explains the large average gap between MEFs and EAs. If we exclude the first quarter, the average gap is about 10 to 20 days.

[6] Diff-Earn has a mean of 0.126 for the sample of mandatory MEFs disclosing good or bad news, well below the mean of 1.113 for only bad news, which implies that earnings forecasts are overly optimistic for the subsample disclosing bad news.

Table 3
Announcement returns/volume/ volatility sorted by earnings seasonality around MEFs and EAs.

EarnRank	1 (Low)	2	3	4	5	6	7	8 (High)	Low − High
Panel A: CAR									
CAR-MEF	2.584	2.131	1.080	0.876	0.690	0.629	0.564	0.462	2.122***
CAR-EA	1.951	1.882	1.796	1.535	0.538	0.248	−0.114	−0.481	2.432**
Panel B: Trading volume									
TOV-MEF	1.554	1.531	1.333	1.271	0.721	0.667	0.414	0.211	1.343***
TOV-EA	1.401	1.319	1.282	1.153	0.955	0.797	0.499	0.092	1.309**
Panel C: Return volatility									
STDEV-MEF	3.354	3.068	2.942	2.934	2.923	2.894	2.801	2.771	0.583**
STDEV-EA	2.868	2.830	2.827	2.817	2.751	2.723	2.615	2.606	0.262**

Note: The sample includes 18,945 firm-quarters issuing MEFs. Earnings seasonality is measured by *EarnRank*. Events for MEFs or EAs are sorted into eight groups based on *EarnRank* and the *CAR*, *TOV* and *STDEV* of each group and the differentials between the two most extreme groups are reported. *CAR-MEF*, *CAR-EA*, *STDEV-MEF* and *STDEV-EA* are in percentage. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively, based on two-tailed t-tests.

volatility and earnings seasonality around MEFs and EAs. We divide the event sample equally into eight groups based on *EarnRank* and calculate the average and low-minus-high *CAR*, *TOV* and *STDEV* of the event firms during the event window (−5, 5).

The results are reported in Table 3. Panel A shows that during the MEF periods, the average *CAR* of firms in the off-peak season group (*EarnRank* = 1) is 2.584% and that of the peak season group (*EarnRank* = 8) is only 0.462%, a difference of 2.122%, which is significant at the 1% level. This novel finding shows that in Chinese A-share markets, stocks exhibit seasonal return predictability associated with earnings seasonality around MEFs.

The negative relationship between MEF announcement returns and *EarnRank* suggests that a similar announcement effect documented by He et al. (2020) during the EA periods manifests before an EA and around an MEF. This is consistent with the conjecture that investors in China are subject to the representativeness bias and overreact to earnings seasonality and that such mispricing is partially corrected by MEFs and later on by EAs. Furthermore, we replicate the findings of He et al. (2020) in our sample period. The estimates in Panel A show that the average *CAR-EA* in the off-peak and peak season groups is 1.951% and −0.481%, respectively, a difference of 2.432%, which is significant at the 5% level.

Panel B reports excess trading volume across the *EarnRank* groups around MEFs and EAs. We again observe that *TOV-MEF* and *TOV-EA* monotonically decline as *EarnRank* increases. The average *TOV* in the off-peak season group is visibly higher than that in the peak season group, a difference of 1.343% around MEFs and 1.309% around EAs, significant at the 1% and 5% levels, respectively. This is the first evidence that trading volume also exhibits seasonality around MEFs and EAs that suggests investors mispricing earnings seasonality.

Panel C shows a similar pattern for price volatility. *STDEV-MEF* and *STDEV-EA* decrease as *EarnRank* increases. This evidence adds to the literature by showing that seasonality in return volatility is induced by earnings seasonality. The tests in He et al. (2020) focus on return seasonality around EAs, whereas our evidence shows that trading volume and price volatility also exhibit seasonal predictability based on earnings seasonality.

The evidence in Table 3 strongly supports H1 and shows that there is a significant and negative relationship between announcement returns/volume/volatility and historical quarterly earnings rankings around MEFs and EAs. The magnitude of the return differentials between the off-peak and peak season groups suggests that the seasonality effects in returns/volume/volatility around MEFs are at least as strong as those around EAs.

5.2.2. Panel regressions

We test whether releasing MEFs before the EA helps mitigate the seasonal predictability of returns, volume and volatility around EAs to explore H2. We use the panel OLS regression model in equation (4) to study the effects of an MEF and its interaction with earnings seasonality (*EarnRank × MEF*) on *CAR-EA*, *TOV-EA* and *STDEV-EA*.

Table 4
MEFs and return/volume/volatility seasonality effects around EAs.

	(1)	(2)	(3)	(4)	(5)	(6)
	CAR-EA		TOV-EA		STDEV-EA	
EarnRank	−1.102***	−1.135***	−1.148**	−1.378***	−1.005**	−1.018**
	(−3.94)	(−4.17)	(−2.46)	(−3.25)	(−2.39)	(−2.47)
EarnRank × MEF	0.624**	0.658**	1.045**	1.173**	0.218**	0.246**
	(2.49)	(2.51)	(2.17)	(2.48)	(2.22)	(2.41)
MEF	−0.586	−0.352	−0.426	−0.141	−0.221	−0.326**
	(−1.18)	(−1.05)	(−0.45)	(−0.29)	(−1.23)	(−2.15)
PastRet		2.147***		1.100**		0.940***
		(3.00)		(2.23)		(2.98)
Size		0.310**		0.565***		0.285***
		(2.41)		(4.39)		(3.08)
BM		0.379***		0.488***		0.499***
		(10.64)		(13.71)		(14.64)
LEV		1.813***		0.345***		2.409***
		(3.16)		(3.42)		(3.18)
Quality		0.126		−0.006		0.079***
		(0.63)		(−0.43)		(3.91)
Loss		0.276		0.005*		0.003
		(0.89)		(1.78)		(1.01)
Inst		4.789***		4.177***		4.017***
		(4.38)		(3.04)		(2.92)
Industry Fes	Yes	Yes	Yes	Yes	Yes	Yes
Year × Qtr Fes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.037	0.044	0.243	0.360	0.236	0.375
N	49,080	49,080	49,080	49,080	49,080	49,080

Note: This table reports the panel OLS regression results of CAR-EA, TOV-EA and STDEV-EA on MEF, EarnRank and their interaction term, together with the control variables. The t-statistics are based on standard errors adjusted for firm clustering and reported in parentheses. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively.

H1 predicts that MEF should have a negative coefficient and EarnRank × MEF should have a positive coefficient, suggesting that MEFs moderate the seasonality effects of EAs. The panel regressions control for various firm or stock characteristics that may affect returns, volume and volatility, as well as time and industry fixed effects. We include all firm-quarters, regardless of whether the MEF is issued before the EA, as we are interested in comparing firms that issue MEFs and firms that do not issue MEFs.

The results in Table 4 show that EarnRank has a negative and significant coefficient across all regressions that include MEF, EarnRank × MEF and fixed effects, with or without other controls. These estimates confirm and broaden our evidence in Table 3 for the sample of firms issuing MEFs; there is a significant and negative relationship between announcement returns, volume or volatility and earnings seasonality around EAs for firms not issuing MEFs.

Moreover, the coefficients on EarnRank × MEF are all positive and significant, which suggests a moderating effect of MEFs on the negative seasonal predictability of returns, volume and volatility based on earnings seasonality. Specifically, in columns (1) and (2) of Table 4, the coefficients on EarnRank × MEF are 0.624 and 0.658 for the CAR-EA regressions, respectively, both significant at the 5% level. The estimates in column (2) imply that with all of the control variables, the negative effect of EarnRank on CAR-EA (–1.135) is mitigated by 0.658 if a firm issues an MEF before the EA, reducing the net effect to –0.477 (=–1.135 + 0.658) for MEF issuing firms.

Columns (3) and (4) show the regression results for TOV-EA. Column (4) shows that with all of the controls, the negative effect of EarnRank on TOV-EA decreases to –0.205 (=–1.378 + 1.173) for firms issuing MEFs. Similarly, column (6) shows that the negative effect of EarnRank on STDEV-EA decreases to –0.772 (=–1.018 + 0.246) for MEF issuing firms.

Overall, the evidence in Table 4 overwhelmingly supports H2 with the significant and positive coefficients on EarnRank × MEF. Although earnings seasonality negatively predicts the cross-section of returns, volume

and volatility around EAs, firms issuing MEFs before EAs have lower predictability than firms that do not issue MEFs, as the mispricing of these MEF firms is partially corrected around the MEF, as Table 3 shows. These results suggest that MEFs help mitigate stock market seasonality associated with earnings seasonality around EAs.

5.2.3. MEF timeliness

To explore H3, which predicts that timely MEFs have a stronger moderating effect on the negative relationship between announcement returns/volume/volatility and earnings seasonality around EAs, we add *INR* and its interaction term with earnings seasonality, *EarnRank* × *INR*, to the panel regressions in Table 4 but restrict it to firm-quarters issuing MEFs. As *INR* measures the interval between an MEF and an EA, we expect a smaller *INR* value (i.e., a timely MEF) to have a greater moderating effect than a larger *INR* value, or the coefficient on *EarnRank* × *INR* to be negative.

The regression results are shown in Table 5, where we do not report the control variables for brevity. *EarnRank* × *INR* has a significant and negative coefficient across all three dependent variables, with or without control variables. Columns (1) and (2) show the estimates for the *CAR-EA* regressions, where the coefficients on *EarnRank* × *INR* are –0.053 and –0.174, respectively, which are significant at the 5% level. In columns (3) and (4), where the dependent variable is *TOV-EA*, the coefficients on the interaction term are –0.154 and –0.169, respectively, which are also significant at the 5% level. When *STDEV-EA* is the dependent variable, the coefficients are –0.018 and –0.023, which are significant at the 5% and 1% levels, respectively. *EarnRank* continues to have a significant, or marginally significant, and negative coefficient across all regressions.

The estimates in Table 5 suggest that MEFs issued closer to EAs tend to decrease the negative relationship between returns/volume/volatility and earnings seasonality around the EA, compared with those issued long before the EA. This is consistent with the notion that timely MEFs contain more accurate earnings information, which effectively reduces investors' expectation errors and supports H3.

5.2.4. Voluntary MEFs

According to the China Securities Regulatory Commission (CSRC), A-share listed firms must issue an MEF (referred to as mandatory disclosure) if their expected earnings fluctuate considerably (e.g., earnings increase or decrease by more than 50% relative to the earnings for the same reporting period in the previous fiscal year) or the firm is expected to have a net loss during a reporting period or reverse the net loss of the same reporting period in the previous fiscal year. Firms that are not subject to mandatory disclosure may choose to issue MEFs voluntarily.

Table 5
MEF timeliness and return/volume/volatility seasonality effects around EAs.

	(1)	(2)	(3)	(4)	(5)	(6)
	CAR-EA		*TOV-EA*		*STDEV-EA*	
EarnRank	–1.168**	–1.344**	–1.015**	–1.187***	–0.067**	–0.053*
	(–2.37)	(–2.49)	(–2.51)	(–2.74)	(–2.12)	(–1.88)
EarnRank × *INR*	–0.053**	–0.174**	–0.154**	–0.169**	–0.018**	–0.023***
	(–2.31)	(–2.49)	(–2.04)	(–2.26)	(–2.51)	(–2.75)
INR	–0.337	–1.254	–1.111	–0.931	–0.120	–0.231*
	(–0.40)	(–1.33)	(–1.33)	(–0.89)	(–1.06)	(–1.78)
Controls	No	Yes	No	Yes	No	Yes
Industry FEs	Yes	Yes	Yes	Yes	Yes	Yes
Year × Qtr FEs	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.027	0.032	0.012	0.257	0.172	0.151
N	18,945	18,945	18,945	18,945	18,945	18,945

Note: This table reports the panel OLS regression results of *CAR-EA*, *TOV-EA* and *STDEV-EA* on *INR*, *EarnRank* and their interaction term, together with the control variables. The sample includes only firm-quarters issuing MEFs. The *t*-statistics are based on standard errors adjusted for firm clustering and reported in parentheses. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively.

Table 6
Voluntary MEFs and return/volume/volatility seasonality effects around EAs.

	(1)	(2)	(3)	(4)	(5)	(6)
	CAR-EA		TOV-EA		STDEV-EA	
EarnRank	−1.004***	−1.087***	−1.606***	−1.711***	−1.008**	−1.012**
	(−2.99)	(−3.27)	(−3.53)	(−3.64)	(−2.31)	(−2.45)
EarnRank × MEF-Voluntary	0.716***	0.773***	1.291***	1.530***	0.280***	0.449***
	(2.78)	(2.96)	(2.82)	(3.13)	(2.74)	(2.82)
MEF-Voluntary	−0.204	−0.318	−0.059	−0.086	−0.295**	−0.377**
	(−1.20)	(−1.32)	(−0.17)	(−0.19)	(−2.15)	(−2.34)
Controls	No	Yes	No	Yes	No	Yes
Industry FEs	Yes	Yes	Yes	Yes	Yes	Yes
Year × Qtr FEs	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.128	0.132	0.240	0.248	0.337	0.349
N	18,945	18,945	18,945	18,945	18,945	18,945

Note: This table reports the panel OLS regression results of CAR-EA, TOV-EA and STDEV-EA on MEF-Voluntary, EarnRank and their interaction term, together with the control variables. The sample includes only firm-quarters issuing MEFs. The t-statistics are based on standard errors adjusted for firm clustering and reported in parentheses. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively.

Our results in Tables 3 and 4 show that, on average, firms issuing MEFs before the EA cause a price correction in earnings seasonality around MEFs, thereby reducing the seasonal predictability of returns/volume/volatility associated with earnings seasonality around EAs. H4 predicts that voluntary MEFs contain more accurate earnings expectations and have a stronger moderating effect on seasonal predictability than mandatory MEFs. Hence, we add MEF-Voluntary and its interaction with EarnRank to the panel regressions and report the estimates in Table 6 to show the effect of voluntary MEFs. We limit our analyses to firms issuing MEFs because we want to compare voluntary versus mandatory MEFs.

We focus on the estimates presented in columns (2), (4) and (6) of Table 6 with all firm or stock control variables. The coefficients on EarnRank are all negative (–1.087, –1.711 and –1.012, respectively) and significant at the 5% level, which confirms the main negative effect of earnings seasonality in the sample of firms issuing MEFs. More importantly, the coefficients on EarnRank × MEF-Voluntary are 0.773, 1.530 and 0.449, respectively, all significant at the 1% level. That is, after controlling for the main negative effect of EarnRank, the marginal effect of EarnRank is less negative for firms that voluntarily release MEFs than for firms that mandatorily issue MEFs. Thus, compared with mandatory disclosure, voluntary disclosure has a greater moderating effect on the seasonal predictability of returns, volume and volatility based on earnings seasonality around EAs, which supports H4.

5.3. Further evidence

This section contains the results of additional analyses on calendar-time portfolios, additional MEF attributes and robustness checks.

5.3.1. Calendar-time portfolios

Our results in Table 3 are based on a simple event sorting method, which demonstrates the negative effects of earnings seasonality on announcement returns around MEFs and EAs. However, it remains unclear whether abnormal returns can be earned from using trading strategies that exploit this return predictability and account for systemic risks. Hence, we form calendar-time portfolios to estimate abnormal returns relative to multi-factor models.

Each month, we sort firms issuing EAs into eight groups based on earnings seasonality (EarnRank) and calculate the equal-weighted monthly returns for each group. We form a long-short portfolio that is long for the lowest EarnRank group and short for the highest EarnRank group. The portfolio is rebalanced monthly. We report the mean monthly long-short returns and the factor-adjusted abnormal returns (alphas) based on the FF-3, Carhart-4 and FF-5 models.

Table 7
MEFs and long-short portfolio based on earnings seasonality.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Full sample	MEF			Timely MEF		
		Yes	No	No − Yes	Yes	No	No − Yes
Mean	0.050***	0.021***	0.058***	0.037***	0.036***	0.061***	0.025***
	(3.18)	(2.86)	(3.66)	(2.85)	(3.21)	(3.86)	(3.16)
FF-3 alpha	0.003**	0.002**	0.006**	0.004**	0.002**	0.005**	0.003**
	(2.14)	(2.28)	(2.51)	(2.33)	(2.37)	(2.39)	(2.19)
Carhart-4 alpha	0.006**	0.003*	0.009*	0.006*	0.004*	0.008*	0.004*
	(2.43)	(1.85)	(1.91)	(1.89)	(1.81)	(1.95)	(1.73)
FF-5 alpha	0.004**	0.002*	0.007*	0.005*	0.001*	0.005*	0.004*
	(2.23)	(1.89)	(1.85)	(1.76)	(1.78)	(1.88)	(1.79)

Note: Firms issuing EAs in a month are sorted into eight groups based on *EarnRank*. We form the long-short portfolio that goes long for the lowest *EarnRank* group and short for the highest *EarnRank* group. We report mean returns (Mean) and *alphas* for the full sample and separately for the subsamples based on whether an MEF is issued (MEF = Yes) and, among firms issuing MEFs before the EA, whether an MEF is timely, measured using *INR* below the mean (Timely MEF = Yes). The *alphas* are reported based on the FF-3, Carhart-4 and FF-5 models. The Newey–West adjusted *t*-statistics are reported in parentheses. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively.

Column (1) of Table 7 shows that for the full sample (firms with or without MEFs preceding the EA), the long-short average monthly return is 5%, which is significant at the 1% level. The monthly alphas are considerably smaller, 0.3%, 0.6% and 0.4% for the FF-3, Carhart-4 and FF-5 models, respectively. All of the alphas are significant at the 5% level. This evidence confirms return predictability based on earnings seasonality around EAs.

In columns (2)–(4), we separately report the long-short returns for the subsamples based on whether an MEF is issued before the EA (MEF = Yes or No) as well as the difference between the two groups. The No-minus-Yes monthly return differential is 3.7%, which suggests that the long-short portfolio is more profitable when no MEFs are issued before the EAs. The corresponding alpha differentials are 0.4%, 0.6% and 0.5%, respectively, which are significant at the 5% or 10% levels.

In columns (5)–(7), we divide the sample of firms issuing MEFs before the EA into two subsamples based on whether the interval between the MEF and the EA (*INR*) is below (Timely MEF = Yes) or above the mean (Timely MEF = No). Consistent with the evidence in Table 6, we find that the No-minus-Yes long-short monthly return differentials are on average positive (2.5%) and significant at the 1% level. The corresponding alphas are 0.3%, 0.4% and 0.4%, which are significant at the 5% or 10% levels.

The evidence in Table 7 based on the calendar-time portfolio confirms our earlier findings in Tables 4 to 6 of the seasonal return predictability of MEF issuing firms based on earnings seasonality, the moderating effect of MEFs and the stronger moderating effect of timely MEFs. Such return predictability implies that at least marginally significant abnormal returns can be earned even after controlling for portfolio exposure to various systemic factors.

5.3.2. Additional MEF attributes

The moderating effect of MEFs on the seasonal return predictability of EAs stems from management forecasts providing relevant expected earnings information, which helps correct the mispricing of earnings seasonality. However, if the MEFs are inaccurate or disguise the truth, they would not effectively correct investors' expectation errors or mitigate the return seasonality associated with earnings seasonality.

Therefore, we examine several MEF attributes that are more likely to indicate MEF deviation from true expected earnings: *MEF-Weekend*, *MEF-Mand-BNews* and *Diff-Earn* for mandatory MEFs disclosing bad news. We include each of these variables and its interaction with *EarnRank* in the panel regressions in Table 8, as we do in Tables 5 and 6.

In column (1) of Table 8, the regression of *CAR-EA* includes only firms issuing MEFs before the EA in the quarter and tests the effect of weekend versus weekday MEFs. The coefficient on *EarnRank* × *MEF-Weekend* is −0.037, significant at the 5% level, which indicates that weekend MEF announcements increase the return

Table 8
MEF attributes and return seasonality effects around EAs.

	Dependent variable: CAR-EA		
	(1)	(2)	(3)
EarnRank	−0.934**	−1.012***	−1.064**
	(−2.31)	(−2.77)	(−2.18)
EarnRank × MEF-Weekend	−0.037**		
	(−2.24)		
EarnRank × MEF-Mand-BNews		−0.068**	
		(−2.48)	
EarnRank × Diff-Earn			−0.064**
			(−2.53)
MEF-Weekend	−0.285		
	(−1.43)		
MEF-Mand-BNews		−0.881	
		(−1.44)	
Diff-Earn			−0.616
			(−1.49)
Controls	Yes	Yes	Yes
Industry FEs	Yes	Yes	Yes
Year × Qtr FEs	Yes	Yes	Yes
R^2	0.119	0.261	0.226
N	18,945	9,140	5,649

Note: This table reports the panel OLS regression results of CAR-EA on MEF attributes, EarnRank and their interaction terms, together with the control variables. The MEF attributes include MEF-Weekend, MEF-Mand-BNew and Diff-Earn. The sample in Eq. (1) includes only firm-quarters issuing MEFs, Eq. (2) includes only firms issuing mandatory MEFs and Eq. (3) includes only firms issuing mandatory MEFs disclosing bad news. The t-statistics are based on standard errors adjusted for firm clustering and reported in parentheses. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively.

seasonality of EAs associated with earnings seasonality. This is consistent with our conjecture that weekend MEFs tend to be less truthful and do not help correct the mispricing of earnings seasonality or reduce return seasonality around EAs. This can be explained by firms adversely selecting to disclose and sugarcoat bad news to take advantage of limited investor attention on weekend and minimize the negative impact of bad news (Zhang et al., 2012).

In column (2), we explore why mandatory MEFs fail to mitigate the seasonal predictability of returns around EAs. We limit the analysis to firms issuing mandatory MEFs and include MEF-Mand-BNews and its interaction with EarnRank in the panel regression of CAR-EA. The coefficient on the interaction term is −0.068, significant at the 5% level, which suggests that mandatory MEFs disclosing bad news tend to sugarcoat the severity of poor performance and amplify the return predictability associated with earnings seasonality around the EA. In untabulated tests, we find that the average announced earnings are 11.34% below the lower bound of MEFs in our sample of firms issuing mandatory MEFs disclosing bad news, suggesting earnings forecasts are overly optimistic for these MEFs.

To formally test the effect of the earnings forecast sugarcoating, we calculate Diff-Earn to measure the gap between the forecasted and realized earnings when mandatory MEFs disclose bad news. Because MEFs tend to provide a range, we use the lower bound of this range to measure the forecasted earnings. We explore whether sugarcoated forecasts (larger Diff-Earn) increase return seasonality around EAs. In column (3) of Table 8, the interaction term EarnRank × Diff-Earn has a coefficient of −0.064, significant at the 5% level, which indicates that sugarcoated MEFs tend to strengthen return seasonality because they fail to communicate truthful information that could correct mispricing around MEFs. We obtain similar findings when the regression is run on mandatory MEFs or all MEF issuing firms.

Table 9
Announcement returns sorted by our alternative measure of earnings seasonality around MEFs and EAs.

$EarnRank_1$	1 (Low)	2	3	4	5	6	7	8 (High)	Low–High
CAR-MEF	2.575	2.418	2.292	2.029	1.515	0.353	–0.021	–0.119	2.694**
CAR-EA	2.097	1.821	1.727	1.076	0.579	0.209	0.125	–0.646	2.743**

Note: Earnings seasonality is measured by $EarnRank_1$. MEF and EA events are sorted based on $EarnRank_1$ into eight groups and the average CAR for each group and the differentials between the two extreme groups are reported. The sample includes only 18,945 firm-quarters issuing MEFs. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively, based on two-tailed t-tests.

Table 10
MEF attributes and return seasonality effects around EAs: Alternative measure of earnings seasonality.

	Dependent variable: CAR-EA					
	(1)	(2)	(3)	(4)	(5)	(6)
$EarnRank_1$	–1.113***	–1.082***	–1.117***	–1.216**	–1.002***	–1.074***
	(–4.73)	(–3.58)	(–2.61)	(–2.44)	(–2.81)	(–2.98)
$EarnRank_1 \times MEF$	0.411*	0.537*				
	(1.84)	(1.92)				
$EarnRank_1 \times INR$			–0.100*	–0.116*		
			(–1.78)	(–1.87)		
$EarnRank_1 \times MEF\text{-}Voluntary$					0.561***	0.630***
					(2.69)	(2.75)
MEF	–0.575*	–0.438				
	(–1.85)	(–1.58)				
INR			–0.598	–0.134		
			(–1.49)	(–1.38)		
MEF-Voluntary					–0.143	–0.217
					(–1.22)	(–1.37)
Controls	No	Yes	No	Yes	No	Yes
Industry FEs	Yes	Yes	Yes	Yes	Yes	Yes
Year × Qtr FEs	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.015	0.021	0.113	0.127	0.118	0.123
N	49,080	49,080	18,945	18,945	18,945	18,945

Note: This table reports the panel OLS regression results of CAR-EA on MEF or MEFs attributes, $EarnRank_1$ and their interaction terms, together with the control variables. MEF attributes are measured by INR and MEF-Voluntary. The t-statistics are based on standard errors adjusted for firm clustering and reported in parentheses. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively.

Token together, the evidence in Table 8 suggests that weekend disclosures tend to be adversely selected and mandatory disclosures tend to be sugarcoated. Both fail to mitigate the seasonal predictability of returns associated with earnings seasonality around EAs.

5.4. Robustness tests

We conduct several robustness tests to confirm our main findings. First, we use an alternative measure of EarnRank, $EarnRank_1$, which is constructed using adjusted earnings per share instead of total net profit. We repeat the sorting and regression analyses in Tables 3 and 4 by replacing EarnRank with $EarnRank_1$ and report the results in Tables 9 and 10.

The event sorting results in Table 9 show similar patterns to those of Panel A in Table 4. Both CAR-MEF and CAR-EA monotonically decrease as $EarnRank_1$ increases, which confirms that firms in off-peak earning season tend to outperform firms in peak earnings season during both MEF and EA periods. The panel regression estimates in Table 10 also confirm that the coefficient estimates on $EarnRank_1 \times MEF$, $EarnRank_1 \times INR$ and $EarnRank_1 \times MEF\text{-}Voluntary$ are qualitatively and quantitatively similar to those in Tables 4, 5 and 6, respectively, which validates our earlier findings that voluntary or timely MEFs have a stronger mitigating

effect on the seasonal predictability of returns associated with earnings seasonality around EAs than mandatory MEFs.

Last, in untabulated robustness checks, we change the event window from 5 to 2 trading days before and after the MEF or EA event date and repeat the main tests as in Table 10. Our results remain qualitatively similar, suggesting that our findings are independent of the choice of event window.[7]

6. Conclusion

This study shows that the cross-sectional stock return, trading volume and price volatility exhibit seasonality associated with earnings seasonality around MEFs and EAs using data on Chinese A-share firms from 2010 to 2020. The findings extend the previous research (e.g., Chang et al., 2017; He et al., 2020) that documents earnings seasonality-induced return seasonality effects around EAs. More importantly, we find that firms issuing MEFs before the EA help mitigate the return/volume/volatility seasonality effects around EAs.

On average, firms in historically low earnings seasons earn 2.1% higher CAR than firms in historically high seasons during the 5 trading days before and after MEFs. A long-short portfolio that buys stocks of firms not issuing MEFs in the off-peak earnings season and sells those stocks in the peak season during the EA months earns an average monthly return of 5.8% and alpha of 0.6% to 0.9% after fitting several multi-factor models. In contrast, the same strategy yields significantly lower returns and alphas when implemented on firms issuing MEFs before EAs. The panel regression results confirm that MEFs weaken the seasonal predictability of returns, volume and volatility based on earnings seasonality around EAs, even with controls for various firm and stock characteristics as well as time and industry fixed effects.

Following He et al. (2020), we attribute the negative relationship between MEF announcement returns and earnings seasonality to the representativeness bias of investors in China, which leads to their extrapolation of and overreaction to earnings seasonality. In general, MEFs disclose relevant expected earnings information that helps to correct some of the mispricing of earnings seasonality ahead of the EA. Consistent with this explanation, we show that more informative disclosures, such as voluntary or timely MEFs, enhance this mitigation effect. In contrast, less informative disclosures, such as weekend MEFs and mandatory MEFs, especially those disclosing bad news and overly optimistic forecasts, tend to strengthen return seasonality around EAs. This evidence calls for stronger corporate disclosure regulatory measures to improve the pricing efficiency of earnings seasonality.

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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[7] The results are available from the authors upon request.

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Mandatory CSR disclosure and analyst forecast properties: Evidence from a quasi-natural experiment in China

Check for
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ABSTRACT

Based on a quasi-natural experiment that mandates a subset of listed firms to issue standalone corporate social responsibility (CSR) reports, we examine whether mandatory CSR disclosure improves analysts' information environment. We focus on two properties of analysts' earnings forecasts: forecast error and forecast dispersion. We find that the mandatory issuance of standalone CSR reports is related to less forecast error and less dispersed forecasts, and the effect varies with the firm-level information environment and province-level marketization. Additional tests show that the improvement in forecast properties is mainly driven by CSR reports that i) are of high quality and ii) contain more long-term-oriented information than other CSR reports. Our findings provide evidence that mandatory CSR disclosure plays an important informational role for financial analysts.

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1. Introduction

Corporate social responsibility (CSR) generally refers to a firm's responsibilities toward the community and environment in which it operates. CSR typically includes economic, legal, ethical, and philanthropic responsibilities (Carroll, 1991). Despite early opponents to CSR argue that managers' only responsibility is profit

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maximization (Friedman, 1970), investment in CSR activities has shown an increasing trend worldwide because of CSR's strategic implications (McWilliams et al., 2006). Taking the social expenditure dimension as an example, public social spending has comprised approximately 21% of the gross domestic product across Organisation for Economic Co-operation and Development (2016) countries since 2009.

Given widespread CSR practices, the disclosure of CSR activities is of particular interest to various stakeholders. An increasing number of firms are choosing to voluntarily disclose their CSR practices. The literature documents favorable consequences of voluntary CSR disclosure, as it can reduce the cost of equity capital (Dhaliwal et al., 2011), improve the accuracy of analyst forecasts (Dhaliwal et al., 2012), mitigate corporate tax aggressiveness (Lanis and Richardson, 2012), increase the value of cash holdings (Lu et al., 2016), discourage high-profile misconduct (Christensen, 2016), and lower stock price synchronicity (Grewal et al., 2017).

Despite its potential benefits, however, the disclosure of CSR activities is typically self-regulated. Regulators in some capital markets (e.g., Australia, Belgium, China, Denmark, France, Malaysia, Sweden, and the United Kingdom) mandate certain types of firms to disclose their CSR activities, whereas other markets (e.g., Hong Kong) plan to mandate CSR disclosure. Mandatory disclosure differs from voluntary disclosure in several ways. First, it is nonreversible and typically involves nontrivial costs for the disclosing firms (e.g., Dye, 1990; Fishman and Hagerty, 2003). Second, compared with voluntary disclosure, mandatory disclosure is less costly for information users to obtain because it is usually made through prescribed channels and with prescribed timing. Third, although a firm's voluntary disclosure is endogenously determined (Verrecchia, 1983) and can be influenced by mandatory disclosure (Einhorn, 2005; Bischof and Daske, 2013), mandatory disclosure substantially mitigates concerns over endogeneity issues. Because of these differences, it is ex-ante unclear whether and to what extent the previously documented financial and/or informational benefits of voluntary CSR disclosure apply to mandatory CSR disclosures (Chen et al., 2018).[2]

We investigate the informational consequences of mandatory CSR disclosure from the perspective of financial analysts because they represent investors and are sophisticated information users. Analysts play valuable informational roles through their ability to clarify and confirm corporate disclosures. Moreover, they can discover information beyond corporate disclosures (Huang et al., 2018). Analysts' reports usually incorporate a substantial amount of nonfinancial information (Orens and Lybaert, 2007) that can be provided by CSR reports.

We examine whether mandatory CSR disclosure improves the quality of analysts' earnings forecasts based on a quasi-natural experiment in China. We conduct this study in the context of the Chinese market for the following two reasons. First, China has experienced decades of rapid economic growth and is now the second-largest economy in the world. In addition, a series of environmental, social, and governance problems have arisen. It is particularly important for stakeholders to enhance their understanding of the potential consequences of these problems. Financial analysts play a crucial informational role in the fast-growing Chinese capital market because it is dominated by individual retail investors.[3] Analysts' services can add great value by informing ordinary investors and improving market efficiency (Gu et al., 2013).

Second, unlike many developed capital markets, where the disclosure of CSR activities is voluntary, China has required certain types of listed firms to issue standalone CSR reports since 2008. The Shanghai Stock Exchange (SHSE) mandates standalone CSR reports for firms included in the Corporate Governance Index, firms with overseas listed shares, and firms in financial industries. The Shenzhen Stock Exchange (SZSE) mandates standalone CSR reports for firms included in the SZSE 100 Index. The requirement of only a subset of listed firms to issue standalone CSR reports provides a quasi-natural experimental setting in which we can use a difference-in-differences (DID) research design to investigate the consequences of mandatory CSR disclosure. Accordingly, our study can better address the endogeneity issue and establish a causal relation between CSR disclosure and analysts' information environment than previous studies on the consequences of voluntary CSR disclosure (Clarkson et al., 2008).

Using a DID approach, we find that the mandatory issuance of standalone CSR reports reduces both analyst forecast error and analyst forecast dispersion. However, this improvement only occurs in firms that are less transparent and domiciled in more marketized provinces than in other firms. The improvement in ana-

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[2] In the scenario of the adoption of International Financial Reporting Standards (IFRS), previous studies (e.g., Daske et al., 2008; Florou and Pope, 2012) show that benefits related to the IFRS adoption do not apply equally to voluntary and mandatory adopters.

[3] Individual investors contributed approximately 85% of the total trading volume in 2017 (SHSE, 2018).

lysts' information environment also varies by CSR report. Further analyses show that this improvement only occurs when the CSR report i) is of high quality and ii) contains more long-term-oriented information than other CSR reports. Our results hold for a battery of robustness tests. Overall, our findings provide evidence that mandatory CSR disclosure plays an important informational role for analysts.

We contribute to the literature in the following three ways. First, our study fits into the literature that investigates the effect of mandatory disclosure. Although mandatory disclosure by its nature differs from voluntary disclosure, the literature examines the effect of mandatory disclosure requirements regarding accounting standards, such as segment reporting (Cho, 2015), risk factor disclosure (Chiu et al., 2018), 8-K expansion (McMullin et al., 2019), and the dissemination of patent information (Saidi and Zaldokas, 2021). These studies tend to support the positive informational consequences of mandatory disclosures. However, Blankespoor et al. (2019) suggest that reporting regulations have limited usefulness because of users' significant processing costs. Leuz and Wysocki (2016), based on an excellent discussion of the economics of financial reporting regulation, suggest that exploring nontraditional forms of disclosure more generally tends to be a fruitful area of accounting research.

Our study echoes Leuz and Wysocki's (2016) suggestions in the context of CSR reporting requirements. Recent research pays attention to the various consequences of mandatory CSR disclosure. One stream of literature examines the real effects of mandatory CSR disclosure, including a decrease in the number of mining-related citations and injuries (Christensen et al., 2017), decreases in both profitability and industrial wastewater and SO_2 emission levels (Chen et al., 2018), improved investment efficiency (Liu and Tian, 2021), and reduced pay gaps (Huang et al., 2022). The other stream investigates the informational effects of CSR disclosure and finds constrained earnings management (Wang et al., 2018), enhanced CSR reporting quality (Hamed et al., 2021), and enhanced stock market liquidity and higher market valuation (Roy et al., 2022). However, Grewal et al. (2019) document an overall negative market reaction to events that increase the likelihood of the European Union's passage of a directive mandating increased nonfinancial disclosures. Our study joins this line of literature and adds to its knowledge of the informational consequences of mandatory CSR disclosure by investigating whether financial analysts, as a group of sophisticated information users, incorporate this type of information into their earnings forecasts. To this end, we contribute to the literature on the effect of a mandatory disclosure policy in China.

Second, a growing stream of the literature examines whether and how investors and creditors use nonfinancial characteristics (i.e., information not directly available from financial statements) in general and CSR information in particular (e.g., Dhaliwal et al., 2011; Dhaliwal et al., 2012; Cao et al., 2015; Griffin et al., 2017; Amel-Zadeh and Serafeim, 2018; Kim et al., 2018). Our study adds to this stream of literature by investigating the usefulness of mandatory CSR disclosure to financial analysts and documenting that high-quality CSR reports and reports with long-term-oriented information improve analysts' information environment.

Third, we contribute to the literature on analysts' role in China. As information intermediaries, analysts play an important role in the capital market. They create value for investors by discovering and interpreting information (Chen et al., 2010; Huang et al., 2018). Analysts' informational role is particularly important in emerging markets such as China because of the prevalence of individual investors in the capital market. Recent studies document that analysts in China deter corporate fraud (Chen et al., 2016), abate bubble intensity by coordinating investors' beliefs (Andrade et al., 2013), and produce information concerning the pricing of initial public offerings (Jia et al., 2018). Our study sheds new light on this line of research by showing that nonfinancial information, such as firms' CSR disclosures, can affect analyst forecast properties.

The remainder of the paper is organized as follows. Section 2 reviews the literature and develops our hypothesis. Section 3 describes our sample and data. Section 4 specifies our empirical model. Section 5 discusses our empirical results, and Section 6 concludes the paper.

2. Literature review and hypothesis development

2.1. Institutional background on mandatory CSR disclosure in China

In recent decades, the world has witnessed exponential growth in the number of firms that quantify and report nonfinancial information from environmental (e.g., carbon emissions, water consumption, and waste

generation), social (e.g., employee, product, and customer-related), and governance (e.g., political lobbying, anti-corruption, and board diversity) perspectives. Whereas<20 firms worldwide disclosed nonfinancial information in the early 1990 s, the number of firms issuing such information, either in the form of a standalone report or integrated reports, increased to nearly 9,000 by 2016 (Amel-Zadeh and Serafeim, 2018). One possible reason for the increase in disclosure is pressure from various stakeholders to disclose information related to the environmental and social impacts of firms' operations. Another possible reason for the increased disclosure is regulatory requirements imposed around the world, such as in China, Denmark, Malaysia, and South Africa.

Concerning China, in December 2008, the SHSE and SZSE stock exchanges issued a Notice Concerning Listed Companies' Preparation for 2008 Annual Reports (hereafter the Notice). The Notice mandates the following types of listed firms to issue standalone CSR reports from fiscal year 2008 onward: i) firms included in the Corporate Governance Index, ii) financial firms, iii) firms cross-listed on overseas stock exchanges, and iv) firms included in the SZSE 100 Index. Accordingly, the SZSE issued Social Responsibility Guidelines to Listed Companies (hereafter the Guidelines). According to the Guidelines, the standalone CSR reports should i) describe whether and how various CSR activities (e.g., labor protection, environmental protection, work safety, welfare plans, and community relationships) are carried out, ii) assess the outcomes of the implementation of the Guidelines and explain the reason for any gaps, and iii) describe the plans and timetables for potential improvements. The mandatory disclosure of standalone CSR reports for only a subset of firms provides us with a quasi-natural experimental setting in which we can compare changes in analysts' information environment between the treatment group (i.e., firms subject to the mandatory CSR disclosure) and the control group (i.e., firms not subject to the mandatory CSR disclosure) after 2008.

Based on this setting, several recent studies examine the impact of mandatory CSR disclosure on the information environment. This stream of literature generally documents that CSR disclosure leads to a favorable change in the information environment. For example, Ioannou and Serafeim (2017) find a significant increase in the disclosure of corporate environmental, social, and governance information in four countries (China, Denmark, Malaysia, and South Africa) that mandate CSR disclosure. Enhanced disclosure is associated with increases in firm valuation. Based on high-frequency trade data, Hung et al. (2015) document a decrease in information asymmetry resulting from China's mandatory CSR disclosure. Wang et al. (2018) examine financial reporting information and find a decrease in earnings management after the institution of the mandatory CSR disclosure regulation. Another stream of literature finds that the mandatory CSR disclosure has real effects in terms of i) decreased numbers of mining-related citations and injuries and reduced labor productivity (Christensen et al., 2017); ii) lower industrial wastewater and SO_2 emission levels (Chen et al., 2018); iii) reduced investment inefficiency, especially overinvestment (Liu and Tian, 2021); and iv) reduced pay gaps, promoting economic growth by improving innovation and productivity (Huang et al., 2022).

However, these positive social externalities are associated with deterioration in financial performance (Chen et al., 2018). Following this line of literature, we can reasonably expect the mandatory disclosure requirement to improve the information environment. In turn, improved transparency changes firm behavior and, subsequently, financial performance. Financial analysts, as an important type of information intermediary, are likely to incorporate information in CSR reports into their earnings forecasts. We thus expect mandatory CSR disclosure to affect analyst forecast properties.

2.2. CSR disclosure and analyst forecasts

China's mandatory CSR disclosure can potentially affect analysts' earnings forecasts through the following two channels. First, standalone CSR reports provide important nonfinancial information to market participants. Although there is no specific requirement for the content or format that a firm should follow in presenting its CSR report, a typical CSR report describes a firm's CSR activities that are of interest to various stakeholders (shareholders, creditors, employees, customers, suppliers, the government, and the community). In this sense, market participants can extract valuable information from CSR reports (Griffin and Sun, 2013). For example, some firms describe their customer care from the perspectives of product quality, customer satisfaction, post-sales services, and innovation activities. CSR reports can also show various examples of how firms care for their employees, such as by providing incentive schemes, training programs, and career

opportunities. The literature supports the informativeness of CSR disclosure in that it affects firm value (Matsumura et al., 2014; Plumlee et al., 2015).

Unlike lagged financial information, these nonfinancial perspectives provide forward-looking information. The literature provides potential explanations for why nonfinancial information can predict future financial performance. For example, employee satisfaction can attract talent and improve operational efficiency (Berns et al., 2009), predict future firm performance (Huang et al., 2015), and enhance firm value (Edmans, 2011). Similarly, customer satisfaction can serve as a leading indicator of customers' future purchase behaviors and help predict accounting performance (Ittner and Larcker, 1998). Financial analysts, as sophisticated information users, are expected to be able to utilize and incorporate the nonfinancial information contained in CSR reports when making their forecasts.

Second, firms that are mandated to issue standalone CSR reports expect that their CSR activities will be disclosed to the public yearly and thus that they will be subject to the scrutiny of capital market participants. This expectation serves a self-disciplining and monitoring role. For example, if a firm explains in its current CSR report that it values customers by committing to high product quality, its managers will then be motivated to improve or at least maintain product quality in future years because they are aware of the capital market's expectations. As sophisticated information intermediaries, financial analysts are likely to understand the self-disciplinary effect of mandatory CSR disclosure on managerial behaviors and firm performance and to take this effect into account when forecasting firms' future earnings. Thus, we hypothesize the following:

Hypothesis: Analyst forecast properties improve significantly after mandatory CSR disclosure.

3. Sample and data

Although the two stock exchanges mandated certain types of listed firms to disclose standalone CSR reports in 2008, most of these firms began complying with the requirement in 2009. Our sample period is from 2005 to 2012, that is, four years before and four years after the effective adoption year of 2009.[4] We use a DID approach to compare the impact of the mandatory CSR disclosure on analyst forecast properties. To do so, we identify all of the firms included in the mandatory adoption list, which comprises our treatment firms. We filter data from the SHSE and SZSE websites to identify the firms covered by the Notice. To ensure the validity of our identification, we confirm the list by checking the official websites of all of the treatment firms. The initial identification procedure results in 252 unique treatment firms.

Next, we apply the following procedures to all of the listed firms to filter the sample. We first delete financial-industry firms and then remove firm-year observations with missing values for the required variables. To ensure that our results are not contaminated by voluntary CSR disclosures, we exclude firms that voluntarily disclosed CSR reports in the pre-adoption period. This leaves us with 13,513 firm-year observations, 1,893 of which are from the treatment group and 11,620 from the control group.

We then construct a matched sample using a propensity score matching (PSM) approach. We regress a logit model on whether an observation is a mandated firm for the period from 2005 to 2008 by including a set of control variables that are likely to affect the probability of inclusion in the mandatory disclosure list. Following Chen et al. (2018), we include market capitalization (*Market_CAP*), stock returns (*Return*), share turnover (*Turnover*), profitability (*ROA*), the percentage of government shareholdings (*Stateshare*), the donations the firm makes (*Donation*), the number of analysts following the firm (*Analyst_N*), whether the firm's chief executive officer or chairperson is politically connected (*PC*), and whether the firm operates in a polluting industry

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[4] We use several approaches to mitigate the concern about concurrent events. First, we search the relevant regulations mandating disclosure of CSR-related issues during our sample period. In 2010, the Ministry of Ecology and Environment (MoEE) required heavily polluting firms to disclose their environmental reports. Because this requirement came later than our setting period and the scope of CSR reports is wider than that of environmental reports, we expect that analysts' information set is not significantly affected. In addition, in Section 5.4, we exclude polluting firms to examine the robustness of our results. Second, both the MoEE and the two stock exchanges encouraged the voluntary disclosure of environmental or CSR reports prior to such disclosure becoming mandatory. We therefore exclude voluntarily disclosing firms in the pre-adoption period to mitigate the potential impact of voluntary disclosure. Third, we conduct placebo tests in Section 5.4. We use a similar research design to that found in the literature (Wang et al., 2018; Liu and Tian, 2021; Huang et al., 2022) to examine the impact of mandatory CSR disclosure, and we are thus less concerned that our conclusions could be unduly influenced by concurrent events.

(*Polluting*). We also control for industry and year fixed effects. All of the variables are defined in Appendix A. The results of the logit model for the PSM approach are reported in Panel A of Appendix B.

As shown in Appendix B, the probability of being included in the CSR mandatory disclosure list is positively (negatively) associated with firm size, profitability, government shareholdings, and analyst following (share turnover). We then match each treatment firm to a control firm using nearest-neighbor matching. The PSM procedure leaves us with 3,540 firm-year observations, 1,681 of which are from treatment firms and 1,859 of which are from control firms, corresponding to 249 and 317 unique firms, respectively.[5] Panel B of Appendix B reports the parallel trends test. As shown, the differences in the dependent variables between the treatment and control groups increase significantly from the pre- to the post-adoption period.

Table 1 describes our sample distribution, with Panel A reporting the yearly distribution and Panel B reporting the industry distribution. More than half of the treatment sample belongs to the manufacturing industry, which is consistent with the general distribution of the Chinese A-share market. In addition, the treatment and control groups display similar industry distribution patterns.

4. Model specification

To empirically examine whether the mandatory CSR disclosure has any impact on analyst forecast properties, we estimate the following ordinary least squares (OLS) regression model based on the PSM sample described in Section 3:

$Forecast \quad Properties(Y)_{t+1} = a_0 + a_1 Treat + a_2 Post + a_3 Treat*Post + Analyst\text{-}specific \quad Controls_t + Firm\text{-}specific \; Controls_t + fixed \; effects + error \; term$ (1).

where analyst forecast properties are measured in the dimensions of analyst forecast error (*Ferr*) and analyst forecast dispersion (*Disp*). Analyst forecast error captures the amount of information that analysts incorporate into their forecasts, and analyst forecast dispersion captures the degree of uncertainty in their information set (Barron and Stuerke, 1998). We calculate forecast error and forecast dispersion with earnings forecasts for three different forecast horizons. The terms *Ferr(0), Ferr(1),* and *Ferr(2)* are the absolute values of the mean errors for forecasts on a firm's earnings per share (EPS) in years t, $t + 1$, and $t + 2$, respectively, scaled by the actual EPS; *Disp(0)*, *Disp (1)*, and *Disp(2)* are the standard deviations of forecasts on EPS in years t, $t + 1$, and $t + 2$, respectively, scaled by the actual EPS; *Treat* is an indicator variable that equals one if the firm is included in the mandatory CSR disclosure list (i.e., a treatment firm), and zero otherwise (i.e., a control firm); and *Post* is an indicator variable that equals one for the post-mandatory period from 2009 to 2012, and zero for the pre-mandatory period from 2005 to 2008 (Chen et al., 2018).[6]

The coefficient of the interaction term, a_3, thus captures the DID effect of whether analyst forecast properties change significantly for the treatment group after the mandatory CSR disclosure requirement compared with the control group. If the standalone CSR reports are informative for analysts making earnings forecasts, we expect both analyst forecast error and analyst forecast dispersion to decrease with the incremental information; in other words, a_3 is expected to be significantly negative.

We include two types of control variables, namely, analyst-specific controls and firm-specific controls, to control for other factors that could affect analyst forecast error and analyst forecast dispersion. Following Cheng et al. (2016), we control for the forecast horizon (*Horizon*) because analyst forecast error and analyst forecast dispersion are likely to increase with the forecast horizon. Brokerage size (*BrokerSize*) and the brokerage age (*BrokerAge*) are controlled for because financial analysts from larger and longer-lived brokerage houses are likely to make more accurate earnings forecasts than financial analysts from other brokerage houses. Analyst experience is further controlled for by the average number of companies covered by analysts forecasting the firm's earnings (*Coverage*). We control for the frequency of new information incorporated by

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[5] We allow all of the nearest neighbors to be included in the control group, resulting in an unbalanced number of treatment and control firms.

[6] As a sensitivity check, we calculate the alternative measures of analyst forecast error and analyst forecast dispersion by using the closing stock price at the last fiscal year-end date as the scale and re-estimate all of the regressions with the alternative variables. Although not tabulated, the results show that our inferences are not sensitive to measures of scale.

Table 1
Sample distribution, Panel A: Sample distribution by year, Panel B: Sample distribution by industry.

Year	PSM Sample			
	Treatment Group, # of Unique Firms = 249		Control Group, # of Unique Firms = 317	
	N	%	N	%
2005	156	9.28	160	8.61
2006	188	11.18	200	10.76
2007	210	12.49	231	12.43
2008	217	12.91	246	13.23
2009	238	14.16	279	15.01
2010	231	13.74	267	14.36
2011	225	13.38	247	13.29
2012	216	12.85	229	12.32
Total	**1,681**	**100**	**1,859**	**100**
Industry	Treatment Group		Control Group	
	N	%	N	%
Agriculture, forestry, animal husbandry, & fishery	11	0.65	27	1.45
Mining	86	5.12	81	4.36
Manufacturing	973	57.88	1135	61.06
Electricity, heat, gas, & water supply	110	6.54	67	3.6
Construction	33	1.96	27	1.45
Wholesale & retail	58	3.45	157	8.45
Transportation, warehouse, & postal services	185	11.01	108	5.81
Accommodation & catering	3	0.18	14	0.75
Information technology	59	3.51	41	2.21
Real estate	115	6.84	122	6.56
Business services	16	0.95	19	1.02
Scientific research & technical services	0	0	4	0.22
Water, environmental, & public facilities management	8	0.48	27	1.45
Sports & entertainment	12	0.71	16	0.86
Conglomerate	12	0.71	14	0.75
Total	**1,681**	**100**	**1,859**	**100**

analysts with the variable *Revise.* In addition to the above analyst-specific control variables, we include a set of firm-specific controls that could affect analyst forecast error and analyst forecast dispersion: firm size (*Size*), sales growth (*Growth*), volatility in sales revenue (*SD(sales)*), profitability (*ROE*), leverage (*Lev*), a loss firm indicator (*Loss*), and firm age (*Age*). A firm's corporate governance can also affect its information environment and, thus, analyst forecast error and analyst forecast dispersion. We therefore control for the largest shareholder (*Top1*), institutional ownership (*Inst*), whether the firm is audited by a Big 4 auditor (*Big4*), and whether the firm is a state-owned enterprise (*SOE*). Appendix A provides detailed definitions of all of the variables. All of the continuous variables are winsorized at the first and 99th percentiles.

Table 2 reports the descriptive statistics for our PSM sample. As shown in Panel A, the mean values of *Ferr (0)* and *Disp(0)* are 0.186 and 0.128, respectively. As expected, analyst forecast error and analyst forecast dispersion increase with the length of the forecast horizon. For forecasts made in the concurrent year, analysts make an average of 1.6 revisions, with a 250.7-day difference between the forecast date and the earnings announcement date. The average brokerage house employs 30 analysts and has been in business for approximately 13 years. On average, each analyst in our sample follows 18 firms.[7]

Panel B of Table 2 provides the mean and median values of our two dependent variables for the treatment and control groups for both the pre- and post-mandate periods. For the treatment sample, we observe an

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[7] We use the logarithmic transformation of the variables *Revise, Horizon, BrokerSize, BrokerAge,* and *Coverage* in the regression model. Although Table 2 reports the descriptive statistics of these variables after their logarithmic transformation, we describe the means of the raw values of these variables in the text for ease of interpretation.

Table 2
Descriptive statistics, Panel A: Descriptive statistics Panel B: Differences in the mean and median values of the treatment and control groups.

	N	Mean	Std. Dev.	Min.	P25	Median	P75	Max.
Dependent Variables								
Ferr(0)	3,540	0.186	0.225	0.002	0.046	0.111	0.232	1.261
Disp(0)	3,302	0.128	0.138	0.001	0.042	0.081	0.16	0.793
Ferr(1)	3,511	0.306	0.317	0.004	0.095	0.204	0.404	1.766
Disp(1)	3,276	0.177	0.175	0.005	0.068	0.119	0.221	1.048
Ferr(2)	3,313	0.449	0.401	0.009	0.174	0.346	0.588	2.275
Disp(2)	2,973	0.218	0.204	0.004	0.091	0.156	0.264	1.278
Control Variables: Analyst-specific								
Revise(0)	3,540	1.626	0.517	1	1.25	1.556	1.9	5
Horizon(0)	3,540	5.500	0.246	3.935	5.385	5.521	5.655	6.136
BrokerSize(0)	3,540	3.643	0.325	1.099	3.475	3.653	3.854	4.691
BrokerAge(0)	3,540	2.574	0.323	0	2.442	2.611	2.773	3.332
Coverage(0)	3,540	2.789	0.545	0.693	2.436	2.773	3.135	5.421
Revise(1)	3,511	0.949	0.184	0.693	0.811	0.941	1.066	1.792
Horizon(1)	3,511	5.484	0.245	3.935	5.364	5.506	5.634	6.136
BrokerSize(1)	3,511	3.648	0.327	1.099	3.483	3.663	3.862	4.691
BrokerAge(1)	3,511	2.575	0.325	0	2.442	2.615	2.773	3.332
Coverage(1)	3,511	2.763	0.544	0.693	2.404	2.741	3.109	5.421
Revise(2)	3,313	0.928	0.186	0.693	0.78	0.916	1.041	1.792
Horizon(2)	3,313	5.396	0.26	3.784	5.268	5.423	5.549	6.098
BrokerSize(2)	3,313	3.673	0.327	1.099	3.526	3.696	3.88	4.691
BrokerAge(2)	3,313	2.566	0.381	0	2.428	2.629	2.791	3.332
Coverage(2)	3,313	2.783	0.576	0.693	2.404	2.76	3.143	5.421
Control Variables: Firm-specific								
SD(sales)	3,540	0.119	0.122	0.004	0.042	0.081	0.148	0.701
Growth	3,540	0.244	0.415	−0.542	0.049	0.178	0.346	3.231
Loss	3,540	0.030	0.17	0	0	0	0	1
ROE	3,540	0.113	0.095	−0.442	0.065	0.107	0.16	0.364
Size	3,540	22.435	1.201	19.451	21.584	22.314	23.148	25.742
Lev	3,540	0.512	0.179	0.048	0.389	0.526	0.649	0.91
Age	3,540	2.38	0.403	1.099	2.079	2.485	2.708	3.135
Top1	3,540	0.404	0.159	0.091	0.275	0.411	0.522	0.756
Inst	3,540	0.074	0.057	0.001	0.027	0.061	0.109	0.225
Big4	3,540	0.147	0.355	0	0	0	0	1
SOE	3,540	0.740	0.439	0	0	1	1	1

	Treatment Group			Control Group		
	N	Median	Mean	N	Median	Mean
Pre-mandate period: 2005–2008						
Ferr(0)	771	0.097	0.165*	837	0.099	0.185
Disp(0)	725	0.076	0.128	754	0.076	0.117
Ferr(1)	765	0.179	0.276**	818	0.198	0.317
Disp(1)	717	0.121	0.186	740	0.114	0.171
Ferr(2)	721	0.311*	0.422*	743	0.337	0.461
Disp(2)	643	0.161	0.232	638	0.152	0.217
Post-mandate period: 2009–2012						
Ferr(0)	910	0.107***	0.172***	1,022	0.131	0.216
Disp(0)	871	0.085	0.129	952	0.086	0.136
Ferr(1)	908	0.188***	0.275***	1,020	0.244	0.348
Disp(1)	870	0.117	0.168*	949	0.127	0.181
Ferr(2)	877	0.326***	0.408***	972	0.404	0.499
Disp(2)	825	0.152	0.206	867	0.160	0.220

The superscripts *, **, and *** indicate $p < 0.1$, $p < 0.05$, and $p < 0.01$, respectively. All of the variables are defined in Appendix A.

overall increasing trend from the pre- to the post-mandate period in the mean and median values of both analyst forecast error and analyst forecast dispersion regardless of the forecast horizon, except for *Disp(1)* and *Disp(2)*. However, the increase in the mean and median values of *Ferr* and *Disp* from the pre- to the

post-mandate period is even higher for the control sample than for the treatment sample. This result is confirmed by the differences in the median values of the two dependent variables between the treatment and control groups. As shown, in the pre-mandate period, the median values of both analyst forecast error and analyst forecast dispersion are not significantly different between the two groups (except for *Ferr(2)*). In comparison, the median values of the forecast error in the treatment group are significantly lower than in the control group in the post-mandate period. However, we do not observe a clear pattern in terms of change with respect to the mean values of the dependent variables. Panel B thus provides preliminary support for the proposition that the treatment group experiences a larger decrease in forecast error from the pre- to the post-mandate period compared with the control group.

The correlation coefficients of all of the variables are presented in Table 3, with the cells below the diagonal reporting the Pearson correlation coefficients and the cells above the diagonal reporting the Spearman correlation coefficients. To be concise, we only report the correlations of *Ferr(0)* and *Disp(0)* with the other variables. As expected, *Ferr* and *Disp* are highly correlated, with a coefficient of 0.662. Concerning the control variables, the highest correlation coefficient is 0.444, between *BrokerAge* and *Coverage*. This is a reasonable finding because older brokerage houses are likely to cover more firms than newer brokerage houses. We are thus relatively unconcerned about multicollinearity issues in our research design.

5. Empirical results

5.1. Regression results for hypothesis

Table 4 reports the results of the OLS regression of the current period's independent variables on the next period's forecast properties. Columns (1) to (4), (5) to (8), and (9) to (12) present the results for analyst forecasts made for the current year, the next year, and the year after, respectively. Columns (1), (3), (5), (7), (9), and (11) include year and firm fixed effects, and the effects of *Treat* and *Post* are therefore subsumed. Columns (2), (4), (6), (8), (10), and (12) include only industry fixed effects. The variable *Treat* captures the difference in forecast properties between the treatment and control groups. The coefficient of *Treat* is significantly positive in columns (4), (8), and (12), providing some evidence that analyst forecast dispersion is greater for the treatment firms than for the control firms. The variable *Post* measures the overall change in forecast properties from the pre- to the post-mandate period for all of the sample firms. As shown, the coefficient of *Post* is significantly positive in columns (6) and (10), providing some evidence of an overall increase in analyst forecast error and analyst forecast dispersion from 2009 to 2012, compared with 2005 to 2008.

Our variable of interest is *Treat*Post*, which captures the DID effect. As shown, the coefficient of *Treat*Post* is significantly negative in all of the columns of Table 4. In column (1), for example, the coefficient of *Treat*Post* is −0.036, with a *t*-value of −2.59. The significantly negative coefficient provides strong evidence that analysts' information environment improves significantly for firms that have been subject to mandatory CSR disclosure since 2009 compared with firms that have not been subject to mandatory CSR disclosure. Because of the improved information environment, analyst forecast error and analyst forecast dispersion decrease significantly regardless of the forecast horizon. The results in Table 4 support the view that financial analysts are likely to incorporate the incremental information contained in standalone CSR reports even though most of those reports are not subject to mandatory audits.

Concerning the control variables, the following findings are noteworthy. First, as expected, analyst forecast error and analyst forecast dispersion increase with the forecast horizon. Second, we find some evidence that brokerage size (*BrokerSize*), brokerage age (*BrokerAge*), and analysts' general experience (*Coverage*) reduce analyst forecast error and analyst forecast dispersion. Third, volatility in sales revenue, sales growth, loss indicator, size, and leverage is positively related to analyst forecast error and analyst forecast dispersion. Fourth, institutional ownership is positively related to analyst forecast error and analyst forecast dispersion, probably because of institutional investors' predatory role (Gu et al., 2013). Fifth, we find some evidence that greater firm age, Big 4 auditors, and state ownership improve analysts' forecast properties.

Table 3
Correlation matrix.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
1 Ferr(0)		0.516	-0.039	0.229	0.033	0.047	0.050	0.129	0.041	0.060	-0.003	0.066	0.187	0.062	-0.066	0.026	-0.075	-0.024
2 Disp(0)	0.662		0.030	0.219	0.059	-0.003	0.075	0.176	0.049	0.055	0.019	0.069	0.159	-0.019	-0.030	0.080	-0.055	-0.035
3 Revise(0)	-0.054	-0.023		-0.254	0.146	0.127	0.127	0.021	0.085	-0.030	0.193	0.140	-0.006	0.061	-0.042	0.166	0.092	-0.077
4 Horizon(0)	0.262	0.199	-0.275		0.118	0.153	0.232	-0.001	-0.038	0.007	-0.072	0.069	0.017	0.096	0.004	-0.086	-0.054	0.021
5 BrokerSize(0)	-0.014	0.025	0.120	0.099		0.370	0.232	-0.02	-0.191	0.002	-0.037	0.278	0.057	0.262	-0.032	-0.029	0.073	-0.028
6 BrokerAge(0)	0.039	0.01	0.101	0.168	0.290		0.444	-0.011	-0.094	0.016	-0.063	0.170	0.013	0.245	-0.039	-0.093	0.009	-0.059
7 Coverage(0)	0.013	0.014	0.029	0.175	0.001	0.255		0.027	-0.030	0.030	-0.022	0.120	-0.003	0.209	-0.033	-0.037	-0.018	-0.071
8 SD(sales)	0.091	0.109	0.011	-0.009	-0.034	-0.039	-0.002		0.030	0.028	0.058	0.120	0.151	0.023	-0.009	0.017	-0.061	-0.039
9 Growth	0.063	0.085	0.043	-0.037	-0.089	-0.064	-0.028	0.013		-0.032	0.338	-0.041	0.103	-0.115	0.024	0.131	-0.032	-0.004
10 Loss	0.062	0.047	-0.006	0.003	-0.005	0.014	0.044	0.005	-0.012		-0.149	0.043	0.135	0.007	-0.037	-0.081	0.044	0.02
11 ROE	-0.028	0.028	0.119	-0.063	-0.021	-0.061	-0.036	0.058	0.256	-0.206		-0.062	-0.125	-0.048	0.029	0.275	0.019	-0.090
12 Size	0.037	0.042	0.183	0.048	0.271	0.146	0.018	0.019	-0.014	0.051	-0.056		0.393	0.291	0.231	-0.259	0.359	0.237
13 Lev	0.164	0.120	0.024	0.008	0.049	0.006	-0.006	0.123	0.088	0.141	-0.142	0.386		0.136	-0.036	-0.065	0.016	0.105
14 Age	0.030	-0.015	0.063	0.131	0.250	0.225	0.140	0.022	-0.066	0.009	-0.031	0.257	0.124		-0.076	-0.037	0.013	0.117
15 Top1	-0.029	-0.009	-0.048	-0.008	-0.029	-0.036	-0.045	0.026	0.058	-0.046	0.045	0.234	-0.015	-0.094		-0.238	0.101	0.281
16 Inst	0.015	0.057	0.133	-0.105	-0.041	-0.081	-0.069	-0.003	0.068	-0.079	0.232	-0.255	-0.052	-0.058	-0.249		-0.181	-0.107
17 Big4	-0.062	-0.044	0.096	-0.049	0.075	0.003	-0.033	-0.050	-0.02	0.044	-0.009	0.390	0.018	0.02	0.108	-0.164		0.066
18 SOE	-0.009	-0.030	-0.077	0.029	-0.017	-0.052	-0.045	-0.009	-0.024	0.017	-0.077	0.221	0.096	0.108	0.278	-0.107	0.065	

The cells below the diagonal report the Pearson correlation coefficients and the cells above the diagonal report the Spearman rank correlation coefficients. Bold italics indicate a significance level of <0.01, bold indicates a significance level of <0.05, and italics indicate a significance level of <0.1.

Table 4
OLS regression results.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
		$Ferr(0)_{t+1}$		$Disp(0)_{t+1}$	$Ferr(1)_{t+1}$			$Disp(1)_{t+1}$		$Ferr(2)_{t+1}$		$Disp(2)_{t+1}$
Treat		−0.015 [−1.35]		0.013* [1.79]		−0.014 [−0.91]		0.023** [2.52]		0.000 [0.01]		0.027** [2.39]
Post		0.024* [1.95]		0.012 [1.46]		0.033* [1.84]		0.005 [0.46]		0.084*** [3.66]		0.016 [1.22]
Treat*Post	**−0.036*** [−2.59]**	**−0.032** [−2.26]**	**−0.022** [−2.39]**	**−0.022** [−2.39]**	**−0.037*** [−2.00]**	**−0.037* [−1.84]**	**−0.029** [−2.57]**	**−0.029** [−2.48]**	**−0.051** [−2.15]**	**−0.050* [−1.89]**	**−0.029** [−2.11]**	**−0.029** [−2.00]**
Revise(Y)	−0.001 [−0.17]	0.003 [0.34]	0.002 [0.26]	0.002 [0.43]	0.060* [1.85]	0.056* [1.82]	0.021 [1.01]	0.022 [1.18]	0.056 [1.43]	0.064* [1.65]	0.014 [0.56]	0.015 [0.65]
Horizon(Y)	0.240*** [13.49]	0.234*** [14.83]	0.104*** [8.15]	0.130*** [12.05]	0.303*** [12.63]	0.307*** [13.60]	0.106*** [6.72]	0.144*** [10.27]	0.220*** [7.90]	0.209*** [7.44]	0.075*** [4.04]	0.101*** [5.81]
BrokerSize(Y)	−0.027* [−1.81]	−0.028** [−2.21]	0.024** [2.07]	0.017* [1.94]	−0.018 [−0.88]	−0.035** [−2.03]	0.016 [1.08]	0.012 [1.02]	0.010 [0.38]	−0.016 [−0.70]	0.011 [0.61]	0.012 [0.85]
BrokerAge(Y)	−0.019 [−1.37]	0.006 [0.44]	−0.025** [−2.10]	−0.009 [−0.84]	−0.046** [−2.41]	−0.015 [−0.84]	−0.026* [−1.78]	−0.012 [−0.95]	−0.019 [−0.97]	−0.038* [−1.96]	−0.012 [−0.73]	−0.016 [−1.17]
Coverage(Y)	−0.024*** [−2.65]	−0.026*** [−3.21]	−0.013** [−1.97]	−0.009* [−1.65]	−0.039*** [−2.97]	−0.019 [−1.57]	−0.014 [−1.62]	−0.004 [−0.50]	−0.042*** [−2.74]	−0.028* [−1.89]	−0.028*** [−2.66]	−0.011 [−1.22]
Sd(sales)	0.080* [1.91]	0.118*** [3.84]	0.068** [2.48]	0.101*** [5.07]	0.126** [2.20]	0.166*** [3.81]	0.113*** [3.31]	0.127*** [5.01]	0.180** [2.48]	0.197*** [3.47]	0.082* [1.91]	0.102*** [3.24]
Growth	0.012 [1.33]	0.036*** [3.93]	0.013** [2.19]	0.024*** [4.11]	0.024* [1.92]	0.059*** [4.65]	0.022*** [2.94]	0.039*** [5.28]	0.031* [1.93]	0.080*** [4.83]	0.028*** [2.84]	0.051*** [5.31]
Loss	−0.020 [−0.88]	0.043** [1.99]	0.016 [1.04]	0.034** [2.38]	−0.029 [−0.97]	0.036 [1.19]	0.028 [1.50]	0.036** [1.99]	−0.003 [−0.08]	0.062 [1.53]	−0.001 [−0.06]	0.016 [0.70]
ROE	0.172*** [3.34]	−0.039 [−0.93]	0.023 [0.67]	0.005 [0.19]	0.084 [1.22]	−0.215*** [−3.64]	−0.011 [−0.26]	−0.019 [−0.55]	0.121 [1.36]	−0.280*** [−3.63]	0.020 [0.37]	−0.044 [−1.02]
Size	0.024* [1.89]	0.009** [2.14]	0.021** [2.42]	0.005* [1.72]	0.011 [0.63]	−0.011* [−1.74]	0.018* [1.67]	−0.004 [−1.02]	−0.023 [−1.02]	−0.034** [−4.21]	0.002 [0.16]	−0.010** [−2.29]
Lev	−0.050 [−1.11]	0.191*** [7.92]	−0.060** [−2.00]	0.088*** [5.57]	−0.082 [−1.33]	0.299*** [8.78]	−0.057 [−1.52]	0.127*** [6.27]	−0.041 [−0.52]	0.404*** [9.00]	−0.025 [−0.53]	0.158*** [6.31]
Age	−0.060 [−1.26]	0.002 [0.20]	0.019 [0.60]	−0.010 [−1.44]	−0.018 [−0.28]	−0.034** [−2.36]	0.021 [0.55]	−0.026** [−3.12]	−0.003 [−0.04]	−0.074*** [−3.96]	0.001 [0.01]	−0.033*** [−3.16]
Top1	−0.039 [−0.53]	−0.014 [−0.56]	0.050 [1.04]	0.008 [0.52]	−0.019 [−0.19]	−0.013 [−0.36]	0.007 [0.11]	0.001 [0.05]	0.002 [0.02]	−0.044 [−0.94]	0.018 [0.24]	−0.020 [−0.99]
Inst	0.416*** [4.42]	0.141** [1.98]	0.393*** [6.38]	0.195*** [4.24]	0.682*** [5.34]	0.379*** [3.76]	0.488*** [6.36]	0.232*** [3.93]	0.807*** [4.94]	0.622*** [4.72]	0.538*** [5.64]	0.272*** [3.69]
Big4	−0.003 [−0.13]	−0.024** [−2.10]	0.013 [0.83]	−0.012* [−1.70]	−0.006 [−0.19]	−0.039** [−2.48]	0.014 [0.69]	−0.014 [−1.47]	0.013 [0.30]	−0.043** [−2.05]	0.019 [0.74]	−0.011 [−0.99]
SOE	0.023 [1.23]	−0.005 [−0.54]	0.004 [0.32]	−0.010* [−1.75]	0.023 [0.91]	−0.019 [−1.48]	−0.005 [−0.36]	−0.012* [−1.66]	0.034 [1.04]	−0.023 [−1.38]	0.002 [0.11]	−0.013 [−1.45]
Constant	−1.478*** [−4.81]	−1.209*** [−9.67]	−1.018*** [−4.88]	−0.779*** [−9.11]	−1.516*** [−3.65]	−0.991*** [−5.55]	−0.904*** [−3.48]	−0.615*** [−5.57]	−0.423 [−0.80]	0.280 [1.24]	−0.340 [−1.05]	−0.142 [−1.06]

Table 4 (*continued*)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Year	Yes	–	Yes	–	Yes	–	Yes	–	Yes	–	Yes	–
Firm	Yes	–	Yes	–	Yes	–	Yes	–	Yes	–	Yes	–
Industry	–	Yes	–	Yes	–	Yes	–	Yes	–	Yes	–	Yes
R^2	0.151	0.133	0.136	0.109	0.133	0.140	0.138	0.111	0.089	0.142	0.106	0.098
F-Value	21.719	14.970	17.750	11.047	18.591	15.660	17.888	11.230	11.138	15.025	11.943	8.871
N	3,540	3,540	3,302	3,302	3,511	3,511	3,276	3,276	3,313	3,313	2,973	2,973

This table shows the OLS regression results of *Forecast Properties*$_{t+1}$ = a_0 + a_1*Treat* + a_2*Post* + a_3*Treat*Post* + *Analyst-specific Controls$_t$* + *Firm-specific Controls$_t$* + *fixed effects* + *error term*. The variable *Forecast Properties* is proxied by the forecast error *Ferr* and the forecast dispersion *Disp*. Columns (1)–(4), (5)–(8), and (9)–(12) present the results for analyst forecasts made for the current year, the next year, and the year after, respectively. Columns (1), (3), (5), (7), (9), and (11) include year and firm fixed effects. Columns (2), (4), (6), (8), (10), and (12) include only industry fixed effects. The *t*-statistics are in brackets. The superscripts *, **, and *** indicate $p < 0.1$, $p < 0.05$, and $p < 0.01$, respectively. All of the variables are defined in Appendix A.

5.2. Cross-sectional test

5.2.1. Role of the existing information environment

CSR reports' usefulness to financial analysts can vary with the firms' information environment, which affects the demand for the information contained in those reports. For firms with a high level of information asymmetry, CSR reports can serve as an important source of information that supplements other publicly available information (Clarkson et al., 2013). In this case, CSR disclosure is expected to be of greater importance to financial analysts than for firms with a low level of information asymmetry. In contrast, if the firm is relatively transparent, the incremental contribution of the CSR reports is of less importance than for firms with a high level of information asymmetry. Our first cross-sectional test thus examines whether the impact of mandatory CSR disclosure on analyst forecast properties varies with the firm's existing information environment.

Empirically, firms' existing information environment is proxied by stock price synchronicity. Stock price synchronicity measures the level of firm-specific information that is incorporated into a firm's stock prices. A higher value of synchronicity means a lower level of firm-specific information being reflected in stock prices, and thus a higher level of information asymmetry (Jin and Myers, 2006; Hutton et al., 2009; Gul et al., 2010). One can reasonably argue that outsiders, such as analysts, demand more alternative information when the firm has a higher level of information asymmetry than when it is relatively transparent. Thus, we expect standalone CSR reports to provide more incremental information for analysts following opaque firms than for those following transparent firms. We then split the sample into two subsamples based on the sample's median value of synchronicity and then re-estimate Eq. (1) for each subsample.

Panel A of Table 5 presents the results of the cross-sectional test. As shown, the coefficient of Treat*Post is significantly negative only in the subsample of firms with high stock price synchronicity. In comparison, the coefficient is insignificant in subsamples with low stock price synchronicity. In other words, standalone CSR reports help analysts improve their forecasts' properties when the firm's information environment is opaque and the CSR report serves as an important alternative information source.

5.2.2. Role of marketization

Arguably, because most CSR reports are unaudited, they can lack credibility. Coram et al. (2009) point out that corporate disclosures are not useful if they are perceived as not credible. In such a situation, financial analysts might not incorporate the disclosed CSR information into their forecasts. We expect credibility-related concerns to be alleviated if firms are domiciled in highly marketized provinces. Such firms typically face more stringent legal enforcement and have more developed financial intermediaries (Fan et al., 2017) and are thus more strictly monitored than firms domiciled in less marketized provinces. In addition, firms in less marketized provinces rely on political connections (Hou et al., 2022) and local protectionism (Hu et al., 2021) rather than capital markets to obtain resources. These firms lack incentives to provide high-quality CSR disclosures despite the mandatory disclosure requirement. We thus conjecture that the CSR reports of firms in highly marketized provinces contain more reliable and relevant information than the CSR reports of firms in less marketized provinces. Therefore, the impact of CSR disclosure requirements on forecast properties is expected to be more pronounced if the firms are domiciled in highly marketized provinces than if they are not. Our second cross-sectional test examines whether the impact of mandatory CSR disclosure on analyst forecast properties is influenced by province-level marketization.

We split the sample into two subsamples based on the Fan Index (Fan et al., 2017) and re-estimate Eq. (1) for each subsample. Specifically, we assign the province-level Fan Index to the firms registered in that province. Eight provinces (Shanghai, Tianjin, Zhejiang, Beijing, Fujian, Guangdong, Jiangsu, and Shandong) are classified as provinces with a high Fan Index, with the rest classified as provinces with a low Fan Index.[8]

The results for the cross-sectional analyses are presented in Panel B of Table 5. Consistent with our expectations, the coefficient of Treat*Post remains significantly negative for the subsample of firms located in highly

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[8] Because some provinces tend to have more firms than others, we do not use the sample median values of the Fan Index to split the sample. Partitioning by the median value results in unbalanced subsample sizes.

Table 5

Cross-sectional tests Panel A: Role of firms' existing information environment, proxied for by stock price synchronicity Panel B: Role of marketization.

Panel A

	$Ferr(0)_{t+1}$		$Disp(0)_{t+1}$		$Ferr(1)_{t+1}$		$Disp(1)_{t+1}$		$Ferr(2)_{t+1}$		$Disp(2)_{t+1}$	
	(1) Low	(2) High	(3) Low	(4) High	(5) Low	(6) High	(7) Low	(8) High	(9) Low	(10) High	(11) Low	(12) High
Treat*Post	−0.018	−0.052**	−0.017	−0.027**	−0.023	−0.072***	−0.020	−0.051***	−0.015	−0.098***	−0.012	−0.042**
	[−0.81]	**[−2.53]**	**[−1.20]**	**[−1.98]**	**[−0.75]**	**[−2.69]**	**[−1.08]**	**[−3.24]**	**[−0.38]**	**[−2.93]**	**[−0.52]**	**[−2.08]**
Constant	−2.042***	−1.523***	−1.281***	−0.978***	−2.146***	−1.925***	−1.091***	−1.134***	−0.536	−0.384	−1.092**	−0.687
	[−4.29]	[−3.15]	[−4.00]	[−2.98]	[−3.28]	[−3.05]	[−2.63]	[−2.93]	[−0.64]	[−0.48]	[−2.13]	[−1.39]
Analyst-specific controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm-specific controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.182	0.155	0.159	0.150	0.156	0.157	0.149	0.167	0.078	0.150	0.097	0.157
F-Value	10.968	9.597	8.508	8.523	9.028	9.594	7.771	9.594	3.867	8.414	4.322	7.772
N	1,742	1,791	1,620	1,675	1,733	1,771	1,608	1,661	1,638	1,669	1,471	1,496

Panel B

	$Ferr(0)_{t+1}$		$Disp(0)_{t+1}$		$Ferr(1)_{t+1}$		$Disp(1)_{t+1}$		$Ferr(2)_{t+1}$		$Disp(2)_{t+1}$	
	(1) High	(2) Low	(3) High	(4) Low	(5) High	(6) Low	(7) High	(8) Low	(9) High	(10) Low	(11) High	(12) Low
Treat*Post	−0.044***	−0.022	−0.030***	−0.007	−0.049**	−0.013	−0.041***	−0.007	−0.059***	−0.027	−0.028	−0.017
	[−2.70]	**[−0.91]**	**[−2.63]**	**[−0.47]**	**[−2.18]**	**[−0.41]**	**[−2.82]**	**[−0.39]**	**[−2.07]**	**[−0.66]**	**[−1.54]**	**[−0.77]**
Constant	−1.095***	−1.879***	−0.882***	−1.216***	−0.730	−2.448***	−0.631*	−1.394***	0.821	−1.913***	0.024	−1.065**
	[−3.07]	[−3.39]	[−3.41]	[−3.40]	[−1.49]	[−3.30]	[−1.91]	[−3.25]	[1.32]	[−2.01]	[0.06]	[−2.01]
Analyst-specific controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm-specific controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.131	0.193	0.129	0.166	0.134	0.163	0.137	0.173	0.095	0.115	0.114	0.124
F-Value	10.399	12.480	9.473	9.572	10.554	10.080	10.061	9.958	6.708	6.239	7.323	6.060
N	2,008	1,532	1,872	1,430	1,990	1,521	1,856	1,420	1,881	1,432	1,686	1,287

This table shows the OLS regression results of *Forecast Properties*$_{t+1}$ = a_0 + a_1*Treat*Post* + *Analyst-specific Controls*$_t$ + *Firm-specific Controls*$_t$ + *firm and year fixed effects* + *error term*. The variable *Forecast* Properties is proxied for by forecast error, *Ferr*, and forecast dispersion, *Disp*. The sample is split into two subsamples and the regression is estimated for each subsample. Panel A partitions the sample based on the sample median of stock price synchronicity. Panel B partitions the sample based on whether the firm is domiciled in provinces with a high Fan Index. Columns (1)–(4), (5)–(8), and (9)–(12) report the results for analyst forecasts made for the current year, the next year, and the year after, respectively. The *t*-statistics are in brackets. The superscripts ** and *** indicate $p < 0.05$ and $p < 0.01$, respectively. All of the variables are defined in Appendix A.

marketized provinces (e.g., −0.044 with a *t*-value of −2.70 in column (1)). In comparison, the coefficient becomes insignificantly different from zero for the subsample of firms located in less marketized provinces (e.g., −0.022 with a *t*-value of −0.91 in column (2)). Therefore, the results in Panel B provide evidence that the impact of mandatory CSR reports on analyst forecast properties is more pronounced for firms domiciled in highly marketized provinces than for firms domiciled in less marketized provinces.

In short, the two cross-sectional tests provide scenarios in which a firm-specific factor (i.e., the information environment) and an external factor (i.e., provincial-level marketization) can affect the relation between mandatory CSR disclosure and analysts' information environment.

5.3. Further analyses

Table 4 provides evidence that mandatory CSR disclosure is informative for analysts in making forecasts. The baseline results assume homogeneity in the usefulness of all CSR reports to financial analysts. However, it is intuitive to argue that the usefulness of CSR reports depends on their quality and the information they contain.

5.3.1. Does CSR report quality matter?

The literature documents improved analyst forecast quality when disclosure quality improves (Brown et al., 1987; Lang and Lundholm, 1996; Healy et al., 1999). In our CSR disclosure setting, despite the Notice and the Guidelines, the standalone CSR reports do not use a prescribed format or types of CSR activities to be disclosed. Therefore, in practice, we observe that the information disclosed in the CSR reports varies greatly across firms. Variations can be found in both the form and content of the CSR reports. These variations unavoidably lead to a lack of comparability, which can impair the CSR reports' usefulness. In addition, the CSR reports are not subject to external audits. Thus, it is reasonable to expect analysts to gain more informational benefits from CSR reports of higher disclosure quality than from CSR reports of lower disclosure quality. Accordingly, we examine whether CSR report quality matters for analyst forecast properties.

To do so, we construct three proxies to measure CSR report quality: *Score*, *Pages*, and *Content*. *Score* is an overall disclosure quality measure provided by the RKS database.[9] This quality measure gauges the following four dimensions of CSR disclosure quality: i) the macrocosm, such as whether CSR is considered a strategic issue and how the firm governs its CSR activities; ii) content, such as how the firm conducts and discloses specific CSR activities related to its employees, the community, customers, and shareholders; iii) technique indicators related to the CSR report, such as comparability with previous CSR reports, along with the reliability and transparency of the report; and iv) industry-specific factors. These four dimensions are then assigned the following weights: 30% to the macrocosm, 45% to content, 15% to technique, and 10% to industry-specific factors. The final score is then calculated based on the weighted scores on a scale of zero to 100. The second quality measure, *Pages*, is the length of the CSR report measured by the natural logarithm of the number of pages plus one. The third quality measure, *Content*, measures the content in the CSR report. It quantifies the number of items disclosed in the CSR report in terms of 10 aspects: shareholder protection, creditor protection, employee protection, supplier protection, customer and consumer protection, the environment and sustainability, public welfare, policy related to CSR activities, workplace safety, and deficiencies in CSR activities. A score of one is given for each of these items that the firm discloses in its CSR report. The variable *Content* is the sum of the scores ranging from zero to 10. All three of these variables are designed so that larger values indicate higher CSR report quality. A value of zero is assigned to the firm-year observations of the control group and the pre-mandate period of the treatment group.

The sample is then split into two subsamples. Given the definition of the three report-level variables, it is infeasible to partition the full sample based on the median values of *Score*, *Pages*, and *Content*. To solve this issue, we first take the median values of those observations with nonzero values for the report-level variables (i.e., the treatment firms during the post-mandate period). We then split the sample according to the

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[9] RKS is a leading commercial database that provides CSR rankings for Chinese firms that disclose their CSR reports. More detailed information can be found on its official website at https://www.rksratings.cn.

above-mentioned median values. The control firms and pre-mandate period treatment firms are included in each subsample.[10] Equation (1) is then re-estimated on each subsample.

The results are reported in Panel A of Table 6, with columns (1)–(6) presenting the analyst forecast error results and columns (7)–(12) presenting the analyst forecast dispersion results.[11] As observed, the coefficient of *Treat*Post* remains significantly negative only in the subsamples with high-quality CSR reports (e.g., the coefficient of −0.043 with a *t*-value of −2.58 in column (1)). In comparison, the coefficient of *Treat*Post* is insignificant in the subsamples with low-quality CSR reports. In other words, the improvement in analyst forecast properties after the mandatory CSR disclosure requirement occurs only when the CSR report is of high quality.

5.3.2. What type of CSR information matters?

In this section, we investigate what type of information contained in the CSR report is useful for analysts to make forecasts. As discussed in Section 2.2, the nonfinancial information described in the CSR report differs from traditional lagged financial information by providing forward-looking information. We are thus motivated to examine whether the CSR reports containing more long-term-oriented information, compared with those containing less long-term-oriented information, can provide more information to financial analysts.

Empirically, we count how many times the word "long-term" appears in each CSR report and classify the CSR reports into the following two categories based on the median count: CSR reports with more long-term information and CSR reports with less long-term information. CSR reports that do not mention long-term information are included in the less long-term-oriented information group.[12] Next, all of the control firms and treatment firms in the pre-mandate period are appended to observations with two different types of CSR reports separately to form two subsamples. We then re-estimate Eq. (1) with each subsample.

As shown in Panel B, Table 6, the coefficient of *Treat*Post* is significantly negative only in columns (1) and (3) in the subsample of CSR reports containing more long-term-oriented information (e.g., the coefficient of −0.052 with a *t*-value of −3.22 in column (1)). In comparison, the coefficient of *Treat*Post* becomes insignificantly different from zero in columns (2) and (4), in which the CSR reports contain less long-term-oriented information. In other words, mandatory CSR disclosure affects analyst forecasts only when the CSR reports contain more long-term-oriented information, not when they contain less long-term-oriented information.

Taken together, the results in Table 6 provide evidence of how heterogeneity in the CSR report affects the relation between the mandatory disclosure requirement and analyst forecast properties. We find that analysts' information environment improves only when the CSR report is of high quality and contains more long-term-oriented information.

[Insert Table 6 here].

5.4. Robustness tests

In the main test, we use a DID approach based on a PSM sample to examine the impact of mandatory CSR reports on analyst forecast properties. In this section, we conduct several robustness tests to ensure that our findings are not unduly influenced by other confounding events.

First, as explained in Section 2.1, the Notice mandating particular types of firms to issue standalone CSR reports was issued by the two Chinese stock exchanges in December 2008. Following Chen et al. (2018), we thus define the pre-mandate period as 2005–2008 and the post-mandate period as 2009–2012. However, the transitional year 2008 is arguably noisy because in 2008, i) a firm might have begun releasing CSR-related information through alternative channels or ii) analysts could have begun incorporating CSR-related information into their forecasts with the expectation of CSR disclosure in the near future. To alleviate the concern about the potential noise in 2008, our first robustness check excludes the year 2008 from our sample. By doing so, *Post* is redefined as zero for the sample period from 2005 to 2007 and as one for the sample period from

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[10] This research design results in different subsample sizes in Table 6 compared to those in Table 5.

[11] For brevity, Tables 6 and 7 report the results for analyst forecasts made for the current year only (*Ferr(0)* and *Disp(0)*). The results remain statistically similar for analyst forecasts made for the next year and the year after.

[12] Although it is untabulated for brevity, the mean value of "long-term" frequency for the treatment group is 2.236, with a maximum (minimum) value of 13 (0).

Table 6
Further analysis: Information in the CSR report Panel A: Overall CSR report quality, Panel B: CSR reports containing long-term-oriented information.

Panel A

	DV = $Ferr(0)_{t+1}$						DV = $Disp(0)_{t+1}$					
	Score		Content		Pages		Score		Content		Pages	
	(1) High	(2) Low	(3) High	(4) Low	(5) High	(6) Low	(7) High	(8) Low	(9) High	(10) Low	(11) High	(12) Low
Treat*Post	−0.043***	−0.025	−0.045***	−0.029*	−0.040**	−0.025	−0.030***	−0.007	−0.025**	−0.014	−0.028***	−0.007
	[−2.58]	**[−1.43]**	**[−2.72]**	**[−1.81]**	**[−2.42]**	**[−1.43]**	**[−2.86]**	**[−0.66]**	**[−2.40]**	**[−1.37]**	**[−2.67]**	**[−0.62]**
Constant	−1.449***	−1.440***	−1.485***	−1.491***	−1.422***	−1.509***	−0.974***	−0.958***	−0.905***	−0.925***	−0.923***	−1.038***
	[−4.25]	[−4.11]	[−4.42]	[−4.46]	[−4.20]	[−4.29]	[−4.38]	[−3.99]	[−4.08]	[−4.08]	[−4.15]	[−4.34]
Analyst-specific controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm-specific controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.157	0.167	0.156	0.165	0.156	0.169	0.153	0.151	0.148	0.153	0.151	0.157
F-Value	18.957	19.614	19.318	20.397	18.967	19.886	16.902	15.907	16.645	17.089	16.720	16.635
N	3,037	2,945	3,098	3,072	3,048	2,943	2,825	2,730	2,878	2,855	2,839	2,725

Panel B

	DV = $Ferr(0)_{t+1}$		DV = $Disp(0)_{t+1}$	
	(1) High	(2) Low	(3) High	(4) Low
Treat*Post	−0.052***	−0.024	−0.025**	−0.017
	[−3.22]	**[−1.45]**	**[−2.44]**	**[−1.60]**
Constant	−0.770***	−0.926***	−0.525***	−0.416**
	[−2.65]	[−3.20]	[−2.78]	[−2.19]
Analyst-specific controls	Yes	Yes	Yes	Yes
Firm-specific controls	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
R^2	0.172	0.166	0.152	0.145
F-Value	20.949	19.927	16.651	15.529
N	3,108	3,094	2,893	2,872

This table shows the OLS regression results of Forecast Properties$_{t+1}$ = a_0 + a_1Treat*CSR quality + Analyst-specific Controls$_t$ + Firm-specific Controls$_t$ + year and firm fixed effects + error term. The variable Forecast Properties is proxied for by forecast error, Ferr, and forecast dispersion, Disp. The sample is split into two subsamples and the regression is estimated for each subsample. Panel A partitions the sample based on the median values of CSR report quality, which are measured by Score, Pages, and Content, respectively. Panel B partitions the sample based on the median value of frequency of the word long-term contained in the CSR report. The control firms and pre-mandate period treatment firms are included in each subsample. Each panel presents the results for analyst forecasts made for the current year. The t-statistics are in brackets. The superscripts *, **, and *** indicate p < 0.1, p < 0.05, and p < 0.01, respectively. All of the variables are defined in Appendix A.

Table 7
Robustness check.

	A: Excluding 2008		B: Placebo Analysis		C: Polluting Industries Deleted	
	(1)	(2)	(3)	(4)	(5)	(6)
	$Ferr(0)_{t+1}$	$Disp(0)_{t+1}$	$Ferr(0)_{t+1}$	$Disp(0)_{t+1}$	$Ferr(0)_{t+1}$	$Disp(0)_{t+1}$
*Treat*Post*	−0.043***	−0.020*			−0.050***	−0.031***
	[-2.74]	[-1.90]			[-3.16]	[-2.99]
*Treat*Placebo*			−0.017	0.029**		
			[-0.81]	[2.14]		
Constant	−1.527***	−1.005***	−1.574**	−0.533	−1.101***	−0.742***
	[-4.63]	[-4.49]	[-2.45]	[-1.32]	[-3.17]	[-3.17]
Analyst-specific controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm-specific controls	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
Firm	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.159	0.150	0.229	0.250	0.122	0.133
F-Value	20.355	17.419	15.809	15.984	10.862	10.945
N	3,077	2,856	1,608	1,479	2,260	2,092

This table reports the OLS regression results of *Forecast Properties*$_{t+1}$ = a_0 + a_1*Treat*Post* + *Analyst-specific Controls*$_t$ + *Firm-specific Controls*$_t$ + *firm and year fixed effects* + *error term*. The variable *Forecast Properties* is proxied for by forecast error, *Ferr*, and forecast dispersion, *Disp*. Section A reports the results of a reduced sample excluding the transitional year 2008. Section B reports the results of a placebo analysis. We randomly assign a pseudo-mandatory disclosure year, 2007, and restrict the sample period to 2005–2008. Then we define a new variable, *Placebo*, to be equal to one for the period from 2007 to 2008 and zero for the period from 2005 to 2006. Section C reports the results of a reduced sample excluding firms in polluting industries. In each section, the results for analyst forecasts made for the current year are reported. The *t*-statistics are in brackets. The superscripts *, **, and *** indicate $p < 0.1$, $p < 0.05$, and $p < 0.01$, respectively. All of the variables are defined in Appendix A.

2009 to 2012. Equation (1) is then re-estimated for the reduced sample, and the results are reported in columns (1) and (2) of Table 7. As shown, the coefficient of *Treat*Post* remains significantly negative, suggesting that the impact of the mandatory CSR disclosure on forecast properties is not unduly influenced by the transitional period.

Second, to mitigate the potential impact of any confounding events, we conduct a placebo analysis. Instead of defining 2009 as the mandatory disclosure year, we randomly assign a pseudo-mandatory disclosure year, 2007, and restrict the sample period to 2005–2008. We then replace *Post* with a new variable, *Placebo*, in Eq. (1). *Placebo* equals one for the period from 2007 to 2008 and zero for the period from 2005 to 2006. If the redefined coefficient of *Treat*Placebo* remains significantly negative, then our findings are likely driven by other confounding events that might not be related to the mandatory CSR disclosure requirement. The results of the placebo analysis are reported in columns (3) and (4) of Table 7. We find that the coefficient of *Treat*-Placebo* becomes insignificant (significantly positive) when the dependent variable is *Ferr(0)* (*Disp(0)*). The placebo analysis supports our conclusion that the decreases in analyst forecast error and analyst forecast dispersion are attributed to the mandatory CSR disclosure, rather than to concurrent events.

Third, China's MoEE required firms in polluting industries to disclose environmentally related information even before the 2008 mandate. Accordingly, there could be a concern that our results are contaminated by polluting firms. To address this concern, we exclude polluting firms from the sample and re-estimate Eq. (1) based on this reduced sample. The results are reported in columns (5) and (6) of Table 7. As shown, the coefficient of *Treat*Post* remains significantly negative. Therefore, our main conclusions are not unduly influenced by polluting firms.

6. Conclusions and implications

Based on a quasi-natural experiment that mandates certain listed firms to issue standalone CSR reports, we construct a PSM sample to examine whether the CSR reports provide incremental information. We focus on financial analysts, a group of sophisticated information users, and examine whether the standalone CSR reports improve their earnings forecasts. Consistent with our expectations, we document a significant decrease

in both analyst forecast error and analyst forecast dispersion for the treatment firms after the CSR disclosure requirement was implemented compared with the analyst forecast error and analyst forecast dispersion of the control firms. Analysts incorporate the incremental information contained in the CSR reports when making their forecasts. Our findings are not unduly influenced by potential confounding factors, as evidenced by alternative sampling and a placebo analysis.

More interestingly, we document that the informativeness of the CSR reports varies with firms' existing information environment and external monitoring. The evidence in our study supports the view that the improvement in analyst forecast properties by the mandatory CSR disclosure is more pronounced if the firms are opaque and domiciled in highly marketized provinces than if they are transparent and domiciled in less marketized provinces. We also highlight the importance of the CSR report by showing that analysts' information environment is improved only when the CSR report is of high quality and contains more long-term-oriented information than when it is of low quality and contains less long-term-oriented information.

Our study provides important implications for financial analysts, along with investors, indicating the need to pay attention to the incremental information in CSR reports. Given the global trend of mandating CSR disclosure, our study also provides useful insights for countries in which policymakers plan to mandate or enhance disclosure requirements for nonfinancial information in general and CSR-related information in particular.

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.

Acknowledgement

Appendix A:. Variable definitions

Variables	Definitions
Dependent variable	
Ferr(Y); (Y = 0, 1, or *2)*	Analyst forecast error. The variables *Ferr(0)*, *Ferr(1)*, and *Ferr(2)* represent the forecast errors for forecasts made in year t for the EPS of the years t, $t + 1$, and $t + 2$, respectively. The forecast error of each firm is calculated as the absolute value of the difference between the mean value of the most updated forecasts and the actual EPS, scaled by the absolute value of the actual EPS.
Disp(Y); (Y = 0, 1, or *2)*	Analyst forecast dispersion. The variables *Disp(0)*, *Disp(1)*, and *Disp(2)* represent the forecast dispersions for forecasts made in year t for the EPS of the years t, $t + 1$, and $t + 2$, respectively. The forecast dispersion of each firm is calculated as the standard deviation of the most updated forecasts scaled by the absolute value of the actual EPS.
Variable of interest	
Post	A dummy variable that equals one for the period from 2009 to 2012 and zero for the period from 2005 to 2008.

(*continued*)

Variables	Definitions
Treat	A dummy variable that equals one for the treatment group and zero for the control group. A firm is included in the treatment group if it is mandated by the SHSE and SZSE to issue standalone CSR reports and it issued CSR reports between 2009 and 2012. The control group is constructed based on the PSM procedure. The PSM procedure is described in Appendix B.
Control variables: Analyst-specific	
Revise(Y); (Y = 0, 1, or 2)	Average number of forecast revisions. The variables *Revise(0)*, *Revise(1)*, and *Revise(2)* represent the logarithmic transformations of the average number of revisions made on a firm's EPS for the years t, $t + 1$, and $t + 2$, respectively.
Horizon(Y); (Y = 0, 1, or 2)	Average forecast horizon. The variables *Horizon(0)*, *Horizon(1)*, and *Horizon (2)* represent the logarithmic transformations of the average number of days between the issuance date of a firm's earnings forecasts for the years t, $t + 1$, and $t + 2$, respectively, and the corresponding earnings announcement date.
BrokerSize(Y); (Y = 0, 1, or 2)	Brokerage size. The variables *BrokerSize(0)*, *BrokerSize(1)*, and *BrokerSize(2)* represent the logarithmic transformations of the average number of active analysts in the brokerage houses whose analysts forecast a firm's earnings for the years t, $t + 1$, and $t + 2$, respectively.
BrokerAge(Y); (Y = 0, 1, or 2)	Brokerage age. The variables *BrokerAge(0)*, *BrokerAge(1)*, and *BrokerAge(2)* represent the logarithmic transformations of the average age of the brokerage houses whose analysts forecast a firm's earnings for the years t, $t + 1$, and $t + 2$, respectively.
Coverage(Y); (Y = 0, 1, or 2)	Number of firms covered by analysts. The variables *Coverage(0)*, *Coverage(1)*, and *Coverage(2)* represent the logarithmic transformations of the average number of firms covered by analysts forecasting firm earnings for the years t, $t + 1$, and $t + 2$, respectively.
Control variables: Firm-specific	
SD(sales)	The standard deviation of sales revenue divided by total assets in the past three years.
Growth	Revenue growth, calculated as the increase in revenue divided by the revenue in the previous year.
Loss	A dummy variable equal to one if the net income is negative in the previous year and zero otherwise.
ROE	Return on equity, calculated as net income divided by net assets.
Size	Firm size, calculated as the logarithmic transformation of total assets.
Lev	Leverage, calculated as total liabilities divided by total assets.
Age	Firm age, calculated as the logarithmic transformation of the number of years since the firm was first listed.
Top1	Percentage of shareholdings held by the largest shareholder.
Inst	Percentage of shareholdings held by institutional investors.
Big4	A dummy variable equal to one if the firm is audited by one of the Big 4 auditors and zero otherwise.
SOE	A dummy variable equal to one if the firm is ultimately controlled by the government and zero otherwise.
Variables in cross-sectional tests	
Synchronicity	Stock price synchronicity, calculated as $\log(R^2/(1 - R^2))$, where R^2 is obtained from the market model by regressing the firm's weekly return on the weekly market return.

(*continued*)

Variables	Definitions
Marketization	The marketization development index compiled by Fan et al. (2017) of the province in which the firm is domiciled. The following eight provinces are classified as having high marketization: Shanghai, Tianjin, Zhejiang, Beijing, Fujian, Guangdong, Jiangsu, and Shandong. The remaining provinces are classified as having low marketization.
Score	Social responsibility disclosure ranking from RKS, including the macrocosm score, content score, technique score, and industry score. The variable *Score* is calculated as 30%*macrocosm score + 45%*content score + 15%*technique score + 10%*industry score, with a scale from zero to 100.
Content	Content of the CSR report, counted as the number of disclosed items in the CSR report in 10 aspects: shareholder protection, creditor protection, employee protection, supplier protection, customer and consumer protection, the environment and sustainability, public welfare, policy related to CSR activities, workplace safety, and deficiency in CSR activities. A score of one is assigned for each item the firm discloses in the CSR report. The variable *Content* is the sum of the scores, with a scale from zero to 10.
Pages	Length of the CSR report, calculated as the natural logarithm of the number of pages plus one.
Long-term-oriented information	Long-term-oriented information contained in the CSR report, measured by the frequency of the word "long-term" in the report.
Variables in the PSM	
Market_CAP	Logarithmic transformation of the total market value of the firm.
Return	Yearly return of the firm's stock price.
Turnover	Turnover of the firm's shares during the year.
ROA	Return on assets, calculated as net income divided by total assets.
Stateshare	Percentage of shares held by the government.
Donation	Total donations made during the year, scaled by revenue.
Analyst_N	Number of analysts following the firm.
PC	A dummy variable that equals one if the firm is politically connected and zero otherwise.
Polluting	A dummy variable that equals one if the firm operates in a polluting industry and zero otherwise.

Appendix B:. Construction of the PSM samples

Panel A: Logit regression results

	Coefficient	*z*-Value	*p > z*
Market_CAP	0.726***	12.410	0.000
Return	−0.068	−1.360	0.175
Turnover	−0.001***	−4.290	0.000
ROA	1.892**	1.980	0.048
Stateshare	0.915***	4.640	0.000
Donation	−1.546**	−2.190	0.029
Analyst_N	0.422***	6.860	0.000

(*continued on next page*)

(*continued*)

	Coefficient	*z*-Value	*p* > *z*
PC	0.065	0.650	0.518
Polluting	0.020	0.210	0.835
Constant	−12.562***	−15.120	0.000
Industry and Year	Yes		
N	3,207		
Pseudo-R^2	0.195		

Panel B: Parallel trends test
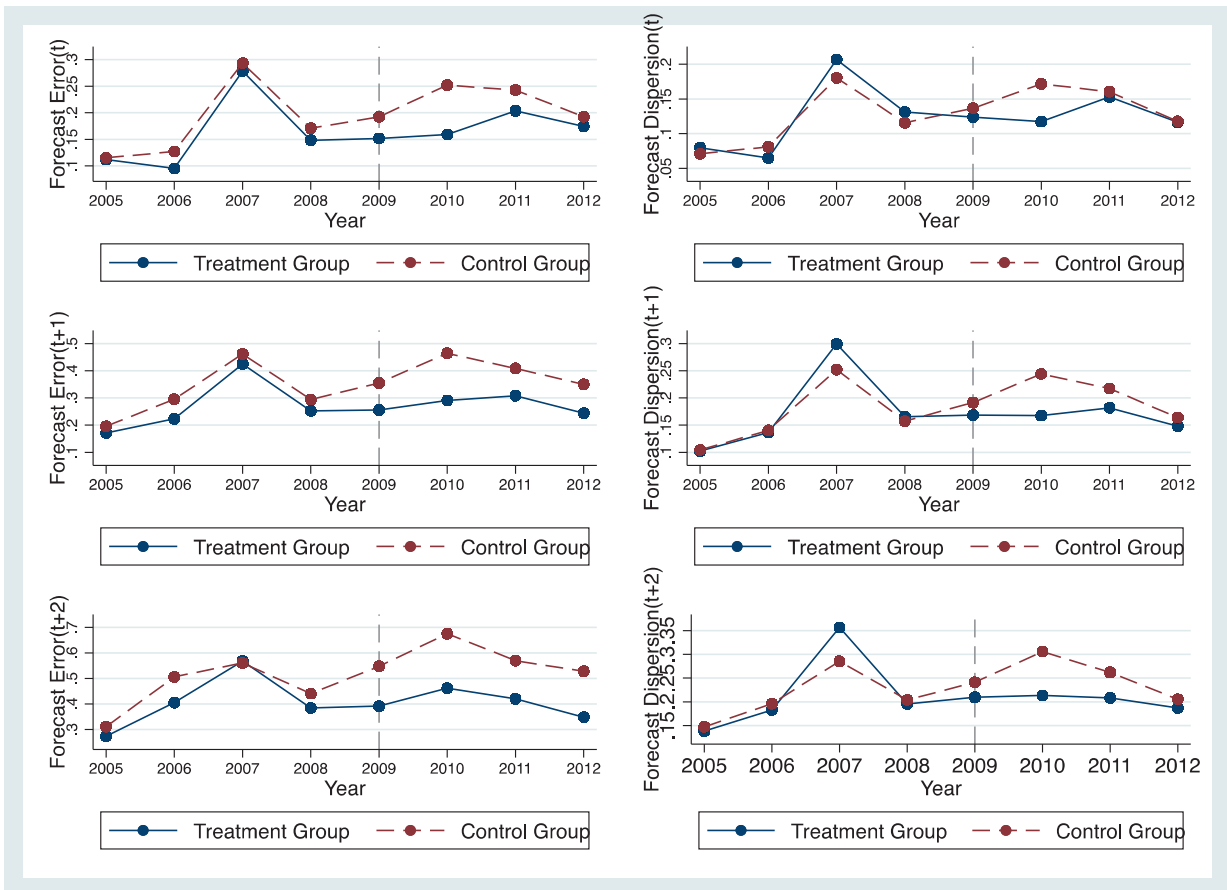
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The state capital investing and operating company pilot reform and SOE bailouts

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ABSTRACT

This paper explores the influence of the State Capital Investing and Operating Company (SCIOC) pilot reform on SOE bailout using a staggered difference-in-differences model. Based on a sample of listed SOEs during 2011–2018, we find that when the real controllers of listed SOEs enter the list of SCIOCs, soft budget constraints are alleviated and listed subsidiaries are less likely to become distressed. Mechanism tests indicate that SCIOCs help distressed firms through exiting the market, reducing bank loans, enhancing corporate governance, and improving operating efficiency. Heterogeneity tests show that the effect of SCIOC establishment is more significant in central and western regions, in public welfare and special function industries, for central SCIOCs, for state capital investing companies, when firms are organized in more layers, and for firms that engage in M&As. The empirical results show that the implementation of SCIOCs benefits both micro-enterprise development and state capital layout optimization.

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1. Introduction

In recent years, coinciding with the COVID-19 pandemic, the efficiency of state-owned enterprises (SOEs) in China has declined. The bailout of SOEs has thus become an important concern for the government, industry and academia (Yang, 2020). Historically, China underwent the bailout and reform of SOEs from 1998 to 2001 due to total losses of approximately 66.59 billion RMB by 39.1% of China's large- and medium-sized SOEs at the end of 1997. To deal with this situation, China implemented a battery of reforms, including adjustment of the industrial structure, debt-to-equity swaps and reform of the social security system.

Currently, SOEs are again experiencing low operating efficiency and losses, but the bailout differs from that of 1998–2001. On the one hand, some SOEs that have become financially distressed have still received plenty of support from majority shareholders and governments (Zheng et al., 2020). On the other hand, the state capital layout experienced structural problems. State capital is involved in too many industries and sometimes results in industry overcapacity (Huang et al., 2019). In March 2016, Huang Danhua, Vice Director of the State-Owned Assets Supervision and Administration Commission (SASAC) of the State Council, said at the SOE reform conference that the loss-making by central listed SOEs was concentrated in industries with over-capacity such as the coal, steel and nonferrous industries. As shown in Table 1, the number of listed SOEs making losses and the amount of these losses increased greatly from 2011 to 2015. After 2015, as China initiated a new round of SOE reform and applied a series of new policies such as "Guiding Opinions on Deepening the SOE Reform" (CCCPC and State Council, 2015) and "Several Opinions on Reforming and Improving the State Asset Management System" (State Council, 2015), SOE losses reduced and profits increased.

SOE distress hampers SOEs' goal of becoming stronger, better and bigger, thus impeding China's overall economic development. SOE distress is closely related to inappropriate government "helping hand". Zheng et al. (2020) find that there is a soft budget constraint problem behind the endless help, and that governments cannot save SOEs from distress but rather deprive them of viability, creating a vicious circle of "performance deterioration → government subsidy → performance deterioration." This pattern reduces the operating efficiency of state capital and the resource allocation efficiency of the capital market. The literature draws complex conclusions about the relationship between government intervention and the bailout of enterprises. Some scholars suggest that government intervention can alleviate the financial distress of enterprises (Zhu et al., 2015; Chen et al., 2015), while others argue that subsidies from the government or majority shareholders may help distressed firms in the short term but hamper their development in the long term (Faccio et al., 2006; Pan et al., 2009; Du et al., 2016; Zheng et al., 2020). Nevertheless, for SOE bailouts, it is rare to find an assistance mechanism with relatively low government intervention.

The State Capital Investing and Operating Company (SCIOC) pilot reform may provide a new approach to resolving SOE distress. On the one hand, SCIOCs are an important means of optimizing state capital layout. On the other hand, the SCIOC pilot reform has changed the current state-owned asset supervision system and reduced government intervention. The task of optimizing state capital layout requires SCIOCs to help sound enterprises and properly dispose of distressed enterprises. Disposing of distressed enterprises can recharge inferior assets with resource value, avoid state asset loss and reduce the state's fiscal burden (Qi and Xiao, 2019), in turn improving state capital operating efficiency. In October 2015, "Several Opinions on Reforming and Improving the State Asset Management System" (State Council, 2015) was issued to accelerate the concentration of state capital in important, competitive and forward-looking strategic industries. This requires the liquidation, restructuring and development of a number of SOEs; the establishment of a market-based exit mechanism based on the principle of survival of the fittest; and faster elimination of outdated capacity, the reduction of excess capacity and disposal of inefficient assets. The establishment of SCIOCs has had a significant impact on the state-owned asset supervision system. In July 2018, the "Opinions on Implementation of the State Capital Investment and Operation Companies Pilot Reform" ("Opinions of Implementation") was issued, stating that SCIOCs are professional platforms for state capital marketization (State Council, 2018). SCIOCs bear limited liability within the amount of capital contribution, exercise shareholder duties in the SOEs in which they hold shares and do not engage directly in production and business activities. This orientation ensures an appropriate distance between SCIOCs, state-owned asset management departments and SOEs. Since then, the state-owned assets management system has been reformed in two ways: by reorganizing industrial groups into SCIOCs and by setting up SCIOCs between SASAC and SOEs to form an "isolation belt."[1]

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[1] According to our hand-collected data, between 2014 and 2020, reorganization accounted for 78.98% (278) of all SCIOCs, new establishments accounted for 19.03% (67) and the origins of the remaining 1.99% (7) are unknown due to lack of information. Most SCIOCs were formed by reorganization of the original industrial groups that had invested in non-performing or "toxic" assets. These assets form the distressed firms we investigate.

Table 1
The profits and losses of listed state-owned firms, 2011–2018.

Year	Number of loss-making firms	Number of profitable firms	Total amount of loss	Total amount of profit	Average amount of loss	Average amount of profit
2011	90	799	−359	8480	−3.99	10.61
2012	115	786	−813	8110	−7.07	10.32
2013	105	801	−475	8990	−4.52	11.22
2014	123	780	−678	8790	−5.51	11.27
2015	174	737	−1460	8170	−8.39	11.09
2016	94	833	−1020	9030	−10.85	10.84
2017	78	867	−466	12,100	−5.97	13.96
2018	84	875	−596	13,700	−7.10	15.66

Notes: Loss is judged by whether net income is less than 0. Average amount of loss = Total amount of loss / Number of loss-making firms. Average amount of profit = Total amount of net income / Number of profitable firms. The total number of firms is equal to the total observations in our regression sample described in Section 4.3. The unit of the amount is 100 million RMB yuan.

In sum, SCIOCs are entrusted with special missions, empowering them to carry out SOE bailouts. At the central government level, the China Chengtong Holdings Group (Chengtong) was reorganized into a state capital operating company in 2016. Chengtong has provided hosting services for several distressed SOEs by implementing the classified management; one enterprise, one principle; and state capital layout optimization policies.[2] At the local government level, Chongqing has accumulated rich experience in SCIOC pilot reform and designed a "3 + 3 + 1" capital-based management mode. Specifically, Chongqing set up three state capital investment companies, three state capital operating companies and the Yukang Asset Management Company to dispose of non-performing state assets (Hu and Huang, 2017).

The establishment of SCIOCs reduces direct government intervention in SOEs and alleviates soft budget constraints, increasing SOE viability and decreasing the probability that an SOE will become distressed. Our study exploits a quasi-natural experimental setting resulting from the establishment of SCIOCs and uses a staggered difference-in-differences (DID) model to explore the effect of capital-based management on SOE bailouts. We find that when the real controllers of state-controlled listed firms enter the list of SCIOCs, their listed subsidiaries are less likely to become distressed. Channel tests indicate that SCIOCs help distressed firms to exit the market, deleverage, improve governance and raise their operating efficiency. We conduct heterogeneity tests according to regional and industrial features and SCIOC- and firm-level characteristics. The results show that the effect of SCIOCs on the bailout of SOEs is more significant in central and western regions, in public welfare and special function industries, for central rather than local SCIOCs, for state capital investing rather than operating companies, for firms with more organization layers and for firms that engage in M&As. Our conclusions stand after a battery of robustness tests.

Our study broadens the research on the economic consequences of SCIOCs from the perspective of bailing out financially distressed firms. The existing literature discusses the economic consequences of SCIOCs from the perspective of delegation, supervision and motivation. Research shows a positive impact of the SCIOC pilot reform on firm value, decision-making and top-management incentives (Li and Song, 2020; Bu and Sun, 2021; Chen, 2021; Chen and Jiang, 2021; Xiao and Sun, 2021). Our study adds to the literature by utilizing the soft budget constraint theory and systematically comparing the change in each player after the SCIOC pilot reform. Specifically, SASACs can no longer intervene in SOEs, SCIOCs implement market rules and the SOEs increase their viability, all of which decrease the probability of SOEs becoming distressed again. From this point of view, the SCIOC pilot reform achieves the objective of capital-based management, which has a positive influence on micro-enterprise development and macro state capital distribution.

Our study also enriches the research on the determinants of SOE bailouts. The existing literature finds that government intervention profoundly affects the performance of distressed firms (Chen et al., 2015; Zhu et al.,

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[2] "Chengtong Advanced a Step Toward Capital Operation and Management," 2016–8-12, Economic Information Daily. The article is available at:https://dz.jjckb.cn/www/pages/webpage2009/html/2016–08/12/node_17.htm.

2015). The supporting effect lasts only a short time, and firms easily return to distress (Pan et al., 2009; Du et al., 2016; Zheng et al., 2020). Our study indicates that the SCIOC pilot reform can boost the bailout of SOEs. Thus, a state assistance mechanism featuring low government intervention can play a positive role. Furthermore, our study contrasts with the conclusions of studies on rescuing subsidiaries by state-owned holding groups (Zheng et al., 2020). SCIOCs have the advantage of rescuing distressed firms over industrial groups.[3] Due to government intervention and the expectation of soft budget constraints, SOEs can easily suffer from "relief dependency" and lack the internal drive, ability and pressure to get out of distress (Du et al., 2015; Zheng et al., 2020). Our study suggests that SCIOCs provide a new approach that can help SOEs improve operating performance by following market rules and setting up an isolation belt.

The rest of this paper proceeds as follows. Section 2 presents the institutional details of SCIOCs. Section 3 provides the theoretical framework and develops the research hypotheses. Section 4 introduces the research design and descriptive statistics. Section 5 reports the results of the baseline regression analysis and robustness tests. Section 6 presents further analysis, and Section 7 concludes the paper.

2. Institutional background

2.1. Market economy reform and power delegation to SOEs

SOE reform is an essential part of Chinese macroeconomic system adjustment and market economy reform (Lin et al., 1998). Since the economic reform and opening-up, China has gradually set up a socialist market economy. Correspondingly, China has delegated greater autonomy to its SOEs. The SOE reform has undergone four stages: power delegation and profit sharing (1978–1992), the modern enterprise system (1993–2002), establishment of the state asset management system (2003–2012) and capital-based management (2013–present). The first two periods failed to address the fundamental reason why SOEs show low vitality. The last two periods are progressive and demonstrate creative reform from the perspective of capital provision. The third period unified the caliber of investment and supervision, and the fourth period involves changes to the structure of the capital providers. In this period, SCIOCs act as an "isolation belt" between SOEs and government. The roles of the three players, the government (SASACs), SCIOCs and SOEs, are now more clearly defined (Liu et al., 2021).

China's socialist market economy has achieved remarkable success. However, due to unfair competition such as government subsidies and distorted credit allocation, the compatibility of China's SOEs with a market economy is questioned by global society. Positioned as interlayers, SCIOCs can prompt SOEs to comply with market rules, promote the separation of enterprise and government and stimulate the vitality of SOEs (Liu et al., 2021). In 2013, the Third Plenary Session of the 18th CCCPC approved the "Decision on Major Issues Pertaining to Deepening Reform" (CCCPC, 2013) and formally proposed the SCIOC pilot reform. In 2017, the State Council issued "Functional Transformation by Focusing on Capital-Based Management" (State Council, 2017), which simplified some of the monitoring and supervisory functions of SASACs, delegated some supervisory functions to SOEs and transferred some of the public administrative functions of SASACs to the respective government departments. In 2019, the State Council issued the "Notice on Reforming the Authorized Operation System of State Capital" (State Council, 2019) which requires the representative offices of capital providers to properly delegate authority to SCIOCs and other SOEs. The authority delegated to SCIOCs includes strategic planning and main business management, personnel selection, equity incentive planning, payroll and major financial transaction management.

2.2. Basic statistics of the SCIOC pilot reform

According to our hand-collected data, by the end of 2020, 352 central, provincial or prefectural SCIOCs had been set-up under the pilot reform. As shown in Fig. 1, China started the SCIOC pilot reform in 2014,

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[3] The sample used by Zheng et al. (2020) ranges from 2005 to 2016, whereas the SCIOC pilot reform started in 2014; thus, the samples of Zheng et al. (2020) consist mainly of industrial groups rather than SCIOCs.
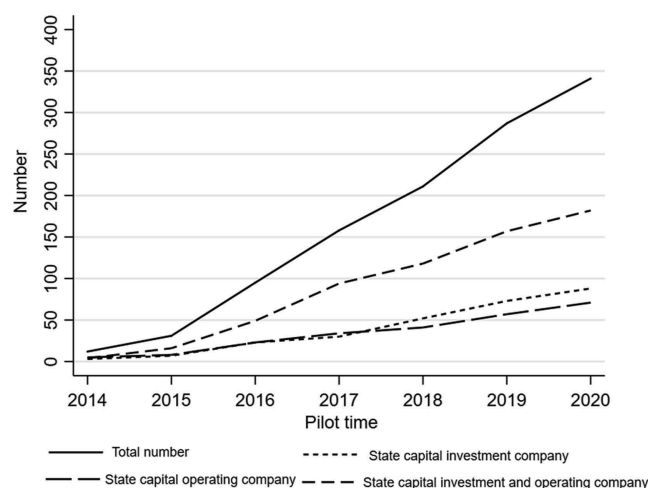
Fig. 1. The number of pilot SCIOCs by year and type (accumulate annually).

Table 2
The number of pilot SCIOCs by region.

Region	Pilot	Region	Pilot	Region	Pilot
Shandong	45	Ningxia	10	Hebei	5
Sichuan	32	Zhejiang	9	Hainan	5
Liaoning	27	Guangxi	9	Hunan	5
Henan	23	Jilin	8	Xinjiang	5
Guangdong	18	Guizhou	8		
Jiangxi	14	Anhui	7	Central	21
Hubei	14	Shanxi	7	Beijing	2
Inner Mongolia	13	Heilongjiang	7	Shanghai	2
Shaanxi	11	Gansu	6	Tianjin	4
Fujian	11	Qinghai	5	Chongqing	4
Yunnan	10	Jiangsu	5		
Total					352

Notes: There are three types of regions: province, municipality, and the central government. Provincial data includes both provincial SCIOCs and prefecture-level SCIOCs. The total number includes 11 SCIOCs with type and pilot time unknown – not disclosed.

increasing the number of SCIOCs year by year. The number of state capital investment and operating companies shows the fastest growth. The number of state capital investment companies is now nearly equal to that of state capital operating companies.

Table 2 reports the regional distribution of SCIOCs. As shown in Table 2, except for Tibet, all other areas of China have conducted capital-based management reform. The number of SCIOCs varies greatly among provinces. The top five provincial administrative regions are Shandong, Sichuan, Liaoning, Henan and Guangdong. At the central government level, 21 SCIOCs have been established. The number of SCIOCs in municipalities appears to be fewer but may be with better quality.

3. Theoretical framework

3.1. Measuring bailouts and their determinants

Enterprise distress includes financial distress, operating distress, economic distress and so on. Our study mainly focuses on financial distress. In the Western literature, financial distress appears in the form of operational failure, bankruptcy and debt defaults (Altman, 1968; Merton, 1974; Habib et al., 2020). Under China's

weak bankruptcy laws, few bankruptcy cases occur in listed firms and the possibility of debt default is relatively low (Fan et al., 2013a; Xu and Jing, 2016). Moreover, delisting and stock market risk warning systems pay strong attention to the earnings of listed firms; therefore, scholars study financial distress mainly from the angle of operational failure. The many indexes to measure financial distress in terms of operational failure vary with the context. The most intuitive indicators include special treatment (ST) (Zheng et al., 2020), delisting (Zhang, 2015) and consecutive loss (Deangelo and Deangelo, 1990). The measures are typically used separately, but sometimes they are used in combination. For example, Bhaskar et al. (2017) consider whether consolidated net income and operating cash flow are both negative. Lv and Han (2004) use current ratio, operating profit and listing age jointly. Hoshi et al. (1990) and Liao and Chen (2007) judge firms as distressed if their earnings before interest, taxes, depreciation and amortization are larger than the interest cost in the first year and less than the interest cost in the following two years. Altman (1968) proposes the Z-score to predict bankruptcy risk. Guan et al. (2011) use a survey to determine whether firms are in financial distress. The above measures are static. Some scholars employ dynamic measures such as the time taken to recover from distress (Fan et al., 2013a; Chen et al., 2015), recovery of profits (Guan et al., 2011) and the extent of loss reversal (Du et al., 2016).

Government intervention is an important feature of transitional economies (Zhu et al., 2015) and a key external factor in bailouts. A multi-case study by Zhu et al. (2015) finds that government intervention can provide "supporting hands" for financially distressed SOEs and privately owned firms. Government intervention is positively associated with the performance of distressed firms (Chen et al., 2015), but the beneficial effect may not last long. Based on global data, Faccio et al. (2006) shows that firms with political connections are more likely to receive government subsidies. Furthermore, the political connections of distressed private firms positively affect the government subsidies received. Government subsidies can boost performance in the receiving year but may not exert positive effect on long-term firm performance (Pan et al., 2009). Li (2014) argues that political connections may influence the bailout methods of distressed listed firms. For example, they may prompt firms to select debt restructuring. Government subsidies reduce the loss amount in the receiving year but restrain loss reversal in the following year (Du et al., 2016). Whether government subsidies are distributed to those with serious losses (save the poor) or those with slight losses (save the starving) is influenced by industry, region and ownership (Wang et al., 2015). Apart from government subsidies, support from major shareholders can also help bail out SOEs, but the effect is more limited (Zheng et al., 2020).

Our study is directly related to the literature on ownership and bailouts. Liao and Chen (2007) find that state ownership has a significant positive effect on the performance of distressed firms. Li et al. (2008) conclude that state ownership reduces the likelihood that firms will become distressed. Conversely, Fan et al. (2013a) find that private ownership is positively correlated with the performance of distressed firms. Among the research on bailout measures, Chen and Dai (2004) find that related party transactions and restructuring are the main methods used to bail out distressed listed firms. In a study of the bailout methods of first-time loss-making firms, Dai and Deng (2007) find that changing the business strategy is the most common, and control transfer and financial planning are also frequently used. Zhu et al. (2015) summarize bailout through restructuring, which includes governance, strategic, operational, asset and financial restructuring. SOEs prefer to use non-market measures. Dividend reduction is also an important tool to deal with financial distress (Deangelo and Deangelo, 1990). Relationships with stakeholders may influence the bailout strategy and, thereby, the bailout results (Guan et al., 2011).

The above literature discusses the role of government in bailouts and bailout methods but does not draw consistent conclusions. In addition, there is still little research on the effect of SOE reform on financial distress. This constitutes the motivation for our study.

3.2. SCIOC pilot reform, budget constraint hardening and SOE bailouts

SCIOCs are important hubs for state capital layout. SCIOCs have natural advantages in arranging state capital layout. Specifically, SCIOCs start out as shareholders of SOEs and arrange state capital layouts through equity investment. SCIOCs help state capital to flow flexibly without the constraints of inherent interest groups and business scope (Liu et al., 2020). To facilitate capital flow, SCIOCs need to support both competitive SOEs and distressed SOEs, reform incremental businesses and revive existing businesses. To cultivate competitive SOEs, SCIOCs need to concentrate state capital in important, competitive, strategic and forward-

looking industries. To dispose of distressed SOEs, SCIOCs need to withdraw state capital from low-end, outdated industries that are inconsistent with new development concepts. SCIOCs encourage SOEs to exit non-core businesses and liquidate inefficient assets, and to restructure distressed SOEs that are of strategic significance (Xiao, 2021).

The SCIOC pilot reform alters the state asset management mode and eases the soft budget constraint problem. Soft budget constraint theory originates from a study by Kornai (1979). If firms in a socialist country suffer from a loss, governments rescue these firms through increases in investment, loans and subsidies and reductions in taxes to keep them alive. Under soft budget constraints, firms lack viability and thus survive on government subsidies. Soft budget constraints are the main reason that a large proportion of SOEs increasingly fall into distress (Lin and Liu, 2001).

The pilot reform brings changes to SASACs, SCIOCs and subordinate SOEs. Under the old state asset management mode, in the period of "management of personnel, business and assets," SASACs played dual roles as shareholders and supervisors. To maintain and increase the value of state assets and act as a shareholder, SASACs intervened in SOEs' daily decision-making about personnel, investments, and operations, strategy and other factors (Wang, 2017). The Chinese government feels obliged to protect SOEs due to its strong paternalism (Erben and Güneşer, 2008). As a result, if a loss occurs in SOEs, SASACs rescue SOEs unconsciously, resulting in a soft budget constraint problem. The "intervening hand" of government forces SOEs to undertake policy burdens that may increase the possibility of loss. When losses occur, the government cannot identify the real reason for the loss so it decides to rescue SOEs, which upsets the market selection process of firms (Kornai, 1998). Firms that should exit remain in the market, enjoy government subsidies and depend on government support. Under the capital-based management mode, SASACs transfer their shareholder role to SCIOCs and delegate autonomous power, including investment, planning and strategic development, to the SOEs. Therefore, the SASAC's extended regulation stops: it reduces its intervention in SOEs and only supervises the SCIOCs (He, 2018). The above changes break the SOEs' expectation of government support and harden the budget constraints.

At the SCIOC level, SCIOCs target market-oriented capital operation. An important function of state capital investment companies is to reduce excess capacity through market-oriented means and to rescue and reorganize distressed SOEs (Hu and Huang, 2017; Zhou et al., 2018). In contrast, industrial groups need to conduct physical business operations and concentrate on their main business; thus, capital operation is a supplementary function for them. The support from industrial groups to SOEs is usually related to the support of SASACs and has a strong sense of government intervention (Zheng et al., 2020). As professional platforms for state capital marketization, SCIOCs can widely absorb a variety of industrial and financial capital, attract more financial providers and thereby provide more abundant bailout means (Zhou et al., 2018). Huang and Xu (1998) find that the richness of financial providers can effectively ease the soft budget constraints. Specifically, SCIOCs apply the closed loop management mode of "finance, invest, manage, and exit" (Xiao, 2021). SCIOCs help to revive distressed firms through free transfer of, for example, ownership, entrusted management, equity management and fund investment (Yang, 2020).

At the SOE level, the SCIOC pilot reform can strengthen SOE viability, thereby removing the soft budget constraints. Under capital-based management, SCIOCs act as "isolation belts" between supervision departments and SOEs, lowering the possibility of the government helping the SOEs and boosting fair competition between firms with different ownership. This creates a competitive environment for SOEs and eliminates weak SOEs through the law of survival of the fittest. At the same time, SOE operation should move towards market rules, indicating that SOEs take responsibility for gains and losses and the burden of operating risk. The soft budget constraint problem originates from the attribution of government responsibility, under which the government instead of the SOE carries the final burden of operating failure (Tan and Lin, 1999). This interrupts the normal survival mechanisms of enterprises and the market selection process (Kornai, 1998). However, as only a capital relationship exists between SCIOCs and subordinate SOEs, SCIOCs can choose to "vote with their feet" and break the relief mechanism when SOEs are in distress. The literature indicates that the SCIOC pilot reform can improve SOE viability and efficiency, such as through firm performance (Xiao and Sun, 2021), firm value (Li and Song, 2020) and economic value added (EVA) (Guo and Wu, 2018). The SCIOC pilot reform can promote better corporate decision making, such as by improving innovation input (Chen, 2021) and reducing inefficient investment (Chen and Jiang, 2021). Under the SCIOC pilot reform,

the managerial market mechanism is safeguarded and corporate governance is improved. For example, the SCIOC pilot reform has a positive impact on executive compensation-performance sensitivity (Bu and Sun, 2021). As executives pay more attention to growth quality rather than scale expansion, SOEs are less likely to fall into financial distress. Based on the above discussion, we propose our main hypothesis:

Hypothesis: Other things being equal, when the real controller of state-controlled listed firms enters the list of SCIOCs, its listed subsidiaries are less likely to become distressed.

4. Research design and descriptive statistics

4.1. Model specification and variable definition

To test the impact of the SCIOC pilot reform on the bailout of Chinese state controlled listed firms, we construct models (1) and (2). Following Beck et al. (2010) and Xiao and Sun (2021), we view the SCIOC pilot reform as a quasi-natural experiment and set up a staggered DID model. Because the dependent variable in our study is a dummy variable (whether the SOE is in distress or not), model (1) uses a panel logit regression[4] and controls firm and year fixed effects. If the dependent variable for a firm remains unchanged during the sample period, the observations for the firm are omitted from the panel logit model regression. As a result, model (1) loses a large number of observations. To include more observations, model (2) uses logit regression; controls for year, industry and province fixed effects; and calculates the robust standard error clustered at the firm level.

$$DISTRESS1_{i,t} = \alpha TREAT_i \times POST_t + \beta Controls_{i,t} + Firm_i + Year_t + \varepsilon_{i,t} \tag{1}$$

$$DISTRESS1_{i,t} = \alpha_1 TREAT_i \times POST_t + \alpha_2 TREAT_i + \alpha_3 POST_t + \beta Controls_{i,t} + Year_t + Industry_n + Province_p + \varepsilon_{i,t} \tag{2}$$

In the above models, i represents the firm, t represents the year, n represents the industry and p represents the province. Following Rao and Wan (2018) and Zheng et al. (2020), we add a series of control variables including firm size ($LNASSET$), leverage (LEV), listing age ($FAGE$), administrative expense ratio ($EXPENSE$) and industry average profitability (IND_PROFIT). The variable definitions and descriptions are listed in Table 3.

The dependent variable, $DISTRESS1$, is a dummy variable, which equals 1 if net income, excluding non-recurring items, is negative for the next three successive years, and 0 otherwise. This measurement follows Rao and Wan (2018). Non-recurring items are somewhat discretionary and are often used to adjust profit (Xu, 2009). Therefore, we use net income excluding non-recurring items for the next three successive years to evaluate SOEs' long-term operating profitability.[5] Zhang and Wu (2005) argue that any firm may have financial distress costs, and therefore they use the full sample to study financial distress. Using $DISTRESS1$ as a dependent variable based on the full sample, our study aims to explore the impact of SCIOC pilot reform on both normal and distressed firms.

4.2. Data source and sample

To explore the relationship between SCIOC pilot reform and SOE bailouts, we manually collect data on the setting up of SCIOCs. To confirm the exact time of the policy shock, we collect the lists of pilot SCIOCs for central, provincial and prefecture-level governments and their pilot times from the websites of the central and local SASACs.[6] For those SCIOCs without formal website announcements, we check by leaving website messages and telephone consultations.

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[4] We use the xtlogit command in STATA15 to estimate the panel logit model.

[5] Note that $DISTRESS1$ is not equivalent to "ST". The mean of "ST firms" occupies 2.53% of observations in our sample, which is much smaller than that of $DISTRESS1$, 12.44%.

[6] We first collect regional policies, including the "Promote the Functional Transformation Plan by Focusing on Capital-Based Management, Reform the Authorized Operation System of State Capital" and the "Implementation Plan of State Capital Investing and Operation Companies Pilot Reform". We collect the list of pilot SCIOCs from these documents and supplement the lists from other sources. We determine whether SCIOCs are pilot units according to the following keywords: pilot, opening ceremony, authorize, implement after approval, official reply, and so on.

Table 3
Definitions and descriptions of variables.

Variable name	Symbol	Variable definition
Distressed firms	DISTRESS1	Dummy variable, equaling one if net income excluding non-recurring items in successive three future years is negative, and zero otherwise
Experiment group	TREAT	Dummy variable, equaling one if the enterprise immediately under the ultimate real controller of state-controlled listed firms is SCIOC (experimental group), and zero otherwise (control group)[1]
Post-period	POST	Dummy variable, equaling one if the period is post-period, and zero otherwise; post-period refers to the year that SCIOCs are set up as a result of the pilot reform and the years thereafter
SCIOC pilot reform	TREAT × POST	The interaction term of TREAT × POST
Firm size	LNASSET	The logarithm of the value of total assets at the fiscal year-end
Leverage	LEV	Measured as the book value of total liabilities divided by total assets at the fiscal year-end
Listing age	FAGE	The logarithm of the listing age plus one at the fiscal year-end
Administrative expense ratio	EXPENSE	Measured as the administrative expense ratio minus the average industry administrative expense ratio for the same year; administrative expense ratio is administrative expense divided by sales
Industry average profitability	IND_PROFIT	The average industry profitability for the year, profitability is measured as the ratio of net income excluding non-recurring items to sales

[1] We do not judge according to the ultimate real controllers or controlling shareholders of the state-controlled listed firms, as there can be multiple layers between some SCIOCs and the state-controlled listed firms. Typically, the ultimate real controllers of state-controlled listed firms are state-owned asset supervision departments, and the enterprises immediately under the ultimate real controllers are SCIOCs or industrial groups. Moreover, we study SOEs that are absolutely rather than relatively state controlled.

To ensure at least three years before and after the pilot time to measure *DISTRESS1*, we select all A-share state-controlled listed firms from 2011 to 2018 as the initial sample, as the latest accounting data available are for 2021. We further exclude the following: (1) firms whose ultimate controllers are at the county level, to limit our sample to central, provincial and prefecture-level SCIOCs; (2) financial firms; (3) firms controlled by multiple ultimate controllers, as we mainly focus on firms controlled by a sole ultimate controller; (4) firms for which we could not determine whether control was by a pilot SCIOC; and (5) firms with other missing data. Finally, we obtain 7341 firm-year observations for 1036 firms. All continuous variables are winsorized at the upper and lower 1 percentile. The data on control chains are manually collected, and other data are obtained from the China Security Market and Accounting Research Database.

4.3. Descriptive statistics

Table 4 reports the descriptive statistics. The mean of distressed firms (*DISTRESS1*) is 12.44%, which indicates that certain Chinese SOEs have losses in successive years. The experimental group comprises 21.11% of the sample and the mean of *POST* and *TREAT × POST* is 5.83 percent, implying that 21.11% of the SOEs' ultimate controllers have gone through a SCIOC pilot reform, and 5.83% of the observations fall into the post-pilot reform period. Other variables are consistent with the descriptive results in the comparable literature (Rao and Wan, 2018).

5. Empirical results and robustness tests

5.1. Baseline regression results

Table 5 reports the baseline regression results of the effect of SCIOC pilot reform on bailouts. In columns (1) and (2), the panel logit model regressions show that the interaction coefficients of *TREAT × POST* are negative and significant at the 1% level. *TREAT × POST* remains negative using the logit model in columns (3) and (4). The results in Table 5 suggest that when the real controller of state-controlled listed firms enters the list of SCIOCs, its listed subsidiaries are less likely to become distressed. The baseline regression results

Table 4
Descriptive statistics.

Variable	N	Mean	SD	Min	p25	p50	p75	Max
DISTRESS1	7341	0.1244	0.3300	0	0	0	0	1
TREAT	7341	0.2111	0.4081	0	0	0	0	1
POST	7341	0.0583	0.2343	0	0	0	0	1
TREAT × POST	7341	0.0583	0.2343	0	0	0	0	1
LNASSET	7341	22.7343	1.4058	19.9019	21.7536	22.5843	23.6070	26.6600
LEV	7341	0.5161	0.2070	0.0824	0.3594	0.5213	0.6728	0.9732
FAGE	7341	2.5749	0.6297	0	2.3979	2.7726	2.9957	3.2581
EXPENSE	7341	0	0.0649	−0.1697	−0.0363	−0.0134	0.0165	0.4078
IND_PROFIT	7341	0.0271	0.0548	−0.6146	−0.0040	0.0249	0.0659	0.2070

therefore support our hypothesis that the SCIOC pilot reform can lower the probability of listed subsidiaries becoming distressed.

5.2. Robustness tests

5.2.1. Measurement error

To lower the measurement error of pilot timing, we conduct a placebo test in which the policy time is randomly generated. We group the data by province, randomly select a year for each province as the assumed policy time and conduct two-way fixed effect OLS regressions. We repeat this random process 500 times. Fig. 2 shows the distribution of the coefficients of $TREAT \times POST$ for the 500 random processes. As shown in Fig. 2, the coefficients of $TREAT \times POST$ are concentrated around 0, which is far greater than the estimated coefficients in the two-way fixed effect model based on the true pilot time, −0.0485. The above results indicate that the measurement error for the policy shock of our original treatment is tolerable.

To test the robustness of our measure of financial distress, we use alternative measures to that of *DISTRESS1*. These are dummy variables. *DISTRESS2* equals 1 if net income excluding non-recurring items is negative for the next two successive years, and 0 otherwise; *DISTRESS3* equals 1 if EVA is negative for the next three successive years, and 0 otherwise. The results are reported in Table 6, where columns (1) to (3) show that the coefficients of $TREAT \times POST$ are negative and significant, which is largely consistent with our baseline results.

To test the robustness of the model specification, we replace the panel logit model with a two-way fixed effect OLS regression with year and firm fixed effects. We replace the logit model with an OLS regression, controlling for year, industry and province fixed effects and the robust standard error clustered at the firm level. Columns (1) and (2) of Table 7 report the results, which indicate that the coefficients of $TREAT \times POST$ are negative and significant at the 5% level. Therefore, the regression results using alternative models are consistent with those of the baseline regressions.

5.2.2. Self-selection problem and reverse causality

To confirm the random assignment of the experimental and control groups, we use propensity score matching (PSM) plus the DID approach as a robustness test. We calculate the SCIOC pilot reform propensity score using the logit model regressed on all the control variables in the main regression, including industry and year fixed effects. Using the 1:3 matching method and the sample of ultimate controllers who never initiate a SCIOC pilot reform during the sample period as the control group, we rerun the baseline regressions. Columns (3) and (4) of Table 7 report the results, which indicate that the coefficients of $TREAT \times POST$ remain negative and significant at the 5% level.

An important premise of the DID approach is the parallel trend between the experimental and control groups before the shock. We follow Bertrand and Mullainathan (2003) and carry out a parallel trend test by adding the interactions of time and *TREAT*. We divide the sample into eight periods by setting the year of the SCIOC pilot reform as *After0*, the years before the pilot reform as *Before4-*, *Before3*, *Before2*, *Before1* and the years after the pilot reform as *After1*, *After2*, *After3+*. The years more than 4 years before the pilot

Table 5
SCIOC pilot reform and bailout of SOEs.

	(1)	(2)	(3)	(4)
DISTRESS1	Xtlogit	Xtlogit	Logit	Logit
TREAT × POST	−0.8609***	−0.8716***	−0.6944**	−0.7671**
	(−3.0041)	(−2.9093)	(−2.2109)	(−2.3195)
TREAT			0.0732	0.0827
			(0.3758)	(0.4232)
LNASSET		0.7572***		−0.2272***
		(4.9800)		(−3.7117)
LEV		1.5128***		4.1396***
		(2.9812)		(10.9001)
FAGE		1.4774***		0.6086***
		(2.8127)		(3.9315)
EXPENSE		4.8066***		3.6092***
		(4.3297)		(3.4334)
IND_PROFIT		−7.4425***		−4.8604***
		(−4.8052)		(−3.6152)
Constant			−1.0433**	0.2649
			(−2.2784)	(0.1865)
Firm	YES	YES	NO	NO
Year	YES	YES	YES	YES
Industry & Province	NO	NO	YES	YES
N	2139	2139	7341	7341
Pseudo R²	0.0190	0.0809	0.1297	0.2300

Notes: T-statistics are in parentheses. *, **, and *** indicate significance at the 10%, 5% and 1% levels (two-tailed), respectively. The dependent variable is *DISTRESS1*, variable definitions are given in Table 3. Columns (1) and (2) report panel logit regressions with firm and year fixed effects. When using panel logit model and if there is no variance in dependent variable for the same firm across the sample period, the sample will be omitted and thereby induce loss of a large number of observations. Columns (3) and (4) report logit model regressions with year, industry and province fixed effects, and robust standard error clustered at the firm level.

year are included in *Before4-*, and those more than 3 years after the pilot reform are included in *After3+*. Dummy variables are constructed for each period. The default base period is *Before4-*. Table 8 reports the results, which show that the coefficients of the interactions before policy implementation (*TREAT × Before3*, *TREAT × Before2*, *TREAT × Before1*) are nonsignificant. The coefficients of interactions after policy implementation (*TREAT × After0*, *TREAT × After2*, *TREAT × After3 +*) are significant in some columns, implying that the parallel trend test holds in our study.
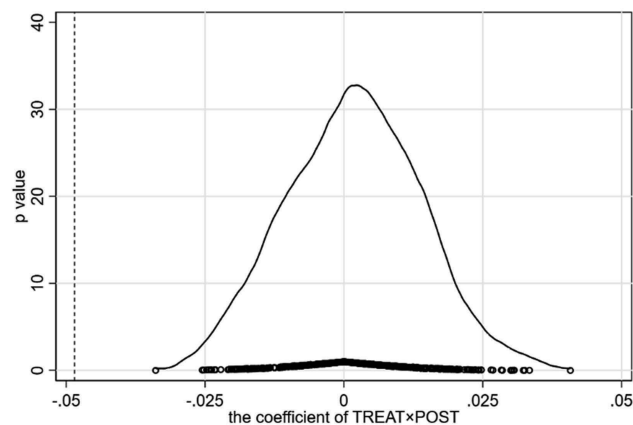
Fig. 2. The distribution of the coefficients of *TREAT × POST* in 500 random processes.

5.2.3. Alternative samples

We also check the robustness of our results using alternative samples. First, we exclude observations whose ultimate controllers are research institutions, universities or cultural and media organizations because it is almost impossible to set up such organizations as SCIOCs, which are usually piloted by SASACs and governments. The results shown in columns (1) and (2) of Table 9 confirm our main results.

Next, we exclude observations whose ultimate controllers experience the SCIOC pilot reform passively due to equity transfer or asset restructuring. The above situations are disrupted by other events and thus fail to reflect the net effect of the SCIOC pilot reform. The results are reported in columns (3) and (4) of Table 9 and imply that our main results are robust.

Finally, we exclude special treatment (ST, ST*) companies and particular transfer companies. Because these companies are supervised and warned by supervision departments, they have a strong motivation to engage in earnings management (Chen and Dai, 2004). The results are reported in columns (5) and (6) of Table 9, and again suggest that our main results are robust.

6. Further analysis

6.1. Mechanism test

The above tests show that the SCIOC pilot reform has a governance effect on the bailout of subsidiaries. In this section, we explore the specific mechanism of the bailout process. To conduct the mechanism tests, we compare the variation in distressed firms before and after their bailout, and drop firms that have not fallen into distress in the sample period. We set up model (3) to examine four types of bailouts measures, including exiting the market, deleveraging, improving corporate governance and boosting operating efficiency.

$$MEASURE_{i,t} = \alpha_1 TREAT_i \times POST_t + \alpha_2 TREAT_i + \alpha_3 POST_t + \beta Controls_{i,t} + Year_t + Industry_n + Province_p + \varepsilon_{i,t}$$
(3)

The dependent variable *MEASURE* represents the bailout mechanism. Under soft budget constraints, governments are unwilling to let unviable firms exit the market (Lin and Tan, 2000). Furthermore, the bank loan policies for SOEs are relatively loose and include longer loan terms (Fang, 2007). Therefore, we use market exit

Table 6
Robustness tests of alternative measures.

	DISTRESS2		DISTRESS3	
	(1)	(2)	(3)	(4)
	Xtlogit	Logit	Xtlogit	Logit
$TREAT \times POST$	−0.7697***	−0.6442**	−0.5846**	−0.2132
	(−3.0175)	(−2.1934)	(−2.4782)	(−1.0178)
$TREAT$		0.1901		0.0583
		(1.0613)		(0.4043)
Constant		2.0881		6.0044***
		(1.6248)		(5.6864)
Control variable	YES	YES	YES	YES
Firm	YES	NO	YES	NO
Year	YES	YES	YES	YES
Industry & Province	NO	YES	NO	YES
N	2705	7341	4005	7335
Pseudo R^2	0.1046	0.2379	0.1483	0.1314

Notes: T-statistics are in parentheses. *, **, and *** indicate significance at the 10%, 5% and 1% levels (two-tailed), respectively. The dependent variable *DISTRESS2* is a dummy variable coded 1 if the net income excluding non-recurring items in successive two future years is negative, and 0 otherwise. The dependent variable *DISTRESS3* is a dummy variable coded 1 if EVAs in successive three future years is negative, and 0 otherwise. Other variables are defined in Table 3. Columns (1) and (3) report panel logit regressions with firm and year fixed effects. Columns (2) and (4) report logit model regressions with year, industry and province fixed effects, and robust standard error clustered at the firm level.

Table 7
Robustness tests of alternative model and PSM approach.

DISTRESS1	Alternative model		PSM	
	(1) Two-way fixed effect model	(2) OLS model	(3) Xtlogit	(4) Logit
TREAT × POST	−0.0485**	−0.0515**	−0.8452**	−0.7036**
	(−2.2562)	(−2.2757)	(−2.2710)	(−2.0854)
TREAT		0.0083		0.0997
		(0.4550)		(0.4870)
Constant	−1.2157***	0.5535***		1.0295
	(−3.8225)	(3.8569)		(0.6262)
Control variables	YES	YES	YES	YES
Firm	YES	NO	YES	NO
Year	YES	YES	YES	YES
Industry & Province	NO	YES	NO	YES
N	7406	7406	958	4137
Adj.R^2/Pseudo R^2	0.0282	0.1716	0.0867	0.2202

Notes: T-statistics are in parentheses. *, **, and *** indicate significance at the 10%, 5% and 1% levels (two-tailed), respectively. Dependent variable is DISTRESS1. Variable definitions are given in Table 3. Column (1) reports OLS regressions with firm and year fixed effects. Column (2) reports OLS recessions with year, industry, and province fixed effects and the robust standard error clustered at the firm level. Column (3) reports panel logit regression based on PSM sample. Column (4) reports logit regression with year, industry and province fixed effects, and robust standard error clustered at the firm level, based on PSM sample.

Table 8
Parallel trend tests.

DISTRESS1	(1) Xtlogit	(2) Xtlogit	(3) Logit	(4) Logit
TREAT × Before3	−0.1752	−0.2109	−0.0930	−0.1126
	(−0.5473)	(−0.6169)	(−0.3687)	(−0.4205)
TREAT × Before2	0.1334	0.1701	0.1502	0.0755
	(0.4309)	(0.5295)	(0.4884)	(0.2272)
TREAT × Before1	−0.3959	−0.5067	−0.2382	−0.3252
	(−1.1734)	(−1.4372)	(−0.6775)	(−0.8302)
TREAT × After0	−0.9195**	−1.1614***	−0.7719*	−0.8773**
	(−2.3712)	(−2.7914)	(−1.9262)	(−2.0450)
TREAT × After1	−0.4826	−0.2724	−0.3186	−0.4720
	(−0.9947)	(−0.5396)	(−0.6900)	(−0.9375)
TREAT × After2	−1.3016**	−0.9762	−0.8470	−0.9413
	(−1.9936)	(−1.4967)	(−1.4792)	(−1.5307)
TREAT × After3+	−2.4356**	−2.8127**	−1.4508*	−1.4865
	(−2.1838)	(−2.2888)	(−1.7241)	(−1.6282)
TREAT			0.1013	0.1418
			(0.3767)	(0.5178)
Constant			−1.0416**	0.2331
			(−2.2803)	(0.1638)
Control variables	NO	YES	NO	YES
Firm	YES	YES	NO	NO
Year	YES	YES	YES	YES
Industry & Province	NO	NO	YES	YES
N	2139	2139	7341	7341
Pseudo R^2	0.0227	0.0862	0.1305	0.2306

Notes: T-statistics are in parentheses. *, **, and *** indicate significance at the 10%, 5% and 1% levels (two-tailed), respectively. Dependent variable is DISTRESS1. Variable definitions are given in Table 3. Columns (1) and (2) report panel logit regressions with firm and year fixed effects. Columns (3) and (4) report logit model regressions with year, industry and province fixed effects, and robust standard error clustered at the firm level.

Table 9
Robustness test of alternative samples.

DISTRESS1	Sample1		Sample2		Sample3	
	(1)	(2)	(3)	(4)	(5)	(6)
	Xtlogit	Logit	Xtlogit	Logit	Xtlogit	Logit
$TREAT \times POST$	−0.8265***	−0.7673**	−0.9433***	−0.7752**	−0.8710***	−0.7865**
	(−2.7520)	(−2.3088)	(−2.9680)	(−2.2966)	(−2.8686)	(−2.3327)
TREAT		0.1054		0.0803		0.1615
		(0.5373)		(0.3956)		(0.8192)
Constant		0.0856		0.1792		0.7605
		(0.0598)		(0.1262)		(0.4968)
Control variables	YES	YES	YES	YES	YES	YES
Firm	YES	NO	YES	NO	YES	NO
Year	YES	YES	YES	YES	YES	YES
Industry & Province	NO	YES	NO	YES	NO	YES
N	2078	7091	2111	7269	1996	7155
Pseudo R^2	0.0791	0.2345	0.0793	0.2289	0.0801	0.2249

Notes: T-statistics are in parentheses. *, **, and *** indicate significance at the 10%, 5% and 1% levels (two-tailed), respectively. The dependent variable is DISTRESS1. Variable definitions are given in Table 3. Sample 1 excludes observations whose ultimate controllers are research institutions, universities, culture and media organizations. Sample 2 excludes observations whose ultimate controllers passively experience SCIOC pilot reform due to equity transfer or asset restructuring. Sample 3 excludes special treatment (ST, ST*) companies and particular transfer (PT) companies.

and long-term bank loans to measure the hardening of budget constraints. We use the dummy variable EXIT to evaluate whether distressed firms undergo the market selection process.[7] Under capital-based management, EXIT measures whether the SCIOCs give up control of poorly run SOEs, sell them to private firms or let them delist or go bankrupt. The regression results are reported in column (1) of Table 10, where the coefficient of $TREAT \times POST$ is positive and significant at the 5% level. This result indicates that SCIOC pilot reform can improve the likelihood of distressed firms exiting the state-controlled sector. Therefore, SCIOCs can "vote with their feet."[8] Long-term bank lending leverage (BANKLONG) is measured as the long-term bank loans divided by total assets. Column (2) in Table 10 reports the regression results, where the coefficient of $TREAT \times POST$ is negative and significant at the 5% level. Therefore, SCIOC pilot reform reduces the long-term bank loans of distressed firms; in other words, it reduces bank subsidies to distressed firms.

Bu and Sun (2021) find that SCIOC pilot reform improves corporate governance by authorizing certain personnel rights to listed subsidiaries. We use the proportion of independent directors on the board (INDEP); whether directors, supervisors and senior managers hold positions in shareholder firms (PART); and CEO age (AGE) to proxy for the governance of listed subsidiaries. The regression results are reported in columns (3), (4) and (5) of Table 10, respectively. The results show that SCIOC pilot reform increases the proportion of independent directors; lowers the tendency of directors, supervisors and senior managers to hold positions in shareholder firms; and encourages the hiring of younger CEOs. The above measures help the management team to address distress and improve professional abilities. Additionally, as the directors, supervisors and senior managers are not in charge of shareholder firms, intervention and control from shareholder firms is reduced, improving the viability of SOEs.

We use total factor productivity (TFP) and Tobin's Q (TOBINQ) to depict the productivity and market value of SOEs, respectively, and the inventory turnover ratio (TURNOVER) to measure how distressed firms reduce inventory.[9] Columns (6), (7) and (8) of Table 10, respectively, report the results, which indicate that SCIOC pilot reform can increase operating efficiency. Specifically, the total factor productivity, Tobin's Q

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[7] If the observations of a firm terminate by 2018 (the last year of the sample period), the firm is regarded as having exited the state-controlled sector and EXIT is coded 1; otherwise EXIT is coded 0.

[8] We track how firms exit the state-controlled sector. Due to the scarcity of shell resources, no state-controlled listed firms delist from the A-share market. Instead, state-controlled listed firms are usually sold to private firms. The related statistics are available on request.

[9] Following Lu and Lian (2012), we use the LP method to calculate total factor productivity (TFP). Inventory turnover ratio = operating cost / average inventory. Average inventory = (opening inventory + ending inventory)/2.

and inventory turnover ratio of listed subsidiaries are improved, showing that state capital operating efficiency is enhanced.

6.2. Heterogeneity test

Previous analysis shows that SCIOC pilot reform contributes to the bailout of listed subsidiaries. In this section, we explore how macro-environmental and micro-enterprise characteristics affect bailouts by conduct-

Table 10
The channel of SOEs' bailout under SCIOC pilot reform.

Panel A: Soft budget constraint	EXIT	BANKLONG
	(1)	(2)
	Logit	OLS
$TREAT \times POST$	2.4930**	−0.0284**
	(2.0251)	(−2.2685)
$TREAT$	−2.9080***	0.0354***
	(−2.6359)	(2.9573)
Constant	28.5789***	−0.4558***
	(2.5759)	(−6.0892)
Control variables	YES	YES
Year & Industry & Province	YES	YES
N	747	1625
Adj.R²/Pseudo R²	0.3652	0.4321

Panel B: Corporate governance	INDEP	PART	AGE
	(3)	(4)	(5)
	OLS	Logit	OLS
$TREAT \times POST$	0.0155*	−1.8761**	−1.7525**
	(1.9570)	(−2.4921)	(−2.5159)
$TREAT$	−0.0183***	0.4914	0.4772
	(−3.1672)	(0.7301)	(0.8701)
Constant	0.2505***	1.6885	32.1757***
	(4.8815)	(0.2966)	(5.4757)
Control variables	YES	YES	YES
Year & Industry & Province	YES	YES	YES
N	1625	784	1592
Adj.R²/Pseudo R²	0.1655	0.2080	0.1825

Panel C: Operating efficiency	TFP	TOBINQ	TURNOVER
	(6)	(7)	(8)
	OLS	OLS	OLS
$TREAT \times POST$	0.1466**	0.2401**	13.8084*
	(2.1024)	(2.0407)	(1.8329)
$TREAT$	−0.0896	−0.0578	−0.4348
	(−1.2556)	(−0.5099)	(−0.1671)
Constant	−2.8164***	17.3198***	6.2238
	(−4.5027)	(13.3302)	(0.1448)
Control variables	YES	YES	YES
Year & Industry & Province	YES	YES	YES
N	1625	1569	1620
Adj.R²/Pseudo R²	0.8020	0.5972	0.0496

Notes: T-statistics are in parentheses. *, **, and *** indicate significance at the 10%, 5% and 1% levels (two-tailed), respectively. Panel A reports regressions of soft budget constraint measures; Panel B governance measures, and Panel C operating efficiency measures. When logit model with robust standard errors clustered at the firm level, and with year, industry and province fixed effects are conducted, if there is no variance in the dependent variable for the same year, industry or province, the sample will be omitted, which induces loss of a large number of observations.

ing grouped tests based on regional and industrial features and the characteristics of SCIOCs and SOEs. We utilize seemingly unrelated regressions (SURs) to test the significance of the differences in coefficients.

6.2.1. Regional and industrial features

First, we test the regional effects by dividing firms according to their registration location in eastern, central and western regions. Eastern regions have a higher degree of marketization than the other regions, and their state-owned asset supervision departments have advantages in dealing with distressed firms. Central and western regions have abundant natural resources but lower marketization and a more simplistic industrial structure. Therefore, the governments of central and western regions have limited market tools to cope with corporate distress. We therefore expect that SCIOC pilot reform may have a greater marginal effect in western and central regions on improving state economy marketization and state capital allocation efficiency. The grouped regressions based on regions are reported in Table 11. The coefficients of $TREAT \times POST$ are negative and significant in columns (2), (3) and (5) and nonsignificant in other columns. These results confirm that the effect of SCIOC pilot reform on bailouts is more pronounced in western and central regions than in eastern regions.

Another SOE reform is classified management based on functions (classified reform, in short). Classified reform is carried out simultaneously with stratified reform (SCIOC pilot reform, or capital-based management reform) (Hu and Huang, 2017). Classified reform clarifies which firms are pure market players and which firms should undertake political tasks. This information helps in dealing with distressed firms in different ways. We refer to the classification method of Wei et al. (2017) and divide firms into two categories: public welfare and special function industries, or competitive industries. Because public welfare and special function industries have less marketization, less ability to integrate resources and a higher chance of being impacted by the business cycle, SOEs in these industries are more likely than those in competitive industries to fall into distress and lack flexible bailout means. As the establishment of SCIOCs provides these industries with more marketization tools, SCIOC pilot reform may have a more pronounced effect on such firms. We conduct regressions for the two classified groups respectively. The results are reported in Table 12, where the coefficients of $TREAT \times POST$ in columns (1) and (3) are greater and more significant than those in columns (2) and (4). These results confirm that the effect of SCIOC pilot reform on bailouts is more significant in the public welfare and special function industries.

6.2.2. SCIOC types

SOE reform differs in efficiency for SOEs controlled by different government layers (Wei et al., 2017). Central SOEs act as fundamental pillars of the Chinese economy. The disposal of distressed central SOEs is important and emergent, as such SOEs are typically in industries that affect national welfare and people's livelihoods (Liu and Li, 2012). Moreover, central SCIOCs can mobilize more resources than provincial and prefecture-level SCIOCs (Xin, 2019), providing an advantage in resource integration. We conduct grouped tests by dividing SCIOCs into central and local levels, as reported in Table 13. The coefficients of $TREAT \times POST$ are negative and significant at the 1% level in columns (1) and (3) but nonsignificant in other columns. This indicates that the effect of SCIOCs on the bailout of SOEs is more pronounced in central SCIOCs.

There are three types of SCIOCs in China: state capital investing companies, state capital operating companies and state capital investing and operating companies. The first two types are regulated by national policies, while the third type comes from practice. A company may be positioned as a state capital investing and operating company because the founders want to combine the functions of state capital investing and operating simultaneously or they may not have specified the concrete purpose of the company. Different types involve different target orientations, operating modes, investment areas and assessment criteria (Xin, 2019). According to "Opinions of Implementation" (State Council, 2018), state capital investing companies are positioned as tools to optimize state capital layout, while state capital operating companies are positioned as instruments to improve capital operating efficiency. The former focus on the "financing, investment, management and exit" of state capital and try to transfer state capital from industries with overcapacity to strategic industries. The state capital operating companies focus on improving the economic performance of SOEs, such as the return on capital and EVA. We run regressions for firms experimenting with each type of SCIOC pilot reform separately, using firms that never undergo pilot reform in the sample period as the control sample.

Table 11
Regional heterogeneity, SCIOC pilot reform, and bailout.

DISTRESS1	Eastern (1)	Central (2)	Western (3)	Eastern (4)	Central (5)	Western (6)
	Xtlogit	Xtlogit	Xtlogit	Logit	Logit	Logit
TREAT × POST	−0.3544	−2.0096***	−1.5191**	−0.5548	−1.4644**	−0.9090
	(−0.9148)	(−2.5790)	(−2.0252)	(−1.2729)	(−2.1852)	(−1.1891)
TREAT				0.3132	0.0767	−0.4061
				(1.1370)	(0.1904)	(−0.8055)
Constant				−1.0243	0.3979	−2.0838
				(−0.5803)	(0.1197)	(−0.5595)
Control variables	YES	YES	YES	YES	YES	YES
Firm	YES	YES	YES	NO	NO	NO
Year	YES	YES	YES	YES	YES	YES
Industry & Province	NO	NO	NO	YES	YES	YES
N	1117	548	463	4192	1481	1309
Pseudo R²	0.0800	0.1037	0.1714	0.2177	0.2938	0.3581
Coefficient diff between groups#			Eastern-Central	0.0077***		
			Eastern-Western	0.0997*		
			Central-Western	0.4433		

Notes(#): This table reports regression results for firms grouped by regions. T-statistics are in parentheses. *, **, and *** indicate significance at the 10%, 5% and 1% levels (two-tailed), respectively. The dependent variable is DISTRESS1. Variable definitions are given in Table 3. We use panel logit model and logit model regressions. However, because the coefficient of logit model is hard to compare directly (Hong, 2015) and we can obtain similar results from two-way fixed effect model. Consequently, we use two-way fixed effect model to estimate the coefficient difference between groups. The related regression results are available on request.

Table 14 reports the results. We find that the coefficients of *TREAT × POST* in columns (1) and (4) are negative and significant, and those in other columns are nonsignificant. Therefore, when SCIOCs are positioned as state capital investing companies, SCIOC pilot reform governance has a better effect on the bailout of SOEs.

6.2.3. Firm characteristics

Although the pyramid structure of SOEs may bring some agency costs, it reduces the political costs induced by government intervention and lessens the policy burden, eventually increasing firm value (Fan et al., 2013b). After a SCIOC pilot reform, some SCIOCs are embedded in the original pyramid ownership structure of state groups. Therefore, the control chain is extended, which reflects the willingness of governments to delegate power. We expect that the longer the control chain and the more delegations, the better the role the SCIOC pilot reform can play. In contrast, a shorter control chain with less delegation results in limited effects of SCIOC pilot reform. Following Fan et al. (2013b), we hand collect control chain data and divide the sample into three groups (short, medium and long) according to its tertiles. Table 15 reports the regression results. As shown in columns (3) and (6), the coefficients of *TREAT × POST* are negative and significant at the 1% level for the group with long control chains, and nonsignificant for the other groups. Therefore, SCIOC pilot reform can delegate more power when the control chain is longer, which promotes the separation of enterprise and government, improves firm viability and lowers the probability of listed subsidiaries falling into distress.

SCIOCs are positioned investment companies with the aim of capital operation, providing platforms for their subsidiaries to carry out capital operations such as equity transfers and mergers and acquisitions (M&As). These functions can provide opportunities for bailing out distressed firms (Zhou et al., 2018). We follow Liao et al. (2020) to create a dummy variable, *MADUM*, to measure the M&A activities of listed SOE subsidiaries. *MADUM* equals 1 if the listed SOE subsidiaries conduct M&A activities in a year, and 0 otherwise. We divide the sample into two groups according to the value of *MADUM* and conduct regressions on the two groups. The results are reported in Table 16. Columns (1) and (3) show that the coefficients

Table 12
Classified reform, SCIOC pilot reform and bailout.

DISTRESS1	Public welfare & special function	Competitive	Public welfare & special function	Competitive
	(1)	(2)	(3)	(4)
	Xtlogit	Xtlogit	Logit	Logit
TREAT × POST	−2.3511**	−0.5610*		−2.7989***	−0.5945*
	(−2.0196)	(−1.7121)		(−2.7052)	(−1.7145)
TREAT			−0.3663	0.1729
			(−0.7864)	(0.8096)
Constant			1.2425	−0.6927
			(0.4109)	(−0.4314)
Control variables	YES	YES	YES	YES
Firm	YES	YES	NO	NO
Year	YES	YES	YES	YES
Industry & Province	NO	NO	YES	YES
N	354	1726	1063	6128
Pseudo R²	0.2298	0.0876	0.3057	0.2452
Coefficient diff between groups # 0.0772*				

Notes (#): T-statistics are in parentheses. *, **, and *** indicate significance at the 10%, 5% and 1% levels (two-tailed), respectively. The dependent variable is *DISTRESS1*. Variable definitions are given in Table 3. Columns (1) and (3) include firms in public welfare and special function industries, columns (2) and (4), competitive industries. We use panel logit model and logit model regressions. However, we use two-way fixed effect model to estimate the significance of the coefficient difference between groups. The two-way fixed effect regression results are available on request.

Table 13
SCIOCs' levels, SCIOC pilot reform and bailout.

DISTRESS1	Central	Local	Central	Local
	(1)	(2)	(3)	(4)
	Xtlogit	Xtlogit	Logit	Logit
TREAT × POST	−2.1882***	−0.0902	−1.7089***	−0.5093
	(−4.0868)	(−0.2205)	(−2.8988)	(−1.1093)
TREAT			0.1394	0.1329
			(0.4541)	(0.4576)
Constant			−1.7651	1.2205
			(−0.6787)	(0.6636)
Control variables	YES	YES	YES	YES
Firm	YES	YES	NO	NO
Year	YES	YES	YES	YES
Industry & Province	NO	NO	YES	YES
N	698	1420	2396	4659
Pseudo R²	0.1345	0.0848	0.2361	0.2799
Coefficient diff between groups #	0.0001***			

Notes (#): T-statistics are in parentheses. *, **, and *** indicate significance at the 10%, 5% and 1% levels (two-tailed), respectively. The dependent variable is *DISTRESS1*. Variable definitions are given in Table 3. Columns (1) and (3) report regressions for central SOEs, columns (2) and (4), for local SOEs. We use panel logit model and logit model regressions. However, we use two-way fixed effect model to estimate the coefficient difference between groups. The two-way fixed effect regression results are available on request.

of *TREAT × POST* are negative and significant at the 1% level, while the coefficients in other columns are nonsignificant. The differences between the groups are significant, meaning that M&A activities promote resource allocation efficiency in listed subsidiaries after SCIOC pilot reform. M&As accelerate the clearing of inferior assets and promote the synergy of superior assets, lowering the probability that the SOEs will fall into distress.

Table 14
SCIOCs' types, SCIOC pilot reform and bailout.

DISTRESS1	SCIC	SCOC	SCIOC	SCIC	SCOC	SCIOC
	(1)	(2)	(3)	(4)	(5)	(6)
	Xtlogit	Xtlogit	Xtlogit	Logit	Logit	Logit
TREAT × POST	−1.4688***	−0.3451	−0.4162	−0.9956**	0.4127	−0.7602
	(−3.5571)	(−0.2951)	(−0.5801)	(−2.2216)	(0.5519)	(−1.1809)
TREAT				0.1875	−0.3072	−0.0739
				(0.7679)	(−0.5882)	(−0.2189)
Constant				0.0252	0.1226	−0.0636
				(0.0165)	(0.0712)	(−0.0386)
Control variables	YES	YES	YES	YES	YES	YES
Firm	YES	YES	YES	NO	NO	NO
Year	YES	YES	YES	YES	YES	YES
Industry & Province	NO	NO	NO	YES	YES	YES
N	1792	1529	1578	6309	5529	5772
Pseudo R²	0.0820	0.0809	0.0736	0.2380	0.2668	0.2708
Coefficient diff between groups #			SCIC-SCOC	0.4283		
			SCIC-SCIOC	0.0130**		
			SCOC-SCIOC	0.3093		

Notes: T-statistics are in parentheses. *, **, and *** indicate significance at the 10%, 5% and 1% levels (two-tailed), respectively. The dependent variable is DISTRESS1. Variable definitions are given in Table 3. SCIC represents state capital investing company, SCOC represents state capital operating company. We use panel logit model and logit model regressions. However, we use two-way fixed effect model to estimate the coefficient difference between groups. The two-way fixed effect regression results are available on request.

Table 15
SCIOC pilot reform, control chain and bailout.

DISTRESS1	Short	Medium	Long	Short	Medium	Long
	(1)	(2)	(3)	(4)	(5)	(6)
	Xtlogit	Xtlogit	Xtlogit	Logit	Logit	Logit
TREAT × POST	−0.8560	0.1777	−2.2432***	−0.6906	−0.1854	−1.8193***
	(−1.2626)	(0.3257)	(−3.1694)	(−1.1187)	(−0.4090)	(−2.7961)
TREAT				0.6899**	−0.0064	0.5099
				(2.0060)	(−0.0235)	(1.4754)
Constant				−3.3715*	−1.6341	3.2094
				(−1.7100)	(−0.6659)	(1.1590)
Control variables	YES	YES	YES	YES	YES	YES
Firm	YES	YES	YES	NO	NO	NO
Year	YES	YES	YES	YES	YES	YES
Industry & Province	NO	NO	NO	YES	YES	YES
N	706	704	430	2800	2458	1534
Pseudo R²	0.1540	0.1227	0.0932	0.3439	0.2785	0.2719
Coefficient diff between groups #			Short -Medium	0.0538*		
			Short -Long	0.4467		
			Medium -Long	0.0087***		

Notes: T-statistics are in parentheses. *, **, and *** indicate significance at the 10%, 5% and 1% levels (two-tailed), respectively. This table reports the grouped regressions according to the length of control chain, grouped by tertiles. The dependent variable is DISTRESS1. Variable definitions are given in Table 3. We use panel logit model and logit model regressions. However, we use two-way fixed effect model to estimate the coefficient difference between groups. The two-way fixed effect regression results are available on request.

Table 16
SCIOC pilot reform, capital operation and bailout.

DISTRESS1	M&A	No M&A	M&A	No M&A
	(1)	(2)	(3)	(4)
	Xtlogit	Xtlogit	Logit	Logit
$TREAT \times POST$	−2.3940***	−0.4668	−2.1341***	−0.5757
	(−2.7529)	(−1.3279)	(−2.9277)	(−1.6318)
TREAT			−0.0102	0.1368
			(−0.0303)	(0.6686)
Constant			−1.8447	0.7509
			(−0.9019)	(0.4753)
Control variables	YES	YES	YES	YES
Firm	YES	YES	NO	NO
Year	YES	YES	YES	YES
Industry & Province	NO	NO	YES	YES
N	339	1382	1940	5260
Pseudo R^2	0.2318	0.0796	0.2498	0.2448
Coefficient diff between groups [#]	0.0391**			

Notes: T-statistics are in parentheses. *, **, and *** indicate significance at the 10%, 5% and 1% levels (two-tailed), respectively. This table reports the grouped regressions according to whether the listed SOEs engaged in M&As. The dependent variable is *DISTRESS1*. Variable definitions are given in Table 3. We use panel logit model and logit model regressions. However, we use two-way fixed effect model to estimate the coefficient difference between groups. The two-way fixed effect regression results are available on request.

7. Conclusions

Based on a sample of A-share state-controlled listed firms from 2011 to 2018, we study the relationship between SCIOC pilot reform and SOE bailouts. We find that when the real controller of state-controlled listed firms enters the list of SCIOCs, listed subsidiaries are less likely to fall into financial distress. SOE bailout activities include exiting the market, deleveraging, enhancing corporate governance and improving operating efficiency. In addition, the effect of setting up SCIOCs on the bailout of SOEs is more pronounced in central and western regions, in public welfare and special function industries, for central rather than local SCIOCs, for stated capital investing companies, for firms with more organizational layers and for firms that engage in M&As. Our results stand after a series of robustness checks. The empirical results in this study indicate that with the help of SCIOCs, SOEs can be converted to market players with improved ability and harder budget constraints.

8. Author Note

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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Mandatory information disclosure and innovation: Evidence from the disclosure of operational information

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ABSTRACT

We use a quasi-natural experiment wherein the Shanghai Stock Exchange requires listed companies in certain industries to disclose operational information and a staggered difference-in-differences model to examine the impact of mandatory information disclosure on corporate innovation. We find that companies subject to mandatory operational information disclosure show significantly increased innovation. This effect is pronounced for companies classified as non-state-owned enterprises, facing severe financing constraints and a high degree of shareholder tunneling behavior and in competitive and high-tech industries. Although mandatory operational information disclosure reduces their competitive advantage, companies appear to compensate by increasing innovation. Our study highlights the positive impact of mandatory operational information disclosure, indicating that it contributes to the high-quality development of both capital markets and companies.
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1. Introduction

In October 2020, the State Council issued *Opinions of the State Council on Further Improving the Quality of Listed Companies*, with the aim of "improving the quality of information disclosure". Information disclosure is an important way of improving the quality of listed companies and the efficiency of resource allocation. Given the importance of research and development (R&D) to companies and economies, Leuz and

Wysocki (2016) call for studies on the effects of information disclosure on companies' R&D investment decisions. However, there is little literature on this subject and most studies focus on voluntary disclosure (Yuan and Wang, 2015; Zhong, 2018; Brown and Martinsson, 2019), which suffers from severe endogeneity problems.

Since 2015, the Shanghai Stock Exchange (SSE) has required the mandatory disclosure of operational information by companies listed in specific industries (the Shenzhen Stock Exchange [SZSE] does not have such a requirement for these industries), providing a good setting in which to examine how mandatory information disclosure affects firms' innovation decisions. Using a difference-in-differences model, we examine the impact of the mandatory disclosure of operational information on firms' innovation. We find that companies subject to mandatory operational information disclosure significantly increase their innovation inputs. After replacing the dependent variable and conducting other robustness tests, our findings remain unchanged. Further analysis reveals that this effect is prominent for firms in competitive industries, those facing severe financing constraints and those that experience a high degree of tunneling behavior by major shareholders. This suggests that operational information disclosure prompts firms to increase investment in innovation by alleviating financing constraints, discouraging large shareholders from tunneling and avoiding market competition. Cross-sectional analyses show that this effect is pronounced for non-state-owned enterprises (non-SOEs) and high-tech industries. Economic consequence analysis reveals that mandatory operational information disclosure significantly reduces firms' gross profit rates, supporting the proprietary information characteristic of operational information. However, firms mitigate this negative relationship by investing in R&D. The disclosure of operational information also significantly improves the quality of innovation outputs, as evinced by an increase in the number of invention patent applications.

Our study contributes to the literature in three ways. First, this paper not only enriches the literature on the factors influencing corporate innovation, but also provides direct evidence on how mandatory information disclosure affects corporate innovation. Most studies investigate the factors influencing R&D investment, such as financing capacity, firm personnel characteristics, and compensation incentives (Atanassov et al., 2007; Galasso and Simcoe, 2011; Hirshleifer et al., 2012; Acharya et al., 2013; Ma et al., 2014; Yu et al., 2016; Wu et al., 2016; Lai and Zheng, 2016; Mukherjee et al., 2017; Wang and Zhu, 2018; Hu et al., 2019). In contrast, we examine the impact of information disclosure on R&D investment. Although some studies examine the impact of information disclosure on corporate innovation (Yuan and Wang, 2015; Zhong, 2018; Brown and Martinsson, 2019), they focus on voluntary information disclosure. This creates severe endogeneity problems and is not conducive to the identification of causality. We use an exogenous shock to circumvent these issues and test the impact of mandatory information disclosure on corporate R&D investment. This helps us better identify causal relationships and draw reliable conclusions. This study is also a response to Leuz and Wysocki's (2016) call to examine the impact of information disclosure on corporate innovation.

Second, this study enriches the literature on the economic consequences of proprietary information disclosure. Managers may choose not to disclose information when it is proprietary, prohibiting researchers from assessing the economic consequences of such information (Zhou, 2020). Thus, one can only study the economic consequences of proprietary information disclosures in the context of mandatory disclosures. The SSE mandates that listed companies in specific industries disclose operational information; such information has proprietary characteristics and provides a good opportunity to test the economic consequences of proprietary information disclosure. Thus, our study enriches the research on this subject. Using the exogenous setting of the American Innovator Protection Act, Kim and Valentine (2021) find that disclosing proprietary information to competitors significantly reduces firms' innovation. However, using a setting that mandates proprietary information disclosure in China, we find that such information improves R&D investment. Thus, this study furthers our theoretical understanding of the relationship between proprietary information disclosure and corporate innovation.

Furthermore, this study enriches the literature on the economic consequences of mandatory operational information disclosure, which is an important way to improve information disclosure by listed companies. However, there is a lack of research on the economic consequences of this mandate. A notable study in this field is that by Liu and Liu (2021), who find that the mandatory disclosure of operational information significantly improves the quality of accounting information. We examine the impact of mandatory operational

information disclosure on firms' innovation and explore its real economic consequences, thereby contributing to the related literature.

Third, this study has important policy implications. Our results provide important references for policy-makers implementing disclosure regulations. To meet investors' demands for operational information, stock exchanges issue disclosure guidelines for different industries based on their business models. These industry guidelines are an important channel by which regulators strengthen regulations and provide investors with effective information for decision-making. However, the literature largely neglects the relevance of these guidelines. We examine the real effects of information disclosure and find that the mandatory disclosure of operational information prompts companies to increase their innovation investment, thus supporting the positive impact of this policy.

2. Institutional background and theoretical analysis

2.1. Institutional background

A change in business model increases investors' demands for information disclosure by listed companies. Some media posit that the existing information disclosure system is inadequate; for example, several companies do not adequately disclose non-financial information. Jiang and He (2008) analyze 1,353 questions asked by investors to listed companies in the *Shareholder Call Center* and find that investors make strong demands for operational information. We examine the *Investor Interactive Platform* to understand the informational needs of public investors and find that investors make strong demands for quantitative non-financial information, such as important operational data (e.g., sales volume and production capacity).

To meet investors' demands for non-financial information, stock exchanges issue disclosure guidelines for different industries. Based on the characteristics of each industry, these guidelines set disclosure requirements for multiple scenarios, such as financial and non-financial information, qualitative and quantitative information. Between 2015 and 2018, the SSE issued more than 20 guidelines on industry disclosure covering a wide range of industries, such as real estate, coal, electricity, retail, automobile manufacturing and pharmaceutical manufacturing. The SZSE also issued similar business disclosure guidelines for the Main Board and Growth Enterprise Market (*GEM*) during this period, covering livestock and poultry, aquaculture, solid mineral resources, real estate, the seed industry, plantations, engineering machinery, decoration, jewelry and software and information technology services.

Although both the SSE and SZSE issue industry disclosure guidelines, there are significant differences in terms of the industries involved. This provides a good opportunity to study the economic consequences of mandatory information disclosure. The industry disclosure guidelines issued by the SSE cover a wider range of industries than those issued by the SZSE. Both exchanges establish disclosure guidelines for the real estate, agriculture, forestry, animal husbandry and fishery, construction and decoration and retailing industries. However, the SSE requires the disclosure of operational information for 20 more industries, such as automobile manufacturing, pharmaceutical manufacturing, textile and garment, apparel, air transportation and furniture manufacturing. Therefore, we consider the companies listed in these 20 additional industries as the treatment group, and those listed on the SZSE and not required to disclose operational information as the control group. We then construct a difference-in-differences model to study the economic consequences of mandatory information disclosure.

2.2. Theoretical analysis and research hypothesis

Unlike other investments, innovation is characterized by long cycle times, high risk and high levels of investment (Holmstrom, 1989; Hirshleifer et al., 2012). Corporate innovation is influenced by two key characteristics: innovation ability and innovation motivation. Operational information disclosure can improve innovation ability by alleviating financing constraints and inhibiting insider tunneling behavior and increase innovation motivation by avoiding industry competition; this in turn increases firms' R&D investment.

The mandatory disclosure of operational information can alleviate the financing constraints of firms and improve their innovation ability, in turn increasing innovation. Firms often face financing constraints

(Jiang et al., 2016), but operational information disclosure can reduce the cost of equity and debt, thereby alleviating said constraints. First, operational information disclosure reduces the internal and external information asymmetry of firms (Glosten and Milgrom, 1985), increases stock liquidity and reduces the cost of equity (Diamond and Verrecchia, 1991). Second, operational information comprises non-financial information such as production and sales volumes, which can predict the future business performance of a firm (Zhang et al., 2022). Therefore, such disclosure helps investors and creditors make accurate assessments of a firm's future risk, thereby lowering risky returns and reducing the cost of equity and debt. Third, the disclosure of information related to investment projects helps creditors track and monitor the use of project funds, reduces shareholders' motivations to engage in behaviors detrimental to creditors and in turn reduces the cost of debt. In addition, operational information is strongly correlated with financial information. This implies that the mandatory disclosure of operational information can be used to verify the reliability of accounting information (Brazel et al., 2009; Dechow et al., 2011; Ye and Liu, 2021), making it difficult for firms to manipulate accounting numbers. Consequently, operational information improves the quality of accounting information (Liu and Liu, 2021), alleviating firms' financing constraints and prompting demands from shareholders and creditors for low risky returns. In summary, operational information disclosure can reduce financing costs and alleviate the financing constraints of firms, releasing cash for investment in R&D projects.

The mandatory disclosure of operational information can inhibit insider tunneling behavior and improve the ability and motivation of firms to make innovative investment, thereby improving innovation. Unlike the relatively decentralized ownership structures in the United Kingdom and the United States, those of listed companies in China are relatively concentrated. Thus, the agency problem in China mainly arises between major shareholders and small and medium shareholders. To obtain private gains, major shareholders tend to "hollow out" companies through related-party transactions and harm the interests of minority shareholders (Wang et al., 2015; Hou et al., 2017). The information asymmetry between internal firms and external investors is an important cause of agency problems (Jensen and Meckling, 1976). Mandatory operational information disclosure can reduce information asymmetry and help small and medium shareholders monitor major shareholders, thereby inhibiting tunneling behavior in major shareholders (Zhong et al., 2014). For example, operational information discloses the production and sales volumes of different products and related revenues. Based on this information, users can deduce the unit prices of different products and determine whether major shareholders engage in unfair connected transaction behaviors. The reduction of tunneling behavior by major shareholders releases company resources for investment in innovation, in turn improving firms' abilities to engage in innovation activities.

Operational information disclosure can enhance the incentives of large shareholders to make innovative investments. The chief sources of gains for large shareholders are tunneling behavior and either rising corporate performance or market capitalization (Desai et al., 2007; Wu and Wu, 2011). When tunneling behavior gains are reduced by operational disclosures, major shareholders can only maintain or increase their gains by improving corporate performance or market capitalization. Studies show that R&D investment significantly improves firms' operating performance or market capitalization (Wu et al., 2016; Yang et al., 2017). Therefore, following the mandatory disclosure of operational information, large shareholders have strong incentives to enhance innovation investment and increase their gains.

Mandatory operational information disclosure can reduce the competitive advantage of firms and intensify competition within the industry; this enhances the incentive of firms to invest in innovation and avoid market competition effect and consequently increases innovation. Operational information has some characteristics of proprietary information, the disclosure of which can reduce the competitive advantage of firms. Berger et al. (2019) find that listed companies that disclose cost structures have low gross margins, operating incomes, and net incomes. Zhou (2020) considers segment information to be proprietary and finds that segment information disclosure significantly reduces firms' competitive advantages by reducing their returns on assets and gross margins. Disclosed operational information can inform on the revenue, cost, and production volumes of different products, which can be used by potential market entrants or competitors to calculate the gross profit margins of different products. Competitors can use this information to adapt their production and sales strategies; for instance, they can enter the market for products with high gross profit margins or lower the sales prices of existing products. These actions may increase industry competition and force firms to increase R&D investment (Nie et al., 2008; Shen and Sun, 2009; Hashmi, 2013). Because firms can only ease compet-

itive pressures such as brutal industry price wars through continuous innovation (Aghion et al., 2005; Zhang et al., 2014), operational information disclosure can also prompt managers to increase innovation and maintain competitive advantages. Therefore, we propose the following testable hypothesis:

H1: Following the mandatory disclosure of operational information, firms increase their innovation investment.

3. Research design

3.1. Data and sample

Since 2015, the SSE has required certain industries (e.g., automobile manufacturing) and the SZE has required listed companies engaged in certain businesses to disclose operational information. To clearly identify the economic consequences of mandatory operational information disclosure, we exclude an industry if it is subject to the requirements of both the SSE and SZSE. For example, in 2015, the SSE required listed companies in the real estate industry and the SZSE required listed companies engaged in the real estate business to disclose operational data. We therefore exclude the real estate industry from our sample. Following this procedure, we retain 20 industries such as electric power, automobile manufacturing and pharmaceutical manufacturing (see Appendix A for details). Companies in these industries are required to disclose operational information if they are listed on the SSE, but not if they are listed on the SZSE. In addition, the SZSE has issued industry information disclosure guidelines for *gEM*-listed companies engaged in certain businesses. If any of the above 20 industries belong to this list, then we exclude *gEM*-listed companies in those industries. From this sample, we exclude pharmaceutical manufacturing, telecommunications, radio, television and satellite transmission services and ecological protection and environmental management.

As the guidelines were sequentially implemented in 2015, the sample period is restricted to 2010 to 2019. We select the sample using the following steps (Quan and Yin, 2017; Liu et al., 2020): 1) retain listed companies in the 20 industries that are required to disclose operational information; 2) exclude listed companies in the three *GEM* industries that need to comply with industry disclosure guidelines; 3) exclude listed companies with ST or *ST status; 4) exclude listed companies from the sample period during which industry classification changes; and 5) exclude observations that are missing values for variables. To mitigate differences between the treatment and control groups, we perform propensity score matching. We first construct an indicator variable that equals 1 for the treatment group, and 0 otherwise. We regress the indicator variable on the control variables, calculate the propensity score of each observation in the treatment group and then match them using the 1:1 no-release nearest neighbor method. Finally, we obtain 4,298 firm-year observations. The patent data are obtained from the Chinese Research Data Services Platform (CNRDS) database, the internal control index is obtained from the Internal Control and Risk Management (DIB) database and the remaining data are obtained from the China Stock Market and Accounting Research (CSMAR) database. To avoid the influence of extreme values, continuous variables are winsorized at the top and bottom 1 % level.

3.2. Model design

To test the impact of operational disclosure on corporate innovation, we construct the following staggered difference-in-differences model (Bertrand and Mullainathan, 2003).

$$RD = \alpha_0 + \alpha_1 \times Disclosure + \alpha_i \times \sum Controls + \gamma + \delta + \varepsilon \tag{1}$$

where *RD* represents the firm's R&D intensity, *Disclosure* is a dummy variable indicating whether the firm is subject to the mandatory disclosure of operational information and *Controls* represents the control variables. We include the following set of control variables: asset size (*SIZE*), firm leverage (*LEV*), sales growth (*GROWTH*), cash holdings (*CASH*), firm age (*AGE*), fixed asset intensity (*PPE*), board size (*BS*), return on assets (*ROA*), executive compensation (*PAY*), agency cost (*AC*), percentage of shares held by the top shareholder (*TOP1*), cash flow (*CFO*), Tobin's Q (*TQ*), annual returns (*RET*), CEO duality (*DUAL*) and state ownership (*SOE*). The detailed variable definitions are provided in Appendix B. To mitigate omitted variable

problems, we also control for firm (γ) and year (δ) effects. If H1 holds, then we expect α_1 to be positive and significant.

4. Empirical results

4.1. Summary statistics

Table 1 shows the descriptive statistics. The mean value of corporate innovation (*RD*) is 2.35, indicating that the average ratio of R&D to sales is 2.35 %. *RD* has a minimum value of 0.00 and a maximum value of 12.59, indicating large differences across companies. The mean value of *Disclosure* is 0.25, indicating that the observations after the 2015 mandatory disclosure of operating information account for 25.34 % of the full sample. Table 2 presents the differences in the mean values of firm characteristics between the treatment and control groups. Table 2 shows that there is no significant difference in firm characteristic variables between the treatment and control groups.

4.2. Regression analysis

Table 3 reports the effect of operational information disclosure on firms' R&D investment. After operational information disclosure, the level of R&D increases significantly. This result is both statistically and economically significant. The coefficient of *Disclosure* is 0.30, indicating that after the mandatory disclosure of operational information, R&D investment as a percentage of sales increases by nearly 0.30 percentage points; this is equivalent to 12.77 % of the mean value (2.35). This result supports H1, which states that mandatory operational information disclosure improves firms' R&D investment.

In terms of control variables, the coefficient of *SIZE* is significantly positive at the 1 % level, indicating that the larger the firm size, the higher the level of R&D. The coefficient of *LEV* is significantly negative at the 10 % level, indicating that the higher the leverage, the lower the level of R&D. The coefficient of *PPE* is significantly positive at the 10 % level, indicating that the higher the ratio of fixed assets, the higher the level of innovation inputs. This is consistent with previous reports (Pan et al., 2015). Most of the remaining control variables are insignificant because we control for firm fixed effects, which absorb most of the effects of the control variables on *RD*.

Table 1
Summary statistics.

Variables	Mean	S. D.	Min	P25	Median	P75	Max
RD	2.3452	2.4836	0.0000	0.0503	1.8959	3.6944	12.5932
Disclosure	0.2534	0.4350	0.0000	0.0000	0.0000	1.0000	1.0000
SIZE	22.3865	1.2380	19.9649	21.5358	22.2361	23.1177	26.3859
LEV	0.4384	0.2085	0.0506	0.2747	0.4324	0.5930	0.9110
GROWTH	0.1476	0.3153	−0.4484	−0.0077	0.1019	0.2404	1.9261
CASH	0.1659	0.1203	0.0123	0.0816	0.1326	0.2149	0.6084
AGE	11.4502	6.9080	0.0000	5.0000	12.0000	17.0000	25.0000
PPE	0.2848	0.1769	0.0086	0.1483	0.2483	0.3890	0.7712
BS	2.1776	0.2016	1.6094	2.0794	2.1972	2.1972	2.7081
ROA	0.0438	0.0603	−0.2008	0.0140	0.0397	0.0743	0.2093
TQ	2.3424	1.5838	0.8589	1.3115	1.8450	2.7387	9.5260
PAY	14.3251	0.6849	12.6475	13.8724	14.3229	14.7378	16.2029
AC	0.0866	0.0559	0.0098	0.0486	0.0769	0.1107	0.3235
TOP1	36.7186	14.9442	9.2738	25.1135	35.5823	46.6457	76.5325
CFO	0.0601	0.0671	−0.1364	0.0199	0.0583	0.0991	0.2418
RET	−0.0057	0.4307	−0.7102	−0.3105	−0.0799	0.1984	1.6345
DUAL	0.2092	0.4068	0.0000	0.0000	0.0000	0.0000	1.0000
SOE	0.4884	0.4999	0.0000	0.0000	0.0000	1.0000	1.0000

Table 2
Comparison between the treatment and control groups.

Variables	Control group		Treatment group		Differences
	N	Mean	N	Mean	
SIZE	2,149	22.3842	2,149	22.3887	−0.0045
LEV	2,149	0.4385	2,149	0.4382	0.0002
GROWTH	2,149	0.1412	2,149	0.1540	−0.0128
CASH	2,149	0.1659	2,149	0.1658	0.0001
AGE	2,149	11.5565	2,149	11.3439	0.2127
PPE	2,149	0.2863	2,149	0.2833	0.0030
BS	2,149	2.1758	2,149	2.1795	−0.0037
ROA	2,149	0.0442	2,149	0.0434	0.0008
TQ	2,149	2.3302	2,149	2.3546	−0.0244
PAY	2,149	14.3274	2,149	14.3227	0.0048
AC	2,149	0.0868	2,149	0.0865	0.0003
TOP1	2,149	36.6667	2,149	36.7706	−0.1040
CFO	2,149	0.0603	2,149	0.0599	0.0003
RET	2,149	−0.0105	2,149	−0.0008	−0.0097
DUAL	2,149	0.2057	2,149	0.2127	−0.0070
SOE	2,149	0.4900	2,149	0.4867	0.0033

Notes: ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, respectively. We also use Chi-square (χ^2) tests to test the difference in DUAL and SOE between the control and treatment groups and find no significant difference.

4.3. Robustness tests

4.3.1. Parallel trend test

The difference-in-differences model assumes that there is no significant difference in the dependent variable between the treatment and control groups before policy implementation. We conduct parallel trend tests (Beck et al., 2010; Li et al., 2018), the results of which are shown in Table 4. *Disclosure Adoption^{-1}* (*Disclosure Adoption^{-2}*, *Disclosure Adoption^{-3}* and *Disclosure Adoption^{-4}*) represents the year before policy implementation (the first 2, 3 and 4 years, respectively); *Disclosure Adoption^0* represents the year of policy implementation; *Disclosure Adoption^1* (*Disclosure Adoption^2*, *Disclosure Adoption^3* and *Disclosure Adoption^4*) represents 1 year after the policy implementation (the next 2, 3 and 4 years, respectively). Table 4 shows that there is no significant difference in the level of R&D between the treatment and control groups before policy implementation, whereas there is a significant difference in the level of R&D between the treatment and control groups in the year after policy implementation. This indicates that the model satisfies the parallel trend.

4.3.2. Placebo test

Based on Liu and Lu (2015), we construct a pseudo-treatment group using the same sample observations as the actual-treatment group. We then generate pseudo-policy years for the pseudo-treatment group. *Disclosure* is defined as 1 for pseudo-treatment group observations in and after the pseudo-policy year, and 0 otherwise. We use the pseudo-variable *Disclosure* to conduct a simulated regression and repeat this process 200 times to determine the *t*-values and coefficient distributions obtained from the simulated regression. The results are shown in Fig. 1. As shown in Fig. 1, the *t*-values and coefficients of *Disclosure* follow a symmetric distribution with a mean value near 0. Moreover, the *t*-values and coefficients in the main results are not in the interval of random sampling, indicating that our results are not driven by chance.

4.3.3. Changing the measurement of the dependent variable

To ensure reliability of the results, we use alternative dependent variables. First, we use R&D investment scaled by total assets (*RD2*) to re-measure innovation investment (Liu et al., 2020); the result is shown in column (1) of Table 5. Second, we use the logarithm of R&D (*RD3*) to measure the dependent variable; the result is shown in column (2) of Table 5. The coefficients of *Disclosure* are significantly positive at the 5 % level, which is consistent with the previous results.

Table 3
The impact of operational information disclosure on R&D investment.

	RD
Disclosure	0.3038***
	(2.9947)
SIZE	0.3798***
	(2.8916)
LEV	−0.7405*
	(-1.6917)
GROWTH	−0.2073**
	(-2.3041)
CASH	−0.0353
	(-0.1017)
AGE	−0.0418
	(-0.2338)
PPE	0.6094*
	(1.6882)
BS	−0.0414
	(-0.1660)
ROA	0.2164
	(0.2604)
TQ	−0.0164
	(-0.4123)
PAY	0.1008
	(1.0203)
AC	15.1872***
	(7.6252)
TOP1	0.0101*
	(1.8075)
CFO	−0.5361
	(-1.2293)
RET	−0.0441
	(-0.7568)
DUAL	−0.1649
	(-1.4970)
SOE	0.1013
	(0.4707)
Constant	−9.8248***
	(-2.8252)
Firm FE	Yes
Year FE	Yes
N	4298
Within R^2	0.3482

Note: This table presents the baseline regression results. The dependent variable is research and development intensity (*RD*). The key independent variable is the disclosure of operational information (*Disclosure*). We also control for firm- and year-fixed effects. Detailed definitions of the variables are presented in Appendix B. The *t*-statistics reported in round brackets are based on standard errors clustered by firm. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.

5. Further analysis

5.1. Mechanism analysis

Next, we examine the mechanism through which the mandatory disclosure of operational information affects innovation investment. The previous theoretical analysis suggests that the mandatory operational infor-

Table 4
Parallel trend test.

	RD
Disclosure Adoption^{-4}	−0.0439
	(-0.3432)
Disclosure Adoption^{-3}	0.1159
	(0.7776)
Disclosure Adoption^{-2}	0.2121
	(1.3227)
Disclosure Adoption^{-1}	0.2051
	(1.2444)
Disclosure Adoption^{0}	0.4206**
	(2.2994)
Disclosure Adoption^{1}	0.3616*
	(1.8661)
Disclosure Adoption^{2}	0.4240**
	(2.0451)
Disclosure Adoption^{3}	0.6047***
	(2.7326)
Disclosure Adoption^{4}	0.5384**
	(2.0921)
Controls	Yes
Constant	−9.6935***
	(-2.7866)
Firm FE	Yes
Year FE	Yes
N	4298
Within R^2	0.3503

Note: This table presents the result of the parallel trend test. The dependent variable is research and development intensity (*RD*). The key independent variable is *Disclosure Adoption*. We also control for firm- and year-fixed effects. Detailed definitions of the variables are provided in Appendix B. The *t*-statistics reported in round brackets are based on standard errors clustered by firm. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.
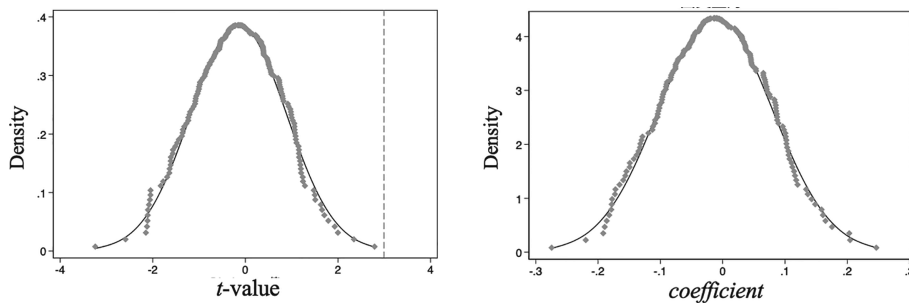
Fig. 1. **Placebo test results** Note: This figure shows the placebo test results. The left panel shows the *t*-value density, and the right panel shows the coefficient density.

mation disclosure prompts firms to increase innovation investment through mechanisms such as alleviating financing constraints, inhibiting large shareholders' tunneling behavior and avoiding market competition. We individually test these mechanisms as described below.

First, we test the alleviating financing constraints mechanism, i.e., operational information disclosure alleviates financing constraints and thus prompts firms to increase their innovation investment. If this mechanism indeed applies, then we expect operational disclosure to have a stronger impact on the innovation investment

Table 5
Changing the measurement of the dependent variable.

	(1)	(2)
	RD2	RD3
Disclosure	0.1669**	0.7414**
	(1.9990)	(2.2306)
SIZE	0.0622	0.9201**
	(0.6072)	(2.3817)
LEV	0.2366	−1.5395
	(0.8146)	(-1.3603)
GROWTH	0.5572***	−0.6909**
	(4.8631)	(-2.3928)
CASH	−0.2339	0.1999
	(-0.8458)	(0.1692)
AGE	−0.1378	−1.5609**
	(-0.6646)	(-2.4830)
PPE	0.3011	2.0801
	(1.0835)	(1.5606)
BS	−0.0248	0.2434
	(-0.1286)	(0.2839)
ROA	2.4277***	0.9813
	(3.5067)	(0.4038)
TQ	0.0184	−0.0034
	(0.7205)	(-0.0316)
PAY	0.0902	−0.0943
	(1.2521)	(-0.2955)
AC	4.6686***	9.1234**
	(4.5378)	(2.5420)
TOP1	0.0076	0.0178
	(1.3056)	(0.7995)
CFO	−0.4392	−1.7719
	(-1.1678)	(-1.1001)
RET	−0.0476	−0.1384
	(-0.9323)	(-0.6867)
DUAL	−0.0021	−0.3600
	(-0.0259)	(-1.1649)
SOE	0.0273	−0.0325
	(0.1598)	(-0.0578)
Constant	−2.2687	−7.5933
	(-0.7894)	(-0.7428)
Firm FE	Yes	Yes
Year FE	Yes	Yes
N	4298	4298
Within R^2	0.2088	0.5354

Note: This table presents the results of changing the dependent variable measurement. The dependent variable is research and development (RD2 and RD3). The key independent variable is the disclosure of operational information (Disclosure). We also control for firm- and year-fixed effects. Detailed definitions of the variables are provided in Appendix B. The t-statistics reported in round brackets are based on standard errors clustered by firm. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.

of firms with severe financing constraints than of firms with lenient financial constraints. We use the size-age (SA) index to measure the degree of financing constraints (Hadlock and Pierce, 2010; Lu and Zhang, 2014). The SA index is calculated as $-0.737 \times$ firm size $+ 0.043 \times$ firm size^2 $- 0.040 \times$ firm age, where firm size is calculated as the logarithm of total assets and firm age is calculated as the number of years since the establishment of the firm. SAdum is defined as 1 if the SA index is greater than the median in the same year and industry, and 0 otherwise. The variable Disclosure × SAdum is added to model (1). Column (1) of Table 6 shows that the coefficient of Disclosure × SAdum is significantly positive at the 10 % level, whereas the coefficient of Disclosure, although still positive, is not significant. This indicates that the mandatory disclosure of

Table 6
Mechanism analysis.

	(1)	(2)	(3)
	RD	RD	RD
Disclosure × *SAdum*	0.2284*		
	(1.7298)		
Disclosure × *abRPT*		0.3446**	
		(2.4162)	
Disclosure × *COMP*			0.7693***
			(4.2913)
Disclosure	0.1713	0.0240	−0.0171
	(1.5260)	(0.1937)	(-0.1858)
SAdum	0.2401*		
	(1.8346)		
abRPT		−0.0219	
		(-0.1488)	
Controls	Yes	Yes	Yes
Constant	−6.5367**	−11.1164**	−5.7284*
	(-2.0512)	(-2.2176)	(-1.8276)
Firm FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
N	4298	4298	4298
Within R^2	0.3535	0.4552	0.3585

Note: This table presents the mechanism analysis results. The dependent variable is research and development intensity (*RD*). The key independent variables are *Disclosure* × *SAdum*, *Disclosure* × *abRPT* and *Disclosure* × *COMP*. We also control for firm- and year-fixed effects. Detailed definitions of the variables are provided in Appendix B. The *t*-statistics reported in round brackets are based on standard errors clustered by firm. *, ** and *** denote statistical significance at the 10 %, 5 % and 1 % levels, respectively.

operational information increases R&D investment only for firms facing severe financing constraints, which supports the alleviating financing constraints mechanism.

Second, we test the inhibiting large shareholders' tunneling mechanism, i.e., operational information disclosure restricts large shareholders' tunneling behavior, and thus increases firms' innovation. If this mechanism indeed applies, then we expect operational disclosure to have a stronger impact on innovation in firms with large degrees of tunneling behavior than in firms with small degrees of tunneling behavior. We use the residuals of the model $RPT = \alpha_0 + \alpha_1 \times LEV + \alpha_2 \times SIZE + \alpha_3 \times MB + \sum \text{Industry} + \sum \text{Year} + \varepsilon$ to estimate the abnormal related-party transactions of firms (Jian and Wong, 2010; Zhang et al., 2016). *RPT* is defined as the sum of two types of related-party transactions (merchandise transactions and provision of labor services), scaled by total assets (Wei et al., 2013). *LEV* is the leverage ratio, *SIZE* is the logarithm of total assets and *MB* is the ratio of market value to book value. Based on these variables, we construct a dummy variable for the degree of abnormal related-party transactions (*abRPT*), which equals 1 if the degree of abnormal related-party transactions is greater than the median in the same year and industry, and 0 otherwise. Then, we add *abRPT* and *Disclosure* × *abRPT* to model (1). The results in column (2) of Table 7 show that the coefficient of *Disclosure* × *abRPT* is significantly positive at the 5 % level, whereas the coefficient of *Disclosure*, although still positive, is not significant. This indicates that the mandatory disclosure of operational information only promotes corporate innovation in companies with a large degree of tunneling behavior by major shareholders. This partially supports the inhibiting tunneling behavior by major shareholders mechanism.

Finally, we test the avoiding industry competition mechanism, i.e., the disclosure of operational information reduces the competitive advantage of firms and induces them to maintain competitive advantage by increasing investment in innovation. If this mechanism indeed applies, then we expect operational disclosure to have a stronger impact on innovation in highly competitive industries than in weakly competitive industries. To test this mechanism, we use the Herfindahl index to measure industry competition. As a lower Herfindahl index represents a more competitive market, *COMP* is defined as 1 if the Herfindahl index is less than the median in the same year, and 0 otherwise. Then, we add *Disclosure* × *COMP* to model (2). Column (3) of Table 7 shows that the coefficient of *Disclosure* × *COMP* is significantly positive at the 1 % level, whereas the coeffi-

Table 7
Cross-sectional analyses.

	(1)	(2)
	RD	RD
Disclosure × SOE	−0.4409**	
	(-2.4645)	
Disclosure × HT		0.8615***
		(5.7783)
Disclosure	0.5380***	−0.1975**
	(3.3221)	(-2.0377)
Controls	Yes	Yes
Constant	−9.2129***	−8.8914***
	(-2.7034)	(-2.6185)
Firm FE	Yes	Yes
Year FE	Yes	Yes
N	4298	4298
Within R^2	0.3509	0.3584

Note: This table presents the cross-sectional analysis results. The dependent variable is research and development (RD). The key independent variables are Disclosure × SOE and Disclosure × HT. We also control for firm- and year-fixed effects. Detailed definitions of the variables are provided in Appendix B. The t-statistics reported in round brackets are based on standard errors clustered by firm. *, ** and *** denote statistical significance at the 10 %, 5 % and 1 % levels, respectively.

cient of Disclosure, although still positive, is not significant. This indicates that the effect of operational disclosure on corporate innovation is only observed in highly competitive industries. This finding partially supports the avoiding industry competition mechanism.

5.2. Cross-sectional analyses

5.2.1. State ownership

We examine whether the main effect differs between SOEs and non-SOEs. Compared with SOEs, non-SOEs are more likely to invest in innovation following operational information disclosure for the following reasons: 1) private firms face more credit discrimination than SOEs (Liu et al., 2014), making the financing constraint alleviation effect of operational information disclosure more pronounced for non-SOEs than for SOEs and 2) non-SOEs mainly operate in highly competitive industries (Tong et al., 2014), implying that, relative to SOEs, non-SOEs are more likely to improve market competitiveness through innovation. Therefore, we expect the positive effect of operational information disclosure on innovation to be more pronounced for non-SOEs than for SOEs. The variable Disclosure × SOE is added to model (1); the result is shown in column (1) of Table 7. The coefficient of Disclosure × SOE is significantly negative at the 5 % level, implying that the effect is more significant and positive for non-SOEs than for SOEs.

5.2.2. High-tech industries

High-tech industries are knowledge- and technology-intensive, relying on high-quality innovation activities for survival amidst fierce market competition (Zucker and Darby, 2007). Therefore, compared with firms in non-high-tech industries, firms in high-tech industries are more likely to maintain their competitive advantage by increasing innovation. Based on this argument and the avoiding market competition hypothesis, we expect the main effect to be more pronounced for high-tech industries (HT) than for other industries. We define automobile manufacturing, pharmaceutical manufacturing, ferrous metal smelting and rolling processing, telecommunications, radio, television and satellite transmission services, chemical raw materials and chemical products manufacturing and non-ferrous metal smelting and rolling processing as high-tech industries (Peng and Mao, 2017). HT equals 1 if a firm operates in a high-tech industry, and 0 otherwise. The results in column (2) of Table 7 show that Disclosure × HT is significantly positive at the 1 % level. This result implies that the main effect is pronounced for high-tech industries.

5.3. Analysis of economic consequences

5.3.1. Improving competitive advantage

We construct the following model (2) to examine whether operational information disclosure has proprietary information characteristics, i.e., whether operational information disclosure significantly reduces the competitive advantage of firms.

$$GPM = \beta_0 + \beta_1 \times Disclosure + \beta_i \times \sum Controls + \gamma + \delta + \varepsilon \qquad (2)$$

Table 8
Economic consequences: improving competitive advantage.

	(1)	(2)
	GPM	*GPM*
Disclosure	−0.0085*	−0.0210***
	(-1.6757)	(-3.2596)
Disclosure × RD		0.0054***
		(2.7696)
RD	0.0044***	0.0031**
	(3.5033)	(2.4123)
SIZE	0.0001	−0.0010
	(0.0205)	(-0.1649)
LEV	−0.0280	−0.0265
	(-1.5509)	(-1.4755)
TOP10	0.0007***	0.0007***
	(2.9244)	(3.0499)
TQ	0.0012	0.0011
	(0.5999)	(0.5719)
SEP	−0.0005	−0.0005
	(-1.4736)	(-1.3668)
MSHARE	0.0272	0.0244
	(0.5894)	(0.5248)
TURN	−0.0819***	−0.0823***
	(-7.1356)	(-7.1633)
AGE	0.0196***	0.0185**
	(2.6418)	(2.4749)
CFO	0.1393***	0.1390***
	(5.8970)	(5.9143)
PPE	0.0155	0.0140
	(0.8008)	(0.7235)
ROA	0.7322***	0.7344***
	(13.0126)	(13.0982)
IC	−0.0000	−0.0000
	(-0.2835)	(-0.2769)
DUAL	0.0005	0.0005
	(0.0905)	(0.1037)
SOE	−0.0214*	−0.0205*
	(-1.8376)	(-1.7588)
Constant	0.1464	0.1756
	(1.0803)	(1.3025)
Firm FE	Yes	Yes
Year FE	Yes	Yes
N	4094	4094
Within R^2	0.3160	0.3196

Note: This table presents the economic consequences of improving competitive advantage. The dependent variable is gross profit margin (*GPM*). The key independent variables are *Disclosure* and *Disclosure × RD*. We also control for firm- and year-fixed effects. Detailed definitions of the variables are provided in Appendix B. The *t*-statistics reported in round brackets are based on standard errors clustered by firm. *, ** and *** denote statistical significance at the 10 %, 5 % and 1 % levels, respectively.

where *GPM* is the gross profit margin, which we use to measure the competitive advantage of firms. We control for the following variables (Li et al., 2018; Berger et al., 2019; Zhou, 2020): *RD*, *SIZE*, *LEV*, the percentage of shares held by the top 10 shareholders (*TOP10*), *TQ*, the separation ratio (*SEP*), the percentage of shares held by executives (*MSHARE*), the asset turnover ratio (*TURN*), *AGE*, *CFO*, *PPE*, *ROA*, the internal control index (*IC*), *DUAL* and *SOE*. In addition, we control for firm (γ) and year (δ) firm fixed effects. If operational information has the characteristics of proprietary information, then we expect the coefficient of *Disclosure*, i.e., β_1, to be significantly negative.

Column (1) of Table 8 reports the regression results of model (2). The coefficient of *Disclosure* is significantly negative at the 10 % level, indicating that the disclosure of operational information significantly reduces the gross profit margin and corroborating the proprietary information characteristic of operational information. As the previous analysis argues that firms maintain their competitive advantage by increasing innovation, we add *Disclosure* $\times$ *RD* to model (2); the results are shown in column (2). The coefficient of *Disclosure* $\times$ *RD* is significantly positive at the 1 % level, suggesting that although operational information disclosure signifi-

Table 9
Economic consequences: increasing innovation outputs.

	(1)	(2)	(3)
	$PAT1_{t+1}$	$PAT2_{t+1}$	$PAT3_{t+1}$
Disclosure	0.0324*	−0.0151	0.0165
	(1.7332)	(-1.1626)	(0.8480)
SIZE	0.0119	−0.0054	0.0178
	(0.6009)	(-0.5178)	(1.1173)
LEV	−0.0918	−0.0311	0.0023
	(-1.4246)	(-0.8158)	(0.0421)
GROWTH	−0.0062	−0.0046	0.0033
	(-0.3812)	(-0.5143)	(0.2136)
CASH	−0.1284*	−0.0452	−0.0135
	(-1.7851)	(-0.8399)	(-0.2091)
AGE	−0.0106	0.0032	−0.0028
	(-0.3032)	(0.1332)	(-0.0571)
PPE	−0.1674**	0.0617	0.1026
	(-2.2005)	(1.4593)	(1.4056)
BS	−0.0225	0.0113	−0.0349
	(-0.4243)	(0.3308)	(-0.7143)
ROA	−0.2911**	0.0280	0.3434***
	(-2.2462)	(0.3370)	(2.7728)
PAY	0.0124	−0.0041	0.0211
	(0.6706)	(-0.3395)	(1.2494)
TOP1	0.0003	0.0005	−0.0002
	(0.3601)	(0.6147)	(-0.2038)
CFO	0.1772*	−0.0494	0.0022
	(1.7145)	(-0.8472)	(0.0254)
DUAL	0.0040	0.0131	−0.0293
	(0.2095)	(1.1537)	(-1.5345)
SOE	0.0361	−0.0116	0.0346
	(1.0071)	(-0.3888)	(1.5172)
Constant	−0.0359	0.2401	−0.4389
	(-0.0716)	(0.7911)	(-0.8885)
Firm FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
N	4264	4264	4264
Within R^2	0.0261	0.0053	0.0202

Note: This table presents the economic consequences of improving competitive advantage. The dependent variables are different types of innovation outputs, and the key independent variable is *Disclosure*. We also control for firm- and year-fixed effects. Detailed definitions of the variables are provided in Appendix B. The *t*-statistics reported in round brackets are based on standard errors clustered by firm. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.

cantly reduces the gross profit margin, an increase in innovation investment can mitigate this negative effect. This result also supports the previous theoretical analysis.

5.3.2. Increasing innovation output

The previous analysis shows that operational information disclosure prompts firms to increase innovation inputs. Therefore, a natural follow-up question is whether it can also prompt firms to increase innovation outputs. Patents are classified into invention, utility model and design patents. Among these, invention patents best represent the quality of innovation and enhance the competitive advantage of firms. To this end, we examine the impact of operational information disclosure on the number of patent applications by firms. The results are shown in Table 9. Operational information disclosure significantly increases the number of applications for invention-type patents (*PAT1*), but not for utility model patents (*PAT2*) and design patents (*PAT3*) in the following year. This result indicates that operational information disclosure also increases the quality of firms' innovation outputs.

6. Conclusions

We examine the impact of mandatory information disclosure on firms' innovation inputs using a quasi-natural experiment in which the SSE mandates companies in selected industries to disclose operational information. We find that firms significantly increase the level of innovation inputs following the mandatory disclosure of operational information. Further analysis shows that this effect is pronounced for firms facing severe financing constraints, a high degree of tunneling behavior by large shareholders and intense industry competition, suggesting that the mandatory disclosure of operational information promotes corporate innovation through mechanisms such as the alleviation of financing constraints, inhibition of shareholder tunneling behaviors and avoidance of industry competition. Cross-sectional analyses shows that this effect is pronounced for non-SOEs and high-tech industries. Economic consequence analysis indicates that although the mandatory disclosure of operational information significantly reduces firms' competitive advantage, firms mitigate this negative effect by increasing innovation inputs. However, mandatory operational information disclosure significantly improves the quality of firms' innovation outputs, as evinced by the increase in the number of invention patent applications.

Guiding firms to enhance innovation is key to achieving high-quality development of the economy. Our findings have important implications. (1) When designing information disclosure policies, regulators should consider requiring firms to disclose proprietary information in a manner that motivates innovation. Although the disclosure of proprietary information can impose certain costs on firms, such disclosures also carry certain benefits and can themselves compensate for the incurred costs. In particular, the disclosure of proprietary information can alleviate the financing constraints of firms and provide them with sufficient funds to drive innovation, thus improving their competitive advantages. Therefore, regulators should consider enriching the types of information disclosed by firms when issuing information disclosure guidelines. (2) Firms should improve their corporate governance to support efficient operation. In the Chinese capital market, it is not uncommon for major shareholders to harm the interests of small and medium-sized shareholders through related-party transactions and other actions. However, such agency problems encroach on firms' resources and impede normal firm operations, which is not conducive to long-term development. Therefore, firms should continuously improve their corporate governance mechanisms and strengthen their internal control systems to address agency problems. This will provide strong support for efficient, long-term operations and contribute to the high-quality development of economy. (3) Banks should consider providing effective financial support for firms. Innovation is an important source of competitive advantage for firms, but its high-risk nature implies a requirement for sufficient cash flow support. Chinese firms have been grappling with the issue of difficult financing for a long time. To address this and boost innovation by firms, the government, banks, and other relevant departments should provide strong financial guarantees. The government can motivate firms to innovate through tax incentives and subsidies and can provide strong financial support for firms to carry out innovation. Banks should make full use of the information available on firms and consider their potential when funding innovation activities.

Our study has some limitations. The scenario we examine does not represent a fully randomized trial and the firms in the treatment and control groups are not fully comparable. Although we take several measures to mitigate the possible endogeneity problem, such as controlling firm fixed effects, conducting parallel trend tests, and adopting propensity score matching, it cannot be completely ruled out. The reliability of our conclusions could be retested in the future using a more suitable randomized scenario.

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.

Acknowledgments

Appendix A. Timeline of industry disclosure guidelines

SSE Industry Name	Implementation Year	SZSE Industry Name	Implementation Year
Real estate industry (K70)	2015	Real estate industry (K70)	2015
Coal mining and washing industry (B06)	2015	Agriculture, forestry and fishery (A)	2015
Electricity, heat production and supply industry (D44)	2015	Coal mining and washing industry (B06)	2015
Retail industry (F52)	2015	Building decoration and other construction industry (E50)	2016
Automobile manufacturing (C36)	2015	Civil engineering construction industry (E48)	2017
Pharmaceutical manufacturing (C27)	2015	Retail industry (F52)	2017
Oil and gas extraction industry (B07)	2015	Postal industry (G60)	2017
Ferrous metal smelting and rolling processing industry (C31)	2015	Software and Information Technology Services (I65)	2018
Housing construction (E47)	2015	Telecommunications, radio and television and satellite transmission services in *GEM* (I63)	2013
Civil engineering construction industry (E48)	2015	Pharmaceutical manufacturing in *GEM* (C27)	2013
Construction and installation (E49)	2015	Ecological protection and environmental management industry in *GEM* (N77)	2015
Building decoration and other construction industry (E50)	2015	Internet and related services in *GEM* (I64)	2015
Textile, clothing and apparel industry (C18)	2015		

(*continued*)

SSE Industry Name	Implementation Year	SZSE Industry Name	Implementation Year
News and publishing industry (R85)	2015		
Alcohol, beverage and refined tea manufacturing (C15)	2016		
Telecommunications, radio and television and satellite transmission services (I63)	2016		
Ecological protection and environmental management industry (N77)	2016		
Water production and supply industry (D46)	2016		
Chemical raw materials and chemical products manufacturing (C26)	2016		
Air transportation industry (G56)	2016		
Agriculture, forestry and fishery (A)	2016		
Railroad, ship, aerospace and other transportation equipment manufacturing (C37)	2018		
Food manufacturing (C14)	2018		
Radio, television, film and video recording production industry (R86)	2018		
Furniture manufacturing (C21)	2018		
Non-ferrous metal smelting and rolling processing industry (C32)	2018		

Note: 1. Both the SSE and SZSE require six industries, namely, agriculture, forestry, animal husbandry and fishery (A), coal mining and washing (B06), civil engineering and construction (E48), building decoration and other construction (E50), retail trade (F52) and real estate (K70), to disclose operational (or business) information. Therefore, these six industries are excluded from our sample. The SSE and SZSE *GEM* require three industries, namely, pharmaceutical manufacturing (C27), telecommunications, radio, television and satellite transmission services (I63) and ecological protection and environmental management (N77), to disclose operational (or business) information. Therefore, the SZSE *gEM*-listed companies operating in these three industries are also excluded from our sample.

2. The SSE issued the *Memorandum on Daily Disclosure of Information by Listed Companies - No. 12 Disclosure of Operational Information by Industry of Listed Companies* on 26 December 2013, which includes the real estate (K70), oil and gas extraction (B07) and coal mining and washing (B06) industries. However, these industries did not disclose operating information in their annual reports in 2013 and 2014, but did so uniformly from 2015 onwards. Our sample does not include the real estate (K70) and oil and gas extraction industry (B07), and the conclusion holds after the coal mining and washing (B06) sample is excluded as well.

3. Although the SZSE has issued several information disclosure guidelines based on business types, some of the guidelines cannot be traced to specific industries. Such guidelines are not presented in the table.

Appendix B. Variable definitions

Variable	Definition
RD	R&D investment scaled by sales and multiplied by 100.
Disclosure	A dummy variable that equals 1 if the listed companies on the SSE in this industry compulsorily disclose operational information, and 0 otherwise. For example, if the company listed on the SSE and in the wine, beverage and refined tea manufacturing (C15) industry started compulsorily disclosing operational information in 2016, then *Disclosure* for the listed companies on the SSE in this industry since the year after 2016 (inclusive) equals 1; *Disclosure* equals 0 for the years before 2016. For companies listed on the SZSE in this industry, *Disclosure* always equals 0.
SIZE	The natural logarithm of total assets.
LEV	The ratio of total liabilities to total assets.
GROWTH	The change in sales revenue divided by sales at the beginning of the year.
CASH	The ratio of cash assets to total assets.
AGE	The number of years since the firm was listed.
PPE	The ratio of fixed assets to total assets.
BS	The natural logarithm of the number of board members.
ROA	Return on assets, calculated as the ratio of net income to total assets.
PAY	The natural logarithm of the total salary of the top three executives.
AC	Agency cost, calculated as management fee scaled by sales.
TOP1	The ratio of the number of shares held by top shareholders to the total number of shares, multiplied by 100
CFO	The ratio of operating cash flow to total assets.
TQ	Tobin's Q.
RET	Annual stock return.
DUAL	A dummy variable that equals 1 if the chair of the board is also the CEO, and 0 otherwise.
SOE	A dummy variable that equals 1 if the firm is state-owned, and 0 otherwise.
SAdum	A dummy variable that equals 1 if the financing constraint of the firm is above the sample median in the same industry and year, and 0 otherwise. Financing constraint equals $-0.737 \times SIZE + 0.043 \times SIZE^2 - 0.040 \times AGE1$, where *AGE1* equals the number of years since the firm was founded.
abRPT	A dummy variable that equals 1 if the abnormal related-party transactions of the firm are above the median in the same industry and year, and 0 otherwise. $RPT = \alpha_0 + \alpha_1 \times LEV + \alpha_2 \times SIZE + \alpha_3 \times MB + \sum Industry + \sum Year + \varepsilon$(Jiang and Wong, 2010; Zhang et al., 2016). *RPT* equals the ratio of the sum of commodity transactions and provision of services to total assets (Wei et al., 2013). *MB* equals the ratio of market value to book value.
COMP	A dummy variable that equals 1 if the industry's Herfindahl index is below the median in the same year, and 0 otherwise.
HT	A dummy variable that equals 1 if the firm operates in a high-tech industry, and 0 otherwise.
GPM	Gross profit margin, calculated as operating revenue minus operating cost and scaled by operating revenue.
PAT1	Innovation quality, calculated as the ratio of invention patents to total patents.
PAT2	The ratio of utility patents to total patents.
PAT3	The ratio of design patents to total patents.

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Confucian culture and the external pay gap

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ABSTRACT

We examine the impact of Confucian philosophy on external pay gaps, and find that a Confucianist atmosphere is negatively associated with firms' external pay gaps for both executives and employees. Mechanistically, the Confucian concept of "righteousness" reduces the self-interested motivation of management, in turn reducing executives' external pay gap; "humaneness" causes management to focus on protecting employees' rights and interests, benefiting employees' compensation; and "honesty" improves information disclosure, reducing the external compensation gap for both executives and general employees. The inhibitory effect of Confucian culture on the external pay gap is greater in regions with weak formal institutions and non-state-owned firms, while foreign cultural shocks attenuate the Confucian influence. Finally, the Confucian culture-driven reduction of the external pay gap improves enterprises' economic efficiency.

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1. Introduction

Shared prosperity is the essential requirement and fundamental principle of socialism with Chinese characteristics. It is also an important measure of the extent to which Chinese society resolves major social contradictions and achieves balanced development in the new era. Solving the structural problems of income distribution and narrowing the income gap are necessary conditions for modern China to advance shared prosperity. In the micro-sector, enterprises, as the ultimate source of the macroscale income distribution, exhibit a continually widening pay gap, which has become emblematic of income distribution inequality in China (Fang and Li, 2015). In particular, as the external pay gap between similar companies continues to deviate from a reasonable level, it exacerbates employees' sense of unfairness and undermines the effectiveness of

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pay agreements (Li et al., 2014; Xu and Tan, 2014). Therefore, to promote shared prosperity, it is necessary to clarify the factors influencing the external pay gap and optimize the income distribution system accordingly.

Rosen (1986), in a classic experiment, finds that a reasonable pay gap facilitates the competitive motivation of individuals in an organization and improves organizational performance. However, in terms of the external pay gap, the positive incentive effect requires a mature managerial market mechanism as a precondition to ensure the mobility of personnel within comparable groups (Li et al., 2014). According to social comparison theory, employees are more likely to make horizontal comparisons between similar positions in the same group of companies than vertical comparisons between different positions within the company (Major and Forcey, 1985). The inequity generated by an excessive external pay gap has a significant negative impact on business efficiency, economic development and even social stability (Festinger, 1954; Akerlof and Yellen, 1988). In fact, China's executive market has long been considered inefficient (Li, 2003; Chen and Fang, 2020), and some corporate compensation systems are highly disorderly, prompting employees to focus closely on the external fairness of pay. In view of the large external pay gap in China, research into the problem of adjusting enterprises' external pay structure to ensure stable economic and social development is of considerable academic and practical interest. In recent years, with the increasing importance of the external pay gap, scholars have begun to explore its economic consequences from the perspective of enterprise performance (Wu et al., 2010; Li et al., 2014; Fang and Li, 2015). However, the literature mostly lacks discussion of the causes and influencing factors of the external pay gap, especially from a cultural perspective. Moreover, China still has a transitional economy, and in the absence of a perfect legal system, the country's deep-seated cultural heritage plays an important role in economic and social development (Allen et al., 2005; Chen et al., 2013). Therefore, we attempt to use Confucian culture as a lens to view the impact of cultural factors on the external pay gap.

Since its founding by Confucius during the *Spring and Autumn Period*, Confucianism has experienced periods of prosperity, such as under Emperor Wu of the Han Dynasty, who exhorted subjects to "ban the other hundred schools of thought and venerate Confucianism only," and periods of decline, such as under Emperor Qin Shi Huang, who sought to "burn books and ban Confucianism." Despite the impact of Buddhism, Taoism and other religions, as well as Western cultures, Confucianism, with the three Principles and five Constants (*San gang wu chang*, 三纲五常) at its core, has been passed down from generation to generation. Confucianism continues to guide social interactions and economic practices and has increasingly become a standard ethic that people "use every day but do not know" (Jin et al., 2017). "Businessmen paying more attention to Confucianism" (*Jia er hao ru*, 贾而好儒) gradually developed into a characteristic of traditional Chinese commercial culture, and the five Constants (*Wu chang*, 五常) of humaneness (*Ren*, 仁), righteousness (*Yi*, 义), propriety (*Li*, 礼), wisdom (*Zhi*, 智) and honesty (*Xin*, 信) provided the "life force" supporting ancient commercial prosperity (Bian, 2017). Today, scholars hold opposing views on the influence of Confucianism on economic development. A branch of the literature based on the ethical values advocated by Confucianism, such as righteousness and moderatism (*Zhong yong*, 中庸), argues that Confucian culture has a positive effect on economic development. For example, in the field of corporate governance, Confucian culture has been found to alleviate agency problems (Du, 2015; Gu, 2015), improve the quality of internal control (Cheng et al., 2016), promote innovation (Xu and Li, 2019), lower the stock price crash risk (Xu et al., 2020) and inhibit executives' incentives for perk consumption (Pan et al., 2020). However, another stream of studies emphasizes that some aspects of Confucian culture, such as hierarchy and risk aversion, can affect communication efficiency, suppress personality development (Chen, 2007) and reduce the level of corporate risk-taking (Li et al., 2013; Jin et al., 2017). It is thus clear that the literature offers no consensus on the economic effects of Confucian culture.

In addition, the design of effective compensation incentives has become a core issue in the field of corporate governance, and there has long been widespread attention to the link between Confucian culture and the corporate compensation gap. Chen et al. (2020) find that companies influenced by Confucian culture uphold the "doctrine of the mean" (*Jun ping*, 均平) in their internal wealth distribution, which significantly reduces the pay gap between executives and employees. Jin et al. (2022) find that the concept of moderatism embedded in Confucian culture helps to restrain unreasonable executive compensation, which in turn reduces the pay gap among executives as a group. However, Rao et al. (2022) argue that the Confucian concept of hierarchy plays a dominant role in corporate compensation arrangements, and that the pay gap for executives and

employees is larger in regions with a stronger Confucian culture atmosphere. It is important to distinguish between the two main types of pay gap: internal and external.[1] The above studies are based on an internal pay gap perspective and thus ignore the role of reference frames in contract design and their intervention effects on employees' subjective psychological perceptions and behavioral choices. In contrast, the external pay gap reflects the dynamic comparison of different firms within comparable groups, emphasizing the external fairness of salary distribution. Second, because the external and internal pay gaps have different connotations and causes, the mechanisms by which Confucian culture affects them are also different. In contrast to the existing literature based on a single dimension of Confucian culture, such as the doctrine of the mean, moderatism or the concept of hierarchy, we start from the cultural connotation of Confucianism and systematically consider the three Principles and five Constants. Based on the research framework "causes of external pay gap—Confucian culture—salary reference benchmark," we compare the characteristics of the external pay gap for executives and employees, and examine the effect of Confucian culture (considering its internal logic) on enterprises' external pay gap under the theoretical framework of institutions and contracts.

Specifically, using a sample of 29,793 firm-year observations from the Chinese stock market for the 2007–2020 period, we take the number of Confucian temples within a radius of 200 km from a listed firm's registered address as a proxy variable for Confucian cultural atmosphere in the firm, drawing on the methods of Du (2015), Gu (2015) and Jin et al. (2017). We provide strong and consistent evidence that Confucian culture can reduce the external pay gap of firms, and our finding holds after a series of robustness tests. We find that the different values embedded in Confucian culture have distinct effects on the external pay gap for executives and general employees. Righteousness, as advocated by Confucianism, can reduce management's self-interested motivation, while humaneness can improve the protection of employees' rights; these values thus have a dampening effect on the external pay gaps of executives and employees, respectively. Honesty in Confucian culture is conducive to improving firms' information disclosure quality, which has an impact on the compensation arrangements of both executives and employees. A heterogeneity analysis shows that Confucian culture and the formal legal institutions and market environment are substitutes for each other in reducing the external pay gap. Foreign cultural shocks weaken the inhibitory effect of Confucianism on the external pay gap. In addition, the inhibitory effect of Confucian culture on the external pay gap is more pronounced in non-state-owned firms than in state-owned firms. Finally, we further examine the effect of a relatively small external pay gap on economic efficiency in firms that are highly influenced by Confucian culture. We find that a Confucian culture-driven reduction in the external pay gap improves business performance.

Our contributions are as follows. First, how to reduce the income gap has become a key issue of widespread concern in practice and academia. According to the basic idea of institutional economics, the institutional environment is an important factor influencing enterprises' behavioral decisions. This study, taking Confucian culture as an entry point, focuses on the practical role of informal institutions in pay distribution fairness, making a contribution to the literature on the factors influencing firms' external compensation gap. Second, the literature mostly addresses the influence of Confucian culture on internal pay disparities; it tends to neglect the significant role of reference frames in the design of compensation contracts and fails to comprehensively and systematically reflect the channels through which Confucian culture influences pay distribution equity. Starting from the characteristics and causes of the external compensation gap, we reveal the effects and mechanisms of the different ideals advocated by Confucian culture on the external pay gap, further deepening the theoretical understanding of the economic effects of Confucianism. Our study contributes empirical evidence on the effects of Confucian culture to the growing literature on the intersectional field of culture and economic development. Third, the finding of different causes of the external pay gaps for executives and employees implies that the external pay gap cannot be leveled in any simple way. Distinguishing between the external pay gaps of executives and employees, we discuss in depth the asymmetric role of different Confucian ideals on the external compensation gaps for executives and employees in Confucian cultures. We also analyze the heterogeneity of the impact of Confucian culture on enterprises' external pay gap under specific circumstances. This not only extends the research perspective on the external pay gap but also elucidates the internal logic of

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[1] The former refers to vertical pay gaps between different ranks within the same company (executive–employee pay gap) or horizontal pay gaps within the same rank (executive internal pay gap, employee internal pay gap), while the latter refers to the average pay gap between companies within a comparison group.

Confucian culture's influence on enterprise compensation contracts. Fourth, this study provides empirical evidence on whether shared prosperity and economic efficiency are compatible. The modernization-oriented shared prosperity in the new era emphasizes both fairness and efficiency; that is, efforts to ensure the reasonable distribution of the socialist "cake" should not result in the cake becoming ever smaller. Therefore, while studying the impact of Confucian culture on enterprises' external pay gap, we further focus on the impact of narrowing the pay gap on economic efficiency under the influence of Confucian culture, providing a robust reference for balancing shared prosperity and economic efficiency.

2. Theoretical analysis and hypothesis development

2.1. Causes of the external pay gap

To explore the factors influencing the external pay gap, we first need to understand the reasons for its formation. Considering that management and ordinary employees assume different functions in enterprises' production and operation activities, their respective positions and the importance of the duties they hold differ. Therefore, we discuss the causes of the external pay gap for executives and employees, respectively. According to the characteristics of subjects at different levels in enterprises, we explore the asymmetric effect of the Confucian cultural connotation on both executives and employees.

Regarding executives' external compensation gap, when the external market for managers is well developed and executives' talent levels are not effectively matched with their salaries, companies tend to offer competitive compensation to attract or retain outstanding executives (Bizjak et al., 2011; Li et al., 2014). When personnel mobility is restricted and executives cannot obtain greater compensation through market mechanisms, companies control the total amount of executive compensation based on a reference benchmark, aiming to keep it lower than the industry average to minimize expenditure. Therefore, in a dynamic comparison of compensation among enterprises, personnel mobility alters the direction of firms' compensation incentives relative to a reference benchmark. This gives prominence to the long-tail effect of the executive compensation distribution within the comparison group, which leads to the continual widening of the external compensation gap (Hayes and Schaefer, 2009). In addition, executives, as agents of funders, are the decision-makers and managers of companies' operations who can use their power to exert significant influence on compensation contracts. Bizjak et al. (2011) find that when corporate governance is inefficient, executives have an incentive to seek higher salaries that exceed their ability and effort, which in turn leads to executive compensation that is out of line with industry norms. Notably, the disclosure system for executive compensation information in China is relatively lax: except for the actual amount of compensation, the disclosure requirements for specific details of compensation settings (e.g., the proportions of fixed and variable compensation, performance criteria for variable compensation and the basis for selecting performance appraisals) are limited. A lenient compensation disclosure policy makes it easier for executives to disguise their true compensation, avoiding the additional "cost of outrage" when executive compensation deviates excessively from the benchmark, and further exacerbating the external compensation gap for executives (Quan et al., 2010; Perry and Zenner, 2001).

Regarding the external compensation gap for ordinary employees, unlike executives, who have greater voice and authority, ordinary employees do not have autonomy in the process of corporate operation, investment and financing decisions or personnel appointments and dismissals. They are more likely to perform "mechanical" work with strong substitutability as directed by management, which usually places employees in a weak position in salary negotiations; thus, they are passive recipients of salary proposals (Fang, 2011). Moreover, throughout China's development, economic policies have mostly served to achieve macroeconomic indicators of sustained growth, while neglecting the institutional constraints of labor rights protection (Li and Qi, 2011). Therefore, when employees' bargaining power is low, the company prioritizes shareholders' value and ignores the reference benchmark of the comparison group when formulating the salary allocation policy, giving rise to a larger external compensation gap for employees.

2.2. Confucian culture and the external pay gap

Since 2006, the U.S. Securities and Exchange Commission has mandated public companies to disclose compensation benchmarks to discourage unreasonable company-set compensation packages (Faulkender and Yang, 2010). Unlike the U.S. and other Western countries, China does not have mandatory disclosure requirements. However, although Chinese listed companies generally do not voluntarily announce compensation reference benchmarks and reference targets, some studies verify that compensation setting in China also exhibits a cohort effect (Jiang, 2010; Zhao, 2016). Zhao (2016) finds that the cohort effect of compensation setting in China is more significant in listed companies with external CEOs, suggesting that it may be a compensation for the higher career risk of external CEOs. From corporate governance perspective, Liang et al. (2019) show that director linkage reinforces the importance of benchmarking in executive salary policy setting and that compensation formulations tend to be similar among director-linked firms. When further embedded in the Chinese social context, related studies may lead to new interpretations with more Chinese characteristics. According to North's (1990) institutional theoretical framework, institutions can be divided into formal and informal institutions, which together shape rules to guide and constrain individual behavior. Culture, as the first level of an informal institution, affects the allocation of social resources by shaping the behavioral philosophy and value judgments of social groups (Williamson, 2000). Thus, we analyze the effect and mechanism of Confucian culture on the external pay gaps for executives and employees.

2.2.1. Narrowing of external pay gap

Righteousness in Confucian culture emphasizes the distinction of right from wrong. Executives whose behavior is guided by righteousness pursue their own wealth on the premise of respecting others' interests, which restrains them from manipulating their performance through earnings management or other means to increase their own compensation. However, the effect of executive righteousness on the external salary gap for employees is relatively limited. Management power theory suggests that when there are limited constraints or supervisory mechanisms, managers in powerful positions have an incentive to use their decision-making power over business activities to engage in rent-seeking activities and thus obtain higher compensation than the industry benchmark (Bebchuk and Fried, 2002). This adjustment of compensation contracts through executive power infringes on the interests of lower-level employees and increases the costs to the company well beyond the incremental value of the executives, which negatively affects firms' development in the long run (Fang, 2011). Confucianism advocates that "Righteousness comes first, not money (*Yi yi zhi shang*, 以义之上)"; according to Confucius, "A gentleman makes money in a proper way (君子爱财, 取之有道)" (Aphorisms from the Ancient Chinese) and "A gentleman is righteous while a villain is profitable (君子喻于义, 小人喻于利)" (Analects 4:16), sayings that convey the idea of strict self-discipline. Therefore, in companies that are strongly influenced by Confucian culture, executives are forced by the moral pressure of Confucian culture to refrain from opportunistic rent-seeking behavior in abuse of their authority to avoid their self-interested behavior being negatively evaluated by the managerial market and affecting their personal reputation and career development. Moreover, Confucian culture emphasizes the self-disciplined ideals of "cultivating the moral self" (*Xiu shen*, 修身) and "being prudent" (*Shen du*, 慎独). Even in the absence of external supervision, executives can restrain their own behavior and align their business management with the principle of "Righteousness comes first, not money" (*Yi yi zhi shang*, 以义至上). Employees, in contrast, are relatively passive recipients of compensation, and their ability to influence their own compensation arrangements through self-regulating behavior is more limited. Therefore, we consider that righteousness is more likely to be reflected in the reduction of the external pay gap for executives than for employees.

Second, the idea of humaneness in Confucianism advocates paying attention to the protection of the rights and interests of the weak and cultivating fairness, which is reflected in the reduction of the external pay gap for employees. Fang (2011) points out those employees in disadvantaged positions generally remain rationally indifferent to their own pay arrangements. When companies fail to protect employees' rights and interests and instead are bent on squeezing the surplus value from them, this leads to unfair social distribution and aggravates the gap between the rich and the poor. Humaneness implies "loving others" and "good human relations," which are the highest values and ethical imperatives of Confucianism. Sayings such as "Love all and be kind (泛爱众, 而亲仁)" (Analects 1:6) and "Do not do unto others what you would not have them

do unto you (己所不欲, 勿施于人)" (Analects 12:2) emphasize mutual care and support among people to create a harmonious social atmosphere. Although Chinese government regulators have introduced many policies and programs to protect the rights and interests of ordinary employees, such systems are often derided as "pie in the sky" due to the unequal status of executives and employees (Fang, 2011). However, under the influence of the humaneness ideal in Confucian culture, companies are guided to meet the core needs of lower-level employees with equality and respect, for example by taking account of the average salaries paid by comparable enterprises during the compensation setting process, thus reducing the external salary gap for employees and improving the perception of fairness among employees in intra-industry companies.

Lastly, honesty in Confucian culture helps to reduce the information asymmetry between a company and the capital market, increase firms' transparency and urge them to focus on compensation benchmarks and thus reduce the external pay gap. Wang and Zhang (2009) find that when accounting information is noisy or distorted, it is difficult for firms to monitor management behavior and evaluate management's levels of effort, and unreasonable compensation contracts are a common outcome. However, in the words of Confucius, "I do not know how a man without truthfulness is to get on (人而无信, 不知其可也)" (Analects 2:22) and "If the people have no faith in their rulers, there is no standing for the state (民无信不立)" (Analects 12:7), sayings that emphasize consistency between words and deeds. In the context of enterprises, honesty in Confucian culture is conducive to improving the truthfulness and integrity of corporate information disclosure, alleviating information asymmetry between enterprises and the capital market and thereby restraining corporate insider decision-making (Bushman and Smith, 2003; Cheng et al., 2016). Regarding the external pay gap, the Confucian cultural embeddedness of honesty can increase the transparency of compensation information. The truthful disclosure of compensation information motivates companies to adjust executive salaries to a reasonable level, in line with the benchmark under external public scrutiny (Perry and Zenner, 2001). Moreover, the reduction in the level of information asymmetry also makes salary arrangements between firms in the same group more transparent. Employees are more inclined to self-evaluate by comparing their salary with peer-group subjects and thus form fairness perceptions (Ambrose et al., 1991). To prevent employees from withholding productivity due to a sense of unfairness, or even resorting to petitions and arbitration to vent their emotions, firms can bring employee compensation closer to industry benchmarks, ultimately reducing the external pay gap for employees. Based on the above analysis, we propose the following hypothesis on the role of Confucian culture in the external pay gap:

Hypothesis 1a: Confucian culture can narrow the external pay gap.

2.2.2. Widening of external pay gap

The concept of hierarchy in Confucian culture, by contrast, may have a widening effect on the external pay gap. Confucianism contains the idea of "the supremacy of monarchic authority" (君权至上、权威至上), which emphasizes the orderliness brought about by subordination and absolute obedience to superiors. For example, the sayings "A gentleman has three fears: the fear of heaven's will, the fear of a highly respected sovereign, and the fear of sages' words (君子有三畏, 畏天命, 畏大人, 畏圣人之言)" (Analects 16:8) and "A man who does not respect his parents and emperor is like a beast or a wolf (无父无君, 是禽兽也)" (Mencius 6:9) both emphasize that one should have respect for authority. Chen (2013) finds that authoritarianism in companies makes employees blind to problems or afraid to raise attention to them. The Confucian cultural concept of hierarchy fosters acceptance of unequal power distribution among members of society. In companies, it makes employees more sensitive to hierarchy and more inclined to suppress their own needs (Chow et al., 1999). Thus, the emphasis on hierarchy in Confucian culture reduces the probability of employees challenging or rebelling against companies for setting unreasonable compensation contracts. Firms are therefore more likely to set compensation that maximizes shareholders' equity, thus ignoring the reference benchmark, which in turn widens the external compensation gap. Based on the above analysis, we propose the following hypothesis on the role of Confucian culture in the external pay gap:

Hypothesis 1b: Confucian culture can widen the external pay gap.

3. Research design

3.1. Sample and data

We take Shanghai and Shenzhen A-share listed firms in China from 2007 to 2020 as our initial research sample, and screen this sample using the following exclusion criteria: (1) companies in the financial sector; (2) special treatment(ST, *ST and PT)companies; (3) companies with missing financial data; (4) companies with gearing ratios greater than 1; (5) companies that have been listed for less than one year; and (6) companies whose average compensation is less than 0. Our final sample consists of 29,793 firm-year observations. Data on Confucian culture are collected from the Chinese Research Data Services Platform (CNRDS) database. We compare and supplement the data according to the Chinese Confucian Temple Directory. Other financial data are collected from the China Stock Market and Accounting Research(CSMAR) database. Data on provincial GDP per capita are obtained from the National Bureau of Statistics, and the numbers of double first-class universities in each province are obtained from the website of the Ministry of Education. In addition, we winsorize all continuous variables at the 1st and 99th percentiles to reduce the influence of outliers. Standard errors are corrected for White's heteroskedasticity and adjusted for firm-level clustering to mitigate the heteroskedasticity and autocorrelation bias.

3.2. Model specification and variable definitions

Following Du (2015), Li et al. (2014) and Jin et al. (2017), we establish regression model (1) to test the effect of Confucian culture on the external pay gap.

$$Gap_{it} = \alpha_0 + \alpha_1 Confu\_200_{it} + \sum \alpha Control_{it} + Year + Industry + \varepsilon_{it} \qquad (1)$$

The dependent variable *Gap* is the external pay gap, including the corporate pay gap (*Wgap_external*), the executive pay gap (*Egap_external*) and the employee pay gap (*Sgap_external*). First, we follow the methods of Kong et al. (2017) and Peng et al. (2020) to calculate the average corporate compensation (*AVECOM*),[2]average executive compensation (*EXECOM*)[3]and average employee compensation (*EMPCOM*).[4] Second, referring to the metric of Li et al. (2014), we calculate *AVECOM*, *EXECOM* and *EMPCOM* based on the same year, same industry and same corporate ownership. Finally, the external compensation gaps are defined as the ratios of *AVECOM*, *EXECOM* and *EMPCOM* to the industry pay averages.

The independent variable *Confu_200* measures Confucian cultural atmosphere in companies. Drawing on Gu (2015) and Jin et al. (2017), we adopt a distance model and use the number of Confucian temples within a radius of 200 km from a company's registered address as a measure of Confucian cultural influence. Specifically, we calculate the spherical distance between the listed company's registered office and the existing Confucian temples based on their latitudinal and longitudinal coordinates, and count the number of Confucian temples within 200 km from the company. This measure is converted to the natural logarithm of 1 plus the number of Confucian temples. In a robustness test, according to the ancient records of Mencius' path to spread Confucianism up to 300 km (Gu, 2015), we also calculate the number of Confucian temples within a radius of 300 km from a company's registered address as a proxy variable for the impact of Confucian culture. Then, given that the Confucian temples were built a century ago and many have been destroyed through dynastic changes and wars, the use of data solely from existing Confucian temples is prone to measurement errors. North (1981) pointed out that culture and education are inherited. *Jinshi* are important intermediaries for the transmission of Confucian culture. Therefore, referring to Pan et al. (2020), we also calculate the num-

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[2] *AVECOM* is equal to the ratio of the current year to prior year change in compensation payable to employees plus the cash paid to employees in the financial report to the number of employees (excluding unpaid directors, supervisors and executives).

[3] *EXECOM* is equal to the total annual compensation of directors, supervisors and executives of listed companies (excluding independent directors and independent supervisors), divided by the number of executives (excluding independent directors and unpaid directors, supervisors and executives).

[4] *EMPCOM* is equal to the ratio of the current year to the prior year change in compensation payable to employees plus the cash paid to employees in the financial report (minus the total annual salary of directors, supervisors and executives) to the number of employees.

ber of *Jinshi* in the Ming and Qing dynasties within 300 km of the listed company's registered address as a proxy for Confucian cultural atmosphere. Finally, in another robustness test, we consider the influence of the personal value orientation of CEOs and chairmen, who have the greatest say over corporate compensation, using the number of Confucian temples within 300 km of the birthplace of CEOs and chairmen to measure Confucian cultural atmosphere.

Control is a firm-level and region-level characteristic variable. The firm-level control variables are firm size (*Size*), firm leverage (*Lev*), return on assets (*Roa*), total asset turnover (*Aturn*), shareholding ratio of top 10 shareholders (*Top10*), size of executive shareholding (*Mshr*), state ownership (*Soe*), firm age (*Age*) and proportion of independent directors (*IDratio*). The region-level control variables are regional economic development (*AveGDP*) and the level of education (*University*). In addition, we control for year (*Year*) and industry (*Industry*) fixed effects. The definitions of the variables are provided in Appendix A.

4. Empirical results

4.1. Descriptive statistics

The descriptive statistics of the main variables are shown in Table 1. We first discuss the dependent variables. The smallest value of the corporate external pay gap (*Wgap_external*) is 0.313, indicating that there are companies in the sample whose average pay is much lower than the industry benchmark. The maximum value of *Wgap_external* is 2.793, indicating that there are companies in the sample with average compensation close to three times the industry average. For the executive external pay gap (*Egap_external*), while the overall average is close to the industry average, the minimum is 0.209 and the maximum is 3.805, indicating a large external pay gap for executives in the sample companies. For the employee external pay gap (*Sgap_external*), the minimum (0.318) is also significantly different from the maximum (2.768), indicating a wide variation in compensation across the industries in the sample observation period. Turning to the independent variables, the mean of Confucianism (*Confu_200*) is 2.669 and the standard deviation is 0.783, indicating that the level of Confucian cultural atmosphere varies across our sample companies. The descriptive statistical results of the control variables are generally consistent with existing studies (Jin et al., 2017; Xu et al., 2020; Zou and Li, 2022).

4.2. Baseline regression results

Table 2 reports the regression results for the effect of Confucian cultural atmosphere on the external pay gap, where columns (1), (2) and (3) examine the effects on the corporate external pay gap, external pay gap

Table 1
Descriptive statistics.

	N	Mean	Std. Dev.	*P*1	Median	P99
Wgap_external	29,793	0.995	0.438	0.313	0.907	2.793
Egap_external	29,793	1.009	0.646	0.209	0.846	3.805
Sgap_external	29,793	1.000	0.434	0.318	0.913	2.768
Confu_200	29,793	2.669	0.783	0.000	2.773	4.007
Age	29,793	16.81	5.760	4.000	17.000	31.000
Soe	29,793	0.392	0.488	0.000	0.000	1.000
Roa	29,793	0.040	0.0620	−0.231	0.038	0.217
Size	29,793	22.130	1.271	19.730	21.960	26.090
Lev	29,793	0.437	0.204	0.0560	0.433	0.887
Aturn	29,793	0.662	0.458	0.0670	0.556	2.691
Mshr	29,793	10.230	7.300	0.000	12.580	19.780
Top10	29,793	0.576	0.152	0.223	0.584	0.901
IDratio	29,793	0.379	0.0710	0.250	0.364	0.600
University	29,793	8.821	9.030	1.000	7.000	34.000
AveGDP	29,793	11.020	0.551	9.508	11.060	12.010

Table 2
Baseline regression results for Confucian cultural and external pay gap.

	(1)	(2)	(3)
	Wgap_external	Egap_external	Sgap_external
Confu_200	−0.023***	−0.027**	−0.021***
	(-2.98)	(-2.51)	(-2.73)
Age	0.002	0.007***	0.001
	(1.52)	(3.54)	(1.15)
Soe	−0.019	−0.129***	−0.035**
	(-1.16)	(-5.62)	(-2.22)
Roa	0.349***	1.613***	0.360***
	(4.06)	(14.75)	(4.28)
Size	0.064***	0.252***	0.079***
	(9.71)	(22.89)	(12.28)
Lev	−0.172***	−0.163***	−0.163***
	(-4.83)	(-3.85)	(-4.71)
Aturn	0.018	0.113***	0.031**
	(1.19)	(5.34)	(2.02)
Mshr	−0.001	0.005***	−0.001
	(-1.58)	(4.20)	(-0.92)
Top10	0.024	−0.097	0.021
	(0.62)	(-1.61)	(0.55)
IDratio	0.008	−0.040	0.013
	(0.13)	(-0.48)	(0.22)
University	0.002*	−0.003*	0.002*
	(1.90)	(-1.89)	(1.78)
AveGDP	0.250***	0.275***	0.245***
	(11.30)	(9.65)	(11.27)
Constant	−2.740***	−6.935***	−3.011***
	(-10.36)	(-18.28)	(-11.59)
Year FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
N	29,793	29,793	29,793
Adj.R²	0.098	0.259	0.111

Note: The numbers in parentheses are *t*-statistics. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.

for executives and external pay gap for employees, respectively. Table 2 shows that the coefficients of *Confu_200* on *Wgap_external* and on *Sgap_external* are both negative and significant at the 1 % level. The coefficient of *Confu_200* on *Egap_external* is negative and significant at the 5 % level. The above results indicate that the more companies are influenced by Confucian culture, the smaller the external pay gap of companies, executives and employees. The above results verify Hypothesis 1a, i.e., Confucian culture can reduce the external pay gap.

4.3. Endogeneity tests

4.3.1. Tests with instrumental variables

In the main regression, we use data on Confucian temples built a century ago to measure the strength of Confucian cultural influence, aiming to avoid reverse causality caused by endogeneity problems. However, due to dynastic changes and the destruction wrought by recent wars, many Confucian temples have been destroyed, leading to measurement error. In addition, the findings of our study may also be influenced by other cultural phenomena, such as religion, resulting in an endogeneity problem due to omitted variables. Therefore, drawing on Chen and Qiu (2021), we use the distance from each listed company's registered address to Qufu, Shandong province (*Distance*) as an instrumental variable to mitigate the potential endogeneity. According to Becker and Woessmann (2009), culture typically spreads outwards from its place of origin at

Table 3
Regression results of instrumental variable tests.

	(1)	(2)	(3)	(4)
	First stage	Second stage		
	Confu_200	Wgap_external	Egap_external	Sgap_external
Distance	−0.171***			
	(-9.86)			
Confu_200		−0.112***	−0.458***	−0.106***
		(-7.59)	(-20.40)	(-7.30)
Age	0.007***	0.002***	0.007***	0.001***
	(3.07)	(3.71)	(9.01)	(2.87)
Soe	−0.038	−0.015**	−0.113***	−0.032***
	(-1.49)	(-2.43)	(-11.92)	(-5.18)
Roa	−0.194*	0.343***	1.587***	0.355***
	(-1.75)	(7.46)	(22.68)	(7.85)
Size	−0.032***	0.062***	0.244***	0.077***
	(-3.28)	(24.20)	(62.38)	(30.59)
Lev	−0.004	−0.174***	−0.172***	−0.165***
	(-0.06)	(-10.41)	(-6.78)	(-10.04)
Aturn	−0.020	0.030***	0.170***	0.042***
	(-0.84)	(4.63)	(17.05)	(6.58)
Mshr	0.003**	−0.001***	0.007***	−0.000
	(2.38)	(-2.67)	(11.07)	(-1.25)
Top10	0.170**	0.029*	−0.068**	0.026
	(2.57)	(1.67)	(-2.54)	(1.51)
IDratio	0.298***	0.012	−0.018	0.017
	(3.34)	(0.35)	(-0.33)	(0.50)
University	−0.010***	0.002***	−0.004***	0.001***
	(-9.53)	(3.79)	(-7.43)	(3.52)
AveGDP	−0.135***	0.303***	0.531***	0.295***
	(-4.55)	(24.76)	(28.52)	(24.57)
Constant	8.919***	−3.067***	−8.526***	−3.325***
	(25.76)	(-26.85)	(-49.07)	(-29.63)
Year FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
N	29,786	29,786	29,786	29,786
Adj.R^2	–	0.076	0.016	0.090

Note: The numbers in parentheses are t-statistics. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.

the center of a circle. The more distant an area is from the place of origin, the weaker the influence of new ideas. Qufu, as the hometown of Confucius, is considered the birthplace of Confucian culture. Qufu also has the largest Confucian temple in China and has been a sacred place of pilgrimage for Confucian scholars throughout all dynasties. Therefore, listed companies that are geographically closer to Qufu should be more deeply influenced by Confucian culture; however, the distance from a listed company's registered address to Qufu should not have a direct impact on the external pay gap. The first-stage regression results in Table 3 show that the coefficient of Confu_200 on Distance is negative and significant at the 1 % level.[5] The second stage of the regression shows that the coefficient of Confu_200 is negative at the 1 % level regardless of the way the external pay gap is measured, indicating that our conclusions still hold after controlling for potential endogeneity issues.

4.3.2. Tests based on the change of corporate registered address

The economic, social and cultural differences across regions are equally important factors influencing the external pay gap. Although we control for the level of regional economic development and education in

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[5] The Cragg–Donald Wald F-statistic for the weak instrumental variable test is much greater than the critical value of 16, rejecting the original hypothesis that the instrumental variable is a weak instrumental variable.

the above tests, there may still be endogeneity problems due to omitted variables. Referring to Jin et al. (2022) and Rao et al. (2022), we use the exogenous shock of a change in corporate registered address to construct a quasi-natural experiment, employing propensity score matching and the difference-in-differences (DID) method to identify the effect of the change in Confucian culture atmosphere caused by a change in corporate registered address on the external pay gap. First, we take *Size*, *Age*, *Lev*, *Roa*, *Aturn*, *Top10*, *Mshr*, *Soe* and *IDratio*. Two region-level control variables, *AveGDP* and *University*, are taken as covariates. A final sample of 3,508 firms is formed by matching the treated firms with control firms having the most similar characteristics according to the kernel matching method. Second, we construct the following DID model to examine the net effect of the change in Confucian cultural atmosphere on the external pay gap:

$$
\begin{aligned}
Gap_{it} = \alpha_0 + \alpha_1 Post_t + \alpha_2 Post_t \times Relocation_i + \alpha_3 Relocation_i \\
+ \sum \alpha Control_{it} + Year + Industry + \varepsilon_{it}
\end{aligned}
\tag{2}
$$

Where *Post* is a dummy variable that takes the value of 1 for the year in which the company changed its registered address and for subsequent years. *Relocation* is a dummy variable for registered address changes that takes the value of 1 for a company moving from a region with a low Confucian cultural level to a region with a high Confucian cultural level and 0 for a company moving from a region with a strong Confucian culture to a region with a weak Confucian culture.[6] The regression results are shown in column (1) of Table 4. The coefficient of the cross product term *Treat × Post* is negative and significant at the 5 % level, indicating that the external pay gap is lower when a company changes its location to a region with a strong Confucian culture than to a region with a weak Confucian culture. The above results suggest that our findings still hold after controlling for potential endogeneity issues.

4.3.3. Placebo tests

To exclude the effect of interference caused by unobservable regional differences on our findings, referring to Zou and Li (2022), we randomly disrupt the number of Confucian temples within a radius of 200 km from a company's registered address and reconstruct the Confucian cultural atmosphere metric. If our findings are due to unobservable regional differences, the significance of the regression coefficients of the core dependent variables should remain; otherwise, the regression coefficients of the core dependent variables should not be significant. The regression results in column (2) of Table 4 show that the coefficients of the Confucian culture indicator (*Random_Confu_200*) calculated from random data on the external pay gap (*Wgap_external*) are not significant, indicating that the main findings of our study are unlikely to be due to unobservable regional differences.

4.4. Robustness tests

4.4.1. Alternative measure of Confucian culture

In the above tests, we employ the number of Confucian temples (*Confu_200*) within a radius of 200 km from a company's registered address to measure the influence of Confucian culture. In this section, we change the calculation radius of the Confucian culture indicator. Specifically, we take the logarithm of the number of Confucian temples within a 300-km radius of a listed company's registered office plus 1 as the proxy variable for Confucian culture. In addition, to alleviate the measurement bias brought about by the Confucian temple data, referring to Pan et al. (2020), we also use the number of *Jinshi*(*LnJS300*) in each region during the Ming and Qing dynasties to measure Confucian cultural intensity. Specifically, we calculate the number of Ming and Qing dynasty *Jinshi*within a radius of 300 km from a listed company's registered office and take the logarithm. The results of the tests using the alternative variables described above are shown in Table 5. In columns (1)–(3), the coefficients on *Confu_300* are all negative and significant at the 1 % level. In columns (4)–(6), the coefficients on *LnJS300* are also negative and significant. The above results indicate that our findings are robust.

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[6] The difference in the number of Confucian temples within a 200-km radius before and after a change in a company's registered address is used to determine whether the company has moved to an area with a strong Confucian cultural atmosphere.

Table 4
Regression results of other endogeneity tests.

	(1)	(2)
	Wgap_external	Wgap_external
Treat × Post	−0.061**	
	(-2.02)	
Treat	0.001	
	(0.03)	
Post	0.009	
	(0.36)	
Random_Confu_200		−0.004
		(-1.16)
Age	0.007***	0.002
	(4.36)	(1.49)
Soe	−0.054***	−0.019
	(-2.95)	(-1.20)
Roa	−0.114	0.350***
	(-0.92)	(4.07)
Size	0.074***	0.064***
	(9.23)	(9.76)
Lev	−0.262***	−0.171***
	(-5.55)	(-4.81)
Aturn	0.049***	0.015
	(2.80)	(0.98)
Mshr	0.000	−0.001*
	(0.23)	(-1.67)
Top10	0.022	0.022
	(0.41)	(0.58)
IDratio	0.135	0.006
	(1.27)	(0.11)
University	−0.000	0.002**
	(-0.03)	(2.00)
AveGDP	0.145***	0.236***
	(5.52)	(10.71)
Constant	−2.091***	−2.644***
	(-6.74)	(-9.97)
Year FE	Yes	Yes
Industry FE	Yes	Yes
N	3508	29,793
Adj.R^2	0.085	0.097

Note: The numbers in parentheses are *t*-statistics. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.

4.4.2. Alternative measure of the external pay gap

In the above test, we calculate the external pay gap for firms, executives and employees on the basis of the mean values of compensation in the same year, the same industry and the same corporate ownership. However, the mean is susceptible to extremes that cause the lower paid workers' pay to be averaged out by the higher paid workers' pay, thus leading to biased findings. Therefore, we recalculate the external pay gap using the median compensation for the same year, the same industry and the same corporate ownership. The regression results are shown in Table 6. In columns (1) and (3), the coefficients on *Confu_200* are –0.028 and –0.025, respectively, both of which are significant at the 1 % level. In column (2), the coefficient on *Confu_200* is –0.034 and is significant at the 5 % level. The above regression results indicate that our evidence that Confucian culture can reduce the external pay gap is robust.

Table 5
Using alternative measures to calculate Confucian culture.

	(1)	(2)	(3)	(4)	(5)	(6)
	Wgap_external	Egap_external	Sgap_external	Wgap_external	Egap_external	Sgap_external
Confu_300	−0.037***	−0.036***	−0.034***			
	(−4.78)	(−3.35)	(−4.57)			
LnJS300				−0.053***	−0.049***	−0.048***
				(−4.30)	(−2.84)	(−4.07)
Age	0.002	0.007***	0.001	0.002	0.007***	0.001
	(1.51)	(3.53)	(1.14)	(1.46)	(3.50)	(1.10)
Soe	−0.018	−0.129***	−0.034**	−0.019	−0.130***	−0.035**
	(−1.10)	(−5.59)	(−2.17)	(−1.19)	(−5.66)	(−2.25)
Roa	0.348***	1.612***	0.360***	0.351***	1.615***	0.362***
	(4.07)	(14.78)	(4.29)	(4.10)	(14.78)	(4.31)
Size	0.064***	0.252***	0.079***	0.064***	0.252***	0.079***
	(9.73)	(22.93)	(12.30)	(9.71)	(22.95)	(12.28)
Lev	−0.173***	−0.164***	−0.164***	−0.172***	−0.163***	−0.163***
	(−4.88)	(−3.88)	(−4.75)	(−4.86)	(−3.86)	(−4.73)
Aturn	0.020	0.114***	0.033**	0.021	0.114***	0.033**
	(1.32)	(5.42)	(2.15)	(1.34)	(5.45)	(2.16)
Mshr	−0.001	0.005***	−0.001	−0.001	0.005***	−0.001
	(−1.48)	(4.26)	(−0.83)	(−1.43)	(4.28)	(−0.79)
Top10	0.023	−0.098	0.020	0.022	−0.099*	0.019
	(0.61)	(−1.62)	(0.54)	(0.57)	(−1.65)	(0.51)
IDratio	0.008	−0.040	0.013	0.007	−0.041	0.012
	(0.14)	(−0.48)	(0.23)	(0.12)	(−0.49)	(0.21)
University	0.002*	−0.003*	0.002*	0.001	−0.003**	0.001
	(1.95)	(−1.84)	(1.82)	(1.36)	(−2.20)	(1.28)
AveGDP	0.251***	0.274***	0.246***	0.261***	0.282***	0.255***
	(11.36)	(9.68)	(11.37)	(11.67)	(9.71)	(11.64)
Constant	−2.708***	−6.891***	−2.985***	−2.765***	−6.942***	−3.036***
	(−10.25)	(−18.26)	(−11.50)	(−10.46)	(−18.28)	(−11.69)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
N	29,793	29,793	29,793	29,793	29,793	29,793
Adj.R^2	0.100	0.260	0.113	0.100	0.260	0.113

Note: The numbers in parentheses are t-statistics. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.

4.4.3. Analysis based on the CEO and chairman birthplace

CEOs and chairmen have the greatest say over the setting of compensation levels for management and employees (Lafley, 2009), and their decisions are influenced by their values and behavioral approaches. Psychological research has shown that the early experiences of individuals influence their thinking patterns and behaviors in adulthood, and that an individual's childhood environment is extremely important for the formation of personal values. Based on this, we further use the number of Confucian temples within a radius of 300 km from the birthplaces of CEOs and chairmen (taking the logarithm) to re-measure the Confucian cultural atmosphere (CEO_300), and the regression results are shown in Table 7. The coefficients of CEO_300 on Wgap_external and on Sgap_external are negative and significant at the 5% level. The coefficients of CEO_300 on Egap_external is negative and significant at the 1 % level, indicating that Confucianism significantly reduces the external pay gap.

4.4.4. Other robustness tests

(1) Excluding samples of first-tier cities. Compared with other cities, China's first-tier cities, namely Beijing, Shanghai, Guangzhou and Shenzhen, have more listed companies. To avoid biased conclusions due to the noise caused by the geographical aggregation, degree of openness to the outside and internationalization of large cities, we exclude companies from these first-tier cities and re-run the regression. As shown in column (1) of Table 8, Confucian culture (Confu_200) continues to have a significant negative correlation with the

Table 6
Using alternative measures to calculate external pay gap.

	(1)	(2)	(3)
	Wgap_external	Egap_external	Sgap_external
Confu_200	−0.028***	−0.034**	−0.025***
	(-2.95)	(-2.46)	(-2.81)
Age	0.002	0.009***	0.002
	(1.55)	(3.71)	(1.09)
Soe	−0.021	−0.202***	−0.036*
	(-1.09)	(-6.52)	(-1.91)
Roa	0.422***	2.135***	0.424***
	(4.09)	(14.73)	(4.26)
Size	0.070***	0.327***	0.087***
	(9.06)	(21.35)	(11.68)
Lev	−0.197***	−0.207***	−0.185***
	(-4.64)	(-3.74)	(-4.52)
Aturn	0.023	0.141***	0.038**
	(1.21)	(5.10)	(2.03)
Mshr	−0.002	0.007***	−0.001
	(-1.56)	(4.03)	(-0.93)
Top10	−0.005	−0.153*	−0.001
	(-0.12)	(-1.89)	(-0.03)
IDratio	0.013	−0.073	0.020
	(0.18)	(-0.67)	(0.29)
University	0.002*	−0.004**	0.002
	(1.74)	(-2.05)	(1.63)
AveGDP	0.298***	0.345***	0.288***
	(11.23)	(9.18)	(11.22)
Constant	−3.096***	−8.901***	−3.393***
	(-9.83)	(-17.19)	(-11.08)
Year FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
N	29,793	29,793	29,793
Adj.R^2	0.100	0.253	0.112

Note: The numbers in parentheses are *t*-statistics. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.

external pay gap of firms. That is, after excluding the first-tier city samples, the effect of Confucian culture in narrowing the external pay gap still exists.

(2) Excluding the impact of the financial crisis. The global financial crisis in 2008 increased business risks and caused fluctuations in corporate performance, which in turn affected corporate compensation levels. Considering that the financial crisis may interfere with our main findings, we exclude samples from 2008 and re-run the regression. As shown in column (2) of Table 8, the coefficient on *Confu_200* is –0.024 and is significant at the 1 % level, indicating that the financial crisis has little impact on our main findings.

(3) Excluding samples where the company's registered address is not the same as its physical location. In some cases, the address of a company's registration is different from its physical location, which may create bias in the calculation of Confucian cultural atmosphere in companies. We further exclude companies with different registration and location addresses and re-run the regression. The regression results in column (3) of Table 8 show that the regression coefficient on *Confu_200* is still negative and significant, indicating that our conclusions are robust.

(4) Excluding the impact of salary restrictions. In 2009 and 2014, the Chinese government issued salary restrictions, aiming to reduce unreasonable incomes for executives in central enterprises and narrow the income gap. Our regression results may not accurately reflect the net effect of Confucian culture on the external pay gap due to the impact of the pay restrictions. Following Wei et al. (2022), we exclude state-owned enterprises throughout the sample period and all samples from 2009, when the salary restriction was first

Table 7
Regression results of the analysis based on the CEO and chairman birthplace.

	(1)	(2)	(3)
	Wgap_external	Egap_external	Sgap_external
CEO_300	−0.030**	−0.053***	−0.029**
	(-2.56)	(-3.04)	(-2.55)
Age	0.002	0.007***	0.002
	(1.46)	(3.19)	(1.10)
Soe	−0.031*	−0.143***	−0.047***
	(-1.78)	(-5.53)	(-2.74)
Roa	0.474***	1.773***	0.492***
	(4.60)	(13.19)	(4.88)
Size	0.064***	0.254***	0.080***
	(8.37)	(19.98)	(10.70)
Lev	−0.149***	−0.152***	−0.140***
	(-3.69)	(-3.02)	(-3.57)
Aturn	0.008	0.111***	0.022
	(0.51)	(4.58)	(1.34)
Mshr	−0.001	0.007***	−0.001
	(-1.46)	(4.81)	(-0.79)
Top10	0.079*	−0.092	0.075*
	(1.82)	(-1.23)	(1.75)
IDratio	−0.020	−0.040	−0.020
	(-0.27)	(-0.39)	(-0.28)
University	0.001	−0.003*	0.001
	(1.16)	(-1.75)	(1.05)
AveGDP	0.249***	0.274***	0.243***
	(9.76)	(8.28)	(9.74)
Constant	−2.688***	−6.887***	−2.959***
	(-8.87)	(-15.74)	(-9.97)
Year FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
N	22,642	22,642	22,642
Adj.R²	0.105	0.269	0.120

Note: The numbers in parentheses are t-statistics. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.

implemented. The regression results are presented in column (4) of Table 8. It can be seen that there is still a significant negative effect of Confucian culture on the company external pay gap, indicating that our main findings still hold after excluding interference caused by the salary restriction.

(5) Excluding the impact of other cultural factors. Considering that the regression results in our study could also be influenced by other cultural factors, referring to Pan et al. (2019), we add the following control variables to the regression: the number of temples within a radius of 200 km from the listed company's registered address (Religion), the number of clan genealogies in the province where the listed company is registered (Clan) and the number of commerce chambers in the province where the listed company is registered (Chamber). The aim is to further control the influence of religious belief, clan culture and merchant culture on our regression results. As Table 8 column (5) shows, the inhibitory effect of Confucian culture on the external pay gap remains significant, ruling out the interference of other cultural factors with the main findings of this study.

5. Further analysis

5.1. The impact of Confucian culture on shared prosperity: mechanism tests

According to the theoretical derivation of Hypothesis 1(a), Confucian culture affects the external pay gap through three channels: (1) righteousness restrains management's self-interest and reduces the external pay

Table 8
Regression results of other robustness tests.

	(1) Excluding samples of first-tier cities	(2) Excluding the impact of the financial crisis	(3) Excluding samples where the company's registered address is not the same as the located address	(4) Excluding the impact of the salary restriction	(5) Excluding the impact of other culture factors
Confu_200	−0.026***	−0.024***	−0.023**	−0.021**	−0.012***
	(−3.25)	(−3.01)	(−2.07)	(−2.01)	(−2.86)
Age	−0.001	0.002	−0.000	0.002	0.001**
	(−0.98)	(1.51)	(−0.09)	(1.11)	(2.24)
Soe	−0.036**	−0.021	−0.013	0.000	−0.031***
	(−2.31)	(−1.35)	(−0.58)	(.)	(−4.47)
Roa	0.425***	0.320***	0.568***	0.164*	0.263***
	(4.79)	(3.75)	(4.73)	(1.71)	(6.25)
Size	0.069***	0.064***	0.067***	0.066***	0.066***
	(10.65)	(9.78)	(7.60)	(7.36)	(23.98)
Lev	−0.109***	−0.176***	−0.186***	−0.136***	−0.178***
	(−3.06)	(−5.01)	(−3.82)	(−3.25)	(−9.97)
Aturn	0.027	0.019	0.017	0.024	0.031***
	(1.55)	(1.26)	(0.73)	(1.19)	(5.62)
Mshr	−0.001	−0.002*	−0.001	−0.000	−0.001**
	(−1.56)	(−1.80)	(−0.88)	(−0.41)	(−1.99)
Top10	0.052	0.018	0.025	−0.059	0.044**
	(1.36)	(0.47)	(0.49)	(−1.30)	(2.29)
IDratio	0.021	0.011	0.025	0.012	0.001
	(0.36)	(0.19)	(0.31)	(0.17)	(0.01)
University	0.003*	0.002**	0.002	0.005***	0.002***
	(1.85)	(2.08)	(1.55)	(3.96)	(4.45)
AveGDP	0.143***	0.244***	0.250***	0.213***	0.296***
	(6.93)	(11.10)	(8.30)	(8.65)	(26.82)
Religion					0.003***
					(6.31)
Clan					−0.000***
					(−7.81)
Chamber					−0.009***
					(−17.14)
Constant	−1.820***	−2.676***	−2.810***	−2.400***	−3.071***
	(−7.56)	(−10.19)	(−7.59)	(−7.74)	(−25.33)
Year FE	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes
N	21,732	28,679	14,523	17,632	29,793
Adj.R²	0.071	0.096	0.121	0.083	0.103

Note: The numbers in parentheses are t-statistics. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.

gap for executives; (2) humaneness helps improve enterprises' protection of employees' rights and interests and reduces the external pay gap for employees; and (3) honesty promotes enterprises to improve information disclosure quality and helps reduce the external pay gap for both executives and employees. In this regard, we further examine the above channels through which Confucian culture affects shared prosperity.

5.1.1. Righteousness in Confucian culture

In the business activities of enterprises, the concept of righteousness in Confucianism is reflected in the management's ability to restrain selfish desires. Managers guided by this concept do not use their own management decision-making power for personal gain even when supervision mechanisms are limited. The above analysis shows that Confucian culture can motivate management to focus on self-restraint and reduce their self-interested seeking of excess compensation, thus reducing the external pay gap for executives and bringing corporate compensation closer to the reference benchmark.

Under an operating performance-based compensation system, earnings management becomes the main means for management to manipulate performance and thus improve compensation levels (Quan et al., 2010). With the continuous improvement of legal systems, regulations and audit procedures, the ability of external regulators to identify accrual manipulation of earnings management is improving, and the space for management to manipulate accrual is gradually decreasing. Unlike accrual manipulation, real activities manipulation affects corporate cash flow and future performance by influencing actual economic activities, making it a more flexible form of earnings manipulation that is less easily noticed by external regulators such as auditors. Therefore, executives are becoming more inclined to adopt earnings management through real activities to manipulate compensation (Luo et al., 2016).

We examine the role of righteousness in Confucian culture by measuring management's self-interested behavior through real activities manipulation. Following Roychowdhury (2006), we calculate abnormal production costs, abnormal operating cash flows and abnormal discretionary expenses, and construct a real activities manipulation indicator (*RM*) from the difference between abnormal production costs and abnormal operating cash flows and discretionary expenses. The regression results in Table 9 show that the coefficients on the cross product term *Confu_200 × RM* are negative and significant at the 1 % level when the dependent variable is *Wgap_external* or *Egap_external*. However, the coefficient on *Confu_200 × RM* is not significant when the dependent variable is *Sgap_external*. The above results indicate that righteousness has a more sig-

Table 9
Regression results of mechanism tests on "Righteousness" in Confucian culture.

	(1)	(2)	(3)
	Wgap_external	*Egap_external*	*Sgap_external*
Confu_200 × RM	−0.038***	−0.044***	−0.045
	(−3.88)	(−3.65)	(−1.61)
Confu_200	−0.024***	−0.025**	−0.021***
	(−2.95)	(−2.26)	(−2.64)
RM	−0.021**	−0.081***	−0.011
	(−2.19)	(−6.22)	(−0.15)
Age	0.002	0.008***	0.002
	(1.58)	(3.87)	(1.23)
Soe	−0.017	−0.125***	−0.040**
	(−1.07)	(−5.26)	(−2.41)
Roa	0.202**	1.319***	0.220**
	(2.28)	(12.19)	(2.52)
Size	0.065***	0.256***	0.084***
	(9.56)	(22.21)	(12.03)
Lev	−0.150***	−0.136***	−0.147***
	(−4.01)	(−3.09)	(−4.06)
Aturn	0.015	0.103***	0.024
	(0.90)	(4.69)	(1.45)
Mshr	−0.001	0.005***	−0.001
	(−1.43)	(4.22)	(−0.96)
Top10	0.036	−0.122*	0.043
	(0.91)	(−1.89)	(1.11)
IDratio	0.040	−0.022	0.052
	(0.65)	(−0.25)	(0.85)
University	0.001	−0.003**	0.001
	(1.32)	(−2.22)	(1.17)
AveGDP	0.258***	0.281***	0.262***
	(11.22)	(9.39)	(11.38)
Constant	−2.843***	−7.031***	−3.277***
	(−10.35)	(−17.69)	(−11.37)
Year FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
N	27,076	27,076	27,076
Adj_R^2	0.106	0.272	0.123

Note: The numbers in parentheses are *t*-statistics. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.

nificant effect on the external pay gap for executives than for ordinary employees, i.e., righteousness reduces the external pay gap for executives by suppressing management's self-interested motivation, which in turn reduces the corporate external pay gap.

5.1.2. Humaneness in Confucian culture

Humaneness in Confucian culture is reflected in companies adhering to the ''humanistic management'' concept, paying attention to the interests and demands of lower-level employees and protecting their individual labor rights and interests, such as working conditions and wages and benefits. The above analysis shows that Confucian culture can prompt companies to pay attention to the interests of lower-level employees, narrow the gap between their employees' compensation and the average compensation level for similar positions at other companies and thus reduce the external pay gap of companies.

Hexun.com provides corporate social responsibility reports that evaluate enterprises' level of employee responsibility in terms of employee income, training and care. The higher the score, the better the company protects the rights and interests of its employees and provides them with humanistic care. Referring to Gu et al. (2020), we use the employee responsibility scores in these corporate social responsibility reports to measure the extent to which companies protect employees' rights and interests as a test of the role of humaneness in Confucian culture.[7] We set a dummy variable (*Responsibility*) for employee rights protection. If the employee responsibility score is higher than the sample median, which means that the company has a relatively high degree of employee rights protection, *Responsibility* takes the value of 1, and 0 otherwise. The regression results are reported in Table 10. When the dependent variables are *Wgap_external* and *Sgap_external*, the coefficients on the cross product term *Confu_200 × Responsibility* are positive and significant at the 5 % level. However, when the dependent variable is *Egap_external*, the coefficient on *Confu_200 × Responsibility* is not significant. The above results show that the impact of humaneness on the external pay gap for employees is greater than its impact on that for executives, i.e. humaneness reduces the external pay gap for employees by improving the protection of employees' rights and interests, which in turn reduces the corporate external pay gap.

5.1.3. Honesty in Confucian culture

Honesty in Confucian culture is reflected in enterprises' honest disclosure of accounting information to ensure the truthfulness and integrity of the information. The above analysis shows that Confucian culture can alleviate corporate information asymmetry, improve the transparency of compensation information and prompt companies to pay attention to the average compensation in the comparison group of companies, all of which further discourage unreasonable compensation packages, lift compensation levels that are currently below the benchmark and reduce the external compensation gap.

Media coverage plays an important function of information intermediation and public supervision in the capital market. Media coverage aggregates and disseminates business information, thus reducing the information asymmetry between firms and the capital market (Fang and Peress, 2009). For example, media reports and analyses on the compensation situations of listed companies have increased the transparency of corporate salary information and raised public and regulatory concerns about ''salary disorder'' (Yang et al., 2012). Additionally, the revelation of corporate violations by the media increases both public pressure on enterprises and the reputational damage caused by their non-compliant operations, thus forcing them to improve their corporate governance mechanisms and the quality of information disclosure (Dyck et al., 2008). Therefore, the greater the number of media reports a listed company receives, the higher the quality of information disclosure and the lower the information friction with the capital market.

We use the number of media reports on a company to measure corporate information asymmetry as a test of the role of honesty in Confucian culture. Following Luo and Du (2014), we use the logarithm of the number of online media reports plus 1 to measure corporate news coverage (*Media*). The regression results are shown in Table 11. The coefficients on *Confu_200 × Media* are all positive and significant at the 1 % level, indicating that Confucian culture plays a greater role in companies with more serious information asymmetry. Confucian

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[7] Hexun.com started to disclose corporate social responsibility data in 2010, so the sample data interval is from 2010 to 2020.

Table 10
Regression results of mechanism tests on "Humaneness" in Confucian culture.

	(1)	(2)	(3)
	Wgap_external	Egap_external	Sgap_external
Confu_200 × Responsibility	0.014**	0.025	0.012**
	(2.17)	(1.41)	(1.98)
Confu_200	−0.037***	−0.044***	−0.034***
	(−6.84)	(−2.64)	(−6.51)
Responsibility	−0.280***	−0.283***	−0.265***
	(−15.45)	(−5.56)	(−15.04)
Age	0.002***	0.007***	0.001***
	(3.26)	(3.66)	(2.58)
Soe	−0.049***	−0.163***	−0.062***
	(−7.39)	(−6.98)	(−9.46)
Roa	0.013	1.294***	0.051
	(0.25)	(12.38)	(1.06)
Size	0.042***	0.237***	0.057***
	(15.65)	(22.01)	(22.16)
Lev	−0.156***	−0.155***	−0.153***
	(−9.40)	(−3.68)	(−9.58)
Aturn	0.024***	0.126***	0.038***
	(3.51)	(5.90)	(5.65)
Mshr	−0.002***	0.005***	−0.001***
	(−4.20)	(3.86)	(−2.70)
Top10	0.046***	−0.080	0.042**
	(2.70)	(−1.33)	(2.48)
IDratio	−0.007	−0.078	0.004
	(−0.20)	(−0.98)	(0.12)
University	0.003***	−0.002	0.002***
	(6.84)	(−1.48)	(6.32)
AveGDP	0.203***	0.238***	0.201***
	(22.92)	(7.94)	(23.05)
Constant	−1.718***	−6.249***	−2.042***
	(−15.54)	(−15.51)	(−18.85)
Year FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
N	26,265	26,265	26,265
Adj.R^2	0.170	0.280	0.180

Note: The numbers in parentheses are t-statistics. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.

culture simultaneously narrows the external compensation gap between executives and employees by improving corporate information disclosure and, in turn, brings corporate compensation closer to the comparative benchmark.

5.2. The impact of Confucian culture on shared prosperity: heterogeneity analysis

5.2.1. Analysis based on formal institutions

According to North's (1990) definition, an institution is essentially a game of rules and can be classified as either formal (laws, regulations and contracts) or informal (culture, norms and customs). Formal and informal institutions work together to shape people's behavioral decisions, and the interaction between the two may be either substitutive or complementary. China is currently characterized by both an emerging market and a transitional economy; the formal institutions are still evolving and improving. We further examine the relationship between informal institutions (Confucian culture) and formal institutions in influencing the external pay gap. Regarding ritual and law, Confucius stated that "When the people are governed by decrees and disciplined by criminal laws, they only seek to avoid punishment for their crimes, but have no shame; when they are guided by morality and have assimilated propriety, they will not only have a sense of shame, but also a sense of

Table 11
Regression results of mechanism tests on "Honesty" in Confucian culture.

	(1)	(2)	(3)
	Wgap_external	Egap_external	Sgap_external
Confu_200 × Media	0.008***	0.012***	0.009***
	(2.99)	(3.50)	(3.22)
Confu_200	−0.059***	−0.080***	−0.058***
	(-4.87)	(-5.48)	(-4.93)
Media	−0.007	0.004	−0.010
	(-0.90)	(0.42)	(-1.26)
Age	0.002***	0.007***	0.001***
	(3.59)	(9.67)	(2.71)
Soe	−0.014**	−0.121***	−0.031***
	(-2.15)	(-13.61)	(-4.79)
Roa	0.319***	1.554***	0.333***
	(6.16)	(24.60)	(6.60)
Size	0.059***	0.243***	0.074***
	(21.71)	(59.58)	(28.27)
Lev	−0.173***	−0.174***	−0.164***
	(-10.12)	(-8.55)	(-9.91)
Aturn	0.018***	0.113***	0.031***
	(2.72)	(12.75)	(4.66)
Mshr	−0.002***	0.005***	−0.001***
	(-4.18)	(8.76)	(-2.70)
Top10	0.030*	−0.098***	0.026
	(1.74)	(-3.92)	(1.54)
IDratio	0.004	−0.049	0.010
	(0.11)	(-1.08)	(0.29)
University	0.002***	−0.003***	0.002***
	(4.43)	(-5.04)	(4.16)
AveGDP	0.255***	0.280***	0.249***
	(28.70)	(25.18)	(28.61)
Constant	−2.633***	−6.765***	0.009***
	(−23.93)	(-46.70)	(3.22)
Year FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
N	29,542	29,542	29,542
Adj.R²	0.100	0.260	0.110

Note: The numbers in parentheses are t-statistics. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.

submission (道之以政, 齐之以刑, 民免而无耻；道之以德, 齐之以礼, 有耻且格)" (Analects 2:3). That is, Confucianism promotes the use of ritual instead of criminal law to govern the people. Thus, we expect an alternative relationship between Confucian culture and the formal institutions.

Regions with a high level of regulation are more vigorous in investigating and punishing opportunistic behaviors such as earnings manipulation (Li et al., 2012), thus reducing the occurrence of compensation manipulation by management. In regions with higher levels of marketization, capital market information is more effective, and full disclosure of corporate information is more likely to make firms focus on comparative benchmarks, thus promoting the fairness and reasonableness of compensation contracts (Xin and Tan, 2009). In addition, regions with a higher level of marketization have a better-developed managerial market, in which compensation setting is more subject to market constraints (Li et al., 2014). Compared with other regions, it is more difficult in these regions for management to obtain compensation that is not in line with their own ability. To test these expectations, we use the intermediary organization development and legal score from China's Provincial Marketization Index Report to measure regional levels of legal regulation, and the marketization index from China's Provincial Marketization Index Report to measure regional levels of marketization. If the legal regulation level in the province where an enterprise is registered is higher than the annual median, it is considered to have stronger laws, so that the variable Legal takes the value of 1, and 0 otherwise. If the

Table 12
Regression results of heterogeneity analysis on formal institutions.

	(1)	(2)	(3)	(4)
	High level of legal regulation	Low level of legal regulation	High level of marketization	Low level of marketization
Confu_200	0.005	−0.048***	0.003	−0.036***
	(0.42)	(-4.97)	(0.23)	(-3.48)
Age	0.002*	0.000	0.002*	−0.002
	(1.69)	(0.06)	(1.80)	(-0.68)
Soe	−0.018	−0.030	−0.022	−0.025
	(-0.95)	(-1.16)	(-1.18)	(-0.89)
Roa	0.415***	0.143	0.379***	0.256
	(4.39)	(0.77)	(4.03)	(1.37)
Size	0.063***	0.064***	0.062***	0.069***
	(8.29)	(5.82)	(8.33)	(5.70)
Lev	−0.152***	−0.233***	−0.167***	−0.180***
	(-3.76)	(-3.52)	(-4.16)	(-2.67)
Aturn	0.017	0.038	0.018	0.040
	(0.96)	(1.37)	(1.09)	(1.26)
Mshr	−0.001	−0.002	−0.001	−0.001
	(-1.02)	(-1.03)	(-1.10)	(-0.68)
Top10	0.007	0.085	0.013	0.069
	(0.16)	(1.33)	(0.31)	(1.02)
IDratio	−0.002	0.098	−0.012	0.155
	(-0.03)	(0.95)	(-0.18)	(1.36)
University	0.001	−0.005	0.001	−0.004
	(1.44)	(-0.75)	(1.28)	(-0.69)
AveGDP	0.287***	0.162**	0.297***	0.162**
	(10.80)	(2.28)	(11.11)	(2.17)
Constant	−3.178***	−1.835***	−3.239***	−2.025***
	(-10.16)	(-2.70)	(-10.13)	(-2.85)
Year FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Chi^2		67.78***		34.17***
N	24,006	5787	24,581	5212
Adj.R^2	0.097	0.078	0.098	0.082

Note: The numbers in parentheses are t-statistics. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.

marketization level in the province where an enterprise is registered is higher than the annual median, it is considered to have a higher level of marketization, so thatthe variable *Market* takes the value of 1, and 0 otherwise. The regression results are reported in Table 12, where columns (1) and (2) show the results of the regressions based on the level of legal regulation, and columns (3) and (4) show the results of the regressions based on the level of marketization. The regression coefficient on *Confu_200* is negative and significant in the sample with low legal regulation and low marketization but insignificant in the sample with high legal regulation and high marketization, indicating that the inhibitory effect of Confucian culture on the external pay gap is more pronounced in firms registered in provinces with low levels of legal regulation and marketization. The above results suggest that there is a substitutive effect between formal systems and Confucian culture. When formal institutions are not perfect, Confucian culture as an implicit substitution mechanism can compensate for the shortcomings of the formal institutions and narrow the external pay gap.

5.2.2. Analysis based on foreign culture shock

Culture varies significantly from country to country, and its influence leads to differences in the values and behaviors of individuals and organizations (Hofstede, 1984). A high degree of openness to the outside increases Chinese firms' exposure to Western governance models and values, and contact between multiple cultures may lead to both confrontation and integration. Based on this, we further investigate the impact of foreign culture shock on the relationship between Confucian culture and the enterprise external pay gap.

Table 13
Regression results of heterogeneity analysis on foreign culture shock.

	(1)	(2)
	High level of openness	Low level of openness
Confu_200	0.055	−0.034***
	(1.12)	(-4.27)
Age	0.003	−0.001
	(1.60)	(-0.58)
Soe	−0.023	−0.034*
	(-0.77)	(-1.93)
Roa	0.305**	0.423***
	(2.20)	(4.06)
Size	0.076***	0.055***
	(6.22)	(7.37)
Lev	−0.165**	−0.132***
	(-2.54)	(-3.29)
Aturn	0.019	0.013
	(0.75)	(0.74)
Mshr	−0.001	−0.001
	(-0.82)	(-0.86)
Top10	−0.037	0.095**
	(-0.52)	(2.22)
IDratio	0.076	−0.040
	(0.74)	(-0.59)
University	0.016***	0.004***
	(5.47)	(2.77)
AveGDP	0.300***	0.142***
	(3.64)	(4.74)
Constant	−3.965***	−1.485***
	(-4.62)	(-4.44)
Year FE	Yes	Yes
Industry FE	Yes	Yes
Chi2		25.44***
N	11,079	18,714
Adj.R2	0.129	0.102

Note: The numbers in parentheses are *t*-statistics. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.

Referring to Pan et al. (2020), we use the five major ports of commerce that were opened after the Opium War as proxy variables for openness to the outside (*Foreign*), and the sample firms are divided into two groups of high and low openness and regressed separately.[8] The regression results are reported in Table 13. The coefficient on *Conf_200* is negative and significant in the low-openness samples but not significant in the high-openness samples, indicating that foreign culture weakens the inhibitory effect of Confucian culture on the external pay gap.

5.2.3. Analysis based on corporate ownership

The compensation systems of state-owned and non-state-owned firms have different characteristics, and thus the influences of Confucian culture on these two types of enterprises are different. In non-state-owned firms, management is mostly selected and hired by shareholders in the managerial market according to their own interests. In contrast, state-owned companies are subordinate to the government, and their management appointments are subject to government intervention and have administrative levels, such as national level, provincial and ministerial level, department and bureau level, county level and township level. This may weaken the influence of the Confucian ideals of humaneness, honesty and righteousness. Unlike in non-

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[8] If a company is registered in a provincial administrative region where one of the five major ports of commerce that were opened after the Opium War—Guangzhou, Xiamen, Fuzhou, Ningbo and Shanghai—is located, it is assigned to the group with a high degree of openness to the outside world, and otherwise to the low-openness group.

Table 14
Regression results of heterogeneity analysis on corporate ownership.

	(1)	(2)
	State-owned enterprises	Non-state-owned enterprises
Confu_200	−0.008	−0.021**
	(-0.69)	(-2.03)
Age	−0.006***	0.002
	(-2.89)	(1.11)
Roa	1.091***	0.180*
	(6.57)	(1.86)
Size	0.043***	0.067***
	(4.02)	(7.29)
Lev	−0.175***	−0.132***
	(-2.82)	(-3.13)
Aturn	0.027	0.025
	(1.08)	(1.18)
Mshr	−0.002	−0.000
	(-1.22)	(-0.30)
Top10	0.166**	−0.062
	(2.21)	(-1.34)
IDratio	−0.072	0.024
	(-0.50)	(0.35)
University	0.004***	0.005***
	(2.66)	(3.90)
AveGDP	0.142***	0.215***
	(5.48)	(8.56)
Constant	−0.991***	−2.438***
	(-3.32)	(-7.75)
Year FE	Yes	Yes
Industry FE	Yes	Yes
Chi^2		4.00**
N	11,682	18,111
Adj_R^2	0.110	0.083

Note: The numbers in parentheses are t-statistics. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.

state-owned firms, compensation in state-owned companies is mostly set by government departments, and insiders have less room to regulate their own salary levels. Therefore, executives are more inclined to use perk consumption and other invisible salaries for personal gain (Chen et al., 2005; Miao and Hu, 2014). Therefore, the role of Confucian culture in restraining the explicit pay of executives in state-owned enterprises may not be significant. Based on the above analysis, we predict that the inhibitory effect of Confucian culture on the external pay gap is more significant in non-state-owned firms.

To test our expectations, we divide the sample firms into state-owned and non-state-owned enterprises and run regressions on the two groups separately. The regression results in Table 14 show that the coefficient on Confu_200 is not significant in state-owned enterprises, while it is negative and significant in non-state-owned enterprises, indicating that the inhibitory effect of Confucian culture on the external pay gap is more pronounced in non-state-owned than state-owned enterprises.

5.3. The economic consequences of Confucian cultural influence

The above tests show that Confucian culture prompts companies to pay attention to the average salaries in the comparison group of companies in the process of formulating compensation policies, which is conducive to narrowing the external pay gap. However, the issues of fairness and efficiency are fundamental in determining the effectiveness of China's corporate compensation system. The steady growth of economic efficiency should be taken into account while narrowing the pay gap. Therefore, we examine the economic consequences of Confucian culture in terms of narrowing the external pay gap from the perspective of economic efficiency.

When the market for managers is well developed, an appropriate external pay gap can motivate management to work hard and thus improve corporate performance (Li et al., 2014). However, an excessively large pay gap also tends to breed a sense of deprivation among employees, reducing their motivation and team cohesion in productive activities and thus undermining firm productivity (Festinger, 1954; Akerlof and Yellen, 1988). Confucian culture may have both positive and negative effects on the economic efficiency of enterprises as a result of reducing the external pay gap. On the one hand, the reduction of the external pay gap tends to weaken management's motivation to work hard and thus may negatively affect corporate performance; on the other hand, the prevention of unreasonable salary packages helps to improve employees' perceived consistency between their contributions and their compensation, which may encourage them to actively engage in production activities, in turn benefiting corporate performance. To test the economic consequences of Confucian culture's external pay gap-reducing effect, we construct the following model:

$$Efficiency_{it} = \alpha_0 + \alpha_1 NWgap\_externalit + \sum \alpha Control_{it}$$
$$+ Year + Industry + \varepsilon_{it} \tag{3}$$

Where the dependent variable is economic efficiency. We use the return on total assets to measure firms' economic efficiency at the accounting level and market capitalization to measure firms' economic efficiency at the market level. Given that using the absolute values of performance indicators to analyze the relationship between pay gap and firm performance may cause serious endogeneity problems (Li et al., 2014), we use the

Table 15
The economic consequences of Confucian culture's influence.

	(1)	(2)
	ΔROA	ΔMV
NWgap_external	0.160**	0.014**
	(1.99)	(2.20)
Age	0.008	0.001
	(1.05)	(1.03)
Roa	28.985***	1.786***
	(22.06)	(14.42)
Soe	0.068	−0.061***
	(0.78)	(-4.23)
Size	−0.033	−0.006
	(-0.92)	(-1.23)
Lev	1.245***	0.230***
	(4.85)	(9.87)
Aturn	−0.219**	0.023*
	(-2.57)	(1.91)
Mshr	−0.003	0.000
	(-0.62)	(0.33)
Top10	−0.776***	0.180***
	(-3.17)	(3.53)
IDratio	−0.722	−0.070**
	(-1.56)	(-2.46)
University	0.021***	0.001*
	(3.19)	(1.80)
AveGDP	0.054	−0.054***
	(0.48)	(-4.74)
Constant	−0.264	1.740***
	(-0.20)	(12.23)
Year FE	Yes	Yes
Industry FE	Yes	Yes
N	13,596	13,986
Adj.R^2	0.190	0.460

Note: The numbers in parentheses are *t*-statistics. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.

changes in accounting performance and market performance as the dependent variables, i.e., the growth rate of return on total assets (ΔROA) and the growth rate of firm market capitalization (ΔMV). Our main independent variable is the negative of the external pay gap ($NWgap\_external$). The larger the value, the closer a company's compensation to the average comparable cohort compensation and the smaller the external pay gap. Furthermore, the sample is divided into two groups with strong and weak Confucian cultural atmosphere based on the annual industry median. The firms in the strong Confucian culture atmosphere group are retained for testing whether the effect of Confucian culture on the external pay gap weakens firms' economic efficiency. The regression results are reported in Table 15, where column (1) shows the results for the dependent variable as ΔROA and column (2) shows the results for the dependent variable as ΔMV. The coefficients on the main independent variable ($NWgap\_external$) are both positive and significant at the 5 % level, indicating that the reduction of the external pay gap is conducive to firms' economic efficiency under the influence of Confucian culture.

6. Conclusion

Shared prosperity is the fundamental principle of socialism with Chinese characteristics and an essential requirement for the Communist Party of China to lead the Chinese people in building a modern socialist country. However, the large external pay gap has hindered the realization of shared prosperity. Our study examines the influence and mechanisms of Confucian culture on the external pay gap. We find that Confucianism has a significant inhibitory effect on the external pay gap, and this finding holds after a series of endogeneity and robustness tests such as instrumental variable tests and DID tests. A mechanism test shows that three of the values idealized in Confucian culture have distinct influences on the external pay gap of managers and employees due to the different causes of the two types of pay gap. Righteousness (Yi, 义) restrains management's self-interest and inhibits the external pay gap for executives, while humaneness (Ren, 仁) promotes the protection of employees' rights and interests, which narrows the external pay gap for employees. Honesty ($Cheng$, 诚) improves the quality of corporate information disclosure, which in turn has an impact on the external compensation gap for both executives and employees. The heterogeneity analysis finds that Confucian culture, as an important informal institution, can compensate for formal institutions, such as the legal and market environment, in reducing the external pay gap. In addition, the inhibitory effect of Confucian culture on the external pay gap is more significant in companies that are more strongly influenced by foreign culture and in non-state-owned firms. Finally, we find that in addition to narrowing the external pay gap, Confucian culture improves corporate economic efficiency. Our findings provide an empirical reference for the contemporary value of laudable aspects of traditional culture in the context of high-quality development, which are of great significance in promoting the realization of shared prosperity and building a modern socialist country.

Our study findings have important policy implications. First, culture plays an important role in the process of China's rapid economic development. Confucian culture is a far-reaching and enduring force in traditional Chinese culture and a spiritual treasure in China's modernization process. Our study finds that Confucian culture can reduce the external pay gap while balancing fairness and efficiency, verifying the important economic value of Confucian culture in reducing the gap between rich and poor. Therefore, Chinese society should vigorously promote Confucianism and apply its values in designing and adjusting income distribution mechanisms, so as to realize the inheritance and innovation of Confucian culture in the new era and make it a strong force for the rejuvenation of China.

Second, narrowing the pay gap and achieving shared prosperity is a gradual process and a theoretical and practical issue related to the political environment, economic system and development strategy. This study demonstrates that deviations of corporate pay levels from the average compensation between different firms within a comparable group are the main source of external pay gaps. Therefore, in addition to tackling the internal pay gap, companies should pay attention to the reference benchmarks of similar companies while setting compensation contracts and thus prevent a large external pay gap from affecting executives' and employees' professional motivation. In the process of designing and improving the salary distribution policy, policy-makers should consider the characteristics of reference industries and groups and adhere to the precise policies of subgroups.

Third, informal systems are the soil in which the formal system is rooted. This study finds that the role of Confucian culture in narrowing the external pay gap is more significant when the efficiency of law enforcement and the degree of marketization are low, suggesting that Confucian culture as an informal institution can compensate for the deficiencies of the legal and market environments as formal institutions. Therefore, considering the necessity of improving China's formal systems, policy-makers should pay attention to the influence of informal systems on socioeconomic development, using the value norms implicit in informal systems to improve formal systems and promote high-quality economic development.

Finally, while opening up to the outside world attracts multinational capital, it also leads to the integration and collision of different cultures. Enterprises should take an objective view of the cultural risks brought about by the intermingling of multiple cultures. Business leaders should be skilled at incorporating Confucian culture into their companies' rules of conduct. However, they should also fully consider the impact of cultural diversity on compensation systems in multinational operations to maintain the motivation of employees from different cultural backgrounds.

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.

Acknowledgement

Appendix A. . Variable definitions

Variable	Definition
Dependent Variables	
Wgap_external	Enterprise external pay gap, *AVECOM/* the annual industry average of *AVECOM* after splitting the corporate ownership.
Egap_external	Executive external compensation gap, *EXECOM/* the annual industry average of *EXECOM* after splitting the corporate ownership.
Egap_external	Employee external compensation gap, *EMPCOM/* the annual industry average of *EMPCOM* after splitting the corporate ownership.
AVECOM	Average corporate salary, (Employee compensation payable in current year - Employee compensation payable in prior year + Cash paid to employees) / (Number of employees - Number of directors, supervisors and executives not receiving compensation).
EXECOM	Average executive salary, Total annual compensation of directors, supervisors and executives / (Number of directors + Number of supervisors + Number of executives - Number of independent directors - Number of directors, supervisors and executives who do not receive compensation).
EMPCOM	Average employee salary, (Compensation payable to employees in current year - compensation payable to employees in prior year + Cash paid to employees - Total annual salary of directors, supervisors and executives) / Number of employees.
Independent Variables	
Confu_200	Confucian culture atmosphere, Ln (the number of Confucian temples within a radius of 200 km from the company's registered address + 1).

(*continued*)

Variable	Definition
Confu_300	Confucian culture atmosphere, Ln (the number of Confucian temples within a radius of 300 km from the company's registered address + 1).
LnJS300	Confucian culture atmosphere, Ln (the number of scholars in the Ming and Qing dynasties within a radius of 300 km from the company's registered address + 1).
CEO_300	Confucian culture atmosphere, Ln (the number of Confucian temples within a radius of 200 km from the birthplace of CEOs and chairmen + 1).
Control Variables	
Size	Firm size, the natural log of total assets.
Lev	Firm leverage, the ratio of total debt to total assets.
Roa	Return on assets, the ratio of net income to total assets.
Aturn	Total asset turnover, the ratio of operating income to total assets.
Top10	Shareholding ratio of top ten shareholders, the ratio of the number of shares held by top ten shareholders to total share capital.
Mshr	Executive shareholding size, Ln (Number of shares held by executives + 1)
Soe	State-owned dummy that is equal to 1 if the ultimate owner of a listed firm is a (central or local) government agency or government controlled enterprise and 0 otherwise.
IDratio	Proportion of independent directors, the ratio of the number of independent directors to the total number of board of directors.
Age	Firm age, years since establishment of companies.
University	Regional education level, number of double-class universities in the province where the company is registered.
AveGDP	Regional economic development, logarithm of GDP per capita in the province where the company is registered.
Industry	A dummy variable that takes a value of 1 if the observation is from this industry and otherwise 0.
Year	A dummy variable that takes a value of 1 if the observation is from this year and otherwise 0.
Other Variables	
RM	Real earnings management, according to Roychowdhury (2006), equals the difference between abnormal production costs and abnormal operating cash flow and abnormal discretionary expenses.
Responsibility	Employee rights protection, ''Employee Responsibility'' Score in Hexun social responsibility report.
Media	Media attention, Ln (number of online media reports + 1).
Legal	Degree of legal regulation, intermediary organization development and legal score from China's Provincial Marketization Index Report.
Market	Degree of marketization, marketization index from China's Provincial Marketization Index Report.
Foreign	Regional openness, dummy variable that is equal to 1 if enterprises are located in the provinces where the five major ports of commerce were opened after the Opium War and 0 otherwise.
ΔROA	Accounting performance, growth rate of return on total assets.
ΔMV	Market performance, growth rate of corporate market capitalization.

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Religiosity and bank earnings management: Revisiting international evidence

Check for updates

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ABSTRACT

The modernization theory forecasts a sharp declining effect of institutionalized religion on human behavior owing to the extensive economic development. However, this prediction is rejected and proved that religious values and beliefs have a pervasive influence on individual conduct. Based on this salient evidence, we examine the influence of religious social norms on bank earnings management behavior with regard to ongoing economic development. We use 20,715 bank-year observations from 1318 listed banks of eight geographical regions. We, further, employ an updated dataset of 2007–2021 to resemble the economic prosperity time period. Our study discards the prediction of the modernization theory and reveals that banks located in countries with high religiosity are less likely to manage their reported earnings. While comparing conventional banks with Islamic ones, conventional banks are found to be less prone to the earnings management practice than that of their Islamic counterparts. We also find religiosity to have a greater magnitude of effect on the accounting manipulation in the crisis period than in the post-crisis one. The cross-regional differences in religious values bring differential effects on this unethical practice. Our results are robust with the alternative measures of earnings management and alternative model specifications.
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1. Introduction

Bank earnings management has been a salient ethical concern over the last decade (Elnahass, Salama, & Yusuf, 2022). Earnings management is when managers opportunistically manipulate financial statements to

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hide real economic conditions, influence contractual outcomes and mislead company stakeholders (Cai, Kim, Li, & Pan, 2019). It worsens financial reporting quality and thus has substantial economic consequences (Zainuldin & Lui, 2020). The desire to curb such behavior, therefore, has prompted scholarly interest in the issue of religiosity and its mitigating effects on earnings management (Baatwah, Al-Qadasi, & Al-Ebel, 2020; Cai et al., 2019; Du, Jian, Lai, Du, & Pei, 2015; Kanagaretnam, Lobo, & Wang, 2015).

The empirical findings regarding religiosity and earnings management are consistent. For instance, Kanagaretnam, Lobo, and Wang (2015) find less earnings management in countries with high (vs low) religiosity as measured by the World Values Survey (WVS) religion dimensions. Du et al. (2015) obtain similar findings using religious sites as the religiosity measure. Cai et al. (2019) use the CIRP Freshman Survey and find less manipulation by firms with a religious CEO than by firms with a nonreligious CEO. However, such research after the global financial crisis (GFC) is limited, and thus whether the effect persists in light of recent economic development is unclear. According to Karl Marx's modernization theory, economic prosperity leads to widespread cultural change and decreases the influence of institutionalized religions (e.g., Islamism, Protestantism and Confucianism) on human behavior (Inglehart & Baker, 2000). Therefore, revisiting the religiosity–earnings management relationship using recent data is necessary to determine whether the mitigating effect of religion remains pervasive.

To fill this gap in the accounting literature and motivated by the importance of understanding the influence of religious social norms on bank managerial opportunism, we examine the 2007–2021 data of listed banks in eight geographical regions: Gulf Cooperation Council (GCC) countries, South America, sub-Saharan Africa, North Africa and South Asia, the non-GCC Middle East and North Africa, East Asia and the Pacific, North America and Europe and Central Asia. This study is based on insights from established theories in the accounting literature, namely, social norm theory, contracting theory, prospect theory and positive accounting theory.

This paper contributes to the literature in several ways. First, prior studies depict the religiosity–earnings management relationship using a dataset from 2007, whereas we use a 2007–2021 dataset that reflects recent economic developments. Therefore, our findings extend the literature and enhance the understanding of whether religion lowers earnings management irrespective of economic conditions. Second, although earlier studies such as Abdelsalam, Chantziaras, Ibrahim, and Omoteso (2021) and Kanagaretnam, Lobo, and Wang (2015) examine the religiosity–earnings management relationship only during the GFC period, we examine the relationship in both the GFC and post-GFC periods. Our findings provide new insights into how religion helps improve banks' performance and financial reporting quality during and after crises. Third, the effect of religiosity on earnings management is re-estimated for conventional and Islamic banks separately, which has not been previously examined (Abdelsalam et al., 2021; Kanagaretnam, Lobo, & Wang, 2015). This line of investigation can help policymakers and regulatory bodies identify which types of banks are resilient to the religiosity–earnings management relationship. Fourth and finally, unlike the studies of Abdelsalam et al. (2021) and Kanagaretnam, Lobo, and Wang (2015), we examine the variations in earnings management across eight geographical regions. This clarifies whether variations in cross-regional religious beliefs, values, cultures and legal systems influence opportunistic behavior in banking.

The rest of this paper proceeds as follows. Section 2 presents the theoretical background and develops the relevant hypotheses. Section 3 describes the methodological approach. Section 4 details the regression results, and additional test results are discussed in Section 5. Section 6 concludes the paper and proposes areas for future research.

2. Theoretical background and hypothesis development

According to contracting theory, earnings management offers potential advantages such as obtaining higher compensation, avoiding the violation of a debt covenant and attracting potential investors (Du et al., 2015). However, the disadvantages often outweigh the advantages. Earnings management masks an organization's real financial condition from stakeholders and investors, who ought to be informed (Elnahass et al., 2022). Therefore, researchers seek ways to curb such opportunistic managerial behavior.

Studies confirm that religion acts as a mechanism that controls an individual's aggressive and unethical behavior (Kanagaretnam, Lobo, Wang, & Whalen, 2015). Religion stimulates morality and faithfulness while

constraining manipulation and fraud in financial operations (Cai et al., 2019). Thus, the stimulation–constrain perspective assumes that religiosity can mitigate earnings management. However, scant research examines this perspective. For instance, Kanagaretnam, Lobo, and Wang (2015) find that compared with banks in countries with low religiosity, banks headquartered in countries with high religiosity are less likely to engage in opportunistic manipulation. However, they do not consider whether religion restrains earnings management under ongoing economic development. The stimulation–constrain notion is supported by social norm theory in which religiosity is seen as a factor that lessens managers' income-increasing intentions (Elnahass et al., 2022). Firms that behave in accordance with religious norms avoid financial misrepresentation and deceptive practices, thereby gaining social recognition and support (Kanagaretnam, Lobo, & Wang, 2015). Given this theoretical inverse association between religion and financial irregularities, we assume that banks headquartered in highly religious areas are less likely to engage in earnings management via discretionary accruals. Thus, we hypothesize the following:

H1. Religiosity is negatively related to earnings management as measured by discretionary accruals.

The literature suggests that managers have strong motivations to avoid reporting earnings decreases (Beatty, Ke, & Petroni, 2002). Specifically, firms whose yearly earnings drop below the zero-income point engage in earnings management to avoid being in the red for the relevant financial year and to exhibit consistent profitability in their annual financial reports, press releases and press coverage (Burgstahler & Dichev, 1997). According to Kanagaretnam, Lobo, and Wang (2015), managers intentionally avoid reporting financial losses to decrease the transaction costs that stakeholders impose on firms. This aligns with prospect theory (Burgstahler & Dichev, 1997). To curb earnings management, we expect religion to be a significant external monitoring mechanism. Thus, we posit the following:

H2. Religiosity is negatively related to earnings management as measured by loss avoidance.

Just meeting or beating analysts' forecasts has become a crucial benchmark for managers (Kanagaretnam, Lobo, & Wang, 2015) because of the increasing media attention to forecasts and the increasing number of analysts making forecasts (Habib & Hossain, 2008). Just meeting or beating analysts' forecasts has both advantages and disadvantages for managers. For instance, firms that just meet or beat analysts' expectations enjoy higher stock returns than other firms, and doing so enhances their credibility and helps avoid costly litigation (Bartov, Givoly, & Hayn, 2002). In contrast, firms that fail to meet or beat analysts' expectations suffer severe financial consequences, including a reduction in the CEO's yearly bonus (Matsunaga & Park, 2001). Considering these benefits and costs, managers actively try to meet or beat earnings forecasts by manipulating financial reports (Habib & Hossain, 2008). This is supported by prospect theory, in which managers manage earnings to meet or beat earnings benchmarks (Kahneman & Tversky, 2013). Such financial misreporting deceives investors and creates agency costs for firms (Habib & Hossain, 2008). We expect that religious norms play a notable role in curbing such opportunistic behavior. Therefore, we hypothesize the following:

H3. Religiosity is negatively related to earnings management as measured by just meeting or beating last year's earnings.

3. Methodology

3.1. Sample selection

Our sample consists of 20,715 bank–year observations from 1,318 listed banks in eight geographical regions: GCC countries, South America, sub-Saharan Africa, North Africa and South Asia, the non-GCC Middle East and North Africa, East Asia and the Pacific, North America and Europe and Central Asia (see Table 1). It comprises 957 conventional and 26 Islamic banks from 2007 to 2021. The data for the country-level religion dimensions are drawn from three waves of the WVS: Wave 5 (2005–2009), Wave 6 (2010–2014) and Wave 7 (2017–2022). The average of the three waves is used to measure the religious variables. Bank-level data for earnings management are extracted from the FitchConnect database, and the country-level regulatory and supervision data are from the World Bank database.

Table 1
Sample countries, number of banks and percentage of bank–year observations.

Country	Number of banks	Obs. (%)	Country	Number of banks	Obs. (%)	Country	Number of banks	Obs. (%)
GCC countries			**Europe and Central Asia**			**North America**		
Bahrain	135	0.63	Austria	105	0.49	Belize	15	0.07
Kuwait	165	0.78	Belgium	30	0.14	Bermuda	30	0.14
Oman	120	0.56	Bulgaria	60	0.28	Canada	135	0.63
Saudi Arabia	180	0.85	Cyprus	45	0.21	Greenland	15	0.07
Qatar	135	0.63	Croatia	120	0.56	Jamaica	30	0.14
United Arab Emirates	255	1.20	Czech Republic	30	0.14	Mexico	90	0.42
			Denmark	300	1.41	Puerto Rico	45	0.21
Sub-Saharan Africa			Estonia	15	0.07	United States of America	7,545	35.47
Kenya	150	0.71	Faroe Islands	15	0.07	Virgin Islands; British	15	0.07
Nigeria	240	1.13	Finland	60	0.28	**South America**		
South Africa	90	0.42	France	255	1.20	Argentina	105	0.49
Sudan	15	0.07	Germany	90	0.42	Ecuador	30	0.14
Benin	15	0.07	Greece	75	0.35	Brazil	270	1.27
Botswana	45	0.21	Hungary	15	0.07	Chile	105	0.49
Burkina Faso	15	0.07	Ireland	45	0.21	Colombia	135	0.63
Ghana	120	0.56	Iceland	15	0.07	Peru	105	0.49
Malawi	60	0.28	Italy	240	1.13	Trinidad and Tobago	45	0.21
Mauritius	60	0.28	Kazakhstan	90	0.42	Venezuela	90	0.42
Namibia	30	0.14	Liechtenstein	15	0.07	**East Asia and Pacific**		
Niger	15	0.07	Lithuania	15	0.07	Thailand	165	0.78
Senegal	15	0.07	Malta	60	0.28	Malaysia	150	0.71
Tanzania	90	0.42	Monaco	15	0.07	Indonesia	645	3.03
Togo	30	0.14	Netherlands	60	0.28	Australia	105	0.49
Uganda	45	0.21	Norway	480	2.26	China	705	3.31
Zambia	60	0.28	Portugal	15	0.07	Guam	15	0.07
Zimbabwe	60	0.28	Poland	195	0.92	Hong Kong	105	0.49
North Africa and South Asia			Republic of Serbia	30	0.14	Japan	1,305	6.14
Morocco	90	0.42	Russia	180	0.85	Korea; Republic (S. Korea)	135	0.63
Ivory Coast	45	0.21	Romania	45	0.21	New Zealand	15	0.07
Pakistan	315	1.48	Slovak Republic	60	0.28	Philippines	210	0.99
Bangladesh	450	2.12	Slovenia	15	0.07			
Sri Lanka	165	0.78	Spain	120	0.56	Vietnam	195	0.92
India	615	2.89	Sweden	75	0.35	**The non-GCC Middle East and North Africa**		

Table 1 (*continued*)

Country	Number of banks	Obs. (%)	Country	Number of banks	Obs. (%)	Country	Number of banks	Obs. (%)
Singapore	45	0.21	Turkey	180	0.85	Egypt	165	0.78
Taiwan	300	1.41	Switzerland	225	1.06	Jordan	225	1.06
			Ukraine	105	0.49	Lebanon	90	0.42
			United Kingdom	195	0.92	Palestine	75	0.35
						Israel	150	0.71
						Tunisia	150	0.71

Note: This table lists the number of banks and % of observations by country. The sample consists of 20,715 bank–year observations from 1,381 banks in 107 countries.

3.2. Variable measurement

3.2.1. Earnings management model development

The dependent variable of interest is earnings management in the banking industry. Three proxies for managerial opportunism are used. The first proxy is the magnitude of discretionary accruals ($DACC_{it}$). The discretionary portion of total accruals may arise from the opportunistic behavior of managers and is often used to detect earnings management. $DACC_{it}$ is estimated using the Jones (1991) model as modified by Yasuda, Okuda, and Konishi (2004) for the banking industry. This model alters firm-specific variables for the banking industry and is widely used in bank earnings management studies (Elnahass et al., 2022; Leventis & Dimitropoulos, 2012). Following Yasuda et al. (2004), the discretionary portion of total accruals is estimated using the following regression model:

$$ACCR_t/TA_{t-1} = a_1(1/TA_{t-1}) + a_2(\Delta OI_t/TA_{t-1}) + a_3(PPE_t/TA_{t-1}) + \varepsilon_t \qquad (1)$$

where $ACCR_t$ is total accruals as measured by the difference between income before extraordinary items and operating cash flow.

TA_{t-1} = the one-year lagged value of total assets.

ΔOI_t = changes in operating income from year t–1 to year t.

PPE_t = property, plant and equipment.

ε_t = the error term.

To overcome heteroskedasticity in the error term, all of the variables and intercepts are deflated by lagged total assets (Jones, 1991). The residuals from Equation (1) are the discretionary component of total accruals in the following regression model:

$$DACC_{it} = a_0 + \beta_1 RELIG_{it} + \gamma_1 BankControl_{it} + \gamma_2 CountryControl_{it} + \varepsilon_{it} \qquad (2)$$

$DACC_{it}$ is an inverse measure of earnings quality, meaning that the higher the discretionary accruals, the lower the quality of the reported earnings. $RELIG_{it}$ is a vector of the religious dimensions; $BankControl_{it}$ is a vector of bank-level variables; $CountryControl_{it}$ is a vector of country-level regulatory and supervision variables, and ε_{it} is the error term. We expect the coefficients of β to be negative and significant, implying that banks in countries with high religiosity have low discretionary accruals and therefore good reporting quality.

Following Elnahass et al. (2022) and Kanagaretnam, Lobo, and Wang (2015), we adopt loss avoidance ($LOSS\_AVOID_{it}$) as the second proxy for earnings management to overcome the shortcomings of accrual models. The rationale is that managers avoid reporting a loss by managing earnings. Therefore, $LOSS\_AVOID_{it}$ equals 1 if net income scaled by lagged total assets is between 0 and 0.015 for the respective year and 0 otherwise (Kanagaretnam, Lobo, & Wang, 2015). The following fixed effects model is then developed to introduce $LOSS\_AVOID_{it}$ as the dependent variable:

$$LOSS\_AVOID_{it} = a_0 + \beta_1 RELIG_{it} + \gamma_1 BankControl_{it} + \gamma_2 CountryControl_{it} + \varepsilon_{it} \qquad (3)$$

A significant, negative estimate of $RELIG_{it}$ indicates that compared with banks in countries with low religiosity, banks in countries with high religiosity are less likely to avoid reporting a loss, which suggests high-quality financial reporting.

Earlier studies conclude that bank managers are motivated to manage earnings to beat certain thresholds or benchmarks (Altamuro & Beatty, 2010). Just meeting or beating last year's earnings ($JMBE_{it}$) is a crucial benchmark for managers (Kanagaretnam, Lobo, & Wang, 2015). Therefore, we develop the following model to include $JMBE_{it}$.

$$JMBE_{it} = a_0 + \beta_1 RELIG_{it} + \gamma_1 BankControl_{it} + \gamma_2 CountryControl_{it} + \varepsilon_{it} \qquad (4)$$

A statistically significant negative coefficient of $RELIG_{it}$ indicates that high religiosity curbs opportunistic behavior aimed at beating last year's earnings.

3.2.2. Religiosity measures

This study follows prior studies to measure religiosity (Kanagaretnam, Lobo, & Wang, 2015; Kanagaretnam, Lobo, Wang, et al., 2015). According to these studies, religiosity is (I) the cognition or knowledge that surrounds

religious beliefs and values, (II) feelings or affection toward religious persons and institutions and (III) behavior such as church attendance, prayer and religious life maintenance. We develop a comprehensive measure of religiosity using three questions from the WVS: (1) "Are you a religious person?" (*MEMBER_RELI*), (2) "How important is religion in your life?" (*RELI_IMP*) and (3) "How often do you attend religious services?" (*RELI_SERV*). In addition, an aggregate measure of religiosity (*RELIGIOSITY*) that extracts the principal components of these dimensions is included. The details of the measurement procedures are provided in Table 2.

3.2.3. Control variables

A series of bank- and country-level control variables are included in the regression models. Following Kanagaretnam, Lobo, and Wang (2015) and Zainuldin and Lui (2020), we include bank size ($SIZE_{it}$), leverage (LEV_{it}), loss ($LOSS_{it}$), growth ($GROWTH_{it}$), changes in annual cash flow (ΔCFO_{it}), International Financial Reporting Standards ($IFRS_{it}$) and GAAP ($GAAP_{it}$) to control for cross-sectional variations in bank characteristics. Furthermore, to control the effects of a country's regulations and supervision on the religiosity–earnings management relationship, we include the private monitoring index (*MONITOR_INDEX*) and official supervisory power index (*OFFICIAL_INDEX*) (Zainuldin & Lui, 2020). The variable definitions and measurements are provided in Table 2.

4. Empirical results

4.1. Summary statistics

Table 3 exhibits the summary statistics for the bank- and country-level variables. As shown in Panel A, 77.4 % of the banks in the sample, on average, have a mean $DACC_{it}$ of 0.026, which is much lower than that in the study by Cai et al. (2019). Approximately 77.8 % of the banks have an average value of 0.521 for $LOSS\_AVOID_{it}$, which is comparatively higher than the value in the study by Kanagaretnam, Lobo, and Wang (2015). Regarding $JMBE_{it}$, approximately 77.1 % of the banks have an average increase of 7.6 % in earnings over the sample period. The banks' asset growth ($GROWTH_{it}$) is 88.5 % over the sample period. The majority of the banks use IFRS. As shown in Panel B, about 64.5 % of the banks report asset deterioration of 0.8 %, as measured by $LARGE\_LLP_{it}$. The results in Panel B further show that approximately 21.3 % of the banks in the sample have poor performance, as indicated by $LOWER\_ROA_{it}$. Panel C reports the results for the country-level variables related to religiosity and bank regulation and supervision. Approximately 62.9 % of the respondents belong to a religion (*MEMBER_RELI*), 62.4 % indicate that religion is important to them (*RELI_IMP*) and 5.9 % participate in religious services more than once a year (*RELI_SERV*). Together, the three religion dimensions generate a mean religiosity value of 43.7 % (*RELIGIOSITY*). However, the mean values of the four religion measures differ from those in the study by Kanagaretnam, Lobo, Wang, et al. (2015) for several reasons. First, we measure religion using the average of the three most recent WVS waves (2005–2009, 2010–2014 and 2017–2022), whereas Kanagaretnam, Lobo, Wang, et al. (2015) use the mean value of two WVS surveys (1999–2002 and 2005–2006). Second, our study examines the 2007–2021 period, while they examine the 2000–2006 period. Third, we estimate the dimensions of religiosity for 32 market economies, whereas they consider 30 countries. Last, this study includes countries such as Australia, Brazil, Chile, China, Taiwan ROC, Cyprus, Georgia, Hong Kong and Iraq that are absent from the sample in the referent paper.

4.2. Correlation matrix

Table 4 presents the Pearson correlation matrix for the full sample. All of the earnings management proxies show a significant inverse relationship with the religiosity dimensions. This offers preliminary support for our conjecture that religion plays a considerable role in mitigating managers' opportunistic behavior. Although the religiosity variables have correlations greater than 0.6, the variance inflation factor test has a correlation value less than 3.30, which is far below the threshold suggested in Johnson Jr, Johnson, and Buse (1987). This indicates that there is no serious multicollinearity among the explanatory variables. Notably, the religiosity

Table 2
Variable definitions and measurements.

Variable	Acronym	Definition and measure	Source
Religion variables			
Member of religion	MEMBER_RELI	The % of respondents affiliated with a religion, measured as follows: Number of respondents who indicate they are religious All respondents	
Importance of religion	RELI_IMP	The % of respondents to whom religion is important, measured as follows: Number of respondents who answer "very important" or "rather important" All respondents	World Values Surveys
Religion services	RELI_SERV	The % of respondents who participate in religious services, measured as follows: Number of respondents who attend religious services more than once a year All respondents	
Religiosity	RELIGIOSITY	An index derived from a principal component analysis of the three religion variables	
Earnings management variables			
Discretionary accruals	DACC	The discretionary portion of total accruals as estimated using the Jones (1991) model modified by Yasuda et al. (2004)	
Loss avoidance	LOSS_AVOID	A dummy variable that equals 1 if the bank's ROA (net income before taxes scaled by beginning total assets) is in the 0–0.015 range; 0 otherwise	
Just meeting or beating last year's earnings	JMBE	A dummy variable that equals 1 if the bank's ΔROA (income before taxes scaled by total assets) from year $t + 1$ to year t is in the 0–0.0005 range; 0 otherwise	
Global financial crisis test variables			
Large loan loss provision	LARGE_LLP	A dummy variable that equals 1 if the ratio of loan loss provisions to total loans is greater than 0.10; 0 otherwise	
Lower return-on-asset	LOWER_ROA	A dummy variable that equals 1 if ROA is less than 0.005; 0 otherwise	Cai et al. (2019), Kanagaretnam, Lobo, and Wang (2015)
Global financial crisis	GFC	A dummy variable that equals 1 for observations from 2007 to 2009; 0 otherwise	
Bank-level variables			
Bank size	SIZE	The natural logarithm of total reported assets over the years	
Leverage	LEV	The ratio of total liabilities to total assets in a particular year	Kanagaretnam, Lobo, Wang, et al. (2015)
Loss	LOSS	A dummy variable that equals 1 if the bank has negative net income; 0 otherwise	
Growth	GROWTH	The growth in total assets from the beginning of the year to the end, measured as follows: current year's assets – previous year's asset previous year's assets	
Change in annual cash flow	ΔCFO	The ratio of the change in annual cash flow (income before taxes + loan loss provision) to total lagged assets	
IFRS	IFRS	A dummy variable that equals 1 if the bank follows IFRS; 0 otherwise	
GAAP	GAAP	A dummy variable that equals 1 if the bank follows GAAP; 0 otherwise	Brennan (2021)

Table 2 (*continued*)

Variable	Acronym	Definition and measure	Source
Country-level variables			
Private monitoring index	MONITOR_INDEX	The private monitoring index	Barth, Caprio, and Levine (2013)
Official supervisory power index	OFFICIAL_INDEX	The official supervisory power index	

Note: This table provides the definitions of the independent, dependent and control variables, their measurements and sources.

Table 3
Summary statistics.

	Mean	Std. Dev.	P25	Median	p75	Observations
PANEL A: Bank-level earnings management data						
DACC	0.026	0.164	−0.020	0.059	0.115	16,037
LOSS_AVOID	0.521	0.500	0.000	1.000	1.000	16,133
JMBE	0.076	0.265	0.000	0.000	0.000	15,983
SIZE	22.199	2.172	20.586	22.059	23.639	17,404
LEV	0.899	0.051	0.880	0.907	0.931	17,282
LOSS	0.071	0.257	0.000	0.000	0.000	17,457
GROWTH	0.885	45.868	−0.007	0.085	0.197	16,165
ΔCFO	−0.320	1.309	−0.081	0.000	0.013	15,350
IFRS	0.337	0.473	0.000	0.000	1.000	16,935
GAAP	0.314	0.464	0.000	0.000	1.000	16,935
PANEL B: Bank-level GFC data						
LARGE_LLP	0.008	0.087	0.000	0.000	0.000	13,360
LOWER_ROA	0.213	0.409	0.000	0.000	0.000	16,871
GFC	0.2	0.4	0.000	0.000	0.000	20,715
PANEL C: Country-level data						
MEMBER_RELI	0.629	0.236	0.425	0.647	0.841	32
RELI_IMP	0.624	0.300	0.364	0.679	0.911	32
RELI_SERV	0.059	0.047	0.033	0.059	0.073	32
RELIGIOSITY	0.437	0.155	0.288	0.473	0.595	32
MONITOR_INDEX	7.393	2.809	6.000	6.000	7.000	14,015
OFFICIAL_INDEX	9.993	2.655	9.000	11.000	12.000	12,676

Note: This table presents the summary statistics of bank earnings management, bank-level GFC data and country-level religiosity for the strongly balanced panel of 20,715 bank–year observations from the 2007–2021 period.

index ($RELIGIOSITY_{it}$) aggregates the three religion variables to examine the combined effect of religiosity on earnings management by the banks in the sample.

4.3. Religiosity and bank earnings management

This section details the empirical results of the religiosity–earnings management regression specification using the banking data from eight regions. Discretionary accruals ($DACC_{it}$) and loss avoidance ($LOSS\_AVOID_{it}$) are the main dependent variables of interest. Just meeting or beating last year's earnings ($JMBE_{it}$) is an additional dependent variable to check the robustness of the main results. We use a fixed effects model to estimate Equation (1), which is similar to previous studies on bank earnings management (Cai et al., 2019; Kanagaretnam, Lobo, & Wang, 2015).

4.3.1. Does religiosity influence bank discretionary accruals?
Table 5 presents the regression results for the effects of religiosity on discretionary accruals ($DACC_{it}$). The first three regression models estimate each religiosity variable separately, and the last model includes the

Table 4
Pearson correlation matrix.

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
(1) DACC	1.00																	
(2) LOSS_AVOID	0.11* (0.00)	1.00																
(3) JMBE	0.04* (0.00)	0.18* (0.00)	1.00															
(4) LARGE_LLP	−0.04* (0.00)	−0.05* (0.00)	−0.04* (0.00)	1.00														
(5) LOWER_ROA	−0.07* (0.00)	0.13* (0.00)	−0.01 (0.11)	0.05* (0.00)	1.00													
(6) MEMBER_RELI	−0.18* (0.00)	−0.27* (0.00)	−0.08* (0.00)	0.07* (0.00)	−0.21* (0.00)	1.00												
(7) RELI_IMP	−0.15* (0.00)	−0.30* (0.00)	−0.08* (0.00)	0.06* (0.00)	−0.22* (0.00)	0.86* (0.00)	1.00											
(8) RELI_SERV	0.05* (0.00)	0.25* (0.00)	0.05* (0.00)	−0.02 (0.06)	0.36* (0.00)	−0.52* (0.00)	−0.62* (0.00)	1.00										
(9) RELIGIOSITY	−0.15* (0.00)	−0.31* (0.00)	−0.08* (0.00)	0.06* (0.00)	−0.29* (0.00)	0.91* (0.00)	0.94* (0.00)	−0.79* (0.00)	1.00									
(10) SIZE	0.25* (0.00)	0.03* (0.00)	0.07* (0.00)	−0.02 (0.02)	−0.01 (0.18)	−0.39* (0.00)	−0.35* (0.00)	0.22* (0.00)	−0.36* (0.00)	1.00								
(11) LEV	0.12* (0.00)	0.26* (0.00)	0.11* (0.00)	−0.03* (0.00)	0.16* (0.00)	−0.31* (0.00)	−0.30* (0.00)	0.28* (0.00)	−0.33* (0.00)	0.33* (0.00)	1.00							
(12) LOSS	−0.12* (0.00)	−0.26* (0.00)	−0.14* (0.00)	0.10* (0.00)	0.53* (0.00)	0.05* (0.00)	0.02 (0.02)	0.03* (0.01)	0.02 (0.08)	−0.10* (0.00)	0.00 (0.56)	1.00						
(13) GROWTH	−0.06* (0.00)	−0.02 (0.01)	0.00 (0.63)	0.00 (0.90)	−0.01 (0.30)	0.00 (0.66)	−0.02 (0.14)	0.00 (0.88)	−0.01 (0.42)	0.04* (0.00)	0.02 (0.02)	0.00 (0.58)	1.00					
(14) ΔCFO	0.08* (0.00)	0.00 (0.82)	0.04* (0.00)	0.00 (0.60)	−0.03* (0.00)	−0.09* (0.00)	−0.06* (0.00)	0.06* (0.00)	−0.08* (0.00)	0.31* (0.00)	0.09* (0.00)	−0.06* (0.00)	0.00 (0.57)	1.00				
(15) MONITOR_INDEX	0.07* (0.00)	0.11* (0.00)	0.09* (0.00)	−0.04* (0.00)	0.04* (0.00)	−0.19* (0.00)	−0.17* (0.00)	0.09* (0.00)	−0.17* (0.00)	0.09* (0.00)	−0.04* (0.00)	−0.02 (0.10)	−0.01 (0.47)	0.04* (0.00)	1.00			
(16) OFFICIAL_INDEX	−0.11* (0.00)	−0.11* (0.00)	−0.04* (0.00)	0.00 (0.84)	−0.06* (0.00)	0.21* (0.00)	0.24* (0.00)	−0.16* (0.00)	0.23* (0.00)	−0.25* (0.00)	−0.06* (0.00)	−0.04* (0.00)	−0.01 (0.50)	−0.07* (0.00)	−0.61* (0.00)	1.00		
(17) IFRS	0.02 (0.04)	−0.07* (0.00)	−0.03* (0.00)	0.03* (0.00)	−0.04* (0.00)	0.06* (0.00)	−0.02 (0.03)	−0.05* (0.00)	0.03* (0.00)	0.19* (0.00)	−0.12* (0.00)	0.01 (0.11)	0.02 (0.06)	0.06* (0.00)	−0.15* (0.00)	−0.16* (0.00)	1.00	
(18) GAAP	−0.04* (0.00)	0.06* (0.00)	0.04* (0.00)	−0.06* (0.00)	−0.05* (0.00)	0.17* (0.00)	0.11* (0.00)	−0.27* (0.00)	0.20* (0.00)	−0.36* (0.00)	−0.05* (0.00)	0.03* (0.00)	−0.01 (0.44)	−0.11* (0.00)	0.24* (0.00)	0.30* (0.00)	−0.48* (0.00)	1.00

Note: ***, ** and * denote statistical significance at the 1 %, 5 % and 10 % levels, respectively.

Table 5
Discretionary accruals and religiosity.

Variable	DACC (I)	DACC (II)	DACC (III)	DACC (IV)
MEMBER_RELI	−0.149***			
	(0.000)			
RELI_IMP		−0.147***		
		(0.000)		
RELI_SERV			−0.340**	
			(0.017)	
RELIGIOSITY				−0.036***
				(0.000)
SIZE	0.035***	0.035***	0.036***	0.034**
	(0.000)	(0.000)	(0.000)	(0.000)
LEV	−0.429***	−0.405***	−0.426***	−0.407***
	(0.000)	(0.000)	(0.000)	(0.000)
LOSS	−0.043***	−0.043***	−0.040***	−0.044***
	(0.000)	(0.000)	(0.000)	(0.000)
GROWTH	−0.001***	−0.001***	−0.001***	−0.001***
	(0.000)	(0.000)	(0.000)	(0.000)
ΔCFO	0.002	0.002	0.001	0.002
	(0.380)	(0.406)	(0.445)	(0.384)
IFRS	−0.029***	−0.027**	−0.024**	−0.027**
	(0.008)	(0.013)	(0.032)	(0.015)
GAAP	0.205**	0.213**	0.236**	0.198**
	(0.027)	(0.022)	(0.011)	(0.033)
MONITOR_INDEX	0.004***	0.004***	0.004***	0.004***
	(0.005)	(0.008)	(0.002)	(0.003)
OFFICIAL_INDEX	0.001	0.001	0.002	0.001
	(0.338)	(0.508)	(0.235)	(0.450)
Constant	−0.338**	−0.371***	−0.464***	−0.440***
	(0.010)	(0.005)	(0.000)	(0.001)
Number of observations	4,748	4,748	4,748	4,748
Number of groups	983	983	983	983
F-statistic (p-value)	21.634***(0.000)	20.095***(0.000)	19.406***(0.000)	20.099***(0.000)

Note: This table presents the fixed-effects estimation of the discretionary accruals–religiosity relationship through a series of four models. The p-values are in parentheses. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively.

overall religiosity index ($RELIGIOSITY_{it}$) to examine the aggregate effect of religiosity on discretionary accruals. The coefficients of the three religion dimensions and the aggregate religiosity index ($RELIGIOSITY_{it}$) are negative and significant across all three $DACC_{it}$ models at the 1 % level. This indicates that religiosity is an important tool in constraining bank managers' use of discretionary accruals to manage earnings.

Regarding the bank-level control variables, we find significant and positive coefficients of $SIZE_{it}$ across the four $DACC_{it}$ models, suggesting that large banks report higher discretionary accruals than small banks. In contrast, the coefficient of LEV_{it} is negative for all four models, significant at the 1 % level. This is inconsistent with positive accounting theory, which posits that managers from highly leveraged firms are more likely than managers from other firms to use discretionary accruals to increase firms' bargaining power and avoid debt covenant violations (Elnahass et al., 2022). One possible explanation for this finding is the monitoring and controls creditors impose to discourage banks from engaging in earnings management (Lazzem & Jilani, 2018). Furthermore, the coefficients of $LOSS_{it}$ and $GROWTH_{it}$ are negative across all of the models. The inverse relationship between $LOSS_{it}$ and $DACC_{it}$ is consistent with the literature because firms with losses have little motivation to use discretionary accruals (Francis & Yu, 2009). However, the negative growth–discretionary accruals association contradicts the finding of Lai, Sasmita, Gul, Foo, and Hutchinson (2018) that high-growth firms have high discretionary accruals to avoid reporting poor earnings. The coefficients of ΔCFO_{it} are positive but not significant for all of the models, indicating that a change in CEO has a trivial effect on discretionary accruals. The results show that the banks that follow IFRS engage in less earnings management

than those that follow GAAP. These findings are in line with the study of Baig and Khan (2016). Last, among the country-level variables, only *MONITOR_INDEX* has a positive and significant coefficient across the models (I–IV).

4.3.2. Does religiosity influence bank loss avoidance?

Table 6 shows the results for the regression of $LOSS\_AVOID_{it}$ on the religion and bank- and country-level variables to investigate the relationship between religiosity and loss avoidance. The variables of interest are the three dimensions of religion, and the results show that they are inversely associated with loss avoidance across all of the models except III. Notably, the aggregate measure of religiosity ($RELIGIOSITY_{it}$) is negative for loss avoidance, significant at the 1 % level. This suggests that the combination of the three religious dimensions put downward pressure on earnings management. This finding is in line with that of Kanagaretnam, Lobo, and Wang (2015) that religion is a nontrivial tool in constraining the frequency of loss reporting.

Regarding the bank-level control variables, the results show that large banks are less likely than small banks to manage their earnings by reporting losses less frequently, which is similar to the findings of Elnahass et al. (2022). The positive and significant coefficients of LEV_{it} suggest that highly leveraged firms often try to reduce the likelihood of violating their debt contracts by managing their reported earnings (Lazzem & Jilani, 2018). The directions of the relationships between $LOSS\_AVOID_{it}$ and $LOSS_{it}$ and $GROWTH_{it}$ are similar to those in Table 5. However, for the banks in the sample following IFRS, $IFRS_{it}$

Table 6
Loss avoidance and religiosity.

Variable	Loss avoidance (I)	Loss avoidance (II)	Loss avoidance (III)	Loss avoidance (IV)
MEMBER_RELI	−0.346***			
	(0.000)			
RELI_IMP		−0.407***		
		(0.002)		
RELI_SERV			1.688***	
			(0.000)	
RELIGIOSITY				−0.178***
				(0.000)
SIZE	−0.029*	−0.017	−0.023	−0.023
	(0.069)	(0.280)	(0.142)	(0.148)
LEV	0.988***	0.324**	0.344**	0.324**
	(0.000)	(0.032)	(0.022)	(0.031)
LOSS	−0.642***	−0.647***	−0.654***	−0.655***
	(0.000)	(0.000)	(0.000)	(0.000)
GROWTH	−0.002***	−0.002***	−0.002***	−0.002***
	(0.000)	(0.000)	(0.000)	(0.000)
ΔCFO	−0.008	−0.009	−0.009	−0.008
	(0.150)	(0.135)	(0.143)	(0.162)
IFRS	−0.038	−0.044	−0.028	−0.053
	(0.297)	(0.224)	(0.435)	(0.140)
GAAP	0.042	0.012	−0.058	−0.076
	(0.893)	(0.969)	(0.851)	(0.806)
MONITOR_INDEX	0.022***	0.020***	0.023***	0.021***
	(0.000)	(0.000)	(0.000)	(0.000)
OFFICIAL_INDEX	0.007	0.006	0.007	0.006
	(0.120)	(0.187)	(0.141)	(0.200)
Constant	0.288	0.703*	0.419	0.605
	(0.491)	(0.073)	(0.272)	(0.113)
Number of observations	4,896	4,896	4,896	4,896
Number of groups	992	992	992	992
F-statistic (p-value)	44.642***(0.000)	43.114***(0.000)	43.526***(0.000)	45.240***(0.000)

Note: This table presents the fixed-effects estimations of the loss avoidance–religiosity relationship using a series of four models. The p-values are in parentheses. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively.

has a negative relationship with loss avoidance across the four models, and the significance of the relationship is low. Among the country-level variables, only *MONITOR_INDEX* has a positive and significant relationship with loss avoidance.

4.3.3. Does religion influence just meeting or beating last year's earnings?

Table 7 presents the fixed-effects estimation results for the religiosity–JMBE relationship. In contrast to the results in Tables 5 and 6, the coefficients of the religion variables are positive in models I–III. However, the aggregate religion variable ($RELIGIOSITY_{it}$) has a negative and significant coefficient. This provides robust evidence that the combined measure of a country's religiosity often inhibits bank managers from engaging in earnings management.

The results for the bank-level control variables show that compared with their counterparts, large banks ($SIZE_{it}$) and those with high growth ($GROWTH_{it}$) or considerable losses ($LOSS_{it}$) are less likely to engage in earnings management. The positive relationship between LEV_{it} and $JMBE_{it}$ aligns with positive accounting theory. Last, the results offer further proof of the role of IFRS in minimizing earnings management. Among the country-level variables, *MONITOR_INDEX* is positively related to earnings management, but the significance level is low. In summary, these results demonstrate the robustness and validity of the proposition that religion plays an important role in curbing managerial opportunism in the banking industry.

Table 7
Just meeting or beating last year's earnings and religiosity.

Variable	JMBE (I)	JMBE (II)	JMBE (III)	JMBE (IV)
MEMBER_RELI	0.062			
	(0.602)			
RELI_IMP		0.239		
		(0.149)		
RELI_SERV			2.193***	
			(0.000)	
RELIGIOSITY				−0.038**
				(0.021)
SIZE	−0.006	−0.007	−0.012	−0.007
	(0.780)	(0.728)	(0.544)	(0.728)
LEV	0.258	0.254	0.283	0.255
	(0.167)	(0.174)	(0.129)	(0.172)
LOSS	−0.194***	−0.193***	−0.207***	−0.196***
	(0.000)	(0.000)	(0.000)	(0.000)
GROWTH	−0.001**	−0.001**	−0.001**	−0.001**
	(0.022)	(0.020)	(0.020)	(0.023)
ΔCFO	0.015**	0.015***	0.016**	0.016**
	(0.036)	(0.035)	(0.032)	(0.033)
IFRS	−0.081*	−0.076*	−0.080*	−0.088**
	(0.070)	(0.089)	(0.070)	(0.047)
GAAP	−0.046	−0.042	−0.167	−0.075
	(0.904)	(0.914)	(0.664)	(0.846)
MONITOR_INDEX	0.005	0.006	0.006	0.005
	(0.362)	(0.276)	(0.274)	(0.422)
OFFICIAL_INDEX	−0.001	−0.000	−0.002	−0.002
	(0.832)	(0.948)	(0.695)	(0.781)
Constant	0.222	0.113	0.276	0.318
	(0.647)	(0.816)	(0.559)	(0.503)
Number of observations	4,867	4,867	4,867	4,867
Number of groups	991	991	991	991
F-statistic (p-value)	3.848***(0.000)	4.031***(0.000)	5.259***(0.000)	3.904***(0.000)

Note: This table presents the fixed-effects estimation of the JMBE–religiosity relationship using a series of four models. The p-values are in parentheses. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively.

5. Additional tests

5.1. GFC period analysis

In this section, we conduct additional tests related to the GFC period. Motivated by Kanagaretnam, Lobo, and Wang (2015) and Kanagaretnam, Lobo, Wang, et al. (2015), we examine the relationship between religiosity and banks' financial trouble by developing eight regression models and applying them to two phases of the GFC: the crisis (2007–2009) and post-crisis (2010–2021) periods. Because greater religiosity curbs reckless risk-taking and improves financial reporting quality, as evidenced in Kanagaretnam, Lobo, and Wang (2015), we hypothesize that banks in countries with high religiosity are less likely to have had financial difficulties during the 2007–2009 period. Furthermore, restricted earnings management during the GFC led to increased earnings management in the post-crisis period (Türegün, 2020). Therefore, we expect that banks may have faced financial trouble in the post-crisis period because of their increased earnings management. To conduct this analysis, we use asset deterioration and poor performance to measure banks' financial trouble. The variable measure-

Table 8
Large loan loss provisions and religiosity.

Variable	Panel A Crisis-period estimation				Panel B Post-crisis estimation			
	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)
MEMBER_RELI	0.041				0.005			
	(0.082)				(0.880)			
RELI_IMP		0.017				0.001		
		(0.311)				(0.989)		
RELI_SERV			–0.018				–0.278	
			(0.779)				(0.102)	
RELIGIOSITY				0.004				–0.093**
				(0.306)				(0.017)
SIZE	0.000	0.000	0.000	0.000	0.024***	0.024***	–0.023	–0.036*
					(0.001)	(0.001)	(0.001)	(0.071)
LEV	–0.199***	0.204***	0.207***	0.202***	0.310***	0.311***	–0.320	0.910***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.007)	(0.007)	(0.005)	(0.004)
LOSS	0.003	0.003	0.003	0.003	0.055***	0.055***	0.056	0.369**
	(0.773)	(0.762)	(0.751)	(0.760)	(0.000)	(0.000)	(0.000)	(0.000)
GROWTH	0.000	0.000	0.000	0.000	–0.007	–0.007	–0.008	–0.017
					(0.210)	(0.211)	(0.171)	(0.295)
ΔCFO	–0.001	–0.001	–0.001	–0.001	0.002	0.002	0.002	0.000
	(0.529)	(0.544)	(0.549)	(0.544)	(0.437)	(0.437)	(0.440)	
IFRS	0.008	0.010	0.011	0.010	–0.040***	–0.040***	–0.040	0.021
	(0.516)	(0.364)	(0.324)	(0.395)	(0.008)	(0.008)	(0.008)	(0.627)
GAAP	–0.033***	–0.032***	–0.032***	–0.033***	–0.101	–0.101	–0.088	–0.792**
	(0.001)	(0.001)	(0.002)	(0.001)	(0.433)	(0.431)	(0.494)	(0.028)
MONITOR_INDEX	0.001	–0.005	–0.008	–0.004	0.002	0.002	0.002	0.006
	(0.948)	(0.551)	(0.395)	(0.634)	(0.296)	(0.304)	(0.380)	(0.260)
OFFICIAL_INDEX	0.007**	0.007**	0.008**	0.007**	0.000	0.000	0.000	0.006
	(0.046)	(0.034)	(0.020)	(0.030)				(0.229)
Constant	0.092	0.142*	0.171**	0.147*	0.841***	0.845***	0.864	1.948***
	(0.306)	(0.089)	(0.029)	(0.070)	(4.59)	(0.000)	(0.000)	(0.000)
Observations	1,350	1,350	1,350	1,350	3,048	3,048	3,048	3,048
Number of groups	527	527	527	527	853	853	853	853
R-squared	0.070	0.065	0.063	0.066	0.051	0.070	0.068	0.075
Chi-square (p-value)	36.991***	34.881***	33.916***	34.903***	104.977***	123.432***	131.998***	143.352***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

Note: This table compares the crisis and post-crisis results of the earnings management–religiosity relationship with large loan loss provision as the dependent variable. The p-values are in parentheses. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively.

ments are described in Table 1. Following Beltratti and Stulz (2012), we use the following regression model for the GFC period (GFC = 1 for observations in 2007–2009; 0 otherwise):

$$BANKTROUBLE_{it} = \beta_0 + \beta_1 RELIG_{it} + \beta_2 X_{i,t} + \beta_3 W_{it} + + \mu_i + \varepsilon_{it} \tag{5}$$

where $BANKTROUBLE_{it}$ is defined as banks experiencing asset deterioration or poor performance at time t; $RELIG_{it}$ represents the set of religion dimensions; X is the bank-level control variables, and w is the country-level institutional variables. β_0, μ_i and ε_{it} denote the constant, bank effects and the stochastic error term, respectively.

The regression results are presented in Tables 8 and 9. The results for the crisis and post-crisis periods are shown in Panels A and B, respectively. In Table 8, the coefficients of the religion variables are not significant in the crisis period, while in the post-crisis period, the coefficient of the aggregate religiosity measure ($RELIGIOSITY_{it}$) is negative and significant. In Table 9, the coefficients of the religion dimensions, except $RELI\_SERV$, and the combined religiosity measure ($RELIGIOSITY_{it}$) are negative and statistically significant.

Table 9
Lower ROA and religiosity.

Variable	Panel A Crisis-period estimation				Panel B Post-crisis period estimation			
	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)
MEMBER_RELI	–0.557***				–0.368***			
	(0.000)				(0.000)			
RELI_IMP		–0.395***				–0.370***		
		(0.000)				(0.000)		
RELI_SERV			2.355***				1.902***	
			(0.000)				(0.000)	
RELIGIOSITY				–0.120***				–0.101***
				(0.000)				(0.000)
SIZE	–0.038***	–0.041***	–0.038***	–0.041***	–0.021***	–0.021***	–0.010**	0.994***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.044)	(0.000)
LEV	0.783***	0.782***	0.630***	0.700***	1.124***	1.049***	1.065***	0.697***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
LOSS	0.676***	0.672***	0.686***	0.684***	0.697***	0.695***	0.691***	–0.011*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.065)
GROWTH	0.000	0.000	0.000	0.000	–0.011*	–0.012**	–0.011*	–0.004
					(0.052)	(0.043)	(0.059)	(0.425)
ΔCFO	0.002	0.002	0.002	0.002	–0.005	–0.004	–0.005	0.020***
	(0.653)	(0.730)	(0.636)	(0.604)	(0.314)	(0.463)	(0.328)	(0.000)
IFRS	0.077***	0.121***	0.097***	0.083***	0.020***	0.021***	0.018***	0.015***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
GAAP	0.003	0.000	–0.003	0.001	0.014***	0.016***	0.011***	–0.024
	(0.712)		(0.680)	(0.892)	(0.000)	(0.000)	(0.000)	(0.145)
MONITOR_INDEX	–0.045	–0.081***	–0.038	–0.048	–0.017	–0.047***	–0.015	–0.135***
	(0.151)	(0.009)	(0.187)	(0.108)		(0.005)	(0.378)	(0.000)
					(0.300)			
OFFICIAL_INDEX	–0.135***	–0.146***	–0.084***	–0.118***	–0.136***	–0.164***	–0.090***	–0.513***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.002)
Constant	0.166	–0.098	–0.297	–0.062	–0.401**	–0.327*	–0.913***	–1.065***
	(0.491)	(0.673)	(0.135)	(0.770)	(0.022)	(0.000)	(0.000)	(0.001)
Number of observations	1,586	1,586	1,586	1,586	3,310	3,310	3,310	3,310
Number of groups	609	609	609	609	975	975	975	975
R-squared	0.382	0.378	0.446	0.415	0.338	0.356	0.358	0.364
Chi-square (p-value)	638.692***	622.786***	845.647***	737.863***	1,160.017***	1,188.450***	1,196.919***	1,241.107***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

Note: This table compares the crisis and post-crisis results of the earnings management–religiosity relationship with lower ROA as the dependent variable. The regression p-values are in parentheses. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively.

However, the magnitude of the effect of religion on bank performance improvement is greater in the crisis period than in the post-crisis period.

Overall, during the GFC, banks in countries with high religiosity experienced less financial trouble as measured by poor performance than their counterparts in less religious countries because bank managers engaged in less earnings smoothing during this timeframe. Even after the GFC, banks experienced less financial trouble as measured by $LARGE\_LLP_{it}$. One possible explanation is that in the post-crisis period, managers may have engaged in less earnings management to attract investors through high-quality financial reporting (Cimini, 2015).

5.2. Religiosity and earnings management: Evidence from conventional and Islamic banks

To compare the earnings management practices of conventional and Islamic banks, we divide the full sample into two subsamples. The results are reported in Table 10, Panels A (conventional banks) and B (Islamic banks). The coefficients of all of the religion dimensions and the religiosity index ($RELIGIOSITY_{it}$) are negative and statistically significant for earnings management by conventional banks. However, for Islamic banks, only

Table 10
Religiosity–earnings management relationship: Conventional versus Islamic banks.

Variable	Panel A Conventional banks				Panel B Islamic banks			
	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)
MEMBER_RELI	−0.134***				0.360***			
	(0.000)				(0.000)			
RELI_IMP		−0.166***				−0.237		
		(0.000)				(0.897)		
RELI_SERV			−0.267*				−2.481**	
			(0.058)				(0.029)	
RELIGIOSITY				−0.036***				−0.148***
				(0.001)				(0.009)
SIZE	0.037***	0.038***	0.038***	0.037***	0.033	0.034	0.003	0.045
	(0.000)	(0.000)	(0.000)	(0.000)	(0.354)	(0.392)	(0.931)	(0.215)
LEV	−0.540***	−0.517***	−0.539***	−0.519***	−0.470	−0.349	−0.074	−0.546
	(0.000)	(0.000)	(0.000)	(0.000)	(0.234)	(0.408)	(0.863)	(0.036)
LOSS	−0.041***	−0.042***	−0.039***	−0.043***	−0.100**	−0.083*	−0.092**	−0.092**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.020)	(0.067)	(0.038)	(0.036)
GROWTH	−0.001***	−0.001***	−0.001***	−0.001***	−0.036	−0.053	−0.052	−0.041
	(0.000)	(0.000)	(0.000)	(0.000)	(0.472)	(0.323)	(0.317)	(0.431)
ΔCFO	0.001	0.001	0.000	0.001	0.007	0.005	0.002	0.007
	(0.753)	(0.745)		(0.740)	(0.420)	(0.631)	(0.796)	(0.424)
IFRS	−0.044***	−0.043***	−0.038***	−0.042***	0.121	0.101	0.193*	0.076
	(0.000)	(0.000)	(0.001)	(0.000)	(0.212)	(0.385)	(0.074)	(0.444)
GAAP	0.184**	0.190**	0.210**	0.176*	0.000	0.000	0.000	0.000
	(0.042)	(0.036)	(0.021)	(0.052)				
MONITOR_INDEX	0.003**	0.003*	0.004**	0.003**	0.016	0.014	0.023	0.012
	(0.022)	(0.051)	(0.011)	(0.019)	(0.298)	(0.395)	(0.153)	(0.461)
OFFICIAL_INDEX	0.002	0.001	0.002	0.002	0.011	0.009	0.020	0.006
	(0.191)	(0.375)	(0.140)	(0.281)	(0.468)	(0.590)	(0.218)	(0.715)
Constant	−0.297**	−0.305**	−0.407***	−0.384***	−0.289	−0.455	−0.372	−0.519
	(0.030)	(0.026)	(0.003)	(0.004)	(0.650)	(0.839)	(0.577)	(0.421)
Number of observations	4,493	4,493	4,493	4,493	142	142	142	142
Number of groups	928	928	928	928	26	26	26	26
F-statistic (p-value)	20.966*** (0.000)	20.551***	19.208***	20.097**	3.161***	1.535***	2.146***	2.425***
		(0.000)	(0.000)	(0.000)	(0.000)	(0.051)	(0.002)	(0.000)

Note: This table compares 957 conventional and 26 Islamic banks in terms of earnings management behavior. The p-values are in parentheses. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively.

Table 11
Earnings management and religiosity by geographical region.

Variable	Gulf Cooperation Council(GCC) countries	South America	Sub-Saharan Africa	North Africa and South Asia	Non-GCC Middle East and North Africa	East Asia and Pacific	North America	Europe and Central Asia
Panel A: Discretionary accruals								
Religiosity	0.179	-0.025	-0.016	-0.032	-0.080***	-0.007	0.072**	-0.056***
Overall R-squared	0.283	0.330	0.247	0.363	0.192	0.282	0.219	0.212
Panel B: Loss avoidance								
Religiosity	0.070	-0.109**	-0.606	-0.345***	-0.009	-0.125***	-0.889***	-0.141***
Overall R-squared	0.433	0.323	0.506	0.216	0.133	0.371	0.132	0.267
Panel C: Just meeting or beating last year's earnings								
Religiosity	0.301	-0.111**	1.986	0.001	-0.082	0.001	0.756***	-0.067***
Overall R-squared	0.192	0.243	0.233	0.155	0.183	0.165	0.285	0.195

Note: This table shows the fixed-effects estimation results for the earnings management–religiosity relationship for the eight regions. The regression p-values are in parentheses. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively.

the coefficients of *RELI_SERV_it* and *RELIGIOSITY_it* are negative and statistically significant. This suggests that conventional banks in more religious countries have stronger incentives to engage in transparent financial reporting than their Islamic counterparts. Notably, the coefficient of *RELI_MEMBER_it* in Panel B is positive and significant. This finding conflicts with the Islamic principles of fairness, justice and accountability that should be reflected in the business activities of Islamic banks (Zainuldin & Lui, 2020).

5.3. Religiosity and earnings management across geographical regions

The baseline regression model is re-estimated separately for the eight geographical regions, and the results are presented in Table 11. The results in Panel A show that religiosity curbs discretionary accruals only in the non-GCC Middle East, North Africa, Europe and Central Asia, whereas North America exhibits statistically greater earnings management. The results in Panel B show a statistically significant inverse relationship between *RELIGIOSITY_it* and *LOSS_AVOID_it* for all of the regions except the GCC countries, sub-Saharan Africa and the non-GCC Middle East and North Africa. The results in Panel C show that religiosity lowers the propensity to manipulate earnings by just meeting or beating last year's earnings only in South America, Europe and Central Asia. Overall, the baseline results hold in Europe and Central Asia for *DACC_it*, *LOSS_AVOID_it* and *JMBE_it* and in South America for *LOSS_AVOID_it* and *JMBE_it*. However, the effect of religion on earnings management is not significant in GCC countries or sub-Saharan Africa.

The data for the United States make up more than one third of the bank–year observations in the sample (N = 7,545; 35.47 %). This high proportion of US data may skew the regression results. Therefore, to check the robustness of our results, we exclude the US observations and rerun the baseline regressions with the remaining 3,600 bank–year observations. The results resemble our baseline findings in which the coefficients of all three of the religion dimensions and the aggregate religiosity index are similar. Thus, the key findings regarding the religiosity–bank earnings management relationship are robust to the elimination of US observations.

Research documents that endogeneity is unlikely to be a concern because country-level religiosity is largely stable over time (Adhikari & Agrawal, 2016). Hence, it predates a bank's presence in a country and is unlikely to be affected by bank activities. Nevertheless, banks may endogenously self-select locations with certain cultural beliefs, such as religiosity. Thus, bank risk and performance could affect religiosity. For instance, a failed bank could harm the local economy, resulting in job losses that force many people to move (Adhikari & Agrawal, 2016). Therefore, to address potential endogeneity, we conduct a two-stage least squares (2SLS) regression in which the religious dimensions are lagged by two years and used as an instrument. The instrument identification strategy is well supported by Hilary and Hui (2009) and Kumar, Page, and Spalt (2011) in that it meets the relevant criteria, such as a strong correlation between the lagged religious compositions and the current level of religiosity, statistically significant F-test and the identified instrument (see Table 12). The

Table 12
Religiosity and earnings management relationship: 2SLS specification.

Variable	DACC (I)	Loss avoidance (II)	JMBE (III)
First-stage regression			
F-statistic (p-value)	35.88***	35.88***	35.45***
	(0.000)	(0.000)	(0.000)
Lagged *Religiosity* instrument	0.147***	0.135***	0.137***
	(0.000)	(0.000)	(0.000)
Second-stage regression			
Religiosity	–0.092*	–0.887***	–0.64***
	(0.059)	(0.000)	(0.004)
Number of observations	3,155	3,252	3,224
Number of groups	885	896	894
Adjusted R-squared	0.247	0.193	0.201

Note: This table presents the 2SLS regression results of the three models for the religiosity–earnings management relationship. The estimation uses the two-year lagged values of the religion dimensions as an instrument for current religiosity. The regression p-values are in parentheses. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively.

instrumental variable regression results match our baseline results in which religiosity is inversely related to earnings management in all of the specifications. Thus, the 2SLS approach controls potential measurement errors in country-level religiosity and rules out omitted variable bias.

6. Conclusion

This study broadly examines how religiosity affects behavior. Specifically, it focuses on whether religion influences bank earnings management. Unlike prior research, we use an updated dataset of 2007–2021 to obtain a contemporary perspective regarding the aforementioned relationship and consider eight geographical regions to conduct a cross-country analysis. Panel data of 1318 banks including 957 conventional and 26 Islamic banks from the FitchConnect database is used.

Our empirical estimations reveal that each dimension of religion as well as the aggregated measure of religiosity are inversely associated with the bank earnings management behavior as measured by discretionary accruals, loss avoidance and just-meeting-or-beating prior year's earnings. The finding implies that banks headquartered in countries with high religiosity are less likely to manage their reported financial earnings. These estimation results are robust to a range of fixed-effects regressions with sets of bank-specific and country-level supervision and regulatory variables. First, the inverse religiosity–earnings management relationship holds when the baseline regression model is run for the GFC period. Although religiosity negatively affected bank earnings management both during and after the GFC, the magnitude of the effect is greater for the 2007–2009 period than for the post-2009 period. Second, we also find less earnings management by conventional banks than by their Islamic counterparts. Third, the parameters for the earnings management model statistically differ across the eight geographical regions, with Europe and Central Asia being at the forefront in high-quality financial reporting. Fourth, the baseline regression results are robust to the exclusion of US observations. Finally, the use of lagged religion instruments in the 2SLS regression mitigates potential endogeneity concerns and reduces estimation bias.

This study offers valuable implications for policy makers, investors, auditors and bank supervisory and regulatory bodies to formulate mechanisms to control managerial opportunism. For instance, the finding that the religiosity–bank earnings management relationship persists despite a continuous decline in institutionalized religion because of economic development shows that core religious beliefs, values and norms persist unchanged (Inglehart & Baker, 2000). Thus, regulators such as central banks could use religion as an informal tool to restrain financial manipulation. The role of religious social norms should be considered to promote quality financial reporting in the banking industry. The findings during the GFC period also signify the role of religion in enhancing bank accounting quality during an economic crisis. Furthermore, the decreasing effect of religiosity on the earnings management practice in Islamic banks compared with conventional banks highlights the necessity of integrating Islamic principles such as transparency, accountability and faithfulness into the accounting regulatory bodies of Islamic financial institutions. Last, the cross-country differences in bank earnings management suggest that regulatory frameworks should be tailored to each country's banking industry.

This study has some limitations. The data cover the 2007–2021 period; however, including pre-GFC data would enable a comparison of the religiosity–bank earnings management relationship before, during and after the GFC. Moreover, this study explores the religiosity–bank earnings management relationship in eight geographical regions. Focusing on a particular country could provide in-depth insights into how a country's regulations, laws and culture affect the relationship. The inclusion of additional earnings management measures such as loan loss provisions and realized security gains and losses would ensure the robustness of the baseline models. In addition, country characteristics such as GDP growth, real GDP per capita, creditor rights, bank environment and rule of law are not considered in this study because of the unavailability of data. Research should be undertaken to bridge these research gaps and make the baseline model more comprehensive.

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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Government social media and corporate tax avoidance

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ABSTRACT

With the advent of the new media era, government social media have become an important paradigm for social governance. We perform a large-sample regression and reveal that the higher the quality of taxation bureaus' operation of government social media, the lower the degree of local enterprises' tax avoidance, which works through reducing tax avoidance incentives and increasing the difficulty of committing tax avoidance. Moreover, government social media play a substitution effect on tax enforcement and administration. We also find that government social media should focus on strengthening its official, formal and professional characteristics. Given the significant recent changes in how enterprises handle taxation, the proportion of information that taxation bureaus post on system operation should be appropriately increased.
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1. Introduction

The information technology revolution has accelerated the advent of the new media era, triggering in-depth discussions of the government's governance model and public–private relations (Criado et al., 2013; Porumbescu, 2016). In line with the new media era and associated government governance reforms, government social media have gradually become the main channel by which governments release information to the public, interpret rules and regulations and respond to public needs (Bertot et al., 2012; Kavanaugh et al., 2011). This channel not only reflects the traditional notion of information media as public goods (Li and Xu, 2013) but also takes the government's official attributes of authority, seriousness and fairness into

consideration (Linders, 2012; Picazo-Vela et al., 2012). Government social media have formed a special information "dissemination–feedback" chain between officialdom and the private domain (Medaglia and Zhu, 2017) that has become one of the core paradigms through which the government carries out social governance.

However, there remains ample room for academic research on the impacts of government social media. Supporters of the government's use of social media provide evidence of its positive impacts, such as improving the government's image (Masngut and Mohamad, 2021), enhancing citizens' satisfaction with and trust in government (Welch et al., 2005; Porumbescu, 2016), obtaining votes (Grover et al., 2019), improving information transparency (Jun et al., 2014) and combatting the corruption of civil servants (Welch and Wong, 2001; Bertot et al., 2010). Nevertheless, conservatives have raised doubts as to its merits. For example, Bertot et al. (2012) assert that although government social media are conducive to improving government services, it brings new challenges related to issues such as citizen privacy, data security and social inclusion. Through an investigation of 982 police Twitter accounts in the Netherlands in combination with 22 interviews with both police officers and communication officers, Meijer and Torenvlied (2016) find that social media have generated a new paradigm of government communication but that this change is hybrid rather than transformative in nature; both the bureaucratic and the new model manifest themselves in social media communications. McNeal et al. (2008) propose that the government's provision of services through the Internet is a double-edged sword. On the one hand, it enhances the interaction between citizens and the government; on the other hand, it widens the cognitive gap between social classes caused by factors such as educational background.

Academics in various countries pay close attention to government social media and conduct useful explorations in various dimensions and at various depths on the impacts thereof; however, there remain limitations to this research. First, the research is relatively widely distributed between the fields of political science, sociology and journalism, applied in combination with theories of business management, corporate governance and other disciplines; however, the relationship between government social media and corporate micro-economic behavior has not attracted enough attention. Second, scholars generally focus on specific social media apps such as Facebook, Twitter, YouTube and *Weibo* (Criado et al., 2013; Meijer and Torenvlied, 2016; Jing and Zhang, 2021; Xu et al., 2021). Although a number of quantitative and qualitative research methods are applied, such as text analysis (Chae and Park, 2018), descriptive statistical analysis (Meijer and Torenvlied, 2016), exploratory factor analysis (Zhao et al., 2019), data regression (Tobin et al., 2014; Oliveira and Welch, 2013) and case analysis, the basic data are mainly obtained through structured or unstructured surveys and experiments, the size of the samples is relatively limited, little of the research involves large-sample empirical tests on the motivations for and impacts of government social media (Sun and Zheng, 2021), and the conclusions are affected by individual differences between the subjects and are highly subjective, which indicates deficiencies in objectivity and systematization (Li and Tang, 2021).

Government social media involve key aspects of government social governance (Criado et al., 2013). As enterprises constitute one of the most important cells in the economic cycle, how government social media affect corporate micro-behavior is of great theoretical and practical significance. This paper addresses this topic as well as the factors affecting corporate tax avoidance, the research on which is relatively rich. In terms of endogenous factors, research confirms the impacts of multiple dimensions such as political connections, management incentives, pyramid structure and non-state shareholder governance on corporate tax avoidance (Adhikari et al., 2006; Lin et al., 2018; Desai and Dhammika, 2006; Liu and Li, 2012; Ma et al., 2021). In terms of exogenous factors, scholars conduct analyses based on tax enforcement and administration, the tax avoidance behavior of competitors in the same industry, local government preferences, the tax distribution ratio, local religion and Confucian culture and other influencing factors (Allingham and Sandmo, 1972; Li and Liu, 2019; Fan and Tian, 2016; Lv et al., 2016; Alharbi et al., 2020). Despite this foundation, there remains a lack of research on the relationship between government social media and corporate tax avoidance. Therefore, it is worth exploring the effect of government social media on corporate tax avoidance and its mechanisms.

The special interactive relationship between Chinese politics and society is represented well in the *Weibo*[1] online space, which displays many "Chinese characteristics" (Li and Cheng, 2020). The "Chinese

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[1] *Weibo* is short for *Sina Weibo,* which is a social media platform operated by a China corporate called *Sina.* It can be accessed through a variety of mobile terminals such as PCs and mobile phones, and can realize real-time sharing, dissemination and interaction of information in the form of text, pictures, videos, etc., with functions similar to *Facebook.*

characteristics" means Chinese government social media are affected by factors such as policy applicability, regional cultural differences and the linkage of entity taxation and online taxation. Meanwhile, Chinese government social media have a strong regional heterogeneity, thus establishing a strong social relationship with its followers and gathering the radiation effect locally. Therefore, this provides an opportunity to study the relationship between government social media and corporate micro-behavior. Based on sufficient case studies, sampling tests, data statistics and other evidence, we assert that the radiating spheres of influence and followers of Chinese government social media significantly represent regional characteristics. This is the result of the influence of formal and informal institutions such as performance appraisal rules, policy applicability, regional cultural differences and the co-movement of entity taxation. Due to this influence, government social media have created fierce competition between regions, which limits the sphere of influence of a given local taxation bureau's *Sina Weibo*. Furthermore, a local bureau's *Sina Weibo* is tailored to its local community in terms of informational content and advice/guidance columns, with the help of Internet information technologies such as user behavior analysis and personalized recommendations, thereby facilitating a strong social relationship with followers that can be strengthened through such targeted recommendations and interaction of information. The people accessing information concerning local taxation bureaus on their *Sina Weibo* are more inclined to pay attention to local information under the theory of rational behavior, while the *Weibo* platform objectively limits the sources of information available through its design. Furthermore, tax bureaus' *Sina Weibo* remain in the early stages of development; therefore, their influence is less than that of more mature social media accounts, meaning that their followers are concentrated in specific, local groups. The combination of these factors makes it possible to connect the actual utility of local taxation bureaus' operation of social media with the micro-behavior of local enterprises and analyze the relationship between the two.

On this basis, in this study we use the total number of "likes, comments and reposts" made by taxpayers on the official *Sina Weibo* of each taxation bureau of 31 provinces (municipalities and autonomous regions) in China, divided by the total number of posts on same *Sina Weibo* in that year, as a proxy variable for the quality of the taxation bureau's social media, with the intention of empirically testing the relationship between the taxation bureau's operation of government social media and corporate tax avoidance. Furthermore, due to the large-scale clean-up and integration of tax-related social media resulting from the merger of state and local taxation bureaus, to eliminate data interference, a two-way fixed effect regression is conducted with the annual data of 7,084 A-share listed enterprises from 2018 to 2020. It is found that the higher the quality of the taxation bureau's operation of government social media, the less its local enterprises engage in tax avoidance. Further research reveals that government social media play a substitution effect on tax enforcement and administration; that is, the inhibitory effect of the taxation bureau's operation of government social media on corporate tax avoidance is more significant in areas with low levels of tax enforcement and administration. We also conduct an empirical test on the mechanism by which the taxation bureau's operation of government social media affect corporate tax avoidance. In our study, we run group regression on the last period ETR (effective tax rate), KZ (financial constrains), and ILLIQ (stock illiquidity), DD (earnings quality calculated according to the DD model) as the measurement standards of corporate tax avoidance incentives and information transparency, which confirms the existence of the "education effect" and "supervision effect" of the taxation bureau's operation of government social media on corporate tax avoidance. Specifically, the education effect reduces the economic incentives of corporate tax avoidance by affecting institutional transaction costs and direct economic benefits and reduces the non-economic incentives of corporate tax avoidance by affecting the public's attitude toward and moral cognition of the government. The supervision effect increases the difficulty of committing corporate tax avoidance by strengthening internal and external supervision. By subdividing the information attributes of government social media, this study further shows that when the content of other types of information released by local taxation bureaus on *Sina Weibo* increases, the degree of corporate tax avoidance increases, which indicates that government social media should strengthen its official, formal and professional characteristics. Moreover, it seems that the content and form of certain strategies that government entities use to benefit and get close to the public do not meet expectations. Specifically, an increase in the content of information on system operations and announcements released by local taxation bureaus on their *Sina Weibo* reduces the degree of corporate tax avoidance. Especially given current changes in how enterprises handle taxation, the proportion of information on system operations should be appropriately increased.

This study makes the following contributions to the literature. First, the research on the impact of government social media is limited in terms of subject distribution and research methods. We use Python to obtain the posts and interaction records of the *Sina Weibo* of taxation bureaus in China and empirically test the impacts and mechanisms of the taxation bureau's operation of government social media on corporate tax avoidance. This method promotes the integration of disciplines and improves on other research methods to a certain extent. Second, although the research on the media and corporate governance has mainly reached the consensus that the media are an important part of the corporate governance mechanism outside of legal measures (Dyck et al., 2008), the official nature of government social media, different from ordinary media, affects the mechanism of corporate governance. Therefore, this study of the relationship between government social media and corporate governance expands and enriches the research related to corporate governance from the perspective of media. Third, although corporate tax avoidance research is relatively abundant, it rarely focuses on government social media's effects. Therefore, this study supplements the research on the influencing factors of corporate tax avoidance.

From a practical point of view, government social media have become a venue for tax propaganda. According to the final accounts report of the State Taxation Administration of China, the expenditure on mandatory tax enforcement and administration projects such as general administrative affairs, invoice management and tax registration and taxation handling was RMB 1,942,994,100 in 2020, accounting for 83.42% of the country's total expenditure on general public services. The expenditure on tax propaganda that year was only RMB 15.0702 million, accounting for only 6.8% of the total general public services expenditure. We find that a one standard deviation increase in the level of interaction of the *Sina Weibo* of a local taxation bureau equates to an increase of RMB 2,866,988.10 in the average annual actual income tax of local enterprises. This finding proves that this method of disseminating tax propaganda, which comes at a lower cost with wider coverage and more convenience than more traditional methods, can effectively exert the effect of tax enforcement and administration and that it has practical significance for innovating tax collection and optimizing government management decision-making. Such information has practical implications for governmental policies around the world concerning the use of government social media to carry out social governance.

2. Institutional background

The concept of "government social media" is developed from "social media" (Criado et al., 2013; Porumbescu, 2016) and is generally understood to comprise social media accounts with government departments or civil servants as the subject (Guo et al., 2016). As the number of social media users continues to grow, governments make increasing use of social media to solve national issues (Pirolli, et al., 2010); thus, government social media have rapidly grown into a core component of government governance in a short period (Bertot et al., 2012). China's special institutional background creates an opportunity to study how government social media affect corporate micro-behavior. This section introduces the characteristics of *Sina Weibo* in terms of market position and operation rules, and it analyzes the institution of government social media with Chinese characteristics in terms of its suitability for achieving the research objectives, particularly in terms of the Chinese *Sina Weibo*.

2.1. Data interpretation capability of Sina Weibo

Taking *Sina Weibo* as the data source to investigate government social media has the following advantages. First, as one of the Chinese social media oligopolies, *Sina Weibo* has a strong representation. *Sina Weibo* is the most mature and most widely radiated government social media platform in China (Yuan et al., 2013). Its overall user scale has exceeded 500 million people, and about 100 million posts are made on *Weibo* every day (Tian et al., 2016). As of March 2019, the average number of *Weibo* users in a month was 4.65 billion, which is 1.5 times that of Twitter (Jing and Zhang, 2021). As of June 2019, there were 139,000 officially

certified government *Weibo* accounts in China, including those of more than 100,000 government agencies below the county level, covering a wide range of administrative districts (Cheng et al., 2020).

Second, according to the Chinese government's requirement for "Dual-Wei Coordination"[2] on government social media, the core social media platforms in China such as *Sina Weibo* and *WeChat*[3] are required to have a high degree of homogeneity in information content. As early as September 2014, the Cyberspace Administration of China required local government agencies to actively use instant messaging tools to provide government information services and clearly proposed to "implement the 'Dual-Wei' Coordination and their coordinated development" (Hou, 2017). In December 2018, the General Office of the State Council of the People's Republic of China issued the "Opinions on Promoting the Healthy and Orderly Development of Government New Media" (2018, No. 123) (Document No. 123), which clearly states in its guiding principles that according to the requirements of front-end diversity and back-end connectivity, the interconnection, overall voice and coordinated co-movement of various government new media should be promoted; the integration and development of government new media and government websites should be promoted as well; and the homology of data and services, which is convenient for enterprises and the public to use, should be realized. In view of the high homogeneity of information content in *Sina Weibo* and other social media platforms such as *WeChat*, although this study only observes *Sina Weibo*, we believe that the research is generalizable. We illustrate this consistency of information content across platforms using the information released by the China Henan Provincial Tax Service on *Weibo* and *WeChat* during a randomly selected five-day period in 2022 (see Table A1).

2.2. Institution of government social media with Chinese characteristics

In this section, we take the *Sina Weibo* of local taxation bureaus as an example to analyze the institution of government social media with Chinese characteristics.

2.2.1. Operational characteristics of Sina Weibo of local taxation bureaus

North (1990) proposes that the political institution is the key to understanding the relationship between politics and economics. In China, the dominant force of both government governance and mass media is from state power (Zhang and Bao, 2019). On the one hand, government social media inherit the authority and legality of the associated government subjects. On the other hand, state power provides a formal institutional foundation for governments to guide and evaluate government social media. China's long history and vast, rich geographical resources have fostered a profound culture, which is manifested in different cultural traditions in different regions of the country. The radiation effect of Chinese government social media is significantly regional, shaping a relationship between government social media and follower groups that is particular to China. This is described in more detail below.

First, central government Document No. 123 encourages all regions and departments to include information about new government media in their annual performance evaluations and to formulate appropriate appraisal and evaluation methods. They should also establish a focus on hard work and performance and encourage and praise units and individuals for their achievements in new government media work in accordance with the relevant regulations. The resulting strict performance evaluation system has given local taxation bureaus the impetus to operate government social media successfully, forming significant competition among regions that has limited the influence of the taxation bureaus' *Sina Weibo*. Furthermore, since China implemented the merger of state and local tax agencies in 2018, taxation bureaus across China have adopted a dual leadership system, with the State Taxation Administration as the mainstay and local governments as the supplement. In other words, the local bureaus' social media operation is simultaneously subject to performance evaluation by the State Taxation Administration and local governments, and compounding the pressure on the local tax bureaus imposed by such evaluation will become more obvious. As an important part of

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[2] It refers to a new media model for dealing with Chinese governmental affairs. It combines two popular media *Weibo* and *Wechat* in China to provide information and services for the public. The name "Dual- Wei" derives from the first syllable "Wei" in both "*Weibo*" and "*WeChat*" in Chinese pronunciation.

[3] Another social media platform and software operated by a China corporate called *Tencent*.

overall performance evaluations, social media performance is directly linked to such benefits as civil servants' performance-related pay and promotion. To accurately identifying performance achievements, local taxation bureaus are asked to track the local influence of their *Sina Weibo* from the onset, and their *Sina Weibo* express the local influence through the regional heterogeneity of information content and operation methods.

Second, factors such as policy applicability, regional cultural differences and their connection with entity taxation result in strong regional heterogeneity in local tax bureaus' social media, which serves to foster strong social relationships with follower groups and concentrate the influence of social media locally. For example, the Henan Provincial Tax Service launched an informational column titled "Yu Talks about Problems" on its official *Weibo*, which summarizes certain common policy issues that concern local taxpayers, presenting them in a question-and-answer format. Such information is closely related to offline taxation activities and displays typical regional heterogeneity. Another example is the Chongqing Municipal Tax Service's online column titled "Yu Tax Weekly Overview." In addition to taking stock of particular policies, the column also reports on tax management activities that are representative of the activities in the jurisdiction. This kind of public information generally focuses on tax services for local enterprises and subordinate counties (cities) as well as information about local tax officials whose content coverage is limited. Similarly, the Tibet Autonomous Region Tax Service runs a column titled "Dolma Talks About Tax," which is available in both Tibetan and Chinese and fully combines tax publicity with the customs of the autonomous region, displaying pictures of local scenery and information on regional planning, local personalities and groups as publicity materials.

An open social media platform provides taxpayers with the ability to choose which accounts to follow. O'Reilly (1988) proposes that the strength of social relationships is affected by emotional closeness, maintenance time and reciprocal services. Government social media fosters a special social relationship between officialdom and the private domain, and its strengths and weakness are also affected by these aspects. As a consequence of the differences in the linkage of entity taxation and online taxation, regional policies, local enforcement and administration as well as local customs, people's interests in Weibo and their habits of following Weibo will be different in this era of big data, thus enabling information to appear significant power-law characteristics. Meanwhile, with the help of computer technologies such as user behavior analysis and personalized recommendation, the more users pay attention to local tax-related information, the easier it will be recommended the tax-related information they are interested in (Luo and Chen, 2018), which is similar to the Matthew's observation that "the stronger the strong are, the weaker the weak are." Such factors fix the interest and focus of information followers while strengthening the publicity effect of the information publishers, deepen the intimacy and interest relationships between the information followers and the local taxation bureaus and ultimately form a strong social relationship through continuing consolidation of the frequency and depth of interaction (Uzzi, 1999).

2.2.2. Characteristics of Sina Weibo followers of local taxation bureaus

In terms of information use utility, the theory of rational behavior indicates that followers are subjectively more inclined to follow the *Weibo* of their local taxation bureau. Information followers can easily get lost in the overwhelming amount of available information (Huang, 2013). Information overload, the creation of fragmented user information and complex social network relationships can all prevent users from effectively acquiring relevant content (Dwivedi et al., 2021), thereby diluting the value of effective information. The information released on *Sina Weibo* by local taxation bureaus cannot be relevant to all taxpayers due to differences in the relationships between entity taxation, regional policies, and local enforcement and administration methods. The evolution of media is the result of human selection, as media that better meet the needs of users tends to be retained (Levinson, 2003). Therefore, information followers have the motivation to actively reduce the interference of irrelevant information and focus on relevant information, such as that provided by social media operated by local taxation bureaus, to maximize the utility of the information they access.

Furthermore, the *Weibo* platform objectively concentrates *Sina Weibo* followers of various taxation bureaus in the places where the taxation bureaus are located. In the social network of *Weibo*, there are two main paths by which users to obtain information. On the first path, users follow bloggers, become followers and receive the information released by the followed bloggers through the "follow" interface on the homepage. On the second path, the *Weibo* platform pushes popular *Weibo* bloggers to all users via the "recommendation" interface on the homepage (Xu et al., 2015). In terms of the first path, that is, obtaining information

by following, information seekers can become followers in three ways: retrieving users, scanning QR codes, and exploring popular recommendations. The first way requires the highest subjective initiative and, in the context of tax bureaus, is mainly suitable for people who have information needs concerning fiscal and taxation policies and taxation requirements. In contrast to other types of *Weibo* accounts, the official *Sina Weibo* of a taxation bureau mainly focuses on policy interpretation, fiscal and taxation knowledge and publicity of political achievements, which is more professional but less entertaining. Unless followers have strong personal needs, it is difficult for them to be motivated to follow tax bureaus actively. Given the strong social relationship between government *Weibo* and information followers as well as the information utility view based on the theory of rational behavior, we assert that local information users (even locals who work in related fields such as accounting and taxation) are more likely to search and follow the *Sina Weibo* run by the local taxation bureau than to search and follow Weibo run by tax bureaus in other areas. The second way is straightforward and simple, but it is only suitable for people who have access to QR code promotions. These are mainly available from the poster boards of physical tax offices, administrators of subordinate tax offices, publicity posters and leaflets; these channels are closely related to the local taxation experience. Due to the fierce performance competition, local taxation bureaus only focus on promoting the local *Sina Weibo*. Thus, followers, especially those with local taxation experience, are concentrated in the local area. The third way overlaps with the second path and is discussed further below.

For users to obtain information based on the "recommendation" interface rather than directly seeking out bloggers to follow, as described above, whether the users rely solely on the recommendation interface or discover bloggers and become followers through popular recommendations and then follow them, high quality information, topic selection and browsing popularity are crucial. Only when traffic and popularity meet certain conditions can a *Weibo* become a popular recommendation. We posit that the *Sina Weibo* of local taxation bureaus are still in the early stage of development, as compared with more mature social media accounts, due to factors such as risk control related to public opinion, regional competitiveness, interestingness and the professional nature of the information they convey. Their popularity is limited, and the explosive influence of social media themselves has not been fully developed; therefore, it is rare that they enter the realm of popular recommendations.

To confirm this assessment, we obtain all of the texts and posting times and the total number of likes, comments and reposts on the *Weibo* of local taxation bureaus from 2018 to 2020 using Python, and we count the number of likes, comments and reposts of each of the *Weibo* (see Table 1, Panel A for details). As shown in Table 1, Panel A, although there is a wide range in the number of likes, comments and reposts for each post on the *Sina Weibo* of taxation bureaus across various provinces, the maximum value fluctuating between 6 and 817, it is difficult even for the most popular such posts to be listed as top recommendations. Therefore, this is not an effective way for local taxation bureaus to attract followers. It is worth noting that the highest number (27,742, in Hubei Province) is excluded here, because when we trace and analyze the *Weibo* information of the Hubei taxation bureau that garnered such unusual popularity, we find that there were five *Weibo* posts accounting for greater than 800 likes, comments and reposts, all of which were released in February 2020 and related to the special taxation policies of Hubei Province during the COVID-19 outbreak (see Table A2 for details). At the time of the outbreak in Hubei Province in China, information related to the prevention and control of the epidemic in Hubei Province was the focus of attention throughout China and the world, which explains this unprecedented attention and traffic. Other than that, the *Sina Weibo* of Hubei Tax Service displays normal activity. We believe that such situations are extremely rare and do not affect our findings on the characteristics of *Sina Weibo* followers of local taxation bureaus.

2.2.3. Additional evidence and findings

To verify whether the *Sina Weibo* followers of local taxation bureaus are mainly local to the bureaus, we first obtain all of the *Weibo* posts with records of comments and randomly select 50 of the posts. Specifically, the comments sampling process is as follows. First, use Python to obtain the relevant information of posts released by the local tax bureaus' *Sina Weibo*, such as time, title, format, and the number of likes, comments, reposts, etc.; Second, filter all *Weibo* posts with more than 0 comments, and select 50 of them randomly. Since we do not directly obtain the specific comment content of each *Weibo* through Python, we can only retrieve the item by the information release time of a single *Weibo*, trace the entry information in *Weibo* web version,

Table 1
Statistical Results of Interactive Behaviors and Source of Followers.

Panel A Descriptive statistical analysis of "Likes + Comments + Reposts" by local taxation bureaus

Serial Number	Province/Municipality/Autonomous Region	Average	Standard Deviation	Maximum Value	Minimum Value	Median	First Quantile	Third Quantile
1	Anhui	1.125	1.708	47	0	0	1	2
2	Beijing	5.567	25.185	489	0	1	2	4
3	Fujian	0.434	1.141	12	0	0	0	1
4	Gansu	2.087	1.648	19	0	1	2	3
5	Guangdong	6.389	15.183	660	0	3	5	8
6	Guangxi	0.913	2.618	49	0	0	0	1
7	Guizhou	0.266	1.062	24	0	0	0	0
8	Hainan	0.128	0.485	9	0	0	0	0
9	Hebei	1.947	3.004	112	0	1	2	3
10	Henan	1.016	1.222	19	0	0	1	2
11	Heilongjiang	0.355	1.011	15	0	0	0	0
12	Hubei	154.804	2031.417	27,742	0	0	1	4
13	Hunan	0.277	1.204	19	0	0	0	0
14	Jilin	0.658	18.390	747	0	0	0	0
15	Jiangsu	4.788	35.990	812	0	0	1	2
16	Jiangxi	32.560	67.590	282	0	0	0	2
17	Liaoning	3.521	3.114	28	0	1	3	5
18	Inner Mongolia	0.227	0.903	20	0	0	0	0
19	Ningxia	1.092	1.557	22	0	0	1	2
20	Qinghai	0.126	0.727	19	0	0	0	0
21	Shandong	1.975	4.559	65	0	0	1	2
22	Shanxi	1.623	2.909	102	0	0	1	2
23	Shaanxi	2.028	5.263	250	0	1	1	3
24	Shanghai	13.700	17.360	650	0	4	10	18
25	Sichuan	2.642	2.872	42	0	1	2	4
26	Tianjin	0.421	1.950	69	0	0	0	0
27	Tibet	0.172	0.535	6	0	0	0	0
28	Xinjiang	0.128	0.477	6	0	0	0	0
29	Yunnan	0.247	0.609	8	0	0	0	0
30	Zhejiang	0.678	6.937	319	0	0	0	1
31	Chongqing	0.453	1.293	41	0	0	0	1
National average (Except Hubei)		2.918	7.617	165.400	0.000	0.433	1.133	2.200
National average (Include Hubei)		7.818	72.901	1054.968	0.000	0.419	1.129	2.258

Panel B Sampling statistics of the source of Sina Weibo followers of local taxation bureaus

Serial Number	Province/Municipality/Autonomous Region	Proportion of local followers	Serial Number	Province/Municipality/Autonomous Region	Proportion of local followers
1	Anhui	70.0%	17	Liaoning	82.5%
2	Beijing	77.5%	18	Inner Mongolia	75.0%
3	Fujian	82.5%	19	Ningxia	72.5%

Table 1 (*continued*)

Panel A Descriptive statistical analysis of "Likes + Comments + Reposts" by local taxation bureaus

Serial Number	Province/Municipality/Autonomous Region	Average	Standard Deviation	Maximum Value	Minimum Value	Median	First Quantile	Third Quantile
4	Gansu	72.5%		20 Qinghai			65.0%	
5	Guangdong	90.0%		21 Shandong			95.0%	
6	Guangxi	65.0%		22 Shanxi			80.0%	
7	Guizhou	80.0%		23 Shaanxi			92.5%	
8	Hainan	70.0%		24 Shanghai			72.5%	
9	Hebei	80.0%		25 Sichuan			85.0%	
10	Henan	72.5%		26 Tianjin			77.5%	
11	Heilongjiang	87.5%		27 Tibet			60.0%	
12	Hubei	85.0%		28 Xinjiang			87.5%	
13	Hunan	60.0%		29 Yunnan			85.0%	
14	Jilin	70.0%		30 Zhejiang			77.5%	
15	Jiangsu	80.0%		31 Chongqing			87.5%	
16	Jiangxi	67.5%		National Average			77.60%	

which is more powerful in search function than the mobile app version, and then sink to collect specific comment content. In contrast to likes and reposts without any descriptive contents, which are difficult to discern in specific situations, follower comments can provide incremental information about the characteristics of *Weibo* followers that is helpful to test our hypothesis. We find that *Weibo* comments are highly correlated with offline tax preparation. For example, some of the comments made by followers are based on the topic of the *Weibo* text, with the followers making further inquiries based on their own information needs. Other comments have nothing to do with the text of the *Weibo* and are instead feedback on the followers' own offline tax handling experience. Furthermore, some of the comments are related to tax evasion reports or feedback on improvements in the work of local taxation bureaus. The comments include many reports of illegal acts on the part of the enterprises under the jurisdiction of the taxation bureau on the account, commentary on the service attitude of the sub-bureaus' staff and opinions on improving e-taxation bureaus and newly launched tax policies. We discover that the response rate of the local taxation bureaus to comments is generally low; only a small number of taxation bureaus reply to comments individually, and some of the replies are relatively formal. The responses tend to lead commenters to the tax service hotline, which is independently operated by the local taxation bureau. By distinguishing between likes, reposts and comments features, we find that the localized characteristics of the information contains in comments can help us better illustrate the strong social relationship between local taxation bureau's *Sina Weibo* and local enterprises. A *Sina Weibo* operated by a taxation bureau appears to expand the entity's tax enforcement and administration functions online. Table 3A presents a sample of the comments.

Next, six postgraduate students are charged with sampling the followers of the observed *Weibo*. They randomly select 40 followers from each province, for a total of 1240 followers. After excluding both "zombie followers," i.e., those who have not posted in the past three years, and "big V followers," who are clearly commercial accounts operated by professional teams, we manually identify and characterize the followers according to their IP address, location of the post, graduation school, hometown, "liked" topic and other information available in the personal data on their accounts. Please refer to Table 1, Panel B for details.

From the sampling results, we find that the proportion of local *Sina Weibo* followers of local taxation bureaus fluctuates between 60% and 92.5%, with an overall average of 77.6%. The sampling results confirm the speculation that followers are mainly concentrated in the location of the taxation bureau, and we believe that this proportion would increase if the sample size were expanded. Other useful findings are also obtained during the sampling process. For example, we find that followers are also willing to follow social media operated by other government departments in their region, particularly government information offices such as the "Chongqing Release" and "Sichuan Release" accounts, which are official news accounts operated by the information offices of Chongqing and Sichuan municipal or provincial governments. In terms of users' personal information, many of the observed *Weibo* followers of taxation bureaus graduated from financial institutions or hold accounting positions at accounting firms, law firms, and proxy bookkeeping companies. An examination of the topics that the *Weibo* followers follow reveals their interest in such topics as CPA (Certified Public Accountant), the Accounting Professional Title Examination and the Civil Service Examination. Due to the influence of individuals' social platform usage habits on their personal information, reposting records and concerned topics, it is difficult for us to draw general conclusions. Therefore, this information is only used as a supplementary reference for the main findings.

In summary, the radiation effect and fan groups of local tax bureaus' government social media in China are significantly regional. First, due to the influence of formal and informal institutions such as performance evaluation rules, policy applicability, regional cultural differences, and the linkage of entity taxation and online taxation, government social media have formed fierce competition among regions, which limits the sphere of influence of the *Sina Weibo* of a given local taxation bureau. Furthermore, the information and informational columns provided by the *Sina Weibo* of local taxation bureaus have distinctive local characteristics. With the help of Internet information technologies such as user behavior analysis and personalized recommendation, the bureaus are able to form strong social relationships with followers and to promote to and interact with followers in a targeted manner. This social relationship is strengthened by targeted recommendations and exchanges of information, focusing the useful radiation effect of the taxation bureau's government *Weibo* on the local area. Second, affected by the utility of information, users seeking information on the *Sina Weibo* of the local taxation bureaus are more inclined to pay attention to the relevant, local information under the

theory of rational behavior. Moreover, the information acquisition method designed by the current *Weibo* platform objectively limits the users' sources of information. As the *Sina Weibo* of local taxation bureaus are in the early stage of development, their spheres of influence are smaller than those of mature social media accounts; therefore, their followers tend to be limited to local areas. The combination of the location limitation of the local user for local taxation bureaus' *Sina Weibo* and the restrictions on how *Weibo* information can be obtained enables the actual utility of local taxation bureaus to operate government social media and the micro-behavior of local enterprises by building a more effective communication mechanism between government and enterprises. Thus, a government social media system with Chinese characteristics is formed, providing a setting for us to carry out research on the relationship between these social media profiles and local enterprises' behavior.

3. Hypothesis development

Through sampling, statistics and summary, we categorize the information on the *Sina Weibo* of taxation bureaus across China into four main types. The first category involves maintaining the image of the taxation bureau and mainly includes relevant reports on the political achievements of the taxation bureau, party members and tax officials. The second category of information is related to tax policy, specifically, announcements of, interpretations of and guidance on tax-related policies and cases. This includes policies and regulations, information on tax-related practices and accounting knowledge. The third category pertains to interaction, that is, the online communication between the taxation bureau and taxpayers through the *Weibo* platform. This takes the form of tax-related consultations, feedback, and lottery activities. The fourth category includes miscellaneous information, such as information to facilitate the life of citizens, breaking news, and lifestyle and entertainment topics. Based on a brief introduction to the types of information released by the taxation bureaus on *Sina Weibo* and a review of the characteristics of government social media in terms of the institutional background and research assumptions, we examine the main paths that affect corporate tax avoidance as described below.

3.1. Reducing tax avoidance incentives: Education effect

3.1.1. Reducing economic incentives for tax avoidance

Taxation bureaus' operation of government social media reduces enterprises' institutional transaction costs in two ways. First, the bureaus use the social media platform to disseminate policy information and offer interpretations of official fiscal and taxation policies, helping enterprises to more easily and conveniently understand and incorporate the latest policies and regulations. This reduces the costs that enterprises incur in searching for and processing such information. Second, the social media platform supports tax-related education in the forms of video tutorials; graphic analysis; interactive, live and broadcast courses, further facilitating the dissemination of policy information and provision of guidance with constantly updating taxation methods. This allows enterprises to make sufficient taxation preparations in advance, such as by preparing required materials and arranging for full-time, specialized personnel. This reduces the need to return to the tax office to provide missing materials or address other shortcomings, thereby reducing travel and other management expenses, and significantly improves enterprises' efficiency in collecting and handling documents, also saving time.

Furthermore, taxation bureaus' use of social media increases enterprises' economic benefits, resulting in improved tax compliance. In the face of special international and domestic circumstances such as the Covid-19 pandemic and economic restructuring, the Chinese government has implemented tax- and fee-reduction policies in recent years. Local taxation bureaus conduct rule interpretation, case analysis and training on various tax policies through social media, helping taxpayers to understand policy requirements and master practical operations and thereby take full advantage of favorable policies and reduce their payable taxes. King and Sheffrin (2002)[p511] assert that there is an "exchange equity" relationship between the taxes paid by taxpayers and the public goods provided by the government. When taxpayers believe that the supply efficiency of public goods is improved and their own benefits are increased, they perceive their payable taxes to be closer to the expected value of the public goods and the "exchange fairness" relationship to be balanced.

According to prospect theory, when an enterprise is faced with the prospect of profit, that is, when it is satisfied with the efficiency and quality of the supply of public goods, its willingness to comply with tax laws is stronger, and the incentive to engage in tax avoidance is weaker (Kahneman and Tversky, 2013).

3.1.2. Reducing non-economic incentives for tax avoidance

Taxation bureaus' operation of social media increases enterprises' perception of fairness in the tax regime and general trust in the government. Government social media reflect the traditional notion of communication media as public goods (Li and Xu, 2013), in which the cost of information disclosure and diffusion is greatly reduced. Such communication is also crucial to improving government transparency (Bertot et al., 2010). Through social media, taxation bureaus may present tax enforcement and administration measures and reform achievements to the public, improving the government's image in terms of governance (Zhang and Bao, 2019), which may increase enterprises' trust in the government (Ma, 2016). It also improves communication from taxpayers, giving them channels through which to file complaints with the tax bureaus and safeguard their legitimate rights when they are treated unfairly, thereby enhancing their sense of fairness. Spicer and Becker (1980) propose that when participants are at a disadvantage in an unfair exchange relationship, they attempt to reduce the sense of unfairness by adjusting their level of input and contribution. In this context, taxation behavior can be regarded as an exchange behavior between taxpayers and the government, wherein taxpayers forfeit some purchasing power in the private market in exchange for government benefits. Therefore, corporate tax avoidance can be regarded as an attempt by enterprises to restore fairness in their exchange relationship with the government. To the extent that government social media reduce enterprises' sense of unfairness and increases their trust in the government, it reduces the incentive to engage in tax avoidance.

Taxation bureaus' social media use also raises enterprises' moral awareness. Government social media foster consistent behavioral tendencies in the public (Zhang and Ji, 2021). Taxation bureaus' *Sina Weibo* can establish taxpayers' awareness of moral and legal boundaries, create an atmosphere of improved taxation knowledge and compliance as well as honesty and self-discipline, and can increase the moral shame in corporate tax avoidance and the moral honor in tax compliance. King and Sheffrin (2002) posit that in addition to the economic costs of being audited and fined, corporate tax avoidance also brings non-economic costs such as embarrassment, loss of self-esteem and loss of social status. Cummings et al. (2009) and Alm and McClellan (2012) use data from the National Comprehensive Social Survey Project to empirically verify that an increase in the level of moral cognition drives more positive tax compliance willingness. Therefore, improving moral awareness decreases the incentive to engage in corporate tax avoidance.

3.2. Increasing the difficulty of engaging in tax avoidance: Supervision effect

3.2.1. Strengthening external supervision of local corporate tax avoidance

Although the research on government social media and micro-enterprise behavior is relatively limited, research on traditional media provides us with a reference. It is generally asserted in the literature that the media are an important part of the corporate governance mechanism outside of legal measures (Dyck et al., 2008; Zhang and Su, 2015), and its supervision mechanism includes three paths. First, it generates strong pressure from public opinion, thereby prompting the government to improve and reform policies and regulations and to deter and punish the enterprises and their executives who violate the laws, through legislation. Second, it affects the image of managers and board members in the eyes of shareholders and future employers, motivating these managers and board members to correct corporate violations. Third, it influences the reputation and image of managers and board members in the eyes of the public (Li and Xu, 2013). As the dissemination and application of social media in government governance (Criado et al., 2013), government social media inherit the external supervision function of corporate governance by ordinary media; however, it also reflects certain differences.

In terms of the first path, the *Sina Weibo* of local taxation bureaus present information in an interactive manner, which allows the bureaus to directly solicit opinions on and suggestions for improving policies and regulations. Other channels for this transfer of information, connection and feedback are no longer needed (Zhang and Bao, 2019), which effectively shortens the chain of information dissemination and

improves the efficiency of policy improvement. In terms of the second and third paths, because government social media have the official attributes of governmental authority, seriousness and fairness (Zhang and Bao, 2019; Zhang and Ji, 2021), the information released through it has more credibility and influence than that released via other media; therefore, it has a natural advantage in dissemination (Jing and Zhang, 2021). When a taxation bureau announces companies blacklisted by the tax authority on *Weibo* and conducts education on honesty cases, this instills in shareholders, future employers and the public a higher degree of trust in the news, strengthening tax compliance as well as the bureau's supervisory role. Austin and Wilson (2017) find that when an enterprise has a greater brand value, it faces greater external supervision pressure and its reputation cost rises sharply, while its incentive to engage in tax avoidance decreases. In the same way, government social media have an external supervision effect, inhibiting the incentives of enterprises to avoid tax.

3.2.2. Strengthening the internal corporate supervision and the effect on tax avoidance

Corporate tax avoidance is complex; when companies engage in tax non-compliance behaviors, such as tax avoidance, managers may cover it up through complex and opaque transactions (Wang et al., 2020; Yu and Fang, 2022). Therefore, tax non-compliance behaviors sometimes provide rent-seeking opportunities for business managers, exacerbating principal–agent conflicts and damaging corporate value (Desai and Dhammika, 2009). Knowledge of finance and taxation is generally considered to require systematic, professional learning and training as well as the long-term accumulation of practical experience. This specialization of fiscal and taxation knowledge exacerbates the information asymmetry between owners and managers, managers and financial professionals to a certain extent. However, the taxation bureau releases policy information through *Weibo* and regularly presents information in interactive forms such as taxpayer classes and teaching tools, which reduces the difficulty and cost of attaining financial and taxation knowledge. Thus, such specialized knowledge is no longer the exclusive intellectual capital of financial or taxation professionals. This reduces the information asymmetry between owners and managers and between managers and financial professionals, rendering it more difficult for managers to cover up opportunistic behavior with non-compliance behaviors such as tax avoidance. This, in turn, strengthens the internal supervision of enterprises and alleviates the conflict between principals and agents.

Based on this, we put forward our main hypothesis as follows:

H1: The higher the quality of a local taxation bureau's operation of government social media, the lower the degree of local enterprises' tax avoidance.

4. Research design and empirical analysis

4.1. Research design

4.1.1. Empirical model and variable definitions

The specific model settings are as follows:

$$TA_{i,t} = \beta_0 + \beta_1 Government\_social\_media_{i,t} + \beta_2 Control_{i,t} + \mu_i + \gamma_t + \epsilon_{i,t}$$

where $TA_{i,t}$ is the predicted variable, corporate tax avoidance; $Government\_social\_media_{i,t}$ is the explanatory variable, the quality of the taxation bureau's operation of government social media; $Control_{i,t}$ refers to other control variables; and $\epsilon_{i,t}$ refers to the stochastic disturbance team. To reduce the endogeneity problem caused by omitted variables, we also control the individual fixed effect, μ_I, and year fixed effect, γ_t. The model also applies cluster corrections to the standard errors at the firm level.

Through the interaction between the public and the government, government social media generate a large number of data resources (Criado et al., 2013). The research on government social media mostly obtain its basic data through structured or unstructured surveys and experiments, with limited sample sizes, which has defects in objectivity and systematization as compared with large-sample empirical tests. We use *Python* to obtain relevant data from the *Sina Weibo* of taxation bureaus across China, which represents a certain improvement over prior research resources and methods.

Many scholars regard responsiveness as an important criterion for measuring the quality of government services (Parasuraman et al., 1985; Scott and Shieff, 1993; Lv et al., 2009; Mustapha, 2014). Therefore, we set up an evaluation index of the operational quality of government social media from the perspective of responsiveness. Wang (2018) states that the public's response to government social media includes two type of behaviors: browsing and interaction, which are difficult to capture given the lack of a direct, visible means of tracing browsing behavior. Therefore, referring to the practices of Sun and Zheng (2021), Wang (2018), and others, taking interactive behavior as the observation perspective to define the quality of the taxation bureau's social media, we obtain the number of taxpayers' likes, comments and reposts on the official *Sina Weibo* of a given local taxation bureau in a year, and divide it by the total number of posts on the same *Weibo* in that year to measure the quality of the taxation bureau's social media (*Government_social_media*). The larger the value of this indicator, the greater the activity and influence of government social media and the higher the operation quality (Sun and Zheng, 2021).

It is worth noting that Document No. 123 clearly stipulates that "the purchase of followers and other data fraud is strictly prohibited, and the masses shall not be forced to download and use mobile clients, or like or repost information." Different from other social media in terms of entertainment and profit functions, government social media have a significant official attribute and is subject to strict performance evaluation by the government. Therefore, we believe the relevant posts and interaction records used in this study to be authentic and credible.

Commonly used measures of corporate tax avoidance include the effective tax rate (Hanlon et al., 2003) and the cash effective tax rate (Dyreng et al., 2008). To ensure the robustness of the results, we use the effective tax rate as the explained variable and the cash effective tax rate in a robustness test. Please refer to Table A4 for the specific calculation method.).

Drawing on the research conducted by Liu and Ye (2013), Li et al. (2020), Sun et al. (2021a, 2021b), Sun and Yuan (2020) and Zhang et al. (2021) to control the year and individual fixed effects, we also control other variables that may affect corporate tax avoidance at the company characteristics level, the governance level and the regional economic level. It should be noted that to eliminate the interference of tax and fee reduction policies on tax avoidance indicators, we also control other tax and fee burdens. Please refer to Table A4 for the specific calculation method.

4.1.2. Sample selection and data sources

We select Chinese A-share listed companies as the research sample and sets the sample period as 2018–2020. Data derived after 2018 raise the following considerations. First, taxation bureaus established their *Sina Weibo* at different times. The bureaus themselves began operations one after another, starting in 2014. They began to establish their *Sina Weibo* in 2018, which is convenient for us in examining regional differences. Second, in accordance with China's State Council's institutional reform plan, local state taxation bureaus and local taxation bureaus were merged in 2018. According to the interviews with tax office staff, in line with the requirements for the merger of institutions, each taxation bureau carried out large-scale data cleaning and content integration on the government social media. The tax bureaus have formulated new unified formats for the original *Weibo* account name, avatar and other basic elements, after the merge of local state taxation bureaus and local taxation bureaus. They also instituted a unified format for basic elements such as a *Weibo* account name and avatar, which not only allows us to control more variables that are difficult to observe but also reduces data interference.

The main micro-level data come from the CSMAR database, and the macro-level data come from the China Statistical Yearbook and China Taxation Yearbook. The relevant data on the local taxation bureaus' official *Sina Weibo* are obtained using Python and are manually sorted. To ensure the validity of the research conclusions, we also remove data-missing, financial, ST (the company has suffered losses for 2 consecutive years), SST (the company has suffered losses for 2 consecutive years, and has not yet completed the stock reform), and *ST (the company has suffered loss for 3 consecutive years) samples as well as outlier samples with ETR (effective tax rate) and CASHETR (cash effective tax rate) values of more than 1 or less than 0, and winsorize all of the continuous variables at the 1% level. Ultimately, our sample comprises 7,084 company-year observations. Please refer to Table 2, Panel A for the specific distribution. The data processing software used is Stata 15.0 and Excel 2016.

Table 2
Sample Distribution and Descriptive Statistics.

Panel A Province-Year sample distribution

Province/Municipality /Autonomous Region	Year 2018	Year 2019	Year 2020	Total
Guangdong	387	373	386	1146
Zhejiang	300	323	325	948
Jiangsu	272	265	277	814
Beijing	199	192	204	595
Shanghai	177	184	183	544
Shandong	144	138	154	436
Fujian	97	93	91	281
Sichuan	79	82	81	242
Hunan	70	68	69	207
Anhui	77	78	80	235
Hubei	68	63	63	194
Henan	51	50	49	150
Liaoning	39	35	42	116
Hebei	41	42	43	126
Tianjin	35	35	37	107
Chongqing	33	34	36	103
Jiangxi	32	31	30	93
Shaanxi	32	27	31	90
Xinjiang	24	31	26	81
Jilin	29	25	21	75
Shanxi	27	24	28	79
Guangxi	20	20	22	62
Yunnan	21	20	18	59
Gansu	20	17	17	54
Heilongjiang	22	17	18	57
Guizhou	21	23	23	67
Hainan	15	10	10	35
Inner Mongolia	15	16	17	48
Ningxia	7	8	10	25
Qinghai	6	4	5	15
Year Total	Year 2018 2360	Year 2019 2328	Year 2020 2396	

Panel B Descriptive Statistical Analysis

VARIABLES	Number of samples	Average	Standard Deviation	Minimum Value	First Quantile	Median	Third Quantile	Maximum Value
Government_social_media	7084	6.5712	25.3486	0.0503	0.6233	2.0000	4.7730	263.7523
Likes	7084	3.4484	22.4521	0.0237	0.2634	0.4562	0.9854	232.8654
Comments	7084	1.2126	3.4635	0.0000	0.0676	0.2573	1.0038	27.0948
Reposts	7084	1.9102	2.3301	0.0057	0.3711	0.8318	2.7544	10.6922
ETR	7084	0.1871	0.1196	0.0019	0.1174	0.1585	0.2332	0.6814
RATE	7084	−0.0010	0.1216	−0.8470	−0.0364	0.0111	0.0605	0.2500
CASHETR	7084	0.1893	0.1516	0.0000	0.0941	0.1483	0.2349	0.9998
ROA	7084	0.0547	0.0499	−0.6614	0.0244	0.0452	0.0756	0.5415
Lev	7084	0.4098	0.1901	0.0644	0.2594	0.4041	0.5466	0.8564
Growth	7084	0.1730	1.2031	−0.9651	−0.0048	0.0982	0.2241	58.8416
INVENT	7084	0.3302	0.7277	0.0000	0.1006	0.1764	0.2990	23.9975
Current	7084	0.5781	0.1972	0.0293	0.4466	0.5947	0.7279	0.9976
PPE	7084	0.2065	0.1557	0.0001	0.0859	0.1758	0.2912	0.9542
NEG	7084	0.8775	0.3279	0.0000	1.0000	1.0000	1.0000	1.0000
Top10hold	7084	0.6022	0.1444	0.0897	0.4999	0.6154	0.7081	0.9793
SOE	7084	0.3241	0.4681	0.0000	0.0000	0.0000	1.0000	1.0000
Burden	7084	0.0736	0.0528	0.0016	0.0374	0.0635	0.0958	0.3050
Loss	7084	0.0078	0.0878	0.0000	0.0000	0.0000	0.0000	1.0000
Mktindex	7084	9.3587	1.7811	3.5300	7.8800	10.0000	10.7100	12.0000
GDP	7084	10.7801	0.6517	7.9604	10.4737	10.7497	11.4360	11.5868
GR	7084	5.1147	2.8895	0.1987	2.2090	4.9888	7.2636	10.0640

Table 2 (*continued*)

Panel A Province-Year sample distribution

Province/Municipality /Autonomous Region		Year 2018	Year 2019	Year 2020	Total	Province/Municipality /Autonomous Region	Year 2018	Year 2019	Year 2020	Total
Employ	7084	0.7708		0.1492	0.9549		0.0768	0.8205	0.6883	0.8785
VAT	7084	2.0860		1.1819	3.9771		0.0927	1.9587	0.9376	3.1135
Private	7084	6.2185		3.5538	12.0140		0.3880	5.8660	2.5040	9.9780

Table 3
Basic regression results.

VARIABLES	Basic Regression				Surrogate Marker
	(1)	(2)	(3)	(4)	(5)
	ETR	RATE	ETR	RATE	CASHETR
Government_social_media	0.0001**	−0.0001**	0.0001**	−0.0001*	0.0002*
	(2.374)	(-1.969)	(2.208)	(-1.856)	(1.705)
ROA			−0.5006***	0.5210***	−1.3340***
			(-6.490)	(6.449)	(-8.569)
Lev			0.0300	−0.0241	−0.1560***
			(1.147)	(-0.856)	(-3.806)
Growth			0.0004	−0.0006	−0.0058**
			(0.466)	(-0.695)	(-2.445)
INVENT			−0.0030	0.0034	0.0127
			(-0.874)	(0.938)	(1.527)
Current			0.0178	−0.0242	−0.1046**
			(0.532)	(-0.659)	(-2.106)
PPE			−0.0306	0.0391	0.0866
			(-0.798)	(0.938)	(1.522)
NEG			0.0026	−0.0026	−0.0097
			(0.482)	(-0.446)	(-1.114)
Top10hold			−0.0610*	0.0681*	−0.0389
			(-1.786)	(1.815)	(-0.705)
SOE			0.0274**	−0.0258**	−0.0046
			(2.354)	(-2.160)	(-0.242)
Burden			0.1890***	−0.1843**	−0.3262***
			(2.752)	(-2.465)	(-2.756)
Loss			−0.2494***	0.2561***	−0.4021***
			(-7.553)	(7.270)	(-7.124)
Mktindex			−0.0248	0.0333*	−0.0473*
			(-1.603)	(1.849)	(-1.824)
GDP			0.0078	−0.0090	−0.0598
			(0.289)	(-0.288)	(-1.401)
GR			−0.0032	0.0037	0.0139
			(-0.346)	(0.368)	(0.882)
Employ			0.0091	−0.0065	−0.0168
			(0.464)	(-0.277)	(-0.527)
VAT			−0.0750	0.0870	0.0961
			(-1.388)	(1.525)	(1.147)
Private			−0.0006	0.0011	−0.0084
			(-0.110)	(0.177)	(-0.912)
Year fixed effect	Control	Control	Control	Control	Control
Individual fixed effects	Control	Control	Control	Control	Control
Constant	0.1932***	−0.0073***	0.5289*	−0.4463	1.2916***
	(111.044)	(-3.847)	(1.652)	(-1.216)	(2.657)
Observations	7,084	7,084	7,084	7,084	7,084
adj_R2	0.6069	0.5503	0.6295	0.5736	0.3877

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

4.2. Descriptive statistical analysis

Table 2, Panel B presents a descriptive statistical analysis. In terms of the explained variables, the annual average total number of likes, comments and reposts for a post on the *Sina Weibo* of the taxation bureaus is 6.5712, the maximum is 263.7523 and the minimum is 0.0503, which indicates large differences in the quality of local taxation bureaus' operation of *Sina Weibo*. Table 2, Panel B also presents the results of the descriptive statistical analysis of all of the explanatory variables used for the basic regression and the robustness test,

Table 4
Analysis of Likes, Comments and Reposts.

VARIABLES	(1)	(2)	(3)	(4)	(3)	(4)
	Likes		Comments		Reposts	
	ETR	RATE	ETR	RATE	ETR	RATE
Likes	0.0001**	−0.0001*				
	(2.151)	(-1.817)				
Comments			0.0010**	−0.0008*		
			(2.276)	(-1.810)		
Reposts					−0.0010	0.0004
					(-0.589)	(0.191)
Control Variable	Control	Control	Control	Control	Control	Control
Year fixed effect	Control	Control	Control	Control	Control	Control
Individual fixed effects	Control	Control	Control	Control	Control	Control
Constant	0.5189	−0.4376	0.4941	−0.4138	0.3737	−0.3423
	(1.623)	(-1.194)	(1.553)	(-1.135)	(1.108)	(-0.875)
Observations	7,084	7,084	7,084	7,084	7,084	7,084
R-squared	0.7914	0.7600	0.7914	0.7599	0.7911	0.7597
adj_R2	0.6294	0.5736	0.6294	0.5735	0.6289	0.5732

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

which do not differ significantly from the literature (Liu et al., 2016; Dyreng et al., 2008). The other control variables are basically consistent with the descriptive statistical analysis results in the literature and are not repeated here.

5. Empirical results and robustness test

5.1. Empirical results

Table 3 presents the basic regression results. The results in columns (1)–(4) are calculated by using the effective tax rate method as the explained variable. As shown in the table, ETR is positive and significant at the 5% level, and RATE is negative and significant at the 10% level, indicating that the higher the operational quality of government social media, the lower the degree of corporate tax avoidance within the jurisdiction. Column (5) displays the results using the cash effective rate method as the explained variable in the robustness test. CASHETR is positive and significant at the 10% level, again supporting our hypothesis. Taking ETR as an example, the actual economic significance of the test conclusion is as follows: the regression results indicate that when the average number of interactions surrounding a single post on the *Sina Weibo* of local taxation bureaus increases by 1 unit, the ETR increases significantly by 0.0001. Therefore, a one standard deviation increase in *Government_social_media* is associated with an increase in the mean of ETR of 1.35%,[4] or an average increase of 0.0025 in the ETR value.[5] In other words, as ETR = (income tax expense – deferred income tax expense)/total profit before tax, calculated with the average total profit before tax of the entire sample of RMB 1,146,795,240, a one standard deviation increase in the degree of interaction of local taxation bureaus' *Sina Weibo* is equivalent to an increase of RMB 2,866,988.10 in the average annual actual income tax of the local enterprises.[6]

From the perspective of interaction depth, there may be a progressive relationship between the three types of behaviors (i.e., likes, comments and reposts) and the quality of the operations on social media. In view of this, we use the number of taxpayer likes, comments and reposts on the official *Sina Weibo* of the local taxation bureaus in the year divided by the total number of posts posted as the explanatory variable for further

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[4] Calculation formula is: 0.0001*25.3486/0.1871=1.35%.
[5] Calculation formula is:0.0135*0.1871=0.0025.
[6] Calculation formula is: 1146795240*0.0025=2866988.10.

regression. The results are displayed in Table 4. As shown, the more likes and comments the government social media of the taxation bureaus receives, the lower the degree of local enterprise tax avoidance; however, there is no such finding for reposts. When the number of likes is used as the explanatory variable, the coefficients of ETR and RATE are smaller than when the number of comments is taken as the explained variable. This may be because the followers represented by comments are more interactive; thus, the influence of government social media on them is greater. As for the results concerning reposts, they may be explained by the fact that reposts, as a reflection of information dispersion, concern breadth of interaction rather than depth. This result confirms the conclusion of previous research on institutional background, that is, the use of *Sina Weibo* of the taxation bureaus in China is still in the early stage of development and its radiation effect is limited.

5.2. Robustness test

To test the robustness of the results, in addition to replacing the explained variables in the basic regression stage, we also run the following tests. First, in view of the possible existence of missing variables, mutual causality and other endogenous problems, we refer to the instrumental variable design put forward by Huang et al. (2019) by selecting the relevant historical data of the postal and telecommunications industry in each province (municipality/autonomous region) in 1984 as an instrumental variable for local taxation bureaus' operation of government social media, which better satisfies the relevance and exogeneity of the instrumental variables. In terms of relevance, the development of online social media began with Internet technology, which is rooted in the popularization of traditional postal and telecommunications industries (e.g., landlines). Extending this thinking, areas with more developed post and telecommunications industry had a better technical foundation to support the development of online social media. Furthermore, before the development of online social media, as represented here by *Sina Weibo*, the traditional post and telecommunications industry was the main media serving communication needs and supporting basic social interaction. Therefore, the development of this industry significantly affected the acceptance and usage habits of local entities and natural persons and the development of online social media. From an exogenous point of view, we take as the instrumental variable the historical data from 38 years ago, which is earlier than the sample period of our primary study and comprises provincial (municipal/autonomous regional) level data that cannot directly affect the current micro-enterprise tax avoidance.

The specific use of the instrumental variable is described as follows. As the historical data on the telecommunications industry in 1984 is cross-sectional, it cannot be directly applied to the regression analysis of panel data. Referring to the practice of Nunn and Qian (2014), we set the instrumental variable as the total revenue of the post and telecommunications industry in each province (municipality/autonomous regions) in 1984, multiplied by the total number of Internet users in the region in the previous year. The test results are shown in Table 5, Panel A. In the first-stage estimation, *Government_social_media* and the instrumental variable are positively correlated with significance at the 1% level, which indicates that the more developed the post and telecommunications industry in the location, the higher the operating quality of government social media. Moreover, the results of the weak instrumental variable test show that the F-statistic value is 27.16, which is much larger than the critical value of 16.38, significant at the 10% level, of the Stock-Yago test. This result rejects the weak instrumental variable hypothesis, meaning that the instrumental variable is effective. In the second-stage estimation, *Government_social_media* is statistically significant and the signs of ETR and RATE are consistent with the expectations, passing the robustness test.

Second, to address the possibility that the regression results are caused by the heterogeneity of certain provinces, we exclude the observations in the two provinces with the largest sample sizes in terms of the number of enterprises. As shown in Table 2, Panel A, the number of samples in Guangdong Province and Zhejiang Province is relatively high in all samples comparing with other provinces, and these two provinces have a relatively high level of economic development and a good business environment. We therefore rerun the regression after eliminating the samples from Guangdong and Zhejiang provinces. Third, to reduce possible interference caused by the content of posts related to personal income tax in the bureaus' *Weibo*, because to a certain extent, personal income tax reflects the public' satisfaction with the public goods provided by the government, and it may affect corporate tax avoidance indirectly, so we remove *Weibo* posts about personal income tax and rerun the regression. Fourth, because corporate tax avoidance may show auto-correlation in the time series

Table 5
Robustness Test Results Summary.

Panel A Instrument variable approach

VARIABLES	First stage regression			Second stage regression		
			(1)			(2)
	Government_social_media			ETR		RATE
TC			0.0037***			
			(18.749)			
Government_social_media				0.0004*		−0.0006**
				(1.787)		(-2.219)
Constant			−211.3963***	0.2246***		−0.0065
	(-15.414)			(3.555)		(-0.095)
Year fixed effect	Control			Control		Control
Individual fixed effects	Control			Control		Control
Observations			7,084	7,084		7,084
Pseudo R^2/R^2			0.1307	0.2420		0.1338
Kleibergen-Paap F statistic			27.16			

Panel B Alternative Sample

VARIABLES	(1)	(2)		(3)	(4)	
	Eliminating economically developed provinces			Excluding personal income tax related Weibo posts		
	ETR	RATE		ETR	RATE	
Government_social_media	0.0002**	−0.0001**		0.0002**	−0.0002*	
	(2.406)	(-2.084)		(2.155)	(-1.764)	
Control Variables	Control	Control		Control	Control	
Year fixed effect	Control	Control		Control	Control	
Individual fixed effects	Control	Control		Control	Control	
Constant	0.4174	−0.3380		0.5264*	−0.4411	
	(1.226)	(-0.875)		(1.646)	(-1.204)	
Observations	4,990	4,990		7,084	7,084	
adj_R2	0.6351	0.5834		0.6295	0.5736	

Panel C Additional Controls

VARIABLES	(1)	(2)		(3)	(4)	
	Add lagged variable			Control tax enforcement and administration		
	ETR	RATE		ETR	RATE	
Government_social_media	0.0001**	−0.0001*		0.0001**	−0.0001*	
	(2.222)	(-1.860)		(2.189)	(-1.839)	
ETR_1	0.0562					
	(0.563)					
RATE_1		0.0138				
		(0.115)				
TE				0.0336*	−0.0317	
				(1.693)	(-1.430)	
Control Variables	Control	Control		Control	Control	
Year fixed effect	Control	Control		Control	Control	
Individual fixed effects	Control	Control		Control	Control	
Constant	0.5333*	−0.4474		−0.0993	0.1454	
	(1.666)	(-1.219)		(-0.196)	(0.252)	
Observations	7,084	7,084		7,084	7,084	
adj_R2	0.6295	0.5735		0.6297	0.5738	

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

due to behavioral inertia, we add ETR and RATE to the model with a lag of one period and rerun the regression. Fifth, to eliminate the impact of tax enforcement and administration intensity on corporate tax avoidance, we add a variable, TE, to measure the intensity of the tax enforcement and administration in the control variables. The variable design refers to Zeng and Zhang (2009) and Ye and Liu (2011). The results of the above robustness tests are detailed in Table 5, Panels B and C. As shown, the ETR and RATE corresponding to Government_social_media are both significant, and the signs are consistent with expectations, meaning that

the conclusions are consistent with the basic regression results. Specifically, we are able to learn from Table 5, Panel B that, after eliminating the economically developed provinces, *ETR* coefficient is significantly positive at 5% level, and *RATE* coefficient is significantly negative at 5% level. After excluding personal income tax related *Weibo* posts, *ETR* coefficient is significantly positive at 5% level, and *RATE* coefficient is significantly negative at 10% level. The results in Table 5, Panel C show that when we add lagged variables as control variables, the *ETR* coefficient is significantly positive at 5% level, and RATE coefficient is significantly negative at 10% level. When we control tax enforcement and administration additionally, the *ETR* coefficient is significantly positive at 5% level, and the *RATE* coefficient is significantly negative at 10% level. To eliminate the potential impact of heteroscedasticity on the conclusions, we further conduct cluster analysis at the year and province levels. The results remain consistent and are not reported individually in the interests of space.

6. Further analysis

6.1. Heterogeneity analysis

Tax enforcement and administration significantly affect corporate tax avoidance (Zeng and Zhang, 2009). To determine whether the effect of government social media on corporate tax avoidance varies according to the intensity of tax enforcement and administration, we make the following analyses. Referring to Ye and Liu (2011) and Zeng and Zhang (2009), we calculate the intensity of tax enforcement and administration (TE) and take the annual mean of TE as the grouping criterion for the regression. As shown in Table 6, the governance effect of government social media on corporate tax avoidance is only present in the group with low-intensity tax enforcement and administration, indicating that the taxation bureau's operation of government social media plays a substitutional role in tax enforcement and administration. That is, in regions with lower levels of tax enforcement and administration, the impact of the taxation bureau's social media on corporate tax avoidance is more significant. This conclusion shows that the tax information promotion method of taxation bureaus' operating social media, which is less costly, provides wider coverage and is more convenient than the traditional mandatory tax enforcement methods and can exert similar effects of tax enforcement and administration, which has important practical significance for building a new type of tax collection system that optimizes government management.

6.2. Mechanism tests

6.2.1. Education effect test

If local taxation bureaus' operation of government social media indeed has an education effect on corporate tax behavior, we expect to see a more obvious improvement in the tax behavior of enterprises with higher tax avoidance motives. In view of the possible behavioral inertia of corporate tax avoidance, when the degree of tax avoidance in the previous period is low, the current period may also have a lower tax avoidance motive (Sun et al., 2021a, 2021b). The annual mean value of the RATE of the previous period is used as the grouping criterion for judging the corporate tax avoidance motive. The higher the RATE value, the higher the corporate tax avoidance motive; therefore, we divide the sample into two groups according to the annual average value of RATE, the enterprises with above-average RATE value in the high tax avoidance motive group and the enterprises with RATE values lower than the annual average in the low tax avoidance motive group. The regression results are detailed in Table 7, Panel A, showing that the results of the regression on local taxation bureaus' operation of government social media and corporate tax avoidance are only significant in the high tax avoidance motive group, and the sign is consistent with expectations. Thus, the education effect of the taxation bureau's operation of government social media on corporate tax avoidance is proved.

To further confirm this education effect, we also measure the tax avoidance motives of enterprises from the perspective of financing constraints. According to the cash flow effect hypothesis, corporate tax avoidance can increase after-tax cash flow and help ease a corporation's financing constraints (Edwards et al., 2016; Goh et al., 2016). Therefore, enterprises with higher financing constraints may have stronger tax avoidance motives. WE use the KZ index formulated by Kaplan and Zingales (1997) to measure enterprises' degree of financing constraints. The larger the index value, the greater the degree of financing constraints of an enterprise.

Table 6
Heterogeneity analysis.

VARIABLES	High intensity of tax enforcement and administration	Low intensity of tax enforcement and administration	High intensity of tax enforcement and administration	Low intensity of tax enforcement and administration
	ETR		RATE	
Government_ social_media	0.0000	0.0002**	0.0000	−0.0002**
	(0.134)	(2.125)	(0.046)	(-2.043)
Control Variables	Control	Control	Control	Control
Year fixed effect	Control	Control	Control	Control
Individual fixed effects	Control	Control	Control	Control
Constant	0.8178	−1.8815	−0.9098	1.0495
	(1.363)	(-0.716)	(-1.367)	(0.368)
Observations	3,675	3,409	3,675	3,409
adj_R2	0.6195	0.6624	0.5508	0.6075

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

Enterprises whose index is above the annual mean are included in the group with high financing constraints, and those whose index is below the annual average are included in the group with low financing constraints. The specific regression results are shown in Table 7, Panel B; specifically, the results of the regression on local taxation bureaus' operation of government social media and corporate tax avoidance are only significant in the group with high financing constraints, and the sign meets expectations. This confirms the education effect of local taxation bureaus' operation of government social media on corporate tax avoidance.

6.2.2. Supervision effect test

Better stock liquidity of an enterprise is associated with a higher degree of information transparency (Qu et al., 2011), less difficulty for society and owners to supervise the enterprise externally and internally, respectively, and more difficulty for its managers to take tax avoidance measures to cover up opportunistic behavior. If local taxation bureaus' operation of government social media has a supervision effect on corporate tax avoidance, then we expect to find a more significant improvement in the tax behavior of enterprises with low information transparency. Following Sun et al. (2021a, 2021b), we use the stock illiquidity indicator (ILLIQ, calculated as the average ratio of the daily absolute return in the current month to the number of daily trading shares) as the grouping criteria, with an ILLIQ value higher than the annual average for the year indicating higher information transparency and an ILLIQ value lower than the annual average for the year indicating lower information transparency. The regression results, presented in Table 8, Panel A, indicate that the regression results are only significant in the group with lower information transparency, which is consistent with our expectations. This proves the supervision effect of local taxation bureaus' operation of government social media on corporate tax compliance.

Considering the literature, we also use the DD index, the proxy variable of earnings quality as another measure of corporate information transparency, which is designed by Dechow and Dichev. For the calculation of this index, we draw on Dechow and Dichev (2002) and refers to Xin et al. (2014) to multiply the DD index by –1 to construct a measure of corporate earnings quality (EQ). The average value of EQ is used as the grouping standard, with a value higher than the annual average in the current year indicating higher information transparency and an EQ value lower than the annual average in the current year indicating lower information transparency. The specific regression results, shown in Table 8, Panel B, show that the regression results are only significant in the low information transparency group, which is consistent with expectations. This confirms the supervision effect of local taxation bureaus' operation of government social media on corporate tax avoidance.

Table 7
Education effect mechanism test.

Panel A Tax Avoidance Motivation

VARIABLES	Group with low tax avoidance motives	Group with high tax avoidance motives	Group with low tax avoidance motives	Group with low high avoidance motives
	ETR		RATE	
Government_ social_media	0.0000	0.0002**	−0.0001	−0.0001*
	(0.242)	(2.153)	(−0.432)	(−1.680)
Control Variables	Control	Control	Control	Control
Year fixed effect	Control	Control	Control	Control
Individual fixed effects	Control	Control	Control	Control
Constant	0.4812	0.0957	−0.5339	−0.0260
	(0.559)	(0.228)	(−0.508)	(−0.055)
Observations	2,723	4,361	2,723	4,361
adj_R2	0.6015	0.6726	0.5020	0.6415

Panel B Financing Constraints

VARIABLES	Group with low financing constraints	Group with high financing constraints	Group with high financing constraints	Group with high financing constraints
	ETR		RATE	
Government_ social_media	0.0000	0.0003***	0.0000	−0.0003***
	(0.080)	(2.610)	(0.326)	(−2.609)
Control Variables	Control	Control	Control	Control
Year fixed effect	Control	Control	Control	Control
Individual fixed effects	Control	Control	Control	Control
Constant	0.1428	0.8538	0.2610	−0.8950
	(0.400)	(1.395)	(0.652)	(−1.251)
Observations	3,229	3,855	3,229	3,855
adj_R2	0.7191	0.5921	0.6608	0.5366

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

6.3. Information attributes of government social media

6.3.1. Research on the actual utility of other types of information

Yin and Huang (2016) study the official government *Weibo* of Beijing, Shanghai, Nanjing, Guangzhou and Chengdu and find that China's government *Weibo* provide convenient information on topics such as life, entertainment and sports, constructing a sub-private domain (a people-centred public realm) of people's lives, which makes government social media a combination of public and sub-private domain. Netizens are concerned solely with the publicity aspect of official government *Weibo*. The convenient information on topics such as life, entertainment and sports weakens people's attention to issues in the public domain and even weakens the authority of public administration, thereby forming a confrontational public space.

The *Sina Weibo* of local taxation bureaus are highly professional; however, our survey results reveal that convenient information on topics such as life, entertainment and sports exists in these *Sina Weibo* to varying degrees. To investigate whether this content affects the governance effect of government social media via corporate micro-behavior, with the goal of providing practical implications for policy development, we conduct the following test. First, we manually screen out information on topics not related to taxes on the *Sina Weibo* of local taxation bureaus, for example, convenient information, breaking news, and common sense. We then carry out the data regression, taking the number of types of non-tax information posted on a local tax bureau's official *Sina Weibo* in the current year, divided by the total number of posts on the *Weibo* in the current year, as an indicator to measure the content of non-tax information (*Other*). The results are detailed in Table 9, Columns (1)–(2). As shown, *Other* is negative and significant for ETR at the 5% level, and positive and significant for RATE at the 10% level, which indicates that when local taxation bureaus release more non-tax content on their *Sina Weibo*, this increases corporate tax avoidance. This confirms the research conclusions of Yin and Huang (2016), indicating that in contrast to other types of social media, government social media should focus on official, formal and professional characteristics and that the content and form associated with a strategy of convenience and closeness to people are associated with counterproductive effects.

6.3.2. Research on subdivision function of policy information

To further explore the impact of different types of policy information on corporate tax avoidance, we use Python to categorize policy information through keyword extraction. First, we identify system operation information by using keywords and terms such as "e-tax bureau," "personal tax system," "declaration," "appointment," "App," "filing" and "client," and we identify announcements by using keywords such as "release," "revision," "report," "announcement," "solicitation," "publication" and "issuance." We carry out the data regression by dividing the number posts concerning system operations (announcements) on the official *Sina Weibo* of the local taxation bureaus in the current year by the total number of bureau *Weibo* posts in the current year to calculate the measurement indicator *Operate* (*Inform*). The regression results are shown in Table 9, Columns (3)–(6). The regression results of *Operate* and *Inform* are both significant and in line with expectations, which indicates that when content regarding system operations and announcement information released by local taxation bureaus on their *Sina Weibo* increases, the degree of corporate tax avoidance decreases. Judging from the coefficient, the amount of system operations information is slightly higher than the announcement information. This may be because the Chinese business tax system is undergoing vigorous reform. To improve taxpayer convenience, taxation bureaus have completely converted from the traditional offline system to an online system, which requires taxpayers to declare, pay and purchase VAT invoices by themselves. By providing guidance and assistance for people's tax process, system operations tutoring is able to support the dramatic increase in online taxation activities significantly which can affect taxpayers' sense of satisfaction, achievement and identification with the government. Announcement information can play a good role in policy notification and publicity, while system operation information can assist announcement information to better implement policies. Therefore, when operating government social media, local taxation bureaus can appropriately increase the proportion of system operations information while performing traditional information announcement functions.

Table 8
Supervision effect mechanism test.

Panel A Stock Liquidity

VARIABLES	ETR		RATE	
	Group with high stock liquidity	Group with low stock liquidity	Group with high stock liquidity	Group with low stock liquidity
Government_social_media	0.0001	0.0002*	−0.0001	−0.0002*
	(1.218)	(1.891)	(−1.065)	(−1.753)
Control Variables	Control	Control	Control	Control
Year fixed effect	Control	Control	Control	Control
Individual fixed effects	Control	Control	Control	Control
Constant	0.2023	0.6286	0.0305	−0.6523
	(0.384)	(1.300)	(0.050)	(−1.159)
Observations	3,559	3,525	3,559	3,525
adj_R2	0.6373	0.6402	0.5752	0.5902

Panel B Earnings Quality

VARIABLES	ETR		RATE	
	Group with high earnings quality	Group with low earnings quality	Group with high earnings quality	Group with low earnings quality
Government_social_media	0.0003	0.0003**	−0.0002	−0.0002*
	(0.910)	(2.031)	(−0.524)	(−1.687)
Control Variables	Control	Control	Control	Control
Year fixed effect	Control	Control	Control	Control
Individual fixed effects	Control	Control	Control	Control
Constant	0.6837	−0.0589	−0.4807	0.3169
	(1.397)	(−0.073)	(−0.893)	(0.341)
Observations	3,151	3,933	3,151	3,933
adj_R2	0.6861	0.5861	0.6330	0.5396

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

Table 9
Analysis on the information attributes of government social media.

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
	Other types of information		System operation information		Announcement information	
	ETR	RATE	ETR	RATE	ETR	RATE
Other	−0.0006**	0.0006*				
	(-2.223)	(1.755)				
Operate			0.0840**	−0.0944**		
			(2.030)	(-2.082)		
Inform					0.0525**	−0.0528*
					(1.962)	(-1.806)
Control Variables	Control	Control	Control	Control	Control	Control
Year fixed effect	Control	Control	Control	Control	Control	Control
Individual fixed effects	Control	Control	Control	Control	Control	Control
Constant	0.4435	−0.3717	0.4223	−0.3490	0.4385	−0.3671
	(1.392)	(-1.020)	(1.330)	(-0.961)	(1.379)	(-1.008)
Observations	7,084	7,084	7,084	7,084	7,084	7,084
R-squared	0.7914	0.7600	0.7913	0.7600	0.7913	0.7599
adj_R2	0.6295	0.5737	0.6293	0.5737	0.6292	0.5735

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

7. Conclusion

The government's application of social media involves key aspects of social governance (Criado et al., 2013) and plays an important role in improving the efficiency of governance, shortening the distance between government officials and the people and flattening communication (Bertot et al., 2012). However, research on the impact of government social media is limited in terms of subject distribution and research methods. Therefore, it is of great theoretical and practical significance to explore the micro-governance effect of government social media and the mechanism thereof.

The institutions of government social media with Chinese characteristics provide a unique, relevant research opportunity. In this paper, the number of likes, comments and reposts made by taxpayers on the official *Sina Weibo* of the taxation bureaus of 31 provinces (municipalities/autonomous regions) in China are added and then divided by the total number of posts on the same *Weibo* in that year as a proxy variable for the quality of the taxation bureau's operation of government social media, with the goal of empirically testing the relationship between a taxation bureau's operation of government social media and corporate tax avoidance. An empirical test based on a large sample reveals that the higher the quality of local tax bureaus' operation of government social media, the lower the degree of local corporate tax avoidance. These findings hold after testing using the instrumental variable method, changing variables, adjusting the sample size and adding control variables. In-depth research reveals that government social media have a substitution effect on tax enforcement and administration; that is, a local taxation bureau's operation of government social media has a more significant inhibitory effect on corporate tax avoidance in regions with low tax enforcement and administration. In this paper, the ETR (effective tax rate), KZ index (financial constrain), ILLIQ (stock illiquidity) and DD index (earnings quality calculated according to the DD model) are used as the measurement standards of corporate tax avoidance motivation and information transparency to perform group regression, which confirms the "education effect" and "supervision effect" of taxation bureaus' operation of government social media on corporate tax avoidance. We also find that when the amount of non-tax-related information released by local taxation bureaus on their official *Sina Weibo* increases, the degree of corporate tax avoidance increases, indicating that government social media should focus on official, formal and professional characteristics and content. By contrast, when system operations–and announcement-related information released by local taxation bureaus on *Sina Weibo* increases, the degree of corporate tax avoidance declines. Especially in the context of the current great changes in how enterprises handle taxation, it is necessary to appropriately increase the proportion of system operations information in tax-related government *Weibo*.

This paper addresses certain shortcomings in the literature on the relative lack of government social media, promotes the integration of disciplines and improves on existing research methods. Furthermore, it supplements the research on corporate governance and corporate tax avoidance factors from the perspective of the media and provides practical policy implications for governments around the world, inspiring the use of government social media to carry out social governance. Government social media have generated a large number of data sources, which have high research value as unstructured text information. However, due to space and technical limitations, we mainly analyze the impact of government social media on enterprises at the utility level, for example, the level of particular activity. On the basis of this analysis, future research could use machine learning and other technologies to conduct text analysis on the specific content released via government social media and conduct in-depth research on the subject and attitude of the information released by government social media in terms of content and expression.

8. Notes

1. Source of information: The 46th "Statistical Reports on Internet Development in China" (full text) - Office of the Central Cyberspace Affairs Commission https://www.cac.gov.cn/2020–09/29/c_1602939918747816.htm.
2. "Dual-Wei" refers to Sina Weibo and Tencent WeChat public accounts, respectively.
3. Due to space limitations, the specific sampling results are not shown. The details can be provided by the author on request.
4. As the specific evaluation methods are internal non-public materials, we use interviews to actually investigate the taxation bureau staff responsible for social media in 5 central and local provinces/municipalities (Beijing, Sichuan, Chongqing, Liaoning, and Anhui). According to the survey, the current State Taxation Administration's assessment of the government social media of local taxation bureaus is included under the "Government Openness" (second-level index) index under "Tax Modernization" (first-level index), and the evaluation method is the benchmark addition and subtraction method.
5. "Yu talks about problems" in Chinese is a homophone with "encounter problems", which means encountering a difficult problem. "Yu" is the abbreviation of the administrative division of Henan Province, and the theme has strong regional characteristics.
6. "Yu" in "Yu Tax Weekly Overview" is the abbreviation of the administrative divisions of Chongqing. The topic in Chinese refers to a weekly news summary of important tax policies and tax management activities in Chongqing.
7. "Dolma" in "Dolma Talks about Tax" is the name given to women by Tibetans in China, meaning "Tara", a beautiful goddess.
8. Due to space limitations, the specific sampling results are not shown. The details can be provided by the author on request.
9. Due to space limitations, the specific sampling results are not shown.
10. The details can be provided by the author on request.

Acknowledgement

Appendix.

See Table A1-A4.

The parts marked in grey in Table A1 represent exactly the same promotional content that appears in Weibo and WeChat official accounts. It can be seen from the table that the content of the two platforms is highly consistent. In the same way, we asked 4 postgraduate students to randomly select the information

Table A1
Comparison of Information Released by Weibo and WeChat of China Henan Provincial Tax Service.

Date	Serial Number	Title of Weibo	Serial Number	Title of WeChat
Apr.2nd	1	Mom and Dad, Look Here! Video Tutorial on Filling and Reporting Special Additional Deductions for Caring Infants and Young Children under 3 Years Old	1	Mom and Dad, Look Here! Video Tutorial on Filling and Reporting Special Additional Deductions for Caring Infants and Young Children under 3 Years Old
	2	Spread the Word! Tax Revenue Policies to Be Implemented in April 2022	2	It is Settled! Our Province Enjoys the Best
	3	The Three Departments Have Made It Clear That the Proportion of Pre-tax Additional Deduction of R&D Expenses for Technology SMEs will be Further Increased.	3	The Three Departments Have Made It Clear That the Proportion of Pre-tax Additional Deduction of R&D Expenses for Technology SMEs will be Further Increased.
	4	VAT Credits at the End of the Period are Refunded! Like! This!	4	Spread the Word! Tax Revenue Policies to Be Implemented in April 2022
	5	As of 24:00 on April 1, the Latest Situation of New Coronavirus Pneumonia in Henan Province	5	As of 24:00 on April 1, the Latest Situation of New Coronavirus Pneumonia in Henan Province
	6	About the Prevention and Control of the Epidemic during the Holiday! Important Reminder from the Henan Provincial Center for Disease Control and Prevention	6	VAT Credits at the End of the Period are Refunded! Like! This!
	7	[Connect the Sky to the Ground! Connect the River to the Sea! Henan Province Recreates the "Traffic Advantage" Trump Card]		
	8	#Tax Preferences Promote Development, Benefit Enterprises, Benefit the People and the Future# #The 31st National Tax Awareness Month# #Implement a New Package of Tax and Fee Supporting Policies# #Smart Tax Will Provide More Convenient Services for the People in the Future# Go All Out to Ensure the New Package of Tax and Fee Supporting Policies Take Root – Henan Provincial Tax Service Launches the 31st Tax Awareness Month Web Link		
Apr.1st	1	#Tax Preferences Promote Development, Benefit Enterprises, Benefit the People and the Future# #The 31st National Tax Awareness Month# #Implement a New Package of Tax and Fee Supporting Policies# #Smart Tax Will Provide More Convenient Services for the People in the Future# Duty Free! The New Policy of Exempting Small-scale Taxpayers from VAT Comes into Effect Today	1	Henan Provincial Tax Service Launches the 31st Tax Awareness Month
	2	#Tax Preferences Promote Development, Benefit Enterprises, Benefit the People and the Future# #The 31st National Tax Awareness Month# #Implement a New Package of Tax and Fee Supporting Policies# #Smart Tax Will Provide More Convenient Services for the People in the Future# It's Time to Set Sails and Take Advantage of the Spring Breeze — Message from the Launch of the "Tax" Channel of Henan Daily Client	2	Duty Free! The New Policy of Exempting Small-scale Taxpayers from VAT Comes into Effect Today
	3	#Tax Preferences Promote Development, Benefit Enterprises, Benefit the People and the Future# #The 31st National Tax Awareness Month# #Implement a New Package of Tax and Fee Supporting Policies# #Smart Tax Will Provide More Convenient Services for the People in the Future# Henan Provincial Tax Service Launches the 31st Tax Awareness Month	3	The First "Tax Lecture" Starts This Year! Interpret the "Six Taxes and Two Fees" Reduction and Exemption Policy

Table A1 (*continued*)

Date	Serial Number	Title of Weibo	Serial Number	Title of WeChat
	4	#Tax Preferences Promote Development, Benefit Enterprises, Benefit the People and the Future# #The 31st National Tax Awareness Month# #Implement a New Package of Tax and Fee Supporting Policies# #Smart Tax Will Provide More Convenient Services for the People in the Future# The Tax Department is Making Every Effort to Prepare for the Implementation of the VAT Exemption Policy for Small-scale Taxpayers	4	Please Accept the Tax Return Reminder in April!
	5	The First "Tax Lecture" Starts This Year! Interpret the "Six Taxes and Two Fees" Reduction and Exemption Policy	5	As of 24:00 on March 31, the Latest Situation of New Coronavirus Pneumonia in Henan Province
	6	The Large-Scale Tax Refund Policy Will Be Implemented Today!	6	The Large-Scale Tax Refund Policy Will Be Implemented Today!
	7	Real Estate Transaction Declaration Operation of Henan E-Tax Service		
	8	As of 24:00 on March 31, the latest Situation of New Coronavirus Pneumonia in Henan Province		
Mar.31st	1	#Tax Preferences Promote Development, Benefit Enterprises, Benefit the People and the Future# #The 31st National Tax Awareness Month# #Implement a New Package of Tax and Fee Supporting Policies# #Smart Tax Will Provide More Convenient Services for the People in the Future# Wait for Your Contribution! The Collection of Works for "Henan Taxation Good News" Has Begun	1	"Cloud Tax Live" Trailer Explanation of the Package of Tax and Fee Supporting Policies
	2	The General Office of the Central Committee of the Communist Party of China and the General Office of the State Council issued the "Opinions on Promoting the Construction of a Social Credit System with High-Quality Development and Promoting the Formation of a New Development Pattern"	2	Real Estate Transaction Declaration Operation of Henan E-Tax Service
	3	#Tax Preferences Promote Development, Benefit Enterprises, Benefit the People and the Future# #The 31st National Tax Awareness Month# #Implement a New Package of Tax and Fee Supporting Policies# #Smart Tax Will Provide More Convenient Services for the People in the Future# People's Daily: This year, Large-scale Tax Refund Will Be Implemented in Advance for VAT Credits to Ease Market Entities	3	People's Daily: This Year, Large-scale Tax Refund Will Be Implemented in Advance for VAT Credits to Ease Market Entities
	4	As of 24:00 on March 30, the Latest Situation of New Coronavirus Pneumonia in Henan Province	4	The General Office of the Central Committee of the Communist Party of China and the General Office of the State Council issued the "Opinions on Promoting the Construction of a Social Credit System with High-Quality Development and Promoting the Formation of a New Development Pattern"
	5	From Tomorrow, These New Regulations Will Affect Your and My Life	5	Wait for Your Contribution! The Collection of Works for "Henan Taxation Good News" Has Begun
			6	As of 24:00 on March 30, the Latest Situation of New Coronavirus Pneumonia in Henan Province
			7	From Tomorrow, These New Regulations Will Affect Your and My Life

Table A1 (*continued*)

Date	Serial Number	Title of Weibo	Serial Number	Title of WeChat
Mar.30th	1	Nanyang Tax Service: Tax and Postal Cooperation to Build a New Channel for Facilitating Taxation	1	"Special Additional Deductions for Caring Infants and Young Children under 3 Years Old" is Coming
	2	The Mourning Day is Approaching! Mourn Ancestors and Sweep tombs in A Suitable Way! Fire Prevention First!	2	The Three Departments Further Regulate the Profit-making Behavior of Webcast to Promote the Healthy Development of the Industry (with documents attached)
	3	#Tips for Travel Safety During the Epidemic#	3	All Preparations for the VAT credits Refund are Progressing Well!
	4	Be Wary of These Dangers Lurking around Your Children!	4	If the Industry Registered by the Taxpayer is Inconsistent with the One Actually Operated, How to Enjoy the Deferred Payment Policy?
	5	The Three Departments Further Regulate the Profit-making Behavior of Webcast to Promote the Healthy Development of the Industry (with documents attached)	5	The State Taxation Administration Revised and Promulgated the Operational Measures for Special Additional Deductions for Personal Income Tax (for Trial Implementation)
	6	"Special Additional Deductions for Caring Infants and Young Children under 3 Years Old" is Coming	6	As of 24:00 on March 29, the Latest Situation of New Coronavirus Pneumonia in Henan Province
	7	The State Taxation Administration Revised and Promulgated the Operational Measures for Special Additional Deductions for Personal Income Tax (for Trial Implementation)	7	Personal Special Additional Deductions Have Increased to 7 Items!
	8	If the Industry Registered by the Taxpayer is Inconsistent with the One Actually Operated, How to Enjoy the Deferred Payment Policy?		
	9	#Implement a New Package of Tax and Fee Supporting Policies# All Preparations for the VAT credits Refund are Progressing Well!		
	10	As of 24:00 on March 29, the Latest Situation of New Coronavirus Pneumonia in Henan Province		
	11	Personal Special Additional Deductions Have Increased to 7 Items!		
Mar.29th	1	Tax Questions and Answers on the Special Additional Deduction for Caring Infants and Young Children under 3 Years Old	1	Tax Questions and Answers on the Special Additional Deduction for Caring Infants and Young Children under 3 Years Old
	2	Tax Questions and Answers on the Special Additional Deduction for Caring Infants and Young Children under 3 Years Old	2	Tax Questions and Answers on the Special Additional Deduction for Caring Infants and Young Children under 3 Years Old
	3	From Today, the Special Additional Deduction for Caring Infants and Young Children under 3 Years Old Can Be Filled out!	3	Authoritative Interpretation! Answers to Reporters' Questions on the Implementation of the Special Additional Deduction for Personal Income Tax for Caring Infants and Young Children under 3 Years Old
	4	Authoritative Interpretation! Answers to Reporters' Questions on the Implementation of the Special Additional Deduction for Personal Income Tax for Caring Infants and Young Children under 3 Years Old	4	From Today, the Special Additional Deduction for Caring Infants and Young Children under 3 Years Old Can Be Filled out!
	5	It's Settled! If the Family Has Children under 3 Years Old, the Personal Income Tax Can Be Deducted 1,000 Yuan per Child per Month	5	As of 24:00 on March 28, the Latest Situation of New Coronavirus Pneumonia in Henan Province
	6	As of 24:00 on March 28, the Latest Situation of New Coronavirus Pneumonia in Henan Province	6	It's Settled! If the Family Has Children under 3 Years Old, the Personal Income Tax Can Be Deducted 1,000 Yuan per Child per Month
	7	The Epidemic is Ruthless and People are Affectionate, Luohe Tax Service Is in Action		

Table A2
Analysis on the abnormal heat of Hubei taxation.

Serial Number	Content	Comments	Likes	Reposts	Total
1	[Warm reminder about 12,366 online tax-related consultation during the epidemic prevention and control period from Hubei Taxation Bureau, State Taxation Administration] In order to conscientiously implement the various measures of the State Administration of Taxation and the People's Government of Hubei Province on the prevention and control of new coronavirus pneumonia epidemic, and to further provide convenient tax consulting services for the majority of taxpayers and payers, during the epidemic prevention and control period, you can use the following methods to conduct tax-related consultation. Warm reminder about 12,366 online tax-related consultation during the epidemic prevention and control period from Hubei Provincial Taxation Bureau, State Taxation Administration	280	1942	13	2235
2	Announcement on Postponing the 2020 Civil Service Examination, Open Selection and Open Recruit for The departments under the CPC Central Committee	317	3186	3	3506
3	[Questions and answers on goods and labor tax-related businesses by Hubei Taxation Bureau to support the prevention and control of new coronavirus pneumonia epidemic] In order to further support the prevention and control of new coronavirus pneumonia epidemic, and actively play the role of tax control, we have compiled a series of tax business issues related to goods and services tax support for epidemic prevention and control in forms of questions and answers, according to the latest national policies and tax hotspots concerned by taxpayers, to provide you with more accurate, convenient and high-quality goods and labor tax policy services. Let us join hands with you to overcome the difficulties together, and resolutely win the people's war, the general war, and the blocking war for epidemic prevention and control! Questions and Answers on goods and labor tax-related businesses by Hubei Taxation Bureau to support the prevention and control of new coronavirus pneumonia epidemic	405	1973	3	2381
4	[Quick Question and Answer of Hubei Taxation Bureau's non-tax business for epidemic prevention and control] In order to do well in the epidemic prevention and control caused by new coronavirus pneumonia, and give full play to the role of non-tax income in epidemic prevention and control, we have compiled a series of non-tax-related business issues in forms of quick questions and answers, according to the latest preferential policies and tax hotspots concerned by taxpayers. It is convenient for you to understand the latest preferential policies and payment service measures. Hubei Taxation Bureau will join hands with you to overcome the difficulties together, and win the blocking war for epidemic prevention and control! Quick Question and Answer of Hubei Taxation Bureau's non-tax business for epidemic prevention and control.	2580	24,871	291	27,742
5	[Warm Reminders for Tax Handling on the Prevention and Control of the New Coronavirus Pneumonia Epidemic from Hubei Taxation Bureau, State Taxation Administration] In view of the current severe situation of the new coronavirus pneumonia epidemic in our province, in order to further strengthen the response, prevention and control of the epidemic, taxpayers and payers are requested to adopt the principle of "tax-related matters should be handled online, and if not urgent, there is no need to handle them offline" and try to choose the "contactless" online processing methods such as Hubei Electronic Taxation Bureau, mobile APP, social insurance premium declaration client, etc., to reduce the number of on-site tax processing at the physical window of the tax service hall, thereby minimizing the risk of cross-infection. For on-site business that does not need to be handled in a hurry during the special period, taxpayers and fee payers are requested to give priority to delaying the processing. If it is really necessary to go to the entity tax service hall to handle on-site business, taxpayers and fee payers are requested to conduct self-assessment on their health status. Under the premise of health, they need to do the relevant protection work before choosing to enter the hall to handle the tax. Warm Reminders for Tax Handling on the Prevention and Control of the New Coronavirus Pneumonia Epidemic from Hubei Taxation Bureau, State Taxation Administration.	456	4128	93	4677

Table A2 (*continued*)

Serial Number	Content	Comments	Likes	Reposts	Total
6	[Urgent notice on the process of handling vehicle purchase tax during the Epidemic Prevention and Control period from Hubei Taxation Bureau, State Taxation Administration] In order to effectively do well in the prevention and control of new coronavirus pneumonia epidemic in our province and minimize the risk of cross-infection, according to the principle of "tax-related matters should be handled online, and if not urgent, there is no need to handle them offline", we recommend that the majority of taxpayers minimize the number of going to the physical window of the tax service hall to handle the vehicle purchase tax business. Instead, you can handle the relevant business through the "Hubei Tax" WeChat public account, the Hubei Electronic Taxation Bureau or the self-service tax machine. The specific notices are as follow. [Urgent notice on the process of handling vehicle purchase tax during the Epidemic Prevention and Control period from Hubei Taxation Bureau, State Taxation Administration]	245	808	0	1053

Table A3
Examples of comments on Sina Weibo of Local Taxation Bureaus.

Province	Release Time	Weibo Text	Comment	Reply
Anhui Province	July 25, 2018	[Dedication to work is the most beautiful "background" for the reform of tax institutions]	**Comment 1:** For the newly bought house in Fuyang, the loan is a combination loan. Before our loan, the developer asks us to pay the deed tax. Shouldn't the deed tax be paid when the house is about to be handed over? Is it normal for the developer to let me pay the deed tax a long time in advance with the combination loan I use?	No Reply
Beijing Municipality	February 19, 2020	[Focusing on the "Three Forces", local tax authorities actively carry out "contactless" tax and fee payment services]	**Comment 1:** How can the construction company from other province in Beijing declare VAT online "without face-to-face handling"? **Comment 2:** Colleagues who work in Beijing will not be able to come to their posts in February, and the golden tax disk cannot copy the tax. How can they declare the VAT? I have asked the 12,366 online consultation today which told me to ask the sub-bureau, but I called the sub-bureau and no one answered. I am online waiting for a reply. Urgent!	No Reply
Fujian Province	August 21, 2018	#Tax policy# [State Tax Administration Letter [2018] No. 461: Notice on matters related to implementing the spirit of the national teleconference on deepening the reform of "Delegation, Regulation, Service" and transforming government functions and optimizing the tax and business environment] According to the requirements of the National Teleconference on Deepening the Reform of "Delegation, Regulation, Service" and Transforming Government Functions (General Office of the State Council of the People's Republic of China [2018] No. 79 Document), in order to deepen the reform of "Delegation, Regulation, Service" in the tax system, to effectively solve the pain points and blocking points in tax handling processes, to continuously improve taxpayers' sense of gain, and to continuously optimize the tax business environment, the relevant matters are hereby notified as follows.	**Comment 1:** I want to file a complaint against Fujian Net Dragon Information Company which refused to issue an invoice for my total consumption of RMB 1 million; **Comment 2:** I want to file a complaint against the officer who works in the No. 9 window of Fuding Tax Service! Her attitude was terrible! I just asked her a few words and she seemed to be impatient; **Comment 3:** Hello the editor, my friend recently went to apply for a personal tax certificate. He was required to provide the salary details of all staffs in the company before the director stamped it. Is this request reasonable and legal? **Comment 4:** I went through the deregistration business at Gulou Local Tax Service in July. The staff said they would delivered the result within 20 working days, but now it is almost two months and they are still examining and approving. It's okay for them to have a poor working attitude, but their work efficiency is so low. I am really speechless!	No Reply

Table A3 (*continued*)

Province	Release Time	Weibo Text	Comment	Reply
Gansu Province	January 30, 2019	Check it out! The details of these tax cuts and fee reductions have been clarified, and they are related to you.	**Comment 1:** Can taxpayers who do not apply for tax registration certificates, such as natural persons, also enjoy the preferential policies for small-scale taxpayers?	**Reply to Comment 1:** Hello, please call 0931–12366 for consultation and confirmation for specific business.
Guangdong Province	September 23, 2019	Tribute to the taxpayer | The taxpayers are full of blood to promote reform and the original intention does not change Tribute to the taxpayer | The taxpayers are full of blood to promote reform and the original intention does not change	**Comment 1:** The company has payed wages through Alipay for a long time. The "Alipay account number" is indicated on the interview form. The salary of the last month or the month before the last was paid on the last day of the end of each month or the beginning of the next month. Is it suspected of tax evasion and illegality? @ Guangdong Tax Service @State Taxation Administration @CCTV news @Zhongguo Shuiwu Bao @Hot News @China News @Head News @ The Paper @Sina News @National Business Daily **Comment 2:** Hello, we are a construction company in Beijing and have a project under construction in Huadu District, Guangzhou. Starting from July and August this year, we cannot make tax appointments in the name of companies in Guangzhou tax service. We can only make tax appointments in the name of individuals. Basically, the personal reservation number can only be reserved for three days later on the same day. But there are a lot of enterprise reservation numbers, but we can't make an appointment, which is very inconvenient for us. Can you submit any information?	**Reply to comment 1:** Hello, we have received your feedback. For tax violations such as tax evasion committed by taxpayers in Guangdong Province, if you have relevant evidence and clues, you can log in to the Guangdong Provincial Tax Service of the State Taxation Administration (web link), and go to the "I want to participate -> Reporting tax violations" column on the homepage to make a report or call the 12,366 hotline to report.)
Guangxi Province	April 9, 2020	#The most beautiful spring photo# girls in Guangxi put on spring clothes, and the spring breeze of tax declaration blows to the south of China (the 29th National Tax Awareness Month Glimpse)	**Comment 1:** Hello! Do I need to make an appointment to pay the property deed tax? How to do it?	Reply to Comment 1: Hello, you can follow the WeChat public account of "Guangxi Tax 12366", and use the tax reservation function to make an appointment to get an account

Table A3 (*continued*)

Province	Release Time	Weibo Text	Comment	Reply
Guizhou Province	September 28, 2019	@Weibo Guizhou [Tax processing will be accelerated again! VAT invoice management system version 2.0 has been officially launched in Guizhou] Recently, the VAT invoice management system version 2.0 was officially launched in Guizhou. When handling tax-related business, taxpayers only need to log in to one system and use one account to handle complete VAT business such as issuance of golden tax (tax control) disks, receipt of invoices, etc. It only takes 8 min on average for each business. Compared with the original version, the time is reduced by nearly half, and the "one-window" quick processing is realized. As of 16:00 on September 26, 105 tax collection units in the province have conducted comprehensive business verification in the tax control system and core tax collection and management system. All business verification is progressing smoothly, and all tax-related business can be handled normally. (via. Guizhou Provincial Tax Service)	**Comment 1:** Excuse me, what is the matter with the false comprehensive business certificate of VAT online invoice?	No Reply
Hainan Province	March 29, 2019	[Enjoy the "plus deduction" discount, and send you a set of operation methods!]	**Comment 1:** Excuse me, in Sanya, Hainan, if the developer transfers the resettlement house to the demolished owner for free, should it be regarded as a sale and pay VAT? How to determine the deemed sales price, according to the market price? Or cost plus? Or some other methods?	No Reply
Hebei Province	October 29, 2019	Attention! There are three ways to deal with the abnormal customs payment documents in the audit and comparison. Attention! There are three ways to deal with the abnormal customs payment documents in the audit and comparison.	**Comment 1:** I paid the 2020 NRCMS fee tonight. My mother and my sister's NRCMS fee was paid on WeChat City Service or the Hebei Tax Public Account. I don't know why my father's fee can't be paid. Which one do you know the reason? Thanks!	No Reply

Table A3 (*continued*)

Province	Release Time	Weibo Text	Comment	Reply
Henan Province	February 13, 2019	@State Taxation Administration [New Year's tax reduction gift package is distributed intensively, and local version of the new tax reduction policy conducts top-level tax reduction] New Year's tax reduction gift package is distributed intensively. Recently, more than 20 provinces (autonomous regions and municipalities), including Zhejiang, Shanxi, Beijing, Inner Mongolia, Fujian, Shandong, Sichuan, Yunnan, Jilin, Heilongjiang, etc., have successively issued new policies to reduce taxes and fees in light of local conditions. Judging from the plans announced by the local government, they carried out all tax reductions at the highest level, that is, according to the 50% tax reduction ceiling stipulated by the state, the "six taxes and two fees" for small-scale taxpayers of local VAT would be reduced in the three years from 2019 to 2021". New Year's tax reduction gift package is distributed intensively, and local version of the new tax reduction policy conducts top-level tax reduction	**Comment 1:** When is the last day to pay taxes this month?	**Reply to comment 1:** the 22nd day of the month

Table A4
Definition of Main Variable.

Variable Type	Variable Symbol	Variable Name	Calculation Method
Explained Variable	Main	ETR	Effective tax rate	(Income tax expense - deferred income tax expense)/total profit before tax; the higher the ETR is, the lower the degree of corporate tax avoidance is.
	Test	RATE	Difference between the nominal tax rate and the effective tax rate	Nominal tax rate - effective tax rate; the lower the RATE is, the lower the degree of corporate tax avoidance is.
	Robustness Test	CASHETR	Cash effective tax rate	(Current income tax expense + income tax payable at the beginning of year− income tax payable at the end of year)/ total profit before tax, where taxable income = (income tax expense - deferred income tax expense)/ nominal income tax rate; the higher the CASHETR, the lower the degree of corporate tax avoidance is.
Explanatory Variable		Governemnt_social_media	The quality of taxation bureau's operation of government social media	The official Sina Weibo of the taxation bureaus of various regions received the number of "Likes + Comments + Reposts" from taxpayers that year/ the total number of official Sina Weibo posts of local taxation bureaus that year. The higher the value is, the higher the quality of the local tax office's social media operations is.
Control Variable		ROA	Return on Total Assets	Net profit/ total assets.
		Lev	Asset-liability ratio	(Short-term loans + long-term loans + bond payable)/ total assets.
		Growth	The growth of enterprises	(Amount of operating income in the current year - operating income in the same period of the previous year)/ (ABS operating income in the same period of the previous year).
		INVENT	Inventory-to-income ratio	net inventory at the end of year/ total assets.
		Current	Current asset ratio	net current assets at the end of year / total assets.
		PPE	Fixed asset ratio	net fixed assets at the end of year / total assets.
		NEG	Net operating cash flow	The net cash flow from operating activities is positive and takes 1, otherwise it takes 0.
		Top10hold	Shareholding ratio of top ten shareholders	Shareholding ratio of the top ten shareholders of the company.
		SOE	Equity nature	Dummy variable, if the enterprise is state-owned enterprise takes 1, otherwise it takes 0.
		Burden	Other tax burdens	Other tax expenditures/ operating income, other tax expenditures are calculated as follows: First, estimate the nominal turnover tax amount of the enterprise based on the urban maintenance and construction tax and education surcharge; at the same time, other taxes and expenses such as consumption tax, resource tax, vehicle and vessel tax, and stamp duty are obtained according to the "tax and surcharge" item in the corporate financial statement; finally, the two are added together.
		Loss	Loss of enterprise	Dummy variable, if the company's net profit in the current year is less than 0, take 1, otherwise take 0.
		Mktindex	Market index	The value of the index ranges from 1 to 10. The larger the value is, the higher the degree of regional marketization is.
		GDP	Regional Gross Domestic Product	The annual gross domestic product of the province (municipality) where the enterprise is located.
		GR	Regional fiscal revenue	The total annual regional fiscal revenue of the province (municipality) where the enterprise is located.
		Employ	Regional employment rate	The total number of employed persons in the province (municipality) where the enterprise is located, divided by the total population over the age of 16.
		VAT	Regional valued-added tax	The total annual value-added tax of the province (municipality) where the enterprise is located.
		Private	Regional private employed	The total number of private and self-employed individuals in the province (municipality) where the enterprise is located

released on the "Dual-Wei" platform of the taxation bureaus of the 8 provinces (municipalities/ autonomous regions) in eastern, central and western China. The specific samples are not shown in the text due to the length of the article. These sampling results still support our conclusion that the content of various government publicity platforms is consistent, and we also find some other phenomena as follows. First, since the number of daily releases of WeChat official accounts is controlled by the platform, the overall content of Sina Weibo is more abundant, and some minor increments mainly involve life tips, taxation bureau's performance promotion and other content. However, for the information release of key tax policies, these two social media have always maintained the same frequency of content and timeliness. Second, even though some taxation bureaus have different presentation forms on the two social media, such as titles, illustrations, tables, etc., the actual text content is exactly or basically the same. Considering that the difference in presentation form may have an impact on the effectiveness of social media promotion, we did not grey out this situation, but it can in fact be considered as the homogenous content. Third, the WeChat official account has greater customized permission in terms of function settings, and different official accounts are not unified in the form layout, functional sections and usage settings. For example, the WeChat official account of the Henan Provincial Tax Service can continuously retrieve all historical news, while the Hainan Provincial Tax Service can only review the publicity materials for nearly a week. In comparison, the Sina Weibo of the provincial taxation bureaus is completely unified in the above aspects, which also lays the foundation for us to carry out regional comparisons.

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Can blockchain technology be effectively integrated into the real economy? Evidence from corporate investment efficiency

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ABSTRACT

As a highly disruptive digital technology, blockchain provides new solutions for reshaping corporate governance mechanisms and improving resource allocation. We empirically examine the relationship between blockchain and corporate investment inefficiency. We find that blockchain can help improve corporate investment efficiency, and this result is valid after a series of robustness tests. Blockchain can not only significantly restrain overinvestment but also alleviate underinvestment. Reducing financing costs and alleviating agency conflicts are the two channels through which blockchain is associated with corporate investment efficiency, and financial reporting quality is the condition on which the channels depend. When the CEO holds few shares or the trade credit environment in the region where the company is located is poor, the effect of blockchain is more prominent than it is otherwise. Investment efficiency cannot be improved by blockchain for companies providing blockchain products or services to customers, only for those promoting their own operations and management with blockchain. Ultimately, blockchain can enhance companies' value by alleviating inefficient investment. We reveal the role of blockchain in corporate investment efficiency, furnish microeconomic evidence for the integration of digital technology and the real economy and provide implications for China to promote digital technology to drive high-quality company development.
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1. Introduction

Since the beginning of the 21st century, scientific and technological innovation has been thriving, and the new-generation digital technologies represented by blockchain, big data and artificial intelligence (AI) are profoundly changing our societies' mode of production, way of life and mode of governance. As one of the most important and innovative technologies developed in recent years (Dai and Vasarhelyi, 2017), blockchain was initially primarily known as Bitcoin's underlying technology (Swan, 2015). In reality, blockchain is a "general technology" (FEI, 2018). It emerged before the invention of Bitcoin (Cahill et al., 2020). The value and significance of blockchain technology do not depend on the value and prospects of Bitcoin (Buterin, 2015). Blockchain technology may profoundly affect a company's managers and other stakeholders in many major aspects, and venture capitalists and traditional companies have invested in blockchain technology in recent years. Emerging economies, more than any other, are expected to popularize this technology in securities trading and capital markets (Yermack, 2017).

As a rapidly growing emerging economy, China has prioritized the development of blockchain technology as a national strategy. For example, in 2019, the Political Bureau of the Central Committee of the Communist Party of China (CPC) held a group study session on the situation and trend in the development of blockchain technology chaired by General Secretary Xi Jinping, who urged prioritizing blockchain technology in the independent innovation of core technologies, accelerating the development and industrialization of blockchain technology and promoting the in-depth integration of blockchain technology into the real economy. The Outline of the 14th Five-Year Plan (2021–2025) for National Economic and Social Development and Long-Range Objectives through the Year 2035 of the People's Republic of China (the "Outline of the 14th Five-Year Plan and Vision 2035") released in 2020 expressly advocated for creating new frontiers in the development of the digital economy and fostering the development of blockchain and other emerging digital industries. The application prospect of blockchain technology in the development of the real economy has attracted substantial attention from the Chinese government. Against this background, the mechanism and effects of the integration of blockchain technology into the real economy have become a pressing problem that needs to be addressed by the academic community.

Enterprises are the microscopic medium for the in-depth integration of blockchain technology into the real economy. Investments are financial decisions that are important for an enterprise's economic activity. They not only promote growth and increase the business value of enterprises but also provide a core driving force for national economic development (Abel, 1983). However, studies show that the investment efficiency of Chinese enterprises is generally low (Liu et al., 2015). The 2021 Report on the Work of the Government of the Chinese State Council highlights that "investment growth lacks sustainability." The Outline of the 14th Five-Year Plan and Vision 2035 also highlights the need to "optimize the structure and improve the efficiency of investment." These indicate that improving corporate investment efficiency is a major problem that needs to be urgently addressed by the government and enterprises. With the series of proactive measures adopted by the Chinese government to promote the integration of blockchain technology into the real economy, can enterprises effectively improve their investment efficiency by using the strengths of blockchain technology such as decentralization, tamper resistance and traceability (Huawei blockchain technology development team, 2019)? If yes, what are the internal mechanisms underlying the effect of blockchain technology on corporate investment efficiency? These questions remain to be thoroughly investigated and answered.

For these reasons, we investigated the effects of blockchain technology on corporate investment efficiency, the underlying mechanisms and the economic outcome using a sample consisting of all A-share companies listed on the Shanghai and Shenzhen stock exchanges from 2016 to 2020. The empirical results showed that companies implementing blockchain-related activity had higher investment efficiency than their counterparts. Channel testing showed that blockchain technology helped companies to reduce financing costs and alleviate principal–agent conflict, thereby improving investment efficiency. Financial reporting quality is the premise for the two paths to work. A cross-sectional analysis showed that a lower CEO shareholding ratio or a poorer business credit environment increased the effectiveness of blockchain technology in improving inefficient

investment. Implementing blockchain-related activity significantly inhibited overinvestment and helped alleviate underinvestment. Such an implementation markedly improved investment efficiency when the primary purpose was to improve the company's business operations, but not when the primary purpose was to provide customers with blockchain-related products and services. Blockchain technology increased the market value of companies by improving their inefficient investment. These results demonstrate that blockchain technology can be integrated into the development of the real economy.

The contributions of this study are as follows. First, we focus on the role of blockchain, not big data, AI and other digital technologies in the economic activity of companies, enrich the literature discussing the application value of blockchain technology and provide the academic community with new knowledge for a comprehensive understanding of the driving role of digital technologies in the development of the real economy. Blockchain, big data, AI and other digital technologies inspire strong interest from the academic community in understanding how they affect capital markets (e.g., Goldstein et al., 2019; Wu et al., 2021). However, no other technologies receive attention as broad as that received by blockchain technology (Cahill et al., 2020). The reason that blockchain attracts so much attention could be that, as the central point for combining various technologies (Li and Chen, 2021), blockchain is at the center of commercial technology innovation and profoundly affects corporate governance, industrial organization, corporate finance and other traditional practices (e.g., Yermack, 2017; Cong and He, 2019). Another reason could be that compared with big data and AI, blockchain has a smaller data volume requirement. It does not primarily mine corporate information using massive digital footprints and big data risk control technologies. Instead, it ensures the tamper resistance and traceability of information using technical means such as consensus mechanisms and smart contracts (Gong et al., 2021). This study provides empirical evidence for the effect of blockchain on corporate investments and helps the academic community to identify the internal mechanisms underlying the effect of this digital technology on corporate economic activity.

Second, we broaden the research perspective on the determinants of corporate investment efficiency and provide the field with empirical evidence of the application of digital technologies. Investment is a major topic in theoretical corporate finance research. Academic studies abound on the factors that influence corporate investment efficiency. The field's research perspectives include traditional internal and external governance mechanisms (e.g., Cheng et al., 2013; Bae et al., 2017; Chen et al., 2017; Khan et al., 2017), managers' personal characteristics (e.g., Habib and Hasan, 2017) and institutional factors (e.g., Chen et al., 2011). However, inadequate attention is paid to the effect of recently emerging digital technologies, not least blockchain technology, which is at the center of commercial technology innovation (e.g., Yermack, 2017; Cong and He, 2019), on corporate investment efficiency. This study explores the relationship between blockchain and corporate investment efficiency, helps broaden the research perspective on the determinants of corporate investment efficiency and provides empirical evidence on how digital technologies help alleviate inefficient corporate investment.

Third, we explore the application of blockchain technology and its impacts on the real economy from the microscopic perspective of corporate investment, which has a certain reference value for China's efforts to develop digital technologies and drive their integration into the real economy. As one of the two largest digital economies in the world (United Nations, 2021), China plays a major role in the development of the digital economy. Although the development of blockchain technology is a topic of great interest among researchers and practitioners seeking to understand its application in government agencies and companies (Cheng et al., 2022), empirical evidence remains insufficient (Chen et al., 2022). This study empirically investigates the effect of blockchain technology on corporate investment efficiency, the underlying mechanisms and the consequences of blockchain in the Chinese context. Our results help companies to better understand the positive role of blockchain technology in improving corporate investments and driving efficient resource allocation and increase their interest and confidence in investing in blockchain technology. Our results also provide evidence of the effect of Chinese policies promoting the development of blockchain technology and its integration into the real economy and empirical references for the formulation of policies on digital technologies and high-quality economic development in China.

2. The development of blockchain technology in China: The current situation

2.1. A favorable policy environment and proactive local planning

Blockchain technology is receiving substantial attention from the Chinese government. The CPC Central Committee held a special collective learning session on the current situation and trends in the development of blockchain technology chaired by General Secretary Xi Jinping. General Secretary Xi highlighted the importance of the integrated application of blockchain technology to the new technological and industrial revolutions and urged China to make an effort to obtain the leading position in theoretical research and innovation in this emerging field and to make new advances in the industrialization of this technology. He also urged the in-depth integration of blockchain technology into the real economy and encouraged efforts to solve problems such as the difficulties faced by small and medium-sized companies in obtaining loans and financing, the difficulties faced by banks in risk control and the difficulties faced by regulatory authorities. He also encouraged the application of blockchain technology to promote data sharing, optimize business processes, reduce operating costs and improve coordination efficiency. In addition, the Chinese State Council listed blockchain as a strategic cutting-edge technology in the National Information Technology Development Plan for the 13th Five-Year Period, highlighted blockchain as a digital industry in the Outline of the 14th Five-Year Plan and 2035 Vision and gave important instructions on the development of blockchain technology.[1]

Because of the central government's plans for the blockchain industry, local governments are paying increasing attention to blockchain technology. There are initiatives in a number of regions to develop the blockchain industry, along with policies that encourage the application of blockchain technology. One survey shows the introduction of more than 117 provincial-level policy instruments addressing or covering the development of blockchain between 2016 and 2021. In particular, Guangdong, Shandong and Hebei provinces and Beijing municipality have special policies on the development of blockchain, and Zhejiang and Shaanxi provinces and Shanghai municipality list blockchain technology in their local 14th Five-Year plans, prioritizing and driving the healthy development of local blockchain industrial systems (White paper on blockchain, 2021).

2.2. Extensive efforts to broaden the application of blockchain technology in the private and public sectors

Although blockchain technology was known as the underlying technology of Bitcoin and other cryptocurrencies in its early days, it has prospects for broad application in the private and public sectors. For example, financial institutions are assessing the capacity of blockchain for currency bill tracking. The transportation and logistics industry can use blockchain to improve the tracking of containers and parcels. Regulatory authorities can use blockchain to improve their control efficiency. Blockchain can also increase capital mobility, improve efficiency, reduce costs and build trust between stakeholders and ecosystems (Yiannas, 2018). In a case study, Schneider et al. (2016) elaborate on the application of blockchain technology in fields such as the sharing economy, smart grids, real estate insurance, stock markets, repurchase markets and leveraged loan transactions. Autore et al. (2021) highlight the capacity of blockchain technology for tracking goods throughout supply chains, maintaining digital records and simplifying the clearing and settlement process for financial transactions. Clearly, with many countries' increasing attention to the development of blockchain technology, its broad application prospect has been recognized by both practitioners and researchers.

Currently, the development of blockchain technology in China is approximately at the same level as in other countries (White paper on blockchain, 2020). Finance is the most explored field in the study of blockchain technology application scenarios, and blockchain projects have been implemented in subfields such as supply chain finance, trade finance, payment and clearing and capital management. As of November 2020, finance (including supply chain finance) ranked first in terms of the number of blockchain-based information services projects registered in China, accounting for up to 36 % of all information services projects (White paper on blockchain, 2020).

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[1] Website of the Chinese Central Government: https://www.gov.cn/xinwen/2019–10/25/content_5444957.htm.

With accelerating efforts in China to drive the application of blockchain technology, the "blockchain+" business is now the focus of development for major Internet companies to enter the blockchain industry, and the application of blockchain extends from finance to the real economy, government administration and public services. In particular, the value of applying blockchain technology in the real economy mainly lies in promoting high-efficiency cooperation between upstream and downstream industries and improving the efficiency of industry–finance integration (Tian and Liu, 2022). In blockchain's early days, its mode of application in China was dominated by the storage of documents and contracts, but it now extends to fields such as data sharing, supply chain coordination and cross-border trade. For its application in government administration, blockchain technology plays a major role in fields such as regulatory governance, electronic certification, financial and tax services, administrative review and approval, electronic billing and public resource management, and it has effectively resolved many problems facing the digital government initiative. For its application in public services, blockchain technology is used in many subfields in China, such as healthcare management, education and training, public charity, social governance and targeted poverty alleviation, and the boundary of its applications continues to expand. In addition, as blockchain technology continues to mature, it has become a major technology enabler for deepening the application of electronic judicial evidence, transforming and upgrading industrial manufacturing, developing smart agriculture, accelerating the development of smart transport and realizing the issuing, circulation and regulation of digital assets (Annual white paper on the development of blockchains in China, 2022).

2.3. Accelerating the construction of industrial ecology

The development of the Chinese blockchain industry started early, but it did not have a clear direction and its early stage of development mixed "dragons" and "fishes." The development of the market urgently needed regulation. With national planning and guidance on the development of blockchain technology and the continuous release of policy dividends, the application of blockchain technology and the ecology of the blockchain industry are evolving in an accelerated manner, and the development direction of the industry is becoming increasingly clear. Since 2019, high-level government authorities have clarified the development direction of the blockchain industry, and the overall development strategy of focusing on servicing the real economy has become a matter of consensus in the industry. The Chinese blockchain industry is enjoying rapid development. An industrial chain integrating technology research and development, supporting platforms, service support and industrial applications has gradually taken shape, and the infrastructure, supply chain, environment and ecology of the industry are improving. The Guidelines on Driving the Application and Industrialization of Blockchain Technology jointly issued by the Ministry of Industry and Information Technology (MIIT) and the Cyberspace Administration of China advocate pooling efforts to solve key problems constraining the application and industrialization of blockchain technology, drive the large-scale application of this technology and develop a world-leading ecological system for the blockchain industry.

With the development of blockchain technology adopted as a national strategy and listed in the New Infrastructure Plan (Gong et al., 2021), the industrial community is beginning to reassess the potential of this technology, and diversified industrial entities are participating in the development of blockchain, creating diversified industrial forms. For example, participating industrial entities include not only Internet and technology companies but also traditional industrial entities, which are catching up quickly and proactively investing in blockchain technology based on the strengths of their original industry scenarios. The driving force behind the development of blockchain technology has changed. Previously, technology providers took the initiative to identify application scenarios. Blockchain technology is now dominated by the demand side of the industry, which is taking the initiative to identify business scenarios suitable for the application of blockchain technology and to explore appropriate modes for integrating business development and blockchain technology. Multi-party cooperation between science and technology companies, scientific research institutes and industrial users represents the new trend in blockchain implementation (White paper on blockchain, 2021).

2.4. Coexisting opportunities and challenges

We now have a historical window of opportunity to integrate blockchain technology into China's socioeconomic development. The chief economist of Hong Kong Glory Sun Financial, Lei Zheng, believes that the gap between China and the world's most developed countries in the blockchain field is currently at a minimum, and China now has an opportunity of "corner overtaking". Jian Gao, who is known as the father of Chinese capital market securities, suggests that the competitive edges of China in blockchain technology lie in its extensive application scenarios. Because of the demand from many fields, the return on the application of blockchain technology may exceed the cost of development scenarios, boosting the enthusiasm of all sectors of society for the development of this technology (Ma et al., 2020). With the increasing deepening and diversification of application scenarios, blockchain technology is not only successfully applied in a number of industries in China but also provides strategic support for key emerging fields of development of national importance, such as the carbon peak and carbon neutrality program and the Digital Currency Electronic Payment project.

The development of blockchain technology is also facing challenges. For example, there are challenges in blockchain infrastructure construction, including controversies over the standards for infrastructure construction and the need to maintain a balance in the impossible trinity of scalability, safety and performance (Blockchain infrastructure research report, 2021). For technological challenges, there are risks originating from the providers of blockchain-based information products, blockchain nodes, centralized blockchain controllers and hackers (Wu, 2021). For regulatory challenges, it is difficult to regulate the blockchain industry because of the decentralized and disintermediated nature of blockchains, as pointed out by Ting Li, director of the Research and Consultation Center of the Chinese Institute of Electronics. Although the law establishes that the founders of blockchain organizations or projects bear joint and several liability for all foreseeable damages, it could be very difficult to identify the principal responsible person due to the anonymity of a large number of founders.

Despite all this, following its rapid development in recent years, blockchain technology has become a major infrastructure supporting the Digital China strategy (White paper on blockchain, 2021). The revolutionary effects of blockchain technology on production relationships (Tian and Liu, 2022) will profoundly impact our social environment.

3. Literature review and research hypothesis

3.1. Review of the literature on blockchain

Since it was proposed, blockchain technology has gradually become a hot topic in academic research. The blockchain literature mainly focuses on its concept and technological characteristics and its impact on companies' market value and behavior.

Practitioners, researchers and government agencies all define blockchain differently. For example, from the perspective of practitioners, Ernst & Young partner Tony Klimas defines a blockchain as a distributed database that consists of growing lists of transaction records. These records are stored in the database in the form of blocks, and each block is linked to the next block using an encrypted signature to protect the records from unauthorized modification (Klimas, 2018). From a research perspective, Goldstein et al. (2019) define a blockchain as a distributed ledger running on a peer-to-peer network that validates ownership or enables the safe, efficient transfer of ownership in a decentralized manner. From government agencies' perspective, the MIIT describes a blockchain as a new architecture and computing paradigm that validates and stores data using a blockchain-based data structure, generates and updates data using a distributed node-based consensus algorithm, ensures safe data transfer and access using cryptographic means and programs and processes data using smart contracts consisting of automated script codes (White paper on blockchain technology and its application and development in China, 2016).

The technological characteristics of blockchain include distributed bookkeeping, consensus mechanisms, asymmetric encryption and smart contracts (Swan, 2015). First, a blockchain is essentially an Internet of values, and its underlying technology is a distributed ledger or decentralized database (Mougayar and Buterin,

2016). This is the core characteristic of blockchain technology that distinguishes it from other information technologies. Distributed bookkeeping refers to the recording of transactions at different nodes. No operations can be altered or revoked without authorization, and an attack on the data at any node does not affect the stable operation of the entire blockchain, greatly improving the legal compliance of transactions and the transparency of information (Cuccuru, 2017). Decentralization means that every transaction must be validated, but the validation process does not involve a centralized authority; instead, data consistency in the distributed network is maintained using a consensus algorithm (Zheng et al., 2017). Second, a consensus refers to an agreement between a group of parties (who may distrust each other) on data status (Chod et al., 2020). A blockchain stores the same array of information at different nodes, and a piece of information is added after a consensus has been reached between the nodes (Ølnes et al., 2017); meanwhile, the ledger at every node is updated automatically to the latest version (Ma et al., 2020). During this process, if a node does not agree to update, the chain could split (Tschorsch and Scheuermann, 2016). Next, because the ledger is stored with multiple actors in a distributed manner, mutual reconciliation is objectively necessary. However, there is a problem here—the reconciliation of information records could lead to privacy leaks. Asymmetric encryption can effectively ensure the safe transfer of confidential information (Gao, 2020). Restuccia et al. (2018) point out that blockchain provides information protection for participants using asymmetric encryption algorithms, thereby ensuring public accessibility of data while safeguarding the personal privacy of participants. Finally, smart contracts enable the automatic processing of traditional contracts using computer commands and allow reliable transactions without involving a third party (Tian and Liu, 2022). When the parties to a transaction have reached a consensus and the predefined conditions for the transaction have been mutually satisfied, the program executes the contract and records the transaction in the blockchain (Christodoulou et al., 2018; Cong and He, 2019).

Concerning the impact of blockchain technology on companies' value and behavior, studies show that blockchain technology has a positive effect on improving contracting efficiency, reducing rent-seeking or corruption, preventing accounting fraud, increasing productivity and promoting value growth. With respect to improving contracting efficiency, Cong and He (2019) point out that compared with traditional contracts, blockchains better reflect truths that are closely related to business operations or noteworthy via consensus mechanisms, thereby improving contracting efficiency. With respect to reducing rent-seeking or corruption, blockchains provide unprecedented transparency and thus help identify the properties owned by debt and equity investors and corporate managers, thereby reducing opportunities for rent-seeking or corruption by regulatory authorities, stock exchanges and public companies (Yermack, 2017). With respect to preventing accounting fraud, embedding blockchain technology in accounting information systems improves the reliability of accounting information, the decentralized consensus mechanisms inhibit the motivation for accounting fraud, distributed bookkeeping ensures that there is no alteration of accounting information and timestamps improve the traceability of accounting records (Dai and Vasarhelyi, 2017), thereby providing companies with a major tool for preventing data leakage, avoiding accounting fraud and safeguarding financial safety. In addition, the unalterable nature of blockchain makes it easier for the Public Company Accounting Oversight Board of the United States to review audit processes and prevent accounting firms or hackers from altering the original accounting data (Cao et al., 2018). With respect to improving productivity, blockchain technology allows a company to keep records of all of its operational processes, such as research and development, manufacturing and sales, thereby improving traceability throughout the industrial chain and increasing production efficiency (Ba et al., 2020). With respect to improving corporate value, Chen et al. (2019) suggest that blockchain is the youngest and most rapidly growing technological innovation and helps companies adopting it to increase their economic value. Autore et al. (2021) find that reliable investment in blockchain technology leads to significant growth in corporate shareholder value and that this effect is long-lasting. Cahill et al. (2020) find that companies that publish blockchain-related announcements enjoy long-term and increasing cumulative abnormal returns. However, other researchers show that investors overreact to corporate investment in blockchain technology and find no substantial evidence that adopting blockchain technology has a lasting effect on shareholder value (Cheng et al., 2019).

In summary, as the most rapidly growing and valuable technology in the current wave of financial technology innovation (Chen et al., 2019), blockchain has received extensive attention and exploration from experts and researchers in various fields, and abundant research achievements have been made. Blockchain

technology is penetrating fields such as accounting, finance, logistics and regulation, providing a broad prospect of application (e.g., Yiannas, 2018; Autore et al., 2021) and attracting increasing attention from companies (Deloitte, 2018). Studies on the economic outcome of the adoption of blockchain technology by companies are reported in the literature; however, few studies cover corporate investment, a major type of corporate finance activity. In addition, researchers disagree on the impact of blockchain technology on corporate value. Blockchain technology has a major effect on corporate governance (e.g., Yermack, 2017; Wu, 2021); good corporate governance helps alleviate inefficient investment (Li and Hao, 2020) and investment efficiency is the key to increasing corporate value (Li et al., 2011). To address the inadequate attention paid by previous studies to how blockchain technology impacts corporate investment, we investigate the effect of blockchain technology on corporate investment efficiency, its underlying mechanisms and its effect on corporate value. Our findings provide new insight into the role of blockchain technology in corporate governance and the path through which blockchain technology impacts corporate value.

3.2. Review of the literature on investment efficiency

Investment is a major corporate economic activity and a major topic in theoretical finance research. At the macroscopic level, investment is one of the three driving forces of national economic growth and the engine of macroeconomic development. At the microscopic level, investment is a major basis of corporate cash flow growth, a key driving force of corporate growth and fundamental to value growth (Li et al., 2011). Because of its importance, corporate investment has attracted lasting interest from the academic community. The literature generally recognizes that the separation of ownership and management in the modern corporate structure leads to inconsistencies between the interests of shareholders and managers, causing principal–agent conflict (Jensen and Meckling, 1976). In addition, unlike the idealized framework of neoclassical economics, in which margin q is the only driver of corporate investment (Hayashi, 1982; Abel, 1983), in the real world, information asymmetry causes different degrees of market friction (Stein, 2003). Against this background, many studies (especially by Western researchers) investigate the determinants of corporate investment efficiency from the perspectives of agency problems and information asymmetry. This line of research can be dated back to Ross (1973), Myers and Majluf (1984) and Jensen (1986).

More recently, significant research on the factors impacting corporate investment efficiency has been conducted from more perspectives, such as shareholding structure or equity incentives (Li and Ma, 2014; Chen et al., 2017), internal control (Cheng et al., 2013; Fang and Jin, 2013; Chi et al., 2016), governance of the board of directors or supervisors (Liu et al., 2015; Chen et al., 2016), cash holding (Guariglia and Yang, 2016; Khan et al., 2017), dividend distribution (Chen et al., 2015), debt financing (Stulz, 1990; Ortiz-Molina and Penas, 2008), financial reporting quality (Biddle et al., 2009; Chen et al., 2011; Lara et al., 2016; Houcine, 2017; Dou et al., 2019), analyst forecasts (Chen et al., 2017), resources owned by auditors or audit opinions (Bae et al., 2017; Zhang et al., 2017) and media attention (Zhang et al., 2014).

With the increasing recognition of behavioral finance theory by international mainstream economics at the end of the 20th century, research in behavioral finance flourished and studies abounded on corporate investment efficiency from the perspective of managers' personal characteristics. These personal characteristics include age (Jiang et al., 2009; Xie, 2015), gender (Jin et al., 2014), educational background (Han et al., 2014), life experience (Dai and Kong, 2017), power (Xie and Wang, 2017), overconfidence (Wang et al., 2016) and personal ability (Habib and Hasan, 2017).

Entering the 21st century, the rapid development of the Chinese economy inspired researchers to investigate the factors affecting corporate investment efficiency under the unique Chinese system. These studies mainly focus on political connections (Pan and Tian, 2020), government intervention (Chen et al., 2011), industrial policy (Wang et al., 2017), monetary policy (Yu et al., 2014), the legal environment (Lu et al., 2015), environmental uncertainties (Wang et al., 2016) and government governance (Chen et al., 2012).

In summary, significant research on the factors affecting corporate investment efficiency from a corporate governance perspective has been conducted. As a technological innovation, blockchain may have a major effect on the shareholders and managers of companies and on corporate governance (Yermack, 2017), with

a far-reaching effect on inefficient investment. Unfortunately, however, few studies to date have investigated the effect of this emerging technology on corporate investment efficiency despite its obvious major effects on corporate governance. Therefore, investigating the effect of blockchain technology on corporate investment efficiency can help both researchers and practitioners to identify the mechanisms underlying the effect of this technology on corporate economic activity and provide empirical evidence for the determinants of corporate investment efficiency from the perspective of emerging digital technologies.

3.3. Theoretical analysis and research hypothesis

Blockchain is widely recognized as a very important technology (Ertz and Boily, 2020). Some scholars even believe that blockchain is as important as the Internet and that it will have a profound impact on businesses and societies (Beck et al., 2018). For example, blockchain initiates new modes and pathways for improving corporate governance by alleviating information asymmetry and improving manager supervision (Lafarre and Van der Elst, 2018; Chod et al., 2020; Chen et al., 2022; Chen and Hu, 2022), and good corporate governance helps companies make scientific investment decisions and ensure their effective implementation, thereby preventing and constraining overinvestment and underinvestment (Li and Hao, 2020).

Blockchain technology helps companies to reduce financing costs and constrain inefficient investment by alleviating information asymmetry, which leads to adverse selection, which in turn increases market friction (Myers, 1984). This makes it difficult for management to effectively inform the market about the quality of currently available assets and investment opportunities. Consequently, management cannot raise adequate funds at a reasonable capital cost for a good investment opportunity and has to abandon investment projects with a positive net present value (NPV), leading to underinvestment (Myers and Majluf, 1984). A blockchain stores units of information as blocks and links from the first to the last blocks as a chain of information, enabling the storage of massive information in a distributed manner; thus, the storage of information as a chain means increased information transparency (Gao, 2020). Increasing information transparency helps reduce the information asymmetry between a company and the outside world, thereby alleviating adverse selection that leads to potential investors' expectations of excessively high capital returns (Bhattacharya et al., 2003) and reducing inefficient investment as a result of high financing costs (Biddle et al., 2009).

Unlike traditional modes of bookkeeping, a blockchain is a distributed ledger in which transaction information is not recorded by a single organization and all nodes participate in bookkeeping (Basu, 2019). In this distributed network, every node has a complete copy of the ledger, thus ensuring the transparency of transaction information (Crosby et al., 2016). Song et al. (2022) point out that the transparency of information recorded in blockchain improves the quality of financing information and reduces the adverse selection of fund providers. Chod et al. (2020) find that blockchain technology improves the transparency of information about inventory, logistics and capital flows through supply chains and provides potential investors with timely information about the operational capacity of the company that is more effective than financial information provided via traditional means, thereby helping the company to raise capital at a lower cost. Therefore, companies can provide capital providers with more transparent information to reduce adverse selection and decrease the price of capital (Rajan and Zingales, 1998; Zhu and Chen, 2009) by using blockchain technology, which enables them both to seize good investment opportunities promptly at lower financing costs and to improve their investment efficiency (Li et al., 2011).

In addition, blockchain technology helps companies alleviate principal–agent conflict by improving the supervision of their managers, thereby improving corporate investment efficiency. Jensen (1986) suggests that the personal interests of managers increase as the size of the company increases. Thus, to maximize their personal interests, managers are motivated to become empire builders and invest all available capital (even when the NPV of an investment is negative), leading to overinvestment. Owing to its real-time and unalterable nature, blockchain technology helps companies strengthen manager supervision (Gong, 2021; Wu, 2021), thereby alleviating the agency problem that may lead to inefficient investment (Ross, 1973; Jensen, 1993).

First, in a distributed blockchain-based ledger system, market participants jointly maintain the same "general ledger" in a real-time, synchronized manner; that is, the blockchain-based ledger is updated in real time and is capable of recording the latest transaction information promptly (Klimas, 2018). Because of its real-time nature, blockchain technology enables more rigorous examination of managers by boards of directors and supervisors (Yermack, 2017), ensures the real-time supervision of companies by their stakeholders and improves the timeliness of supervision (Wu, 2021), thereby preventing managers from investing corporate funds in negative NPV projects that advance their personal interests (Blanchard et al., 1994).

Second, the transaction data stored in a blockchain are unalterable owing to the integration of consensus mechanisms, one of the underlying technologies of blockchain, which solve the data writing consistency problem in blockchain's distributed data storage mode (Tian and Liu, 2022). A consensus algorithm requires collective validation by all bookkeeping nodes, thereby ensuring the consistency of data recorded at all nodes. Only two approaches are theoretically capable of altering a record when there are consensus mechanisms: 1) creating a fake transaction chain and 2) controlling more than 50 % of the nodes. Technically, however, neither approach is realistic (Huawei blockchain development team, 2019) without incurring extremely high costs. Thus, the transaction information recorded in a blockchain can be considered unalterable (Klimas, 2018; Yang et al., 2020). The unalterable nature of blockchain ensures that the information recorded in them is authentic and reliable and enables information screening, risk prevention and operational and post-operational supervision using high-quality data (Gong et al., 2021), thereby inhibiting the opportunistic behavior of managers. This is especially important for socioeconomic activities in the digital age, in which the right to data can be directly translated into business advantages. The adoption of consensus mechanisms constrains the exercise of the right to data and alleviates the insider problem (Tian and Liu, 2022), thereby alleviating the problem of inefficient investment (Li et al., 2011).

Based on the above analysis, our core hypothesis is as follows:

H1: *Ceteris paribus*, blockchain technology helps companies alleviate the inefficient investment problem.

4. Research design

4.1. Sample selection and data source

The sample used in this study consisted of all A-share companies listed on the Shanghai and Shenzhen stock exchanges. The study period covered the period from 2016 to 2020. The study period started in 2016 because blockchain technology was first included in the Information Technology Development Plan for the 13th Five-Year Period in 2016. In the same year, the White Paper on Blockchain Technology and Its Application and Development in China (2016), the Chinese government's first guidance document in this regard, was published. Since then, blockchain and the digital economy have received widespread attention. The following companies were excluded from the sample in sequence: financial companies, companies with a debt-to-assets ratio greater than 1 and companies with missing relevant data. Data on the application of blockchain technology in the sample companies were obtained by text analysis of their interim and periodic reports. The financial data of these companies mainly came from the China Stock Market & Accounting Research database. We winsorized all continuous variables in regression model (1) at the top and bottom 1 % to eliminate the potential effect of outliers. All standard errors were clustered at the company level.

4.2. Variables definitions and model specification

H1 was tested using the following econometric model:

$$Abs_{i,t} = \beta_0 + \beta_1 Block_{i,t} + \sum Controls_{i,t-1} + Industry\ FE + Year\ FE + \varepsilon_{i,t} \qquad (1)$$

Table 1
Variable definitions.

Variables	Definitions
Abs	Investment efficiency, equal to the absolute value of the regression residuals of Richardson's (2006) investment model.
Block	Indicator for whether the firm is engaged in blockchain-related activities.
Size	The natural logarithm of total assets.
Lev	The ratio of total liabilities to total assets.
Cash	The ratio of cash and cash equivalents to total assets.
Adm	Administrative expenses divided by revenues.
Orec	The ratio of the difference between other receivables and other payables to total assets.
Market	The marketization index of Wang et al. (2017) of the provinces in which the firm is located.
Bsize	The natural logarithm of the total number of directors on the board.
Indir	The number of independent directors divided by the number of directors.
Dual	Indicator for whether the Chairman and CEO are the same person.
Soe	Indicator for firms that are ultimately controlled by the government.
Listage	Number of years a company has been listed.
Roa	The ratio of net profit to total assets.
Top1	The percentage of the largest shareholding.
Exculholder	The percentage of CEO shareholding.
Industry FE	Industry fixed effects.
Year FE	Year fixed effects.

Here, the independent variable *Block* indicates whether the company was undertaking blockchain-related activity, which was assigned a value of 1 if the company expressly reported that it was implementing blockchain-related activity and 0 otherwise.[2] The explained variable *Abs* is the degree of the company's inefficient investment, with a larger value indicating lower investment efficiency. Corporate investment efficiency was measured following Richardson (2006) and subjected to a robustness test using the model of investment–investment opportunity sensitivity and the model of Biddle et al. (2009).

In addition, following Biddle et al. (2009), Li et al. (2011), Shen et al. (2012), Stoughton et al. (2017) and Wang and Jiang (2020), other factors potentially affecting corporate investment were controlled. Table 1 shows the definitions of the variables. Moreover, to minimize the effects of industry-level time-invariant factors and macro-environmental variations on the research results, industry and year fixed effects were controlled. In model (1), the regression coefficient β_1 was expected to have a negative sign; that is, companies engaged in blockchain-related activity were expected to have higher investment efficiency.

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[2] Some announcements of listed companies only describe the development momentum of blockchain technology or mention relevant products available in the market. These companies might merely be speculating on the concept of blockchain technology and using the concept to grab attention, but not truly engage in blockchain technology-related activity. To identify the companies clearly mentioning their commencement of blockchain-related activity, blockchain technology-related segments were first extracted from the announcements of listed companies using Python and blockchain-related keywords (blockchain, blockchain technology, blockchain projects, digital currency, cryptocurrency, smart contract, decentralization, Bitcoin, distributed ledger, public blockchain, private blockchain and alliance blockchain). Next, these segments were read to determine whether a company truly engaged in blockchain technology-related activity. For example, the social responsibility report released by the New Hope Group (stock code: 000876) on 1 April 2020 contained a blockchain technology-related segment ("This is a great age. 5G, AI, and blockchain technology make the world change with each passing day"), but did not clearly mention that the company engaged in blockchain technology-related activity. Therefore, *Block* was assigned a value for 0 for this company. The investment announcement released by UniTTEC (stock code: 000925) on 23 January 2020 contained the following claim: "To adapt to the changes in the upstream–downstream relationship in the industry's supply chain in the new trend of upgrading main business using smart technologies [. . .] we are focusing on the core positions of both parties in the industrial chain, using the means of innovation provided by the underlying technologies of blockchains, and developing supply chain financial services to broaden the financing channels and optimize the financing structure for the company, reduce the cost of capital, and improve the efficiency of capital use." Based on this statement, we confirmed that this company engaged in blockchain technology-related activity. Therefore, *Block* was assigned a value of 1 for this company.

5. Empirical analysis

5.1. Descriptive statistics

Table 2 shows the distribution of the research sample by year. The number of companies that engaged in blockchain-related activity increased rapidly with time, from only 17 in 2016 to 214 in 2020. The ratio of companies that engaged in blockchain-related activity to the total number of companies in the sample also exhibited an increasing trend. The ratio increased rapidly in 2018 and then stabilized.

Table 3 shows the descriptive statistics of the variables. *Block* (whether a company engaged in blockchain technology-related activity) had an average value of 0.045, indicating that only a small proportion of the sample companies ventured into this emerging technology. *Abs* had a mean of 0.026, a median of 0.017, a 10th percentile of 0.003 and a 90th percentile of 0.057, indicating that the sample companies differed considerably in their investment efficiency. The statistics for the control variables are also presented in Table 3.

Table 4 shows the Pearson correlation coefficients between the variables. The correlation coefficient between *Block* and *Abs* was –0.044 and was significant at the 1 % level, which preliminarily indicated that companies engaged in blockchain technology-related activity had less inefficient investment than those not engaged in blockchain technology. In addition, the correlation coefficients between most of the control variables and *Block* were statistically significant.

5.2. Main results

Table 5 reports the regression results of model (1). In terms of statistical significance, the coefficient of *Block* was negative and significant whether or not we included the control variables or industry/year fixed

Table 2
Sample distribution by year.

Year	Block = 1	Block = 0	Total	Percentage
2016	17	2494	2511	0.68 %
2017	50	2664	2714	1.84 %
2018	179	2721	2900	6.17 %
2019	196	3008	3204	6.12 %
2020	214	3141	3355	6.38 %
Total	656	14,028	14,684	4.47 %

Table 3
Descriptive statistics.

Variable	N	Mean	SD	p10	p25	p50	p75	p90
Abs	14,684	0.026	0.030	0.003	0.008	0.017	0.032	0.057
Block	14,684	0.045	0.207	0.000	0.000	0.000	0.000	0.000
Size	14,684	22.290	1.309	20.770	21.390	22.140	23.020	24.010
Lev	14,684	0.427	0.203	0.163	0.265	0.416	0.575	0.702
Cash	14,684	0.147	0.112	0.039	0.068	0.117	0.191	0.296
Adm	14,684	0.117	0.117	0.032	0.057	0.093	0.138	0.209
Orec	14,684	0.018	0.035	0.001	0.003	0.008	0.018	0.040
Market	14,684	8.228	1.685	6.190	7.000	9.080	9.630	9.780
Bsize	14,684	2.116	0.199	1.946	1.946	2.197	2.197	2.398
Indir	14,684	0.377	0.054	0.333	0.333	0.364	0.429	0.430
Dual	14,684	0.279	0.448	0.000	0.000	0.000	1.000	1.000
Soe	14,684	0.337	0.473	0.000	0.000	0.000	1.000	1.000
Listage	14,684	2.238	0.763	1.099	1.792	2.303	2.944	3.135
Roa	14,684	0.032	0.073	−0.008	0.013	0.034	0.063	0.098
Top1	14,684	0.334	0.145	0.159	0.219	0.312	0.429	0.538
Excuholder	14,684	0.049	0.108	0.000	0.000	0.000	0.024	0.204

Table 4
Pearson correlations.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.
1. Abs	1															
2. Block	−0.044[a]	1														
3. Size	−0.126[a]	0.014[c]	1													
4. Lev	−0.068[a]	−0.025[a]	0.491[a]	1												
5. Cash	0.030[a]	0.060[a]	−0.190[a]	−0.315[a]	1											
6. Adm	0.031[a]	0.066[a]	−0.338[a]	−0.199[a]	0.112[a]	1										
7. Orec	−0.044[a]	0.017[b]	0.037[a]	0.183[a]	−0.063[a]	0.077[a]	1									
8. Market	−0.007	0.042[a]	−0.040[a]	−0.084[a]	0.039[a]	−0.015[c]	−0.039[a]	1								
9. Bsize	−0.049[a]	−0.014[c]	0.268[a]	0.140[a]	−0.045[a]	−0.109[a]	−0.023[a]	−0.084[a]	1							
10. Indir	0.023[a]	0.015[c]	−0.013	−0.008	0.027[a]	0.049[a]	0.032[a]	0.012	−0.573[a]	1						
11. Dual	0.055[a]	0.043[a]	−0.175[a]	−0.111[a]	0.030[a]	0.072[a]	−0.017[b]	0.119[a]	−0.176[a]	0.109[a]	1					
12. Soe	−0.081[a]	−0.054[a]	0.349[a]	0.249[a]	−0.003	−0.142[a]	−0.016[b]	−0.177[a]	0.252[a]	−0.052[a]	−0.287[a]	1				
13. Listage	−0.137[a]	−0.026[a]	0.380[a]	0.312[a]	−0.100[a]	−0.043[a]	0.119[a]	−0.194[a]	0.160[a]	−0.037[a]	−0.231[a]	0.448[a]	1			
14. Roa	0.050[a]	−0.002	0.039[a]	−0.301[a]	0.206[a]	−0.208[a]	−0.182[a]	0.065[a]	0.026[a]	−0.022[a]	0.024[a]	−0.039[a]	−0.165[a]	1		
15. Top1	0.012	−0.059[a]	0.215[a]	0.052[a]	0.043[a]	−0.169[a]	−0.071[a]	−0.001	0.026[a]	0.040[a]	−0.036[a]	0.240[a]	−0.069[a]	0.156[a]	1	
16. Excuholder	0.065[a]	0.031[a]	−0.231[a]	−0.189[a]	0.063[a]	0.058[a]	−0.067[a]	0.154[a]	−0.151[a]	0.087[a]	0.519[a]	−0.312[a]	−0.401[a]	0.094[a]	0.015[c]	1

Notes: a, b, and c indicate statistical significance at 1%, 5%, and 10%, respectively.

effects, indicating that undertaking blockchain-related activity helped companies reduce inefficient investment. In terms of economic significance, the coefficient of *Block* in column (3) was –0.004, indicating that relative to the mean (standard deviation) of *Abs*, the degree of inefficient investment by companies engaging in blockchain-related activity decreased by 15.38 % (13.33 %).

In column (3), the coefficients of *Size* and *Listage* were negative and significant and that of *Cash* was positive and significant. These results indicated that a larger company with a longer listing history and lower cash holdings had less inefficient investment than other companies. This finding is consistent with those reported in the literature (e.g., Stoughton et al., 2017; Wang et al., 2018). The coefficients of *Lev* and *Adm* were positive and significant, indicating that higher financial leverage and a higher administrative expense ratio led to increased inefficient investment. The coefficient of *Market* was negative and significant, indicating that companies located in a region with a developed market had less inefficient investment. The coefficient of *Roa* was positive and significant, indicating that companies with higher profitability had more inefficient investment. The coefficient of *Soe* was negative and significant, possibly because of the reform of the dividend distribution system of state-owned companies (Cao and Lin, 2017). In addition, the coefficients of *Top1*, *Bsize*, *Indir*, *Dual* and *Excuholder* were not statistically significant. These findings are consistent with those reported by Li et al. (2011) and Wang et al. (2018).

6. Robustness tests

6.1. Different measurements of investment efficiency

First, corporate investment efficiency was measured using investment–investment opportunity sensitivity. Corporate investment is sensitive to the investment opportunities available in the market, meaning that a company is capable of seizing good investment opportunities and making corresponding investment decisions promptly. Therefore, if blockchain technology can help companies improve their investment efficiency, it can also improve their investment–investment opportunity sensitivity. Based on the above analysis, corporate investment efficiency was measured using investment–investment opportunity sensitivity. The regression results using this measure are shown in panel A of Table 6, where *Invest* is equal to the amount of cash paid for acquiring and developing fixed assets, intangible assets and other long-term assets minus the amount of cash received from disposing of fixed assets, intangible assets and other long-term assets, divided by total assets, and *Q* is Tobin's q. The coefficient of *Q* was positive and significant and that of the interaction between

Table 5
Regression results of the effect of blockchain on investment efficiency.

| | Dep.Var. = Abs | | |
	(1)	(2)	(3)
Block	−0.006***	−0.006***	−0.004***
	(0.000)	(0.000)	(0.000)
Size		−0.002***	−0.002***
		(0.000)	(0.000)
Lev		0.005**	0.007***
		(0.011)	(0.000)
Cash		0.001	0.006**
		(0.796)	(0.027)
Adm		0.003	0.006*
		(0.302)	(0.075)
Orec		−0.024***	−0.010
		(0.004)	(0.218)
Market		−0.001***	−0.000*
		(0.002)	(0.094)
Bsize		0.000	−0.001
		(0.930)	(0.617)
Indir		0.010	0.011
		(0.171)	(0.133)
Dual		0.001	0.001
		(0.119)	(0.131)
Soe		−0.001	−0.002**
		(0.151)	(0.040)
Listage		−0.004***	−0.004***
		(0.000)	(0.000)
Roa		0.018***	0.018***
		(0.000)	(0.000)
Top1		0.004*	0.004
		(0.073)	(0.125)
Excuholder		−0.002	−0.001
		(0.620)	(0.743)
Constant	0.026***	0.082***	0.078***
	(0.000)	(0.000)	(0.000)
Industry FE	No	No	Yes
Year FE	No	No	Yes
N	14,684	14,684	14,684
R^2	0.002	0.032	0.052

Notes: The numbers reported are the regression coefficients with the p-value in parentheses, with the standard errors clustered at the company level. ***, **, and * represent statistical significance at 1 %, 5 %, and 10 %, respectively.

Q and *Block* was also positive and significant. This indicates that companies undertaking blockchain-related activity had increased investment–investment opportunity sensitivity, consistent with our prediction.

Next, referring to Biddle et al. (2009), we regressed the investment (*Invest*) of companies on their growth opportunity (*Growth*) year by year and industry by industry. *Growth* was measured by the growth rate of company sales. The residuals of the regression were arranged in ascending order and sorted into four equal groups. The first was the smallest residual group, indicating underinvestment (*Inv_Dum* = 1). The fourth was the largest residual group (*Inv_Dum* = 3), indicating overinvestment. The second and third groups were the baseline groups, indicating normal investment (*Inv_Dum* = 2). The multinomial logit regression results (panel B of Table 6) showed that companies engaging in blockchain-related activity were less likely to engage in underinvestment or overinvestment compared with companies in the baseline groups. That is, our finding was robust to changing our measure of investment efficiency.

Table 6
Change the measure of investment efficiency.

Panel A: the sensitivity of investment-investment opportunity (*Dep.Var. = Invest*)		
Block		−0.011***
		(0.010)
Q		0.001***
		(0.009)
Block*Q		0.002*
		(0.070)
Controls	Yes	
Industry FE	Yes	
Year FE	Yes	
N		14,289
R²		0.128
Panel B: multinomial-logit model		
	under-investment vs normal investment	over-investment vs normal investment
Block	−0.199*	−0.239**
	(0.065)	(0.043)
Controls	Yes	Yes
Industry FE	Yes	Yes
Year FE	Yes	Yes
N	14,684	14,684
Pseudo-R²	0.088	0.088

Notes: The numbers reported are the regression coefficients with the p-value in parentheses, with the standard errors clustered at the company level.***, **, and * represent statistical significance at 1 %, 5 %, and 10 %, respectively.

6.2. Different measure of the independent variable

We excluded all sample companies that did not report any engagement in blockchain technology-related activity in their announcements. That is, *Block* was assigned a value of 1 if the company expressly reported that it was undertaking blockchain-related activity and a value of 0 if the company merely mentioned block-chain but did not clearly report the blockchain-related activity in which it engaged. A regression was performed using this measure of *Block*. Table 7 showed that the coefficient of *Block* was still negative and significant whether or not we considered the control variables or industry/year fixed effects. Thus, our main finding was robust to changing the measure of the independent variable.

6.3. Propensity score matching (PSM)

PSM was adopted to reduce the potential effect of selection bias. The treatment and control groups consisted of all companies that engaged and did not engage in blockchain technology-related activity, respectively. A PSM model was established by using the control variables as covariates, and the propensity scores were calculated. This was followed by nearest neighbor matching (1:1, 1:3 and 1:5) with a caliper of 0.03. Our untabulated results showed that the two groups did not differ significantly in their covariates after PSM. Table 8 shows the regression results after PSM. The coefficients of *Block* were negative and significant, indicating that our main conclusion remained robust after PSM.

6.4. The Heckman self-selection model

The China Securities Regulatory Commission does not mandate companies to disclose information about their blockchain technology-related activity. Therefore, companies have the discretion not to disclose their blockchain technology-related activity. Consequently, our results could suffer from a self-selection problem. To avoid this problem, the estimation was rerun using the Heckman self-selection model. Table 9 shows the results, where *Disc* is a dummy variable indicating whether a company disclosed its blockchain technology-related activity, and *Ratio_Disc* is the ratio of companies that disclosed their blockchain

Table 7
Change the measure of independent variable.

	Dep.Var. = Abs		
	(1)	(2)	(3)
Block	−0.005**	−0.006***	−0.005***
	(0.013)	(0.004)	(0.007)
Size		0.001	0.001
		(0.607)	(0.502)
Lev		−0.000	0.003
		(0.972)	(0.628)
Cash		−0.006	−0.001
		(0.521)	(0.888)
Adm		−0.006	−0.005
		(0.475)	(0.530)
Orec		−0.037**	−0.016
		(0.040)	(0.371)
Market		0.000	0.001
		(0.371)	(0.244)
Bsize		−0.002	−0.003
		(0.614)	(0.596)
Indir		−0.022	−0.015
		(0.211)	(0.382)
Dual		0.003	0.002
		(0.257)	(0.272)
Soe		−0.002	−0.002
		(0.320)	(0.346)
Listage		−0.006***	−0.006***
		(0.000)	(0.000)
Roa		0.018*	0.014
		(0.086)	(0.193)
Top1		0.002	−0.003
		(0.743)	(0.690)
Excuholder		0.012	0.013
		(0.244)	(0.202)
Constant	0.025***	0.037	0.062**
	(0.000)	(0.121)	(0.025)
Industry FE	No	No	Yes
Year FE	No	No	Yes
N	1,038	1,038	1,038
R^2	0.008	0.068	0.126

Notes: The numbers reported are the regression coefficients with the p-value in parentheses, with the standard errors clustered at the company level. ***, **, and * represent statistical significance at 1 %, 5 %, and 10 %, respectively.

technology-related activity in a given industry and year.[3] We found that our conclusion did not change substantially using this model.

6.5. Removal of 2016 from the sample

To develop Chinese blockchain technology, the MIIT published the White Paper on Blockchain Technology and its Application and Development in China in October 2016, proposing a roadmap for blockchain standardization and a framework for a system of standards on blockchains for the first time. In December of that year, the Chinese State Council published the National Information Technology Development Plan

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[3] We found that some companies merely mentioned blockchain technology in their announcements but did not make any concrete efforts to use it, and inferred that they did so to grab attention from the market. Our conclusion was still robust, as shown by the Heckman model, after we removed these companies.

Table 8
Regression results after propensity score matching (PSM).

	Dep.Var. = Abs		
	(1) 1:1 match	(2) 1:3 match	(3) 1:5 match
Block	−0.005***	−0.004***	−0.004***
	(0.003)	(0.000)	(0.001)
Size	−0.000	−0.000	−0.001
	(0.778)	(0.718)	(0.354)
Lev	0.010**	0.007*	0.010***
	(0.050)	(0.057)	(0.005)
Cash	−0.011	0.001	0.001
	(0.106)	(0.827)	(0.890)
Adm	0.004	0.005	0.012*
	(0.511)	(0.322)	(0.055)
Orec	−0.053***	−0.017	−0.016
	(0.002)	(0.341)	(0.257)
Market	−0.000	0.000	−0.000
	(0.862)	(0.721)	(0.577)
Bsize	−0.007	−0.003	−0.003
	(0.152)	(0.417)	(0.290)
Indir	−0.006	0.005	0.002
	(0.681)	(0.715)	(0.838)
Dual	0.002	0.000	0.002
	(0.237)	(0.766)	(0.289)
Soe	−0.000	−0.001	−0.001
	(0.987)	(0.592)	(0.362)
Listage	−0.004***	−0.004***	−0.004***
	(0.009)	(0.000)	(0.000)
Roa	0.021**	0.016**	0.022***
	(0.024)	(0.024)	(0.001)
Top1	0.001	−0.005	−0.002
	(0.889)	(0.296)	(0.704)
Excuholder	0.014	0.020**	0.016**
	(0.137)	(0.012)	(0.030)
Constant	0.084***	0.075***	0.080***
	(0.002)	(0.000)	(0.000)
Industry FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
N	1,312	2,624	3,936
R^2	0.114	0.089	0.088

Notes: The numbers reported are the regression coefficients with the p-value in parentheses, with the standard errors clustered at the company level. ***, **, and * represent statistical significance at 1 %, 5 %, and 10 %, respectively.

for the 13th Five-Year Period, which encouraged planning for blockchain and other strategic, cutting-edge technologies to create a first-mover advantage. Considering that clear government guidance and policies on the application of blockchain technology were not introduced until the second half of 2016, and that few listed companies disclosed their involvement in blockchain technology that year, a regression was performed by removing all observations in 2016 from the sample. The results (Table 10) showed that the coefficient of *Block* was negative and significant whether or not the control variables or industry/year fixed effects were considered, indicating that our main conclusion remained robust.

6.6. Considering the long-term effects of blockchains

The above analyses showed that undertaking blockchain-related activity significantly improves current investment efficiency. However, the length of the process from researching, developing and implementing blockchain technology to establishing an ecology varies for different companies. Once the process is com-

Table 9
Heckman self-selection model.

	(1)	(2)
	Dep.Var. = Disc	*Dep.Var. = Abs*
Ratio_Disc	0.712***	
	(0.009)	
Block		−0.004***
		(0.000)
Size	0.123***	−0.001
	(0.000)	(0.679)
Lev	−0.037	0.008***
	(0.806)	(0.000)
Cash	0.561***	0.013*
	(0.005)	(0.051)
Adm	0.492**	0.013**
	(0.016)	(0.026)
Orec	0.297	−0.009
	(0.571)	(0.313)
Market	0.004	−0.000
	(0.769)	(0.482)
Bsize	−0.142	−0.003
	(0.335)	(0.193)
Indir	−0.416	0.005
	(0.390)	(0.575)
Dual	0.159***	0.003*
	(0.005)	(0.100)
Soe	−0.187***	−0.004*
	(0.003)	(0.090)
Listage	−0.005	−0.004***
	(0.903)	(0.000)
Roa	0.310	0.019***
	(0.244)	(0.000)
Top1	−0.568***	−0.003
	(0.001)	(0.586)
Excuholder	−0.256	−0.004
	(0.349)	(0.423)
Lambda		0.013
		(0.272)
Constant	−3.730***	0.027
	(0.000)	(0.555)
Industry FE	Yes	Yes
Year FE	Yes	Yes
N	14,684	14,684
Pseudo-R^2/ R^2	0.220	0.057

Notes: The numbers reported are the regression coefficients with the p-value in parentheses, with the standard errors clustered at the company level. ***, **, and * represent statistical significance at 1 %, 5 %, and 10 %, respectively.

pleted, blockchain technology affects production and operation decisions and the behavior of stakeholders in the current and even future periods. Thus, if blockchain technology helps improve corporate investment efficiency, the effect should be observable at least in some future periods. We tested whether undertaking blockchain-related activity affects future investment efficiency. The results (Table 11) showed that undertaking blockchain-related activity significantly improved investment efficiency in one, two and even three future periods. This indicates that blockchain technology has a far-reaching effect on investment efficiency.

Table 10
Delete the sample in 2016.

	Dep.Var. = Abs		
	(1)	(2)	(3)
Block	−0.006***	−0.006***	−0.004***
	(0.000)	(0.000)	(0.000)
Size		−0.002***	−0.001***
		(0.000)	(0.000)
Lev		0.003	0.005**
		(0.175)	(0.012)
Cash		0.000	0.007**
		(0.961)	(0.026)
Adm		0.003	0.006
		(0.454)	(0.106)
Orec		−0.034***	−0.017***
		(0.000)	(0.005)
Market		−0.001***	−0.000*
		(0.001)	(0.091)
Bsize		−0.000	−0.001
		(0.807)	(0.492)
Indir		0.009	0.010
		(0.176)	(0.130)
Dual		0.001	0.001
		(0.338)	(0.384)
Soe		−0.001	−0.001*
		(0.148)	(0.086)
Listage		−0.004***	−0.004***
		(0.000)	(0.000)
Roa		0.019***	0.018***
		(0.000)	(0.000)
Top1		0.002	0.002
		(0.340)	(0.433)
Excuholder		−0.001	−0.001
		(0.710)	(0.742)
Constant	0.025***	0.072***	0.070***
	(0.000)	(0.000)	(0.000)
Industry FE	No	No	Yes
Year FE	No	No	Yes
N	12,173	12,173	12,173
R^2	0.002	0.036	0.056

Notes: The numbers reported are the regression coefficients with the p-value in parentheses, with the standard errors clustered at the company level. ***, **, and * represent statistical significance at 1 %, 5 %, and 10 %, respectively.

6.7. Controlling company fixed effects

To minimize the potential influence of omitted time-invariant and unobservable factors, our estimation was rerun using a company fixed-effects model. The results (Table 12) showed that the coefficient of Block was negative and significant; that is, companies undertaking blockchain-related activity had less inefficient investment than their counterparts. Thus, our main conclusion did not change substantially.

6.8. Instrumental variable estimation

To address potential endogeneity, an analysis was performed using the instrumental variable method. A company's decision to engage in blockchain technology-related activity may be affected by whether other companies in the same industry do so during the same year. However, a company's investment efficiency is not likely to be directly affected by whether other companies in the same industry engage in blockchain

Table 11
The long-term effects of blockchains.

	Dep. Var.		
	(1) Abs_{+1}	(2) Abs_{+2}	(3) Abs_{+3}
Block	−0.002**	−0.003**	−0.005***
	(0.032)	(0.040)	(0.003)
Size	−0.001***	−0.001***	−0.002***
	(0.000)	(0.000)	(0.000)
Lev	0.005**	0.004*	0.006**
	(0.012)	(0.057)	(0.032)
Cash	0.007**	0.008**	0.006
	(0.030)	(0.013)	(0.149)
Adm	0.006	0.008*	0.008*
	(0.112)	(0.078)	(0.097)
Orec	−0.017***	−0.018**	−0.020**
	(0.005)	(0.013)	(0.017)
Market	−0.000*	−0.000	−0.000
	(0.091)	(0.233)	(0.614)
Bsize	−0.001	−0.001	−0.000
	(0.506)	(0.638)	(0.837)
Indir	0.011	0.013*	0.010
	(0.127)	(0.070)	(0.206)
Dual	0.001	0.000	0.000
	(0.401)	(0.720)	(0.855)
Soe	−0.001*	−0.002*	−0.001
	(0.094)	(0.058)	(0.204)
Listage	−0.004***	−0.004***	−0.004***
	(0.000)	(0.000)	(0.000)
Roa	0.018***	0.017***	0.016***
	(0.000)	(0.000)	(0.000)
Top1	0.002	0.002	0.003
	(0.407)	(0.371)	(0.318)
Excuholder	−0.001	−0.001	0.004
	(0.741)	(0.814)	(0.488)
Constant	0.071***	0.072***	0.078***
	(0.000)	(0.000)	(0.000)
Industry FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
N	12,173	9,444	6,132
R^2	0.055	0.066	0.068

Notes: The numbers reported are the regression coefficients with the p-value in parentheses, with the standard errors clustered at the company level. ***, **, and * represent statistical significance at 1 %, 5 %, and 10 %, respectively.

technology-related activity during the same year. Therefore, the proportion of companies in the same industry engaging in blockchain technology-related activity in the same year was used as an instrumental variable, *IV_Block*. As shown in Table 13, the coefficient of *IV_Block* obtained from the first-stage least squares regression was positive and significant, whereas that of *Block* obtained from the second-stage regression was negative and significant, consistent with our main conclusion. In addition, we tested whether the instrumental variable selected was a weak instrument. Our untabulated results showed that the Cragg–Donald Wald F and Kleibergen–Paap Wald F statistics were greater than the Stock–Yogo critical value, confirming that *IV_Block* was not a weak instrumental variable.

6.9. Difference-in-differences

A difference-in-differences regression was performed by considering undertaking blockchain-related activity as a shock. Referring to Chan et al. (2012) and Chan et al. (2013) for their difference-in-differences regression design, the treatment group (*Treat* = 1) consisted of all companies undertaking blockchain-related activity in

Table 12
Controlling for company fixed effects.

	Dep.Var. = Abs	
	(1)	(2)
Block	−0.005***	−0.004**
	(0.000)	(0.010)
Size		−0.016***
		(0.000)
Lev		0.006
		(0.187)
Cash		0.022***
		(0.000)
Adm		−0.002
		(0.688)
Orec		−0.016
		(0.174)
Bsize		0.002
		(0.515)
Indir		0.004
		(0.697)
Dual		0.001
		(0.649)
Soe		−0.006**
		(0.019)
Listage		0.001
		(0.766)
Roa		0.016***
		(0.003)
Top1		−0.009
		(0.338)
Excuholder		0.011*
		(0.094)
Constant	0.031***	0.376***
	(0.000)	(0.000)
Firm FE	Yes	Yes
Year FE	Yes	Yes
N	14,684	14,684
R^2	0.014	0.048

Notes: The numbers reported are the regression coefficients with the p-value in parentheses, with the standard errors clustered at the company level. ***, **, and * represent statistical significance at 1 %, 5 %, and 10 %, respectively.

the sample period and the control group (*Treat* = 0) consisted of all companies that never engaged in blockchain technology-related activity in the sample period. The variable *AfterTreat* was assigned a value of 1 after all companies in the treatment group engaged in blockchain technology-related activity and 0 otherwise. The coefficient of *AfterTreat* reflected the difference between the investment efficiency of the companies in the treatment group before and after they engaged in blockchain technology-related activity relative to the control group. The results (Table 14) showed that the coefficient of *AfterTreat* was negative and significant, indicating that relative to the control group, the investment efficiency of the companies in the treatment group after they engaged in blockchain technology-related activity was significantly higher than before they did so.

7. Further analysis

7.1. Overinvestment versus underinvestment

Does undertaking blockchain-related activity inhibit overinvestment or underinvestment? Theoretically, both effects may exist. First, blockchain technology increases the transparency of companies' business trans-

Table 13
Instrumental variable approach.

	(1) First Stage *Dep. Var. = Block*	(2) Second Stage *Dep. Var. = Abs*
IV_Block	9.256***	
	(0.000)	
Block		−0.043***
		(0.000)
Size	0.330***	−0.002***
	(0.000)	(0.000)
Lev	0.067	0.007***
	(0.859)	(0.001)
Cash	1.328***	0.008***
	(0.008)	(0.005)
Adm	1.051**	0.008**
	(0.039)	(0.016)
Orec	−0.578	−0.012
	(0.691)	(0.162)
Market	0.025	−0.000
	(0.549)	(0.138)
Bsize	−0.012	−0.001
	(0.974)	(0.603)
Indir	0.086	0.011
	(0.945)	(0.137)
Dual	0.220	0.002**
	(0.133)	(0.045)
Soe	−0.399**	−0.002***
	(0.015)	(0.007)
Listage	−0.085	−0.004***
	(0.375)	(0.000)
Roa	0.556	0.018***
	(0.365)	(0.000)
Top1	−1.261***	0.002
	(0.006)	(0.404)
Excuholder	−0.133	−0.002
	(0.845)	(0.621)
Constant	−10.725***	0.070***
	(0.000)	(0.000)
Industry FE	Yes	Yes
Year FE	Yes	Yes
N	14,684	14,684
Pseudo-R^2/ R^2	0.218	0.414

Notes: The numbers reported are the regression coefficients with the p-value in parentheses, with the standard errors clustered at the company level. ***, **, and * represent statistical significance at 1 %, 5 %, and 10 %, respectively.

action information, thereby reducing the information asymmetry between fund providers and companies, enabling companies to seize good investment opportunities at low financing costs promptly and helping them avoid underinvestment. Second, the real-time and tamper-resistant nature of blockchains helps strengthen manager supervision and prevents them from overinvesting to further their personal interests.

To explore this problem, we divided the sample into two groups: overinvestment and underinvestment. If the residuals of the Richardson (2006) investment model were greater than 0, the observation was classified as overinvestment (*Overinv*). Otherwise, the observation was classified as underinvestment (*Underinv*). As shown in column (1) of Table 15, the coefficient of *Block* was negative and significant, indicating that engaging in blockchain technology-related activity curbed overinvestment. As shown in column (2) of Table 15, the coefficient of *Block* was positive and significant, indicating that engaging in blockchain technology-related activity alleviated underinvestment.

Table 14
Difference-in-differences tests.

	Dep.Var. = Abs	
	(1)	(2)
Treat		0.001
		(0.322)
TreatAfter	−0.004**	−0.004***
	(0.015)	(0.003)
Size	−0.016***	−0.002***
	(0.000)	(0.000)
Lev	0.006	0.007***
	(0.175)	(0.000)
Cash	0.022***	0.006**
	(0.000)	(0.029)
Adm	−0.002	0.006*
	(0.773)	(0.069)
Orec	−0.015	−0.009
	(0.187)	(0.248)
Bsize	0.003	−0.001
	(0.445)	(0.709)
Indir	0.004	0.011
	(0.696)	(0.110)
Dual	0.001	0.001
	(0.549)	(0.141)
Soe	−0.006**	−0.002*
	(0.021)	(0.055)
Listage	0.001	−0.003***
	(0.809)	(0.000)
Roa	0.015***	0.017***
	(0.003)	(0.000)
Top1	−0.008	0.004
	(0.366)	(0.124)
Excuholder	0.010	−0.002
	(0.128)	(0.666)
Constant	0.388***	0.076***
	(0.000)	(0.000)
Industry FE	No	Yes
Firm FE	Yes	No
Year FE	Yes	Yes
N	14,684	14,684
R^2	0.052	0.052

Notes: The numbers reported are the regression coefficients with the p-value in parentheses, with the standard errors clustered at the company level. ***, **, and * represent statistical significance at 1 %, 5 %, and 10 %, respectively.

7.2. Path analysis

According to our theoretical framework, blockchain technology helps inhibit inefficient investment by reducing financing costs and alleviating principal–agent conflict. If this inference is valid, two channels through which blockchain technology affects inefficient investment—reducing financing costs and alleviating principal–agent conflict—should be observable. We tested the two channels, and the results are shown in Table 16. The variable *COD* is the cost of debt equal to the ratio of a company's interest expense to long- and short-term debt. *Agency* is the agency cost equal to the ratio of administrative and sales expenses to revenue.

As shown in columns (1) and (2) of Table 16, undertaking blockchain-related activity led to lower debt costs, and higher debt costs led to increased underinvestment, indicating that reducing financing costs partially mediated the effect of blockchain technology on underinvestment. As shown in columns (3) and (4) of

Table 15
Overinvestment vs Underinvestment.

	(1)	(2)
	Dep.Var. = Overinv	*Dep.Var. = Underinv*
Block	−0.007***	0.003***
	(0.004)	(0.002)
Size	−0.004***	0.001***
	(0.000)	(0.000)
Lev	0.009*	−0.005***
	(0.088)	(0.001)
Cash	0.008	−0.007***
	(0.270)	(0.000)
Adm	0.009	−0.006***
	(0.365)	(0.002)
Orec	−0.013	0.005
	(0.653)	(0.273)
Market	−0.001	0.000**
	(0.243)	(0.023)
Bsize	0.001	0.002*
	(0.777)	(0.076)
Indir	0.037**	0.004
	(0.021)	(0.426)
Dual	0.003	−0.001
	(0.127)	(0.166)
Soe	−0.001	0.002***
	(0.570)	(0.001)
Listage	−0.004***	0.003***
	(0.002)	(0.000)
Roa	0.029**	−0.000
	(0.021)	(0.978)
Top1	0.007	−0.003*
	(0.185)	(0.075)
Excuholder	−0.013	−0.002
	(0.116)	(0.478)
Constant	0.120***	−0.070***
	(0.000)	(0.000)
Industry FE	Yes	Yes
Year FE	Yes	Yes
N	5,715	8,969
R²	0.051	0.075

Notes: The numbers reported are the regression coefficients with the p-value in parentheses, with the standard errors clustered at the company level.***, **, and * represent statistical significance at 1 %, 5 %, and 10 %, respectively.

Table 16, undertaking blockchain-related activity led to lower agency costs, and higher agency costs led to increased overinvestment, indicating that alleviating agency conflict partially mediated the effect of blockchain technology on overinvestment. In addition, our untabulated results showed that the two mediating effects were statistically significant at the 5 % level.

Studies show that high-quality financial information also helps reduce financing costs and alleviate agency conflict, thereby improving investment efficiency (Biddle et al., 2009). Therefore, we hypothesized that financial reporting quality was the premise for blockchain technology affecting investment efficiency through the above channels.[4] Companies with high-quality financial reporting have lower financing costs and fewer agency conflicts. Consequently, blockchain technology has little room to reduce financing costs and alleviate agency conflict and thus has a weaker effect on investment efficiency through the two channels. Companies with low-

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[4] We are grateful to an anonymous reviewer for his constructive suggestion.

Table 16
Path analysis.

	(1) COD	(2) Underinv	(3) Agency	(4) Overinv
Block	−0.011***	0.003***	−0.027***	−0.005**
	(0.005)	(0.001)	(0.000)	(0.011)
COD		−0.006***		
		(0.002)		
Agency				0.047***
				(0.000)
Size	−0.002*	0.001***	−0.013***	−0.003***
	(0.076)	(0.001)	(0.000)	(0.000)
Lev	−0.011	−0.005***	−0.045**	0.011***
	(0.306)	(0.002)	(0.014)	(0.007)
Cash	−0.011	−0.008***	0.070**	0.003
	(0.600)	(0.003)	(0.013)	(0.660)
Adm	0.016	−0.009***	1.089***	−0.043***
	(0.416)	(0.001)	(0.000)	(0.000)
Orec	0.182**	0.005	0.131	−0.025
	(0.011)	(0.385)	(0.228)	(0.201)
Market	−0.001	0.000*	−0.007***	−0.000
	(0.509)	(0.055)	(0.000)	(0.630)
Bsize	0.009	0.002	0.022	−0.000
	(0.343)	(0.128)	(0.114)	(0.973)
Indir	0.023	0.003	0.081	0.032**
	(0.483)	(0.501)	(0.118)	(0.028)
Dual	0.004	−0.001*	−0.000	0.002
	(0.258)	(0.072)	(0.949)	(0.210)
Soe	−0.012***	0.002***	−0.017***	−0.000
	(0.001)	(0.006)	(0.009)	(0.927)
Listage	0.011***	0.003***	0.003	−0.004***
	(0.000)	(0.000)	(0.454)	(0.000)
Roa	−0.141***	−0.001	0.109**	0.029***
	(0.000)	(0.724)	(0.032)	(0.001)
Top1	0.001	−0.003*	0.015	0.004
	(0.917)	(0.060)	(0.435)	(0.370)
Excuholder	−0.007	−0.004	0.043	−0.010
	(0.710)	(0.148)	(0.146)	(0.167)
Constant	0.097**	−0.060***	0.317***	0.081***
	(0.014)	(0.000)	(0.000)	(0.000)
Industry FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
N	7,313	7,313	5,715	5,715
R^2	0.030	0.086	0.448	0.091

Notes: The numbers reported are the regression coefficients with the p-value in parentheses, with the standard errors clustered at the company level. ***, **, and * represent statistical significance at 1 %, 5 %, and 10 %, respectively.

quality financial reporting have higher financing costs and more severe agency conflicts. Consequently, blockchain technology can improve these aspects by a large margin and thus can have a considerable effect on investment efficiency.

Based on the above analysis, we further explored whether the mediating effects of reducing financial costs and alleviating agency conflict varied with different qualities of financial reporting. Table 17 shows the results. Considering that a financial restatement occurs when a company corrects an error in previously issued financial statements (Dai et al., 2011) and that the occurrence of a financial restatement is a straightforward reflection of low financial reporting quality (Wang and Wu, 2011), the dummy variable Restate was used to measure financial reporting quality and was assigned a value of 1 (indicating low financial reporting quality) if a financial restatement occurred and 0 otherwise.

First, as shown in columns (2) and (5) of panel A of Table 17, the coefficients of Block were negative and significant, indicating that undertaking blockchain-related activity helped reduce financing costs and alleviate

Table 17
Path analysis: Additional evidence.

	(1) Underinv	(2) COD	(3) Underinv	(4) Overinv	(5) Agency	(6) Overinv
Panel A: Restate = 1						
Block	0.003**	−0.016***	0.003**	−0.008***	−0.035***	−0.006*** (0.005)
	(0.015)	(0.003)	(0.019)	(0.001)	(0.000)	
COD			−0.007***			
			(0.003)			
Agency						0.054***
						(0.000)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
N	3,286	3,286	3,286	2,679	2,679	2,679
R^2	0.099	0.044	0.101	0.066	0.387	0.115
Panel B: Restate = 0						
	(1) Underinv	(2) COD	(3) Underinv	(4) Overinv	(5) Agency	(6) Overinv
Block	0.003**	−0.007*	0.003**	−0.005*	−0.017*	−0.004*
	(0.019)	(0.063)	(0.021)	(0.067)	(0.060)	(0.097)
COD			−0.006**			
			(0.021)			
Agency						0.036***
						(0.000)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
N	4,027	4,027	4,027	3,036	3,036	3,036
R^2	0.083	0.023	0.084	0.067	0.517	0.082

Notes: The numbers reported are the regression coefficients with the p-value in parentheses, with the standard errors clustered at the company level. ***, **, and * represent statistical significance at 1 %, 5 %, and 10 %, respectively.

agency conflict when a company had low financial reporting quality. As shown in columns (3) and (6) of panel A, reducing financing costs and alleviating principal–agent conflict partially mediated the effect of blockchain technology on investment efficiency. Second, as shown in panel B of Table 17, reducing financing costs and alleviating principal–agent conflict also partially mediated the effect of blockchain technology when a company had high financial reporting quality. A significance test of the mediating effects showed that the mediating effect of reducing financing costs was significant in both the low and high financial reporting quality groups (p-value = 0.021 and 0.097, respectively), but the mediating effect in the former was 2.476 times that of the latter. The mediating effect of reducing agency costs was also significant in both the low and high financial reporting quality groups (p-value = 0.001 and 0.081, respectively), but the mediating effect in the former was 3.062 times that of the latter. Therefore, the magnitude of the mediating effects of reducing financing costs and alleviating agency conflict depends on financial reporting quality.

7.3. Blockchain technology and inefficient investment: A cross-sectional analysis

Management shareholding could affect the relationship between blockchain technology and investment efficiency. The separation of ownership and management leads to conflicts of interest between shareholders and managers, which causes investment decisions to deviate from the goal of maximizing shareholder value (Jensen, 1986). A high management shareholding ratio helps narrow the gap between the interests of shareholders and management, thereby weakening the relationship between blockchain technology and investment efficiency. However, a high management shareholding ratio could also increase management's motivation to maximize their own interests, leaving ample room for blockchain technology to alleviate inefficient investment. We explored how CEO shareholding moderates the effect of blockchain technology on investment efficiency. The results in column (1) of Table 18 showed that the coefficient of *Block* was still negative and significant and that of the interaction between *Block* and *Excuholder* was positive and significant, indicating that less management shareholding led to a larger effect of blockchain technology in improving inefficient investment.

Table 18
Cross-sectional analysis.

| | Dep. Var. = Abs | |
	(1)	(2)
Block	−0.005***	−0.002
	(0.000)	(0.325)
Block × Excuholder	0.005**	
	(0.044)	
Block × Credit_Rank		−0.026**
		(0.038)
Credit_Rank		0.001
		(0.860)
Excuholder	−0.001	−0.001
	(0.561)	(0.719)
Size	−0.002***	−0.002***
	(0.000)	(0.000)
Lev	0.008***	0.007***
	(0.000)	(0.000)
Cash	0.006**	0.006**
	(0.026)	(0.025)
Adm	0.007**	0.005
	(0.020)	(0.113)
Orec	−0.012	−0.009
	(0.150)	(0.292)
Market	−0.000	−0.000
	(0.342)	(0.228)
Bsize	−0.002	−0.001
	(0.437)	(0.622)
Indir	0.009	0.011
	(0.190)	(0.122)
Dual	0.001	0.001
	(0.152)	(0.108)
Soe	−0.001*	−0.002**
	(0.061)	(0.018)
Listage	−0.004***	−0.004***
	(0.000)	(0.000)
Roa	0.016***	0.018***
	(0.000)	(0.000)
Top1	0.003	0.004*
	(0.223)	(0.096)
Constant	0.077***	0.076***
	(0.000)	(0.000)
Industry FE	Yes	Yes
Year FE	Yes	Yes
N	14,684	14,649
R^2	0.057	0.054

Notes: The numbers reported are the regression coefficients with the p-value in parentheses, with the standard errors clustered at the company level. ***, **, and * represent statistical significance at 1 %, 5 %, and 10 %, respectively.

The business credit environment could also affect the relationship between blockchain technology and investment efficiency. A good business credit environment means a higher level of trust between a company and its transaction counterparties and lower transaction costs (Liu et al., 2009), possibly leading to a non-significant effect of blockchain technology on investment. In contrast, in a bad business credit environment, the parties to a transaction distrust each other, thereby increasing transaction costs and aggravating inefficient investment (Cao et al., 2015). Undertaking blockchain-related activity can improve trust between a company and its transaction counterparties (Ma et al., 2020). We hypothesized that a bad business credit environment increased the inhibiting impact of blockchain technology on inefficient investment. The business credit envi-

Table 19
Different types of blockchain activities.

| | Dep.Var. = Abs | | |
	(1)	(2)	(3)
Block_Own	−0.004***		−0.004***
	(0.001)		(0.001)
Block_Other		−0.001	−0.0004
		(0.666)	(0.838)
Size	−0.002***	−0.002***	−0.002***
	(0.000)	(0.000)	(0.000)
Lev	0.008***	0.008***	0.008***
	(0.000)	(0.000)	(0.000)
Cash	0.006**	0.006**	0.006**
	(0.029)	(0.032)	(0.029)
Adm	0.007**	0.007**	0.007**
	(0.022)	(0.025)	(0.022)
Orec	−0.012	−0.012	−0.012
	(0.152)	(0.152)	(0.152)
Market	−0.000	−0.000	−0.000
	(0.330)	(0.323)	(0.330)
Bsize	−0.001	−0.002	−0.001
	(0.446)	(0.432)	(0.444)
Indir	0.009	0.009	0.009
	(0.188)	(0.195)	(0.188)
Dual	0.001	0.001	0.001
	(0.166)	(0.182)	(0.166)
Soe	−0.001*	−0.001*	−0.001*
	(0.064)	(0.073)	(0.064)
Listage	−0.004***	−0.004***	−0.004***
	(0.000)	(0.000)	(0.000)
Roa	0.016***	0.016***	0.016***
	(0.000)	(0.000)	(0.000)
Top1	0.003	0.003	0.003
	(0.199)	(0.182)	(0.199)
Excuholder	−0.001	−0.001	−0.001
	(0.816)	(0.827)	(0.816)
Constant	0.077***	0.078***	0.077***
	(0.000)	(0.000)	(0.000)
Industry FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
N	14,684	14,684	14,684
R^2	0.057	0.056	0.057

Notes: The numbers reported are the regression coefficients with the p-value in parentheses, with the standard errors clustered at the company level.***, **, and * represent statistical significance at 1 %, 5 %, and 10 %, respectively.

ronment (Credit_Rank) of the region where a company was located was measured using the business credit environment index ranking of Chinese cities (https://www.chinacei.org/), with a smaller value of Credit_Rank indicating a better business credit environment. The results in column (2) of Table 18 showed that the coefficient of the interaction between Block and Credit_Rank was negative and significant, indicating that for a company located in a region with a poorer business credit environment, blockchain technology had a stronger inhibiting effect on inefficient investment.

7.4. Classification of blockchain technology-related activity

Different companies engage in blockchain-related activity for different purposes. For companies that invest in research and development of blockchain technology to provide customers with blockchain-related products

Table 20
Blockchain, investment efficiency, and company value.

| | Dep.Var. = Q | |
	(1)	(2)
Block	0.176**	0.175**
	(0.017)	(0.017)
Abs		−0.552*
		(0.077)
Bsize	−0.057	−0.058
	(0.591)	(0.587)
Indir	1.296***	1.303***
	(0.001)	(0.001)
Bholder	−1.177***	−1.178***
	(0.000)	(0.000)
Size	−0.485***	−0.487***
	(0.000)	(0.000)
Soe	−0.139***	−0.139***
	(0.005)	(0.004)
Roa	2.310***	2.310***
	(0.000)	(0.000)
Invest	−0.028	0.063
	(0.899)	(0.775)
Constant	13.141***	13.188***
	(0.000)	(0.000)
Industry FE	Yes	Yes
Year FE	Yes	Yes
N	14,010	14,010
R^2	0.275	0.276

Notes: The numbers reported are the regression coefficients with the p-value in parentheses, with the standard errors clustered at the company level. ***, **, and * represent statistical significance at 1 %, 5 %, and 10 %, respectively.

and services but not to improve their own business operations, blockchain technology might not be able to substantially affect investment efficiency. These companies engage in blockchain-related activity to develop new business, which does not change their corporate governance and is unlikely to affect their investment efficiency.

We split the sample of companies undertaking blockchain-related activity into two groups: 1) companies undertaking blockchain-related activity to improve their own business operations and 2) companies undertaking blockchain-related activity to provide customers with blockchain technology-related products or services. Table 19 shows the results. Block_Own was assigned a value of 1 for all companies undertaking blockchain-related activity to improve their own business operations and 0 otherwise. Block_Other was assigned a value of 1 for all companies engaging in blockchain technology-related activity to provide customers with blockchain technology-related products or services and 0 otherwise.[5] The results showed that undertaking blockchain-related activity significantly improved investment efficiency when the purpose of doing so was to improve busi-

[5] For example, the 2019 semi-annual report of Shenzhen Capstone (000038) contained the following segment: "By investing in media ecological chain, the company aims to effectively reducing false network traffic and advertising fraud using blockchain technology. This also makes it possible to solve the media's trust issue through technical means. Datong China, an achievement of the Company's investment in blockchain technology has now gone live for trial after many internal tests and upgrades." This company clearly developed a blockchain to improve its own business operations, but not to provide a product or service to its customers. Therefore, for this company, Block_Own = 1 and Block_Other = 0. The 2017 semi-annual report of the Busen Group (002569) contained the following segment: "The company uses blockchain and other technologies to build technological infrastructures for various qualified financial institutions, agencies, and internet finance companies, help the participants in the financial market to improve their operating efficiency, help small and micro businesses to obtain required financial products and services in a more convenient and accurate manner, and promote the development of inclusive finance." This company clearly adopted blockchain technology to provide products and services to customers. For this company, Block_Own = 0 and Block_Other = 1.

ness operations, but it did not significantly affect investment efficiency when the purpose was to provide customers with blockchain technology-related products or services.

7.5. Blockchain technology, investment efficiency and company value

Studies show that blockchain technology helps companies improve their value (Cahill et al., 2020; Autore et al., 2021). However, the potential paths of that effect on company value are unknown. Investment is a major means of increasing a company's value (Titman et al., 2004). However, simply increasing investment does not necessarily increase a company's value; instead, low-efficiency investment decreases its value. Only by investing funds in projects with positive NPV can a company increase its profitability, safeguard its sustainable development and realize value creation (Chen et al., 2016).

We further examined whether blockchain technology can increase a company's value by inhibiting inefficient investment. Table 20 shows the results. The value of company Q was measured using Tobin's q. We followed Zhu et al. (2016) and controlled for *Bsize*, *Indir*, *Size*, *Soe*, *Roa*, *Invest* and directors' equity ownership (*Bholder*). The results in column (1) showed that the coefficient of *Block* was positive and significant, indicating that companies implementing blockchain-related activity had higher value than their counterparts. The results in column (2) showed that the coefficient of *Block* was still positive and significant and the coefficient of *Abs* was negative and significant, indicating that blockchain technology significantly improved the value of companies, in part by improving their investment efficiency.

8. Conclusion

In this new era, blockchain technology has attracted increasing attention from the CPC Central Committee as a strategic new-generation information technology (Ma et al., 2020). In particular, the 18th group study session of the Political Bureau of the CPC Central Committee, held on 24 October 2019, focused on the current situation and trends in the development of blockchain technology. At the session, Chinese President Xi Jinping urged China to make an effort to obtain the leading position in theoretical research and innovation in the emerging blockchain industry and make new advances in the industrialization of this technology. He also highlighted the need to accelerate the integration of blockchain technology into the real economy.

The number of companies engaging in blockchain technology-related businesses continues to increase under the active promotion of central and local governments and industry organizations. However, can blockchain technology empower the real economy and truly create value for companies? This is a question worthy of in-depth exploration. This study provides evidence for this question from the perspective of corporate investment efficiency using a sample of all A-share companies listed on the Shanghai and Shenzhen stock exchanges from 2016 to 2020. The results show that blockchain-related activity contributes to improved investment efficiency. The above conclusion does not change substantially after a series of robustness tests. Financing costs and principal–agent conflict partially mediate the effect of blockchain on investment efficiency, and financial reporting quality is the premise of the mediating effects through the two channels. A low management shareholding ratio and a poor business credit environment increase the effect of blockchain technology on improving inefficient investment. Blockchain technology significantly improves investment efficiency in companies undertaking blockchain-related activity primarily to improve their own business operations but not in companies undertaking blockchain-related activity to provide customers with products or services. Blockchain technology has a significant impact on both inhibiting overinvestment and alleviating underinvestment. In terms of economic outcomes, blockchain technology promotes the value of companies by improving their investment efficiency.

This study explores the effect of blockchain technology on corporate investment efficiency at the microscopic level. Our results identify the inherent mechanisms of the integration of blockchain technology into the real economy and have an important reference value for accelerating the commercial application of digital technologies in China. We suggest that companies seize the opportunities provided by the development of digital technologies, invest in blockchain technology based on their own characteristics, accelerate the application of blockchain technology in finance and business scenarios, use the transparent, real-time and tamper-resistant nature of blockchain and promote high-quality blockchain development.

Declaration of Competing Interest

Acknowledgments

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