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Labor protection, information disclosure and analyst forecasts: Evidence from China's Labor Contract Law

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ABSTRACT

Labor protection increases employees' stability and strengthens their monitoring role, improving firms' information environment and increasing analysts' earnings forecast accuracy. Using the implementation of China's Labor Contract Law as a quasi-natural experiment, we find that labor protection significantly improves analyst forecasts. This positive impact is stronger when agency problems are weaker, board independence is greater, corporate reputation is better and industry competition is more intense. Enhanced labor protection significantly reduces firms' business risk and accrual-based earnings management, decreases stock price synchronicity and increases market pricing efficiency. Our findings of significant impacts of China's Labor Contract Law on analysts' forecasting behaviors offer important guidance for promoting the development of the Chinese capital market and policy making in labor protection.

1. Introduction

China's main competitive advantage lies in its labor-intensive industries (Ni and Zhu, 2016). China's rapid increase in labor productivity has been a major pillar of its rapid economic development in the last 40 years (Wang, 2012). As China's economy continues to grow, employees are attaching increasing value to self-protection, and conflicts between employees and enterprises are becoming more common. On 1 January

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2008, to protect employees' legitimate rights and interests, the National People's Congress (NPC) adopted the Labor Contract Law of the People's Republic of China (Labor Contract Law).[1] The enforcement of this law greatly enhanced employees' status (e.g., increased compensation upon the termination of contracts), and has attracted a great deal of attention from both academics and practitioners. Scholars study the economic consequences of labor protection in relation to capital structure (Agrawal and Matsa, 2013), financing cost (Chen et al., 2011), cost stickiness (Liu and Liu, 2014), investment efficiency (Serfling, 2016; Pan and Chen, 2017), corporate innovation (Ni and Zhu, 2016) and information disclosure (Hilary, 2006; Chung et al., 2015). However, little is known about the relationship between labor protection and the capital market or the role of information intermediaries in this relationship. To promote the functions of financial services for entity industries, optimize capital allocation efficiency and strengthen the protection of labor rights, it is of great theoretical and practical significance to explore the impact of labor protection on capital market efficiency.[2]

We use analysts' forecast behaviors as a point of entry to explore whether labor protection affects the information efficiency of the capital market. As key information intermediaries, analysts provide investors with earnings forecasts, representing important guidance for their investment. Analysts' earnings forecasts often contain important information on a firm's intangible assets (Barth et al., 2001), including not only general investments such as R&D and advertising but also the firm's labor force. Considering the important contribution of human capital (e.g., employee training expenditure and motivation) to firm performance and competitiveness (Barney, 1991), Kim et al. (2017) find that analysts incorporate labor costs into their forecasts. That is, a company's labor protection can be an important factor influencing analyst forecasts. Using the implementation of the Labor Contract Law as an exogenous shock to labor protection, we investigate the relationship between the implementation of the Labor Contract Law and analysts' earnings forecast quality.

Theoretically, the effect of enhanced labor protections on the quality of analyst forecasts is unclear. Labor protection such as China's Labor Contract Law increases firms' labor costs (Liu and Liu, 2014) and potentially decreases their profits. Pressure from shareholders and the market may induce managers to conduct earnings management to manipulate information (Lu et al., 2017), reducing information disclosure quality and thus making it more difficult for analysts to produce accurate forecasts. Firms may also actively reduce their information disclosure (Scott, 1994; Hilary, 2006) or engage in selective disclosure (Chung et al., 2015) if their employees are more empowered, because employees may ask for higher wages based on this financial information. This reduction in information transparency may increase analysts' forecast errors. However, labor protection such as the Labor Contract Law also limits firms' ability to terminate employment contracts, which increases employees' cohesion, sense of responsibility, and passion for work (Ye et al., 2013), thus reinforcing the contribution of the workforce to firm value. The resulting reduction in labor risk and increase in earnings help analysts make more accurate earnings forecasts. Moreover, greater organizational commitment motivates employees to monitor their managers more closely (Macleod and Nakavachara, 2007). Employees' proactive identification of corporate malpractice discourages managers from manipulating information and

[1] The Labor Contract Law clearly specifies the types and durations of labor contracts, details the circumstances under which employers are required to pay economic compensation to employees and emphasizes that labor remuneration and labor conditions must not be lower than the local minimum standards. The promulgation and implementation of this law improved China's labor contract system. On 1 July 2013, the Decision of the Standing Committee of the National People's Congress on Amending the Labor Contract Law of the People's Republic of China came into effect, further improving China's labor protection by amending the conditions for operating a labor dispatch business and emphasizing dispatched employees' right to equal pay for equal work with employees in the employing unit.

[2] On 11 March 2021, the Fourth Session of the 13th NPC voted to adopt the Outline of the 14th Five-Year Plan for National Economic and Social Development and Vision 2035 (the "14th Five-Year Plan"). The plan states that the labor contract system should be improved and that the protection of employees' rights should be strengthened. It also emphasizes the need to protect the interests of employees by "safeguarding the treatment and rights of employees, improving the wage system, improving the mechanism for reasonable wage increases and implementing a paid leave system." The plan outlines actions for the development of the capital market, such as improving the dividend system for listed companies, vigorously developing institutional investors, deepening the reform of the New Third Board Market, opening domestic listing and financing channels for technology-based enterprises, steadily expanding the bond market, and promoting the opening up of the financial sector. The "14th Five-Year Plan" is also proposed that highly efficient and high-quality development is key to the reform of the capital market during the 14th Five-Year Plan period. The Opinions of the State Council of the Central Committee of the Communist Party of China on Building a More Perfect Institutional Mechanism for Market-based Allocation of Factors, released on 9 April 2020, emphasize the need to promote the market-based allocation of capital factors and improve the multi-level capital market system.

increases the quality of corporate information disclosure (Li et al., 2019). Therefore, the implementation of China's Labor Contract Law may have improved the corporate information environment and hence increased the quality of analysts' forecasts. Given these two competing arguments, the relationship between labor protection and analysts' forecast quality remains an open empirical question.

Using the 2008 implementation of China's Labor Contract Law as an exogenous shock, we conduct a difference-in-differences analysis and find that the quality of analysts' forecasts significantly increased after the implementation of the Labor Contract Law, as evidenced by reduced forecast error, dispersion and optimism bias. We also find that the positive effect of labor protection on the quality of analysts' forecasts is more pronounced in firms with weaker agency problems, firms with greater board independence, firms with a better reputation and firms in industries with fiercer competition. The results indicate that the positive effect of labor protection on analysts' earnings forecast accuracy depends on firms' internal and external governance environment and that a good governance environment strengthens employees' discourse power and supervisory role. To illustrate how labor protection affects analysts' forecasts, we further show that labor protection significantly reduces firms' risk and accrual-based earnings management, increasing the accuracy of analysts' forecasts. After the implementation of the Labor Contract Law, stock price synchronicity decreased significantly, indicating that labor protection also had a spillover effect on market pricing efficiency. Overall, the implementation of the Labor Contract Law optimized analysts' earnings forecasts by increasing the quality of firms' information disclosure and thus capital market pricing efficiency.

Our paper contributes to the literature in two important ways. First, the paper enriches the literature on labor protection by providing novel insights into the influence of labor protection on analysts' earnings forecast behaviors. Studies provide firm-level evidence of the effects of labor protection on costs (Liu and Liu, 2014), productive investment efficiency (Serfling, 2016; Pan and Chen, 2017), operating elasticity (Lazear, 1990; Chen et al., 2011; Liao and Chen, 2014), innovation capability (Ni and Zhu, 2016) and default risk (Agrawal and Matsa, 2013; Serfling, 2016; Xu and Li, 2020). However, there is little evidence of how labor protection affects analysts' activities or the capital market. As important intermediaries between investors and firms, analysts play a key role in the capital market, and their forecasts affect capital market pricing efficiency (Bai, 2009). This paper sheds light on this issue by studying analysts' earnings forecast behaviors after the implementation of China's Labor Contract Law.

Second, this paper supplements the literature by exploring the factors that influence the quality of analysts' forecasts. Some studies in this area focus on firm characteristics such as the quality of information disclosure (Parkash, 1995), the readability of financial statements (Barber et al., 2010), controlling shareholders' share pledging behaviors (Zhai et al., 2017) and strategic deviance from industry peers (He and Yin, 2018). Factors studied at the analyst level include conflicts of interest (Gu et al., 2019), competence (Chu et al., 2019), and emotion (Dehaan et al., 2017). Other studies examine factors such as product market competition (Mattei and Platikanova, 2017), media coverage (Tan et al., 2015), and transportation conditions (Yang et al., 2019). In contrast with these studies, this paper examines analysts' forecast quality from the perspective of labor protection and shows a positive impact of Labor Contract Law, thus also enriching the literature at the intersection of law and the capital market.

This paper has crucial policy implications. Given the important influence of employees on firms' economic performance, many studies discuss the economic consequences of labor protection. Based on firm-level research, scholars find that labor protection has differing impacts on firms, and many argue that China's Labor Contract Law has reduced firms' efficiency (Liao and Chen, 2014; Liu and Liu, 2014; Lu et al., 2017). However, we find that the Labor Contract Law protects employees' rights and interests and promotes the development of regulations in the Chinese labor market. Additionally, it strengthens the role of analysts as information intermediaries and increases the pricing efficiency of the capital market. Our findings supplement the literature on the economic consequences of the implementation of China's Labor Contract Law by providing evidence from the capital market. They also indicate the value of strengthening labor protection at the micro firm level to support macro policymaking in labor protection.

The rest of the paper is organized as follows. Section 2 introduces the institutional background and develops the theoretical hypotheses. Section 3 describes the empirical design. Section 4 reports the basic empirical results and robustness tests. Section 5 presents heterogeneity analysis of the relationship between labor pro-

tection and analysts' forecasts. Section 6 examines the mechanism by which labor protection affects the quality of analysts' forecasts and its further impact on market efficiency. Section 7 concludes the paper.

2. Institutional background and hypothesis development

2.1. Institutional background

Since the last century, China has introduced a number of policies to protect employees' rights and interests, seeking to continuously strengthen its labor protection system. In 1950, the government promulgated the Trade Union Law of the People's Republic of China, which was China's first labor protection policy. After the launch of the reform and opening-up policy, China's market economy flourished and the labor market largely developed. In this context, the State Council issued the Notice on the Implementation of Incentives and the Piecework Wage System in 1978 to increase employees' motivation to work while safeguarding their legal rights. The State Council also legislated on child labor and the rights of female employees with its Notice on the Prohibition of Child Labor and Regulations on the Labor Protection of Female Employees in 1987 and 1988, respectively. To protect employees, the Standing Committee of the National People's Congress adopted the Labor Law of the People's Republic of China on 5th July 1994, and it has been in force since 1st January 1995. This law has created a bidirectional selection between employers and the workforce, making the allocation of the labor force rational. However, with the continued development of the market economy and labor relations, the Labor Law is no longer comprehensive or effective enough to address complex situations such as the low signing rate of labor contracts, the growth of short-term employment, and other problems that may undermine the rights of the workforce. New forms of employment are constantly emerging. Therefore, the Chinese government solicited public opinion on the Labor Contract Law (Draft) in 2006. At the meeting of the Standing Committee of the 10th National People's Congress held on 29 June 2007, the Labor Contract Law was formally adopted, and it came into force on 1 January 2008.[3]

The Labor Contract Law focuses on the labor contract system and serves as an important complement to other efforts to address problems with labor relations, such as breach penalties and probation periods. Regarding breach penalties, under the Labor Law, an employee can only receive economic compensation if a labor contract that has not yet expired is terminated early by the enterprise and the employee is not at fault. In contrast, the Labor Contract Law requires enterprises to provide compensation for employees upon the termination of their labor contracts. It thus increases the effectiveness of labor contracts and protects employees' rights. Regarding probation periods, in addition to the rule that an employee's salary during the probation period shall not be lower than the minimum wage regulated by the local government, the Labor Contract Law stipulates that the salary of an employee during their probation period shall not be lower than the lowest salary for the same position or 80% of the salary stated in their labor contract. It also specifies the duration of the probation period. In addition, to normalize the signing of contracts, the Labor Contract Law provides that employees may protect their rights by asking for double payment of wages when they have not concluded a written contract with the employer. By clearly defining the rights and obligations of the parties to a labor contract, the Labor Contract Law substantially supports and strengthens the labor contract system in China and fosters harmonious and stable labor relations.

2.2. Theoretical analysis and research hypotheses

In the knowledge-based economy, human capital has become an increasingly important resource, and labor issues have received widespread attention. Studies show that labor protection plays an important role in corporate financing decisions and investment decisions. First, labor protection improves firms' financing conditions. Using a sample of German firms, Lin et al. (2018) find that increased employee participation reduces firms' financing costs. However, labor protection increases firms' labor costs and decreases their operating

[3] The Labor Law was amended twice, in 2009 and 2018, and the Labor Contract Law was amended in 2012. Details of the main labor protection policies introduced and amended in China over the years can be found in Appendix 1.

flexibility (Liao and Chen, 2014), and the resulting deterioration of business risks weakens their external investment intentions (Chen et al., 2011). Labor protection also increases firms' operating liabilities and risk of default (Xu and Li, 2020), leading to a downgrading of corporate credit and thus increased financing costs. Second, labor protection influences firms' capital structure. Agrawal and Matsa (2013) find a positive relationship between unemployment benefits and financial leverage, confirming that an increase in a firm's wage costs raises its marginal return on debt, prompting the firm to adjust its capital structure. In addition, firms use leverage in negotiating with their employees. In the face of stronger unions, firms increase their financial leverage to prevent employees from demanding higher pay when the business is doing well, and they may cite cash-flow shortages as a reason for lowering wages, thus weakening union bargaining power (Matsa, 2010). However, when a firm's operating leverage increases, earnings variability increases, employment becomes more rigid and the firm reduces its debt ratio (Serfling, 2016). Similarly, given the high costs of shedding workers imposed by employment protection legislation, firms may be reluctant to replace innovative staff; such labor rigidity leads to the stagnation of innovation, and firms will thus experience low productivity (Bartelsman et al., 2016). Regarding efficiency, as labor protection increases labor cost stickiness, it prompts firms to use machines to replace human labor, thus increasing their productivity (Liu and Liu, 2014). Although studies explore the issue of labor protection (Chen et al., 2011; Liao and Chen, 2014; Xu and Li, 2020), they mainly focus on the impact of labor protection on firms' internal decision-making, without addressing its external economic consequences. This study examines the external impact of labor protection on the capital market in terms of the relationship between the Labor Contract Law and analysts' forecast behaviors.

Analysts are important information intermediaries in capital markets, providing important reference information for investors. Recent studies show that analysts' earnings forecasts often include important information on intangible assets (e.g., Barth et al., 2001), such as corporate R&D investments and advertising. Human capital is an important means for firms to gain competitiveness (Barney, 1991), and Kim et al. (2017) find that analysts also consider information on firms' labor costs when making forecasts. Therefore, firms' employment policies are likely to influence analysts' forecasts. Thus, theoretically, the Labor Contract Law, which has been in force in China since 2008, is a "double-edged sword" in terms of corporate employee policies and may thus have both positive and negative effects on analyst forecast quality.

The implementation of the Labor Contract Law may have reduced the quality of analysts' forecasts from the perspectives of labor costs and operational flexibility. The Labor Contract Law imposes strict regulations on the signing and termination of labor contracts, with firms facing large penalties if they fail to sign formal contracts with employees or dismiss employees in violation of the law. Firms are also obliged to pay financial compensation if employees' contracts are terminated without their agreement. High levels of employment protection may increase employee absenteeism (Riphahn, 2004), corporate labor costs, and labor cost stickiness (Liu and Liu, 2014) and ultimately cause a short-term decline in book profits. These events may increase pressure on managers to engage in earnings management to whitewash company performance (Lu et al., 2017) and reduce the quality of information disclosure. In addition to raising the cost of employment violations, the rigid regulations of the Labor Contract Law reduce corporate flexibility regarding employment, creating obstacles to the allocation of labor resources, undermining firms' risk adjustment ability and resilience, and decreasing the elasticity of their operations (Liao and Chen, 2014). These effects not only increase the volatility of firms' future operating cash flows and business risks but also reduce the accuracy of analysts' estimates of firm performance and undermine forecast quality. Regarding corporate responses, the enhanced provisions of the Labor Contract Law on collective bargaining and collective contracts have strengthened employees' voices, and firms may have incentives to hide good performance in the face of powerful employee groups (Chung et al., 2015), such as by reducing information disclosure to employees (Scott, 1994; Hilary, 2006) or by selectively hiding good news and disclosing bad news during negotiations (Chung et al., 2015) to increase their bargaining power. Because corporate information disclosure is an important cornerstone of analysts' forecasts (Bai, 2009) and the quality of information disclosure determines the accuracy of analysts' forecasts (Fang, 2007), the low-quality corporate information disclosure that may arise from the implementation of the Labor Contract Law may make it more difficult for analysts to interpret information, reducing the quality of their forecasts. Hence, we propose the following hypothesis:

H1a: The implementation of the Labor Contract Law has reduced the quality of analysts' earnings forecasts.

However, regarding employee stability and supervision, the implementation of the Labor Contract Law may have increased the quality of analysts' forecasts. The Labor Contract Law regulates firms' employment policies, improves employees' status, enhances employees' long-term commitment to their firms, and reduces the impact of their departure on firms' performance volatility (Ye et al., 2013). Labor contracts with a long-term orientation also induce firms to focus on employee development (Ni and Zhu, 2016), human capital investments (e.g., employee training and R&D investment), employee competency enhancement, and firm operation. This in turn increases the positive impact of labor on firm value and mitigates the negative effects of rising labor costs, thereby reducing operational uncertainty and increasing the quality of information disclosure. In terms of employee supervision, employees with greater organizational commitment are more motivated to monitor management (Macleod and Nakavachara, 2007). Employees play an important role as whistleblowers in uncovering corporate fraud (Dyck et al., 2010). In particular, a high-quality workforce plays a prominent role in identifying financial reporting fraud and monitoring management (Call et al., 2017). Employees' increased motivation to monitor and competence in monitoring encourage managers to regulate their disclosure behavior and reduce financial irregularities. This discourages information manipulation by management and improves corporate information disclosure (Li et al., 2019). In addition, employees' enhanced welfare from employee protection earns their company a good reputation (Bhana, 1997), which promotes its development and stability (Clarkson, 1995). The consequent reduction of operational risks weakens managers' profit pressure and their incentive to manipulate information (Lu et al., 2017). Thus, the implementation of the Labor Contract Law may have increased the quality of analysts' forecasts by improving the corporate information environment. Hence, the following hypothesis is proposed:

H1b: The implementation of the Labor Contract Law has increased the quality of analysts' earnings forecasts.

3. Empirical design

3.1. Sample and data

The initial sample used to examine the impact of labor protection on analysts' forecast behaviors includes 41,951 firm-year observations on all Chinese A-share firms listed on the Shanghai and Shenzhen stock exchanges from 2001 to 2019. We collect data on labor intensity from the RESSET database, news coverage data from the CNRDS database, analysts' forecast data and firms' financial data from the CSMAR database. Following previous studies (Chen et al., 2011; Liao and Chen, 2014), we exclude firms in the financial sector and firms with "special treatment" (ST) status (i.e., distressed firms). We also delete firms with fewer assets than liabilities (i.e., with a leverage ratio larger than 1) and firms not covered by analysts.[4] Finally, we drop firm-years with missing data for key variables. All of the continuous variables are winsorized at the 1% and 99% levels to mitigate the potential problem of outliers. Our final sample consists of 19,287 firm-year observations.

3.2. Variable definitions and model specification

3.2.1. Analysts' forecast quality

Following previous studies, we use three measures of analysts' forecast quality: analyst forecast error (Walther and Willis, 2013), dispersion (Lang, 1996), and optimism bias (Jackson, 2005), which are calculated as follows:

[4] See Appendix 2 for the detailed sample screening process.

$$Error = |Mean(Feps) - Meps|/Price$$

$$Disp = SD(Feps)/Price$$

$$Opti = [Mean(Feps) - Meps]/Price$$

where *Mean*(*Feps*) is the mean value of forecast earnings per share (EPS) for the forecasts most recently issued by all analysts for a given company and a given year. *Meps* is the actual earnings per share, and *SD(Feps)* is the standard deviation of analysts' last earnings forecasts. *Price* is the share price at the end of the period. *Error* reflects the difference between the analyst's forecast and the actual value, with larger values indicating greater forecast error and lower accuracy. *Disp* indicates the dispersion of analysts' forecasts. The larger the value, the greater the disagreement in the analysts' forecasts. A positive value of *Opti* denotes optimistic bias in the analyst forecasts, with larger values indicating lower forecast accuracy.

3.2.2. The labor Contract Law and labor intensity

Using the implementation of the Labor Contract Law in 2008 as an exogenous shock, we construct a difference-in-differences model. First, we define a dummy variable *Law*, which equals 1 if the observation is in 2008 or later and 0 otherwise. Second, to construct the treatment and control groups, we use a firm's labor intensity as the classification criterion. As the Labor Contract Law stipulates labor relations, the impact of its implementation is naturally more prominent for more labor-intensive firms. Following Ni and Zhu (2016) and Kim (2011), we define labor intensity (*LaborInt*) as the ratio of labor costs to sales revenue, and labor costs equal cash paid to employees such as employee compensation and training expenditures.

3.2.3. Control variables

Following the literature (Fang, 2007; Li and Jia, 2009; Mattei and Platikanova, 2017; Muslu et al. 2019), we include control variables such as *Size*, *Lev*, *Growth*, *Loss*, *Tang*, *Age*, *Voleps*, *Acca_abs*, *Analyst*, *Big4*, *Top1*, *Execown*, *Institution*, *Indep*, *Board* and *Duality*, the definitions of which are given in Table 1. To exclude the effects of analysts' "busyness" and ability on the quality of their forecasts, we also control for the number of firms followed by an analyst (*Ncov*) and the number of earnings forecasts issued by the analyst (*Fcov*). Finally, we control for firm- and year-fixed effects.

3.3. Model specification

We explore the causal relationship between labor protection and analysts' forecast behaviors by comparing changes in the quality of analysts' forecasts before and after the implementation of the Labor Contract Law. As the law is effective for all firms in China, we construct a difference-in-differences model to determine whether changes in analyst forecasts are influenced by the implementation of the Labor Contract Law or are simply responses to a time trend. To better capture the different impact of the Labor Contract Law across firms with different levels of labor intensity, we follow Ni and Zhu (2016) to use a continuous variable of labor intensity and construct the difference-in-differences model as follows:

$$Forecast = \beta_0 + \beta_1 LaborInt \times Law + \beta_2 LaborInt + \beta_3 Law + \sum Control + \mu_i + \mu_t + \varepsilon_{it,}$$

where *Forecast* is the dependent variable, including three proxies for analysts' forecast quality: analysts' forecast error (*Error*), dispersion (*Disp*) and optimism bias (*Opti*). For the key independent variable, we focus on the interaction term, *LaborInt* × *Law*, which is the product of the labor intensity (*LaborInt*) and labor protection (*Law*) variables. *Control* denotes a set of control variables that affect the quality of analyst forecasts. μ_i and μ_t denote firm- and year-fixed effects, respectively. To ensure the robustness of the results, we cluster standard errors at the firm level.

3.4. Summary statistics

Table 2 reports the descriptive statistics. The mean value of *Error* is 0.018 and the first (third) quartile is 0.003 (0.019), indicating deviation in analysts' forecast quality across firms. The mean value of *Disp* is

Table 1
Variable definitions.

Variable	Definition
Error	The absolute value of the difference between actual and forecasted EPS, scaled by the share price at the end of the period.
Disp	The standard deviation of analyst forecasts for current year earnings, standardized by the share price at the end of the period.
Opti	The difference between forecasted and actual EPS, scaled by the share price at the end of the period.
LaborInt	The ratio of the cash paid to and for employees to sales revenue
Law	An indicator equal to 1 if the observation is in 2008 or after and 0 otherwise
Size	The natural logarithm of the book value of total assets
Lev	The ratio of total liabilities to total assets
Growth	The change in sales revenue divided by the sales revenue at the beginning of the year
Loss	An indicator equal to 1 if the return on assets of the firm is negative and 0 otherwise
Tang	The ratio of fixed assets to total assets
Age	The natural logarithm of the number of years since the firm was founded
Voleps	The standard deviation of earnings per share for the last three years (including the current year)
Acca_abs	The absolute values of discretionary accruals are based on the modified Jones model (1995)
Analyst	The natural logarithm of (1 plus) the number of analyst teams tracking firms
Big4	An indicator equal to 1 if the audit firm is a Big 4 auditing firm and 0 otherwise
Top1	The ownership of the largest shareholder
Execown	The ratio of the number of shares held by executives to the total number of shares
Institution	The ownership by institutional investors
Indep	The ratio of the number of independent directors to the number of directors on the board
Board	The natural logarithm of the number of board members
Duality	An indicator that equals 1 if the board chair also serves as CEO and 0 otherwise
Ncov	The natural logarithm of (1 plus) the number of unique firms followed by the analyst
Fcov	The natural logarithm of (1 plus) the number of earnings forecasts issued by the analyst for the company
Star	An indicator that equals 1 if the analyst is rated as a star analyst by the *New Fortune Best Research* and 0 otherwise
Gender	The percentage of female analysts
Degree	The highest level of education of the analyst team members

0.011, which also confirms the differences in analysts' forecasts. The mean value of *Opti* is positive, indicating that analysts' forecasts are often higher than firms' actual earnings. [5]Overall, the distribution of analysts' forecasts is similar to that in previous studies (Wang et al., 2015; Chu et al., 2019). The mean value of *LaborInt* is 0.119, which is close to the median of 0.098. The mean value of *Law is* 0.907, indicating that most of the observations are after the implementation of the Labor Contract Law. Regarding firm characteristics, 6.4% of the sample firms are loss-making and 7.5% have a Big 4 auditor. The average value of *Institutional* is 7.9%, and 23.6% of our sample firms have the same person as the board chair and CEO.

4. Empirical results

We empirically examine the impact of the Labor Contract Law on analysts' forecast behavior. Next, to control for possible endogeneity between labor protection and analyst forecast quality, we perform a parallel trend test and placebo test. Finally, we verify the robustness of the results by using alternative measures of analyst forecast quality and labor intensity and by controlling for the characteristics of the capital market and individual analysts.

4.1. Baseline results

Table 3 presents the regression results for the impact of the implementation of the Labor Contract Law on analysts' forecasts. The dependent variables are *Error*, *Disp* and *Opti*. The variable of interest is the interaction term *LaborInt* × *Law*. We control for the firm- and year-fixed effects in columns (1) to (3). In columns (4) to (6), we include all of the control variables concerning firm and analyst characteristics. We find that the coefficients on *LaborInt* × *Law* are negative and significant in all of the columns at the 1% or 5% significance level,

Table 2
Summary statistics.

Variable	N	Mean	S.D.	1/4	Median	3/4
Error	19,287	0.018	0.030	0.003	0.007	0.019
Disp	16,169	0.011	0.013	0.003	0.006	0.013
Opti	19,287	0.014	0.031	0.001	0.005	0.017
LaborInt	19,287	0.119	0.086	0.057	0.098	0.156
Law	19,287	0.907	0.290	1	1	1
Size	19,287	22.307	1.288	21.381	22.138	23.048
Lev	19,287	0.451	0.198	0.299	0.454	0.603
Growth	19,287	0.220	0.425	0.013	0.143	0.314
Loss	19,287	0.064	0.245	0	0	0
Tang	19,287	0.234	0.172	0.099	0.199	0.334
Age	19,287	2.106	0.720	1.609	2.197	2.708
Voleps	19,287	0.209	0.229	0.067	0.135	0.261
Acca_abs	19,287	0.136	0.225	0.031	0.070	0.139
Analyst	19,287	1.978	0.874	1.099	1.946	2.639
Big4	19,287	0.075	0.264	0	0	0
Top1	19,287	0.358	0.152	0.236	0.339	0.464
Execown	19,287	0.059	0.127	0	0	0.036
Institution	19,287	0.079	0.079	0.019	0.056	0.114
Indep	19,287	0.370	0.053	0.333	0.333	0.400
Board	19,287	2.166	0.202	2.079	2.197	2.197
Duality	19,287	0.236	0.425	0	0	0
Ncov	19,287	2.916	0.683	2.565	2.944	3.320
Fcov	19,287	1.111	0.357	0.799	1.099	1.359

Note: This table presents summary statistics of the key variables used in the paper. The sample consists of 19,287 firm-year observations from 2001 to 2019. Detailed definitions of the variables are provided in the Table 1.

suggesting that the implementation of the Labor Contract Law has significantly increased the quality of analysts' forecasts by decreasing forecast errors, dispersion and optimism bias. These results support H1b.

4.2. Robustness tests

4.2.1. Parallel trend test

Although the implementation of the Labor Contract Law is exogenous to analysts' forecasts, firms may have anticipated the impact of the law and adjusted their policies in advance, and analysts taking this anticipation into account may have modified their forecasts accordingly. If analysts' forecasts indeed changed significantly before the implementation of the Labor Contract Law, there could be concerns about reverse causality, which would interfere with the establishment of a causal relationship between the Labor Contract Law and analyst forecasts. In addition, a lag in the impact of the implementation of the Labor Contract Law on analyst forecasts might exist. Therefore, to better document the impact of the Labor Contract Law on analysts' forecast behaviors, we conduct a parallel trend test, following Ni and Zhu (2016).

We define a series of time dummy variables, $Law_{t=-4}$, $Law_{t=-3}$, $Law_{t=-2}$, $Law_{t=0}$, $Law_{t=1}$, $Law_{t=2}$, $Law_{t=3}$ and $Law_{t=4}$, representing 2004, 2005, 2006, 2008, 2009, 2010, 2011 and 2012, respectively. If an observation belongs to a certain year, the corresponding variable is equal to 1, and 0 otherwise. $Law_{t\leq -5}$ and $Law_{t\geq 5}$ denote at least five years before (2003 and before) and five years after (2013 and after) the Labor Contract Law was enacted, respectively. Thus, the coefficient estimates of the interaction between *LaborInt* and these yearly dummy variables capture the dynamic impact of labor protection on analysts' forecasts.

Table 4 reports the results of the parallel trend test. Most of the coefficients of the interaction terms $LaborInt \times Law_{t=-2}$, $LaborInt \times Law_{t=-3}$, $LaborInt \times Law_{t=-4}$ and $LaborInt \times Law_{t\leq -5}$ in columns (1) to (3)

[5] To compare analysts' forecast quality between firms in the first quartile and those in the third quartile, we perform univariate tests on *Error*, *Disp*, and *Opti*. All p-values are lower than 0.001, which suggests that there are significant differences between the two groups.

Table 3
Labor protection and analysts' forecasts.

Variable	(1) *Error*	(2) *Disp*	(3) *Opti*	(4) *Error*	(5) *Disp*	(6) *Opti*
LaborInt × *Law*	−0.043***	−0.024***	−0.047***	−0.023**	−0.019***	−0.024**
	(−2.706)	(−3.097)	(−2.793)	(−2.201)	(−2.798)	(−2.020)
LaborInt	0.096***	0.031***	0.102***	0.022*	0.019**	0.020
	(5.348)	(3.576)	(5.369)	(1.866)	(2.515)	(1.497)
Law	0.009***	0.011***	0.007***	−0.006*	0.003***	−0.014***
	(6.271)	(12.734)	(4.626)	(−1.901)	(2.897)	(−3.998)
Size				0.004***	0.001***	0.004***
				(5.546)	(2.961)	(5.974)
Lev				0.009***	0.000	0.008***
				(3.849)	(0.071)	(3.260)
Growth				−0.006***	−0.002***	−0.009***
				(−12.191)	(−6.376)	(−16.948)
Loss				0.055***	0.004***	0.062***
				(31.726)	(5.921)	(33.749)
Tang				−0.003	0.003*	−0.004
				(−1.378)	(1.804)	(−1.492)
Age				0.003***	0.001**	0.002*
				(2.922)	(2.073)	(1.843)
Voleps				0.041***	0.016***	0.028***
				(24.924)	(21.555)	(16.063)
Acca_abs				0.001	−0.001**	0.001
				(0.941)	(−2.036)	(0.607)
Analyst				−0.001**	0.002***	0.001**
				(−2.146)	(7.602)	(2.312)
Big4				−0.002	−0.000	−0.002*
				(−1.242)	(−0.511)	(−1.820)
Top1				−0.014***	−0.003*	−0.016***
				(−4.057)	(−1.730)	(−4.097)
Execown				−0.001	−0.001	−0.000
				(−0.349)	(−0.355)	(−0.003)
Institution				−0.047***	−0.030***	−0.046***
				(−15.098)	(−17.248)	(−13.705)
Indep				0.004	−0.005	0.010
				(0.677)	(−1.391)	(1.581)
Board				−0.001	−0.001	0.000
				(−0.346)	(−1.200)	(0.121)
Duality				−0.000	−0.000	−0.000
				(−0.415)	(−0.645)	(−0.247)
Ncov				−0.000	−0.000	−0.001*
				(−1.095)	(−0.965)	(−1.877)
Fcov				−0.001	−0.000	−0.000
				(−1.066)	(−0.151)	(−0.461)
Constant	0.012***	−0.001	0.009***	−0.066***	−0.016**	−0.075***
	(9.726)	(−0.741)	(6.996)	(−4.706)	(−2.104)	(−5.070)
Year_FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm_FE	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.102	0.117	0.089	0.466	0.221	0.429
N	19,287	16,169	19,287	19,287	16,169	19,287

Note: This table presents the baseline regression results. The dependent variables are analysts' forecast quality (*Error, Disp,* and *Opti*). The key independent variable is the interaction term *LaborInt* × *Law*. In columns (1) to (3), we control for the firm- and year-fixed effects. In columns (4) to (6), we include all of the control variables concerning firm and analyst characteristics. Detailed definitions of the variables are described in the Table 1. The t-statistics reported in parentheses are based on standard errors clustered by firm. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.

Table 4
Parallel trend test results.

	(1) *Error*	(2) *Disp*	(3) *Opti*
$LaborInt \times Law_{t\leq -5}$	0.027	−0.000	0.057
	(0.509)	(−0.002)	(0.953)
$LaborInt \times Law_{t=-4}$	−0.050	−0.048***	−0.011
	(−1.160)	(−2.591)	(−0.251)
$LaborInt \times Law_{t=-3}$	−0.011	−0.001	−0.005
	(−0.400)	(−0.071)	(−0.149)
$LaborInt \times Law_{t=-2}$	−0.023	−0.013	0.003
	(−1.158)	(−1.330)	(0.164)
$LaborInt \times Law_{t=0}$	−0.093***	−0.037***	−0.098***
	(−3.991)	(−3.322)	(−3.763)
$LaborInt \times Law_{t=1}$	−0.003	−0.012*	0.015
	(−0.212)	(−1.924)	(0.975)
$LaborInt \times Law_{t=2}$	−0.038***	−0.035***	−0.032**
	(−2.866)	(−5.018)	(−2.013)
$LaborInt \times Law_{t=3}$	−0.033**	−0.024***	−0.013
	(−2.438)	(−3.581)	(−0.784)
$LaborInt \times Law_{t=4}$	−0.008	−0.024***	0.004
	(−0.619)	(−3.372)	(0.232)
$LaborInt \times Law_{t\geq 5}$	−0.034***	−0.025***	−0.021
	(−2.808)	(−3.908)	(−1.435)
LaborInt	0.031**	0.025***	0.014
	(2.273)	(3.709)	(0.913)
$Law_{t\leq -5}$	0.010***	0.006***	0.011***
	(3.079)	(3.431)	(3.222)
$Law_{t=-4}$	0.026***	0.014***	0.022***
	(5.320)	(5.840)	(4.229)
$Law_{t=-3}$	0.021***	0.011***	0.017***
	(8.122)	(7.067)	(5.837)
$Law_{t=-2}$	0.011***	0.006***	0.006***
	(6.462)	(6.139)	(3.023)
$Law_{t=0}$	0.039***	0.022***	0.038***
	(14.426)	(16.235)	(13.236)
$Law_{t=1}$	−0.002	0.002**	−0.007***
	(−1.639)	(2.360)	(−4.732)
$Law_{t=2}$	0.006***	0.007***	0.003**
	(3.931)	(7.357)	(2.015)
$Law_{t=3}$	0.014***	0.011***	0.010***
	(8.557)	(11.364)	(5.533)
$Law_{t=4}$	0.008***	0.010***	0.005***
	(5.141)	(10.163)	(2.803)
$Law_{t\geq 5}$	0.005**	0.004***	−0.001
	(2.445)	(3.334)	(−0.261)
Constant	−0.077***	−0.017**	−0.088***
	(−4.970)	(−2.190)	(−5.385)
Control	Yes	Yes	Yes
Year_FE	Yes	Yes	Yes
Firm_FE	Yes	Yes	Yes
Adjusted R^2	0.467	0.221	0.431
N	19,287	16,169	19,287
F-value	0.790	1.960	0.270

Note: This table presents the parallel trend test results. The dependent variables are analysts' forecast quality (*Error, Disp,* and *Opti*). The key independent variable is the interaction term of *LaborInt* and time dummy variables. Detailed definitions of the variables are described in the Table 1. The t-statistics reported in parentheses are based on standard errors clustered by firm. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.

Table 5
Placebo test results.

	(1) 2005 *Error*	(2) 2005 *Disp*	(3) 2005 *Opti*	(4) 2006 *Error*	(5) 2006 *Disp*	(6) 2006 *Opti*
LaborInt × *Law1*	−0.017	−0.012	−0.021			
	(−0.774)	(−0.834)	(−0.838)			
LaborInt × *Law2*				−0.010	0.016	−0.033
				(−0.290)	(1.173)	(−0.882)
Law1	−0.007*	−0.008***	−0.014***			
	(−1.884)	(−4.692)	(−3.837)			
Law2				−0.007*	−0.010***	−0.014***
				(−1.884)	(−3.982)	(−3.453)
LaborInt	0.016	0.012	0.016	0.009	−0.016	0.029
	(0.721)	(0.814)	(0.656)	(0.266)	(−1.127)	(0.762)
Constant	−0.066***	−0.003	−0.076***	−0.066***	−0.005	−0.075***
	(−4.693)	(−0.420)	(−5.139)	(−4.707)	(−0.637)	(−5.101)
Control	Yes	Yes	Yes	Yes	Yes	Yes
Year_FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm_FE	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.466	0.220	0.429	0.466	0.220	0.429
N	19,287	16,169	19,287	19,287	16,169	19,287

Note: This table presents the placebo test results. The dependent variables are analysts' forecast quality (*Error, Disp,* and *Opti*). The key independent variable is the interaction term *LaborInt* and placebo time dummy variables. Detailed definitions of the variables are described in the Table 1. The t-statistics reported in parentheses are based on standard errors clustered by firm. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.

are insignificant, suggesting that analyst forecasts for labor-intensive firms do not differ significantly from forecasts for other firms in the years before 2008, thus satisfying the parallel trend requirement.[6] Most of the coefficients of the interaction terms $LaborInt \times Law_{t=0}$, $LaborInt \times Law_{t=1}$, $LaborInt \times Law_{t=2}$, $LaborInt \times Law_{t=3}$, $LaborInt \times Law_{t=4}$ and $LaborInt \times Law_{t\geq 5}$ are significantly negative at the 1% or 5% level, indicating that the implementation of the Labor Contract Law has improved the quality of analysts' forecasts. This again supports the hypothesis H1b of this paper.

4.2.2. Placebo test

To further demonstrate the validity of our difference-in-differences analysis, we perform placebo tests for 2005 and 2006 and then re-estimate model (4). *Law1* and *Law2* denote dummy variables for the implementation of the Labor Contract Law in 2005 and 2006, respectively. *Law1* (*Law2*) is equal to 1 if the observation is in 2005 (2006) or a year after 2005 (2006), and 0 otherwise.

Table 5 reports the results of the placebo tests. Columns (1)–(3) show the results when we assume that the Labor Contract Law was implemented in 2005, and columns (4)–(6) show the results under the assumption that the law was enacted in 2006. As shown, the coefficients of *LaborInt* × *Law1* in columns (1)–(3) and *LaborInt* × *Law2* in columns (4)–(6) are all insignificant. The placebo test results of insignificant findings using alternative event years further validate that the improvement of analysts' forecast accuracy is indeed driven by the implementation of the Labor Contract Law in 2008 rather than other factors.

4.2.3. Other robustness tests

First, to avoid bias introduced by the specific definitions of labor intensity and analyst forecast quality, we conduct additional robustness tests using alternative measures of analysts' forecast quality and labor intensity,

[6] Although $LaborInt \times Law_{t=-4}$ is significantly negative in the model with *Disp* in column (2), a further test of the joint saliency analysis of the four pre-event interaction terms produces an F-statistic of 1.960, which is statistically nonsignificant at the margin. Thus, it meets the general parallel trend requirement. In addition, the significant values are in the four years before the event, which are likely to have a relatively limited impact on the findings. Therefore, the parallel trend hypothesis is satisfied.

as shown in Table 6. *Error2* is redefined as the absolute value of the difference between the mean of all analysts' last EPS forecasts in a given year and the actual EPS divided by the firms' closing price at the beginning of the year. *Error3* is redefined as the absolute value of the difference between the median of all analysts' last EPS forecasts in a given year and the firms' actual EPS divided by the firms' closing price at the end of the year. *Disp2* is redefined as the standard deviation of all analysts' last EPS forecasts in a given year divided by the price at the beginning of the period. *Disp3* is redefined as the absolute value of the standard deviation of all analysts' last EPS forecasts for this year divided by the average of all of the EPS forecasts. *Opti2* is redefined as the difference between EPS forecasts and the firms' actual EPS divided by the closing price at the beginning of the year. *Opti3* is redefined as the difference between the analysts' EPS forecasts and the actual EPS divided by the closing price at the beginning of the month. The results based on these alternative measures of analysts' forecast quality and labor intensity are reported in Panel A. As shown, the coefficients of *LaborInt* × *Law* are all negative and significant at least at the 10% level. Labor intensity is redefined as *LaborInt_r1*, which is the cash paid to and for employees divided by sales revenue, and *LaborInt_r2*, which is 1 minus the ratio of fixed assets to total assets. The corresponding results are shown in Panel B of Table 6, where the coefficients of *LaborInt_r1* × *Law* in columns (1)–(3) and *LaborInt_r2* × *Law* in columns (4)–(6) are also significantly negative. Therefore, our results are robust to alternative measurements of the key variables.

Second, because the volatility of the capital market may also affect analysts' ability to evaluate firms' future performance (Xu et al., 2012) and, in turn, their forecast accuracy, we control for the volatility of stock returns (*Volatility*) and the stock price crash risk (*Crash*) in model (4). Following Kim et al. (2011), we use the negative skewness of stock returns (*Ncskew*) and down-to-up volatility (*Duvol*) to measure stock price crash risk (*Crash*). The results are shown in Panel C of Table 6. The coefficients of *LaborInt* × *Law* remain significantly negative when we control for stock return volatility or stock price crash risk; hence the previous conclusions remain unchanged.

Third, analysts' characteristics can also affect their forecast accuracy (García-Meca and Sánchez-Ballesta, 2006). Thus, we further add the control variables including star analysts (*Star*), the proportion of female analysts (*Gender*), and the highest education level of the analyst team (*Degree*) to model (4).[7] Panel D of Table 6 reports the results. As shown, the coefficients of *LaborInt* × *Law* in columns (1)-(3) are negative and significant, suggesting that our main results hold when we control for analyst characteristics.

5. Heterogeneity analysis

5.1. Managerial agency problems

Employees' monitoring role can depend on the corporate governance environment. Xu and Wang (2007) finds that the agency problem between shareholders and managers affects firms' internal control, which weakens the control and supervision of other agents. Thus, employees' monitoring role and discourse power are expected to be stronger in firms with fewer conflicts of interest. Following Lu et al. (2008), we use managers' perks to measure the severity of agency problems in firms. Specifically, perks are measured as the ratio of cash paid for other operating activities to total assets at the beginning of the year. A higher level of perks indicates more serious agency problems. We divide the sample into two groups based on the median value of perks among firms in the same industry in a given year. If the perquisites are higher than their median, *Perk* takes a value of 1; if they are lower than their median, *Perk* takes a value of 0. We re-estimate the main regression using the subsamples, and we present the results in Table 7. The coefficients of *LaborInt* × *Law* are significantly negative only for the subsample with *Perk* below the median in columns (2), (4), and (6). For firms with higher perks, the coefficients of *LaborInt* × *Law* are all statistically insignificant. These results suggest that labor protection increases analyst forecast quality, especially in firms with weaker agency problems. That is, better governance increases employees' discourse power and ability to execute their monitoring role, which improves firms' information disclosure.

Table 6
Robustness tests.

Panel A: Alternative measures of analysts' forecast quality

	(1) *Error2*	(2) *Error3*	(3) *Disp2*	(4) *Disp3*	(5) *Opti2*	(6) *Opti3*
LaborInt × Law	−0.021*	−0.019*	−0.012*	−0.478**	−0.023*	−0.028***
	(−1.796)	(−1.823)	(−1.771)	(−2.222)	(−1.937)	(−2.619)
LaborInt	0.027**	0.018	0.012	0.989***	0.027**	0.028**
	(2.198)	(1.516)	(1.624)	(3.997)	(2.147)	(2.377)
Law	0.008***	−0.009***	0.004***	0.090**	−0.002	−0.004
	(3.270)	(−2.783)	(3.425)	(2.470)	(−0.662)	(−1.358)
Constant	−0.021*	−0.019*	−0.012*	−0.478**	−0.023*	−0.028***
	(−1.796)	(−1.823)	(−1.771)	(−2.222)	(−1.937)	(−2.619)
Control	Yes	Yes	Yes	Yes	Yes	Yes
Year_FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm_FE	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.445	0.459	0.133	0.134	0.394	0.369
N	19,287	19,287	16,169	16,163	19,287	18,910

Panel B: Alternative measures of labor intensity

	(1) *Error*	(2) *Disp*	(3) *Opti*	(4) *Disp*	(5) *Error*	(6) *Opti*
LaborInt_r1 × Law	−0.023**	−0.019***	−0.024**			
	(−2.201)	(−2.798)	(−2.020)			
LaborInt_r1	0.022*	0.019**	0.020			
	(1.866)	(2.515)	(1.497)			
LaborInt_r2 × Law				−0.005**	−0.006*	−0.006*
				(−2.490)	(−1.872)	(−1.859)
LaborInt_r2				0.054	−0.150	−0.219
				(0.450)	(−0.148)	(−0.195)
Law	−0.006*	0.003***	−0.014***	0.005***	−0.004	−0.011***
	(−1.901)	(2.897)	(−3.998)	(3.310)	(−0.972)	(−2.836)
Constant	−0.066***	−0.016**	−0.075***	−0.069	0.085	0.144
	(−4.706)	(−2.104)	(−5.070)	(−0.574)	(0.084)	(0.128)
Control	Yes	Yes	Yes	Yes	Yes	Yes
Year_FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm_FE	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.466	0.221	0.429	0.221	0.466	0.429
N	19,287	16,169	19,287	16,169	19,287	19,287

Panel C: Volatility of the capital market

	(1) *Error*	(2) *Disp*	(3) *Opti*	(4) *Error*	(5) *Disp*	(6) *Opti*
LaborInt × Law	−0.022**	−0.020***	−0.022*	−0.023**	−0.020***	−0.022*
	(−2.099)	(−3.001)	(−1.847)	(−2.115)	(−3.035)	(−1.856)
LaborInt	0.022*	0.021***	0.018	0.022*	0.021***	0.018
	(1.833)	(2.736)	(1.358)	(1.849)	(2.768)	(1.367)
Law	−0.006*	0.005***	−0.013***	−0.005	0.005***	−0.013***
	(−1.676)	(3.969)	(−3.778)	(−1.577)	(3.967)	(−3.693)
Volatility	−0.018	0.080***	−0.034	−0.015	0.080***	−0.032
	(−0.393)	(3.238)	(−0.732)	(−0.331)	(3.260)	(−0.695)
Ncskew	0.001***	0.001***	0.001***			
	(3.544)	(3.914)	(3.139)			
Duvol				0.002***	0.001***	0.001***
				(3.911)	(3.946)	(3.300)
Constant	−0.063***	−0.021**	−0.069***	−0.063***	−0.021**	−0.070***
	(−4.274)	(−2.542)	(−4.454)	(−4.320)	(−2.571)	(−4.491)
Control	Yes	Yes	Yes	Yes	Yes	Yes
Year_FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm_FE	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.468	0.222	0.432	0.468	0.222	0.432
N	18,642	15,653	18,642	18,642	15,653	18,642

Table 6 (*continued*)

Panel D: Analysts' characteristics

	(1)	(2)	(3)
	Error	*Disp*	*Opti*
LaborInt × *Law*	−0.025**	−0.020***	−0.031**
	(−2.025)	(−2.802)	(−2.213)
LaborInt	0.023*	0.020***	0.025
	(1.675)	(2.596)	(1.591)
Law	0.005**	0.003**	0.001
	(2.027)	(2.243)	(0.242)
Star	0.000	−0.000	0.000
	(0.504)	(−0.486)	(0.045)
Gender	0.162	0.009	0.199
	(1.009)	(0.108)	(1.163)
Degree	−0.023	0.008	−0.035
	(−0.954)	(0.608)	(−1.303)
Constant	−0.072***	−0.021**	−0.077***
	(−4.267)	(−2.538)	(−4.326)
Control	Yes	Yes	Yes
Year_FE	Yes	Yes	Yes
Firm_FE	Yes	Yes	Yes
Adjusted R^2	0.472	0.215	0.435
N	17,029	14,525	17,029

Note: This table presents the placebo test results. Panel A reports the results of alternative measures of analysts' forecast quality. Panel B reports the results of alternative measures of labor intensity. Panel C reports the results of considering volatility of the capital market. Panel D reports the results of considering analysts' characteristics. Detailed definitions of the variables are described in the Table 1. The t-statistics reported in parentheses are based on standard errors clustered by firm. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.

Table 7
Managerial agency problems.

	(1)	(2)	(3)	(4)	(5)	(6)
	Error	*Error*	*Disp*	*Disp*	*Opti*	*Opti*
	Perk = 1	Perk = 0	Perk = 1	Perk = 0	Perk = 1	Perk = 0
LaborInt × *Law*	−0.003	−0.040***	−0.000	−0.022**	0.002	−0.044***
	(−0.217)	(−2.779)	(−0.037)	(−2.339)	(0.135)	(−2.691)
LaborInt	0.009	0.033**	−0.002	0.024**	−0.003	0.043**
	(0.508)	(2.051)	(−0.225)	(2.338)	(−0.169)	(2.342)
Law	−0.014**	0.008***	0.002	0.004***	−0.019***	0.001
	(−2.576)	(2.684)	(1.242)	(2.610)	(−3.508)	(0.310)
Constant	−0.070***	−0.077***	−0.021*	−0.015	−0.065***	−0.102***
	(−2.907)	(−3.525)	(−1.728)	(−1.246)	(−2.675)	(−4.370)
Control	Yes	Yes	Yes	Yes	Yes	Yes
Year_FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm_FE	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.410	0.491	0.196	0.250	0.372	0.459
N	9,608	9,678	8,210	7,958	9,608	9,678
The difference in sample coefficients of LaborInt × *Law*	P-value = 0.040**		P-value = 0.020**		P-value = 0.020**	

Note: This table examines the impact of agency conflicts on relation between labor protection and analyst forecast quality. We divide the samples into two subsamples based on managerial perks, and estimate the sub-samples separately. The key independent variable is the interaction term of *LaborInt* × *Law*. Other variable definitions are provided in the Table 1. The t-statistics reported in parentheses are based on standard errors clustered by firm. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.

5.2. Board independence

External board members are of great value to business operations as an internal governance mechanism (Fama and Jensen, 1983). By monitoring and disciplining management, external independent directors can optimize the internal governance environment and facilitate monitoring by employees. Thus, the effect of employees' monitoring on a firm is expected to be stronger when the firm's board is more independent. We use the proportion of independent directors as a proxy for the quality of internal corporate governance and divide the sample into two subsamples based on the median value of *Indep* among firms in the same industry in a given year. The regression results are shown in Table 8, with columns (1), (3), and (5) showing the results for the group with a larger proportion of independent directors and the other columns showing the results for the group with a smaller proportion of independent directors. The coefficients of *LaborInt* × *Law* are all significantly negative when the board is more independent, but they are not significant in the subsample of firms with a small proportion of independent directors. These results suggest that the effect of labor protection on analysts' forecast quality is more pronounced when the internal corporate governance is stronger.

5.3. Corporate reputation

Employees' monitoring role may be influenced by the firm reputation. Reputable firms might not only pay attention to the personal development and protection of employees' rights and interests (Li and Zhang, 2010) but also have better internal governance, which might increase the reliability, accuracy, and standardization of their financial reports (Tao and Jin, 2012). The impact of enhanced labor protection on analysts' forecast quality would thus be stronger in such firms. Following prior studies (Brammer et al., 2006; Gao et al., 2009; Liu et al., 2015), we use corporate philanthropy as the measure of corporate reputation. *Repu* takes a value of 1 if corporate donations are greater than the median of donations among firms in the same industry in a given year, and 0 otherwise. The results are shown in Table 9. As shown in columns (1), (3), and (5), the coefficients of *LaborInt* × *Law* are all statistically significant for the subsample of firms with a better reputation. However, for the subsample of firms with a poorer reputation, the coefficients of the interaction terms are nonsignificant. These results suggest that reputation strengthens the internal governance role of employees in labor protection and significantly increases the accuracy of analysts' earnings forecasts.

Table 8
Board Independence.

	(1) *Error* Indep = 1	(2) *Error* Indep = 0	(3) *Disp* Indep = 1	(4) *Disp* Indep = 0	(5) *Opti* Indep = 1	(6) *Opti* Indep = 0
LaborInt × *Law*	−0.025**	−0.021	−0.021***	−0.034	−0.026*	−0.009
	(−2.056)	(−0.396)	(−2.947)	(−1.438)	(−1.882)	(−0.113)
LaborInt	0.025*	−0.009	0.021**	0.034	0.023	−0.031
	(1.862)	(−0.178)	(2.532)	(1.377)	(1.501)	(−0.389)
Law	−0.013***	0.012	0.003**	0.009**	−0.019***	−0.004
	(−3.626)	(1.313)	(2.114)	(2.000)	(−4.870)	(−0.361)
Constant	−0.088***	0.031	−0.026***	0.024	−0.097***	−0.015
	(−5.639)	(0.532)	(−3.267)	(0.687)	(−6.028)	(−0.230)
Control	Yes	Yes	Yes	Yes	Yes	Yes
Year_FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm_FE	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.460	0.464	0.235	0.149	0.426	0.404
N	16,583	2,704	13,897	2,272	16,583	2,704
The difference in sample coefficients of LaborInt × *Law*	P-value = 0.080*		P-value = 0.10*		P-value = 0.080*	

Note: This table examines the impact of board independence on relation between labor protection and analyst forecast quality. We divide the samples into two subsamples based on the proportion of independent directors, and estimate the sub-samples separately. The key independent variable is the interaction term of *LaborInt* × *Law*. Other variable definitions are provided in the Table 1. The t-statistics reported in parentheses are based on standard errors clustered by firm. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.

Table 9
Corporate reputation.

	(1) *Error* Repu = 1	(2) *Error* Repu = 0	(3) *Disp* Repu = 1	(4) *Disp* Repu = 0	(5) *Opti* Repu = 1	(6) *Opti* Repu = 0
LaborInt × *Law*	−0.034**	−0.007	−0.026***	−0.009	−0.033**	0.001
	(−2.487)	(−0.398)	(−2.880)	(−0.846)	(−2.144)	(0.063)
LaborInt	0.044***	0.004	0.028***	0.010	0.040**	−0.010
	(2.830)	(0.199)	(2.715)	(0.852)	(2.341)	(−0.429)
Law	0.003	0.005	0.005***	0.001	−0.001	0.001
	(1.238)	(1.452)	(3.660)	(0.547)	(−0.293)	(0.199)
Constant	−0.080***	−0.080***	−0.005	−0.017	−0.081***	−0.084***
	(−3.841)	(−3.417)	(−0.533)	(−1.148)	(−3.891)	(−3.047)
Control	Yes	Yes	Yes	Yes	Yes	Yes
Year_FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm_FE	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.448	0.502	0.234	0.214	0.416	0.452
N	11,815	7,471	10,203	5,966	11,815	7,471
The difference in sample coefficients of LaborInt × *Law*	P-value = 0.080**		P-value = 0.100*		P-value = 0.080**	

Note: This table examines the impact of corporate reputation on relation between labor protection and analyst forecast quality. We divide the samples into two subsamples based on corporate philanthropy, and estimate the sub-samples separately. The key independent variable is the interaction term of *LaborInt* × *Law*. Other variable definitions are provided in the Table 1. The t-statistics reported in parentheses are based on standard errors clustered by firm. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.

5.4. Product market competition

Product market competition, which is an effective external governance mechanism to reduce managerial slack for increased pressure to improve firm competitiveness (Hart, 1983; Bloom et al., 2015; Dasgupta et al., 2017), can also affect employees' monitoring role. The more competitive the industry is in which a firm operates, the stronger the external binding force of the market pressure on the firm to be competitive. This force leads to improvements in the firm's internal governance, which could strengthen the monitoring role of employees. In addition, more intense market competition may increase the status of employees as the experienced staffs may become a key resource for the business, further increasing employees' influence on the firm. Thus, we expect the impact of labor protection on analysts' forecast quality to be more significant when the industry to which the firm belongs is more competitive. Following Gaspar et al. (2006), Peress (2010) and Kale and Loon (2011), we use the Herfindahl index to measure the degree of industry competition. Specifically, industry concentration is the sum of the squares of the proportion of sales revenue for each firm in the industry, with a lower value indicating fiercer market competition. We divided the sample into two groups based on the median value of Herfindahl index across all industries in a given year. *HHI* takes a value of 1 if the Herfindahl index is higher than the median, and 0 otherwise. Table 10 reports the corresponding results when we estimate the main regressions using the subsamples. As shown, the coefficients of *LaborInt* × *Law* are significantly negative only for the group of firms in industries with stronger competition, as shown in columns (2), (4) and (6). These results indicate that the impact of labor protection on a firm is more prominent when the industry is highly competitive, again indicating that employees have greater influence in the context of good governance.

6. Further analysis

6.1. Mechanism test

Above, we show that labor protection increases analyst forecast quality. What are the channels through which employees influence analysts' forecast behavior? The Labor Contract Law has improved employee cohesion and status, enhanced the value contribution of the workforce, reduced corporate operating volatility, curbed information manipulation, and increased the quality of corporate information disclosure, thereby helping analysts to predict firms' future performance and increasing the quality of earnings forecasts. Thus, we

Table 10
Product market competition.

	(1) *Error* HHI = 1	(2) *Error* HHI = 0	(3) *Disp* HHI = 1	(4) *Disp* HHI = 0	(5) *Opti* HHI = 1	(6) *Opti* HHI = 0
LaborInt × *Law*	−0.018	−0.037*	−0.009	−0.039***	−0.012	−0.044**
	(−1.489)	(−1.916)	(−1.080)	(−4.002)	(−0.945)	(−1.991)
LaborInt	0.006	0.054***	0.011	0.038***	−0.003	0.056**
	(0.400)	(2.590)	(1.087)	(3.612)	(−0.187)	(2.370)
Law	0.006**	−0.010**	0.001	0.006***	−0.001	−0.018***
	(1.962)	(−2.291)	(0.753)	(3.350)	(0.190)	(−3.695)
Constant	−0.066***	−0.089***	−0.018	−0.022**	−0.074***	−0.102***
	(−2.862)	(−4.229)	(−1.493)	(−2.094)	(−3.126)	(−4.728)
Control	Yes	Yes	Yes	Yes	Yes	Yes
Year_FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm_FE	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.446	0.478	0.199	0.241	0.402	0.447
N	8,434	10,853	7,033	9,136	8,434	10,853
Difference in sample coefficients of *LaborInt* × *Law*	P-value = 0.080*		P-value = 0.000***		P-value = 0.000***	

Note: This table examines the impact of product market competition on relation between labor protection and analyst forecast quality. We divide the samples into two subsamples based on Herfindahl index, and estimate the sub-samples separately. The key independent variable is the interaction term of *LaborInt* × *Law*. Other variable definitions are provided in the Table 1. The t-statistics reported in parentheses are based on standard errors clustered by firm. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.

examine two channels: operation risks and information quality. Following the literature (Boubakri et al., 2013; Choy et al., 2014; Faccio et al., 2016), we measure the operating risk of a firm by the volatility of its earnings over the past three years, including the current year. We construct the standard deviation of earnings using earnings per share (*EPS*), net profit margin (*ROA*), and operating profit margin (*ROP*) as corporate earnings indicators and defined them as $\sigma\ EPS_{t\text{-}2,t}$,$\sigma\ ROA_{t\text{-}2,t}$ and$\sigma\ ROP_{t\text{-}2,t}$, respectively. Based on the modified Jones model (Dechow et al., 1995), we construct two proxies for accrual-based earnings management, namely the discretionary accrual level (*Acca_raw*) and its absolute value (*Acca_abs*). We also control for real earnings management using abnormal operating cash flow (*Ab_cfo*), abnormal production costs (*Ab_prod*) and abnormal discretionary expenses (*Ab_disexp*) as defined by Roychowdhury (2006).

Table 11 reports the results of our mechanical tests. Columns (1)–(3) report the results with firms' business risk as the dependent variable and columns (4) and (5) report the results with information quality as the dependent variable. The coefficients of *LaborInt* × *Law* are significantly negative in columns (1)–(5), suggesting that labor protection reduces corporate volatility and earnings management. The results verify that increased employee supervision due to labor protection reduces corporate business risk and discourages information manipulation, thus increasing the quality of corporate disclosure and the accuracy of analysts' forecasts.

6.2. Capital market pricing efficiency

Stock price synchronization is an important indicator of the efficiency of the stock market. Numerous studies suggest that stock price synchronization negatively represents information efficiency (Jin and Myers, 2004; Xu et al., 2012; Yi et al., 2019). If stock prices contain more noise, information about corporate fundamentals is less well reflected and pricing and resource allocation are less effective. As information intermediaries between firms and investors, analysts have a comparative advantage in searching for and processing information; they can thus increase the information content of stock prices, ensure that stock prices contain more real information at the company level, reduce stock price synchronization and play an important role in increasing capital market efficiency (Zhu et al., 2007). We find that enhanced labor protection increases employees' voice, participation and monitoring power, prompting firms to improve their information disclosure. This results in greater information transparency and thus higher-quality analyst forecasts. Under such circumstances, more firm-specific information is included in share prices, which reduces share price synchronization and increases capital market pricing efficiency. We define stock price synchronization following the literature (Xu et al., 2013; Yi et al., 2019). The returns of individual stocks are first regressed based on the following model:

Table 11
Results of Further Analyses.

	(1) $\sigma\ EPS_{t-2,t}$	(2) $\sigma\ ROA_{t-2,t}$	(3) $\sigma\ ROP_{t-2,t}$	(4) $Acca\_abs_t$	(5) $Acca\_raw_t$	(6) SYN_t
LaborInt × Law	−0.181*	−0.042***	−0.042***	−0.152*	−0.210**	−0.802*
	(−1.682)	(−2.960)	(−2.591)	(−1.834)	(−2.205)	(−1.672)
LaborInt	0.217*	0.051***	0.051***	0.338***	0.341***	1.124**
	(1.837)	(3.279)	(2.881)	(3.489)	(3.232)	(2.160)
Law	−0.028	−0.001	−0.003	−0.006	0.012	−1.364***
	(−0.780)	(−0.369)	(−0.620)	(−0.207)	(0.428)	(−8.436)
Size	0.036***	−0.006***	−0.005***	0.006	0.025***	0.113***
	(5.250)	(−7.525)	(−6.322)	(1.053)	(4.121)	(3.920)
Lev	0.003	0.000	−0.004	0.006	−0.218***	−0.099
	(0.125)	(0.116)	(−1.292)	(0.273)	(−9.669)	(−0.966)
Growth	0.019***	0.004***	0.005***	0.093***	0.005	−0.024
	(4.533)	(7.439)	(7.951)	(12.351)	(0.678)	(−1.017)
Loss	0.237***	0.031***	0.030***	−0.016**	−0.051***	−0.096**
	(23.492)	(24.306)	(22.309)	(−2.009)	(−5.928)	(−2.355)
Tang	−0.037	−0.010***	−0.010***	−0.009	0.148***	−0.016
	(−1.376)	(−3.107)	(−2.983)	(−0.373)	(5.930)	(−0.131)
Age	−0.050***	0.013***	0.014***	0.049***	0.042***	0.666***
	(−4.491)	(11.786)	(11.483)	(4.579)	(3.637)	(12.784)
Top1	0.040	−0.002	−0.001	−0.054*	−0.067**	−0.635***
	(0.990)	(−0.557)	(−0.147)	(−1.869)	(−2.066)	(−4.027)
Execown	−0.024	−0.012**	−0.012**	0.041	0.094**	0.209
	(−0.750)	(−2.335)	(−2.180)	(1.252)	(2.403)	(0.997)
Institution	−0.010	−0.010***	−0.012***	0.092***	0.084***	−0.465***
	(−0.309)	(−2.959)	(−3.231)	(3.283)	(2.932)	(−2.878)
Indep	0.017	−0.001	−0.003	−0.099**	−0.091*	−0.573**
	(0.276)	(−0.152)	(−0.435)	(−2.037)	(−1.675)	(−1.978)
Board	−0.018	−0.001	−0.002	−0.035**	−0.027	−0.062
	(−0.785)	(−0.531)	(−0.725)	(−2.017)	(−1.492)	(−0.613)
Duality	0.008	0.001	0.001	−0.006	−0.003	−0.017
	(0.969)	(0.845)	(0.885)	(−0.921)	(−0.493)	(−0.478)
Voleps				0.032***	0.015	−0.275***
				(3.349)	(1.587)	(−5.405)
Analyst				−0.007**	−0.001	0.088***
				(−2.139)	(−0.392)	(4.800)
Big4				0.005	−0.003	−0.040
				(0.429)	(−0.227)	(−0.541)
Ab_cfo				−0.056	−0.597***	
				(−1.620)	(−16.482)	
Ab_prod				0.060**	0.128***	
				(2.261)	(4.271)	
Ab_disexp				0.076	0.222***	
				(1.287)	(3.419)	
Constant	−0.439***	0.140***	0.124***	−0.099	−0.536***	0.613
	(−3.080)	(8.162)	(7.022)	(−0.881)	(−4.417)	(1.033)
Year_FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm_FE	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.107	0.147	0.123	0.248	0.206	0.313
N	19,287	19,287	19,287	17,472	17,472	19,084

Note: This table presents the further analyses results. Columns (1)–(3) report the results with firms' business risk as the dependent variable and columns (4) and (5) report the results with information quality as the dependent variable. Column (6) reports the results of capital market pricing efficiency. Detailed definitions of the variables are described in the Table 1. The t-statistics reported in parentheses are based on standard errors clustered by firm. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.

$$R_{i,t} = \beta_0 + \beta_1 R_{M,t} + \beta_2 R_{M,t-1} + \beta_3 R_{I,t} + \beta_4 R_{I,t-1} + \varepsilon_{i,t}$$

where R_i is the daily return of stock i considering the reinvestment of cash dividends; R_M is the daily return calculated using a weighted average of the circulation market value of the sub-market in which stock i is

located; and R_I is the daily return calculated using a weighted average of the circulation market value of other stocks excluding i in the industry in which stock i is located, with the industry classification based on the SEC's 2012 classification criteria. The regression gives the R_i^2 of the model below, with the economic implication that the share price movement of firm i can be explained by the volatility of the sub-market in which it is located. Processing R_i^2 yields the share price synchronization of stock i: $SYN = \ln(R_i^2/(1-R_i^2))$. Column (6) of Table 10 reports the results. The coefficient of $LaborInt \times Law$ is significantly negative, indicating that labor protection reduces share price synchronization. That is, enhanced labor protection increases the validity of analysts' forecasts and reduces share price synchronization, in turn improving the capital market's pricing efficiency.

7. Conclusion

With increasing emphasis on the importance and protection of employees, we construct a difference-in-differences model using the implementation of China's Labor Contract Law as a quasi-natural experiment to examine the impact of labor protection on the quality of analysts' forecasts. This helps us to explore the episodic effect of labor protection in the capital market. The results show that since the implementation of the Labor Contract Law, analysts' earnings forecasts for more labor-intensive firms have been more accurate. The positive impact of labor protection on the quality of analysts' forecasts is more significant for firms with weaker managerial agency problems, firms with greater board independence, firms with a better reputation and firms in more competitive industries. Further analyses show that enhanced labor protection reduces accrual-based earnings management and operational risk, leading to higher analyst forecast quality. Consequently, stock price synchronization decreases, which increases the pricing efficiency of the capital market.

Unlike studies that focus on the impact of labor protection on firm-level characteristics such as labor costs, operational flexibility and innovation capacity (Chen et al., 2011; Agrawal and Matsa, 2013; Liu and Liu, 2014; Serfling, 2016), we focus on analysts, important information intermediaries, to examine the impact of labor protection on the capital market. We provide new insights into the policy effects of the Labor Contract Law from the perspectives of individual analyst behavior and efficiency in the capital market, thereby enriching the literature on labor protection. Furthermore, this paper adds to the literature on the factors influencing analysts' forecasts by exploring the impact of exogenous shocks on analysts' forecast behavior from a legal perspective. In addition, our findings have important practical implications. Through the channel of analysts' forecast behavior, we find that by raising the status of employees as corporate stakeholders, labor protection can regulate corporate information disclosure, reduce information asymmetry and enhance access to information by intermediaries, leading to more efficient pricing in capital markets. This indicates the effectiveness of the Labor Contract Law from a micro analyst forecasting perspective. In addition, analysts should consider not only fundamental information on companies in their forecasts but also macro policies and the market environment. They should evaluate corporate performance in internal and external as well as long-term and short-term dimensions to enhance their forecasts and provide valuable guidance for investors' decision-making. By analyzing evidence surrounding the implementation of China's Labor Contract Law, which emphasizes labor protection, this paper also serves as a reference for analysts' forecast practice and investors' decision-making.

Declaration of Competing Interest

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

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Appendix 1. Major labor protection policies in China

Date	Promulgator	Labor Protection Policy
1950	Central People's Government	Trade Union Law of the People's Republic of China
1950	Ministry of Labor	Regulations on Procedures for the Settlement of Labor Disputes
1951	Government Administration Council	Labor Insurance Regulations of the People's Republic of China
1952	Government Administration Council	Decision on Employment Problem
1954	Government Administration Council	Outline of Internal Labor Rules of State-owned Enterprises
1956	State Council	Decision on Wage Reform
1956	State Council	Employees and Staff Casualty Accident Reporting Regulations
1978	State Council	Notice on the Implementation of the Incentive and Piecework Wage System
1982	State Council	Regulations on the Reward and Penalty for Enterprise
1986	State Council	Regulations on the Staff Congress of Industrial Enterprises under the Ownership of the Whole People
1987	Ministry of Labor	Provisions on Prohibition of Child Labor
1988	State Council	Regulations Concerning the Labor Protection of Female Staff and Workers
1994	National People's Congress Standing Committee	Labor Law of the People's Republic of China
2008	National People's Congress Standing Committee	Law of the People's Republic of China on Labor-dispute Mediation and Arbitration
2008	National People's Congress Standing Committee	Labor Contract Law of the People's Republic of China
2009	National People's Congress Standing Committee	Labor Law of the People's Republic of China (Amended on 27 August 2009)
2010	National People's Congress Standing Committee	Presidential Decree of the People's Republic of China
2012	The State Council	Special Provisions on Labor Protection for Female Employees
2013	National People's Congress Standing Committee	Labor Contract Law of the People's Republic of China (Amended in 2013)
2018	National People's Congress Standing Committee	Labor Law of the People's Republic of China (Amended in 2018)

Appendix 2. Sample selection

Sample selection	No. of observations
Initial sample in 2001–2019 (all Chinese A-share listed companies)	41,951
Excluding firms in the financial sector	1,675
Excluding firms with "special treatment" (ST) status	1,998
Excluding firms with fewer assets than liabilities	130
Excluding firms not covered by analysts	12,365
Excluding samples with missing information on key variables	6,496
Final sample	19,287

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Stock index adjustments and analysts' forecast optimism: A quasi-natural experiment on the CSI 300 Index

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ABSTRACT

As stock index adjustments comprise a basic system of capital market, their potential influence on analysts' earnings forecasts is worthy of research. Based on a research sample of 23 adjustments to the CSI 300 Index from June 2007 to June 2018 and the backup stocks announced during the same period, this study examines the impact of additions to stock index on analysts' forecast optimism using a staggered difference-in-differences model. The research results show that after stocks are added to the stock index, analysts' earnings forecast optimism about these stocks increases significantly. Cross-sectional analysis indicates that this increase is more significant when the market is bullish, institutional ownership is low, the ratio of listed brokerage firms is low, star analyst coverage is low, firms show seasoned equity offering activity, the ratio of analysts from the top five brokerage firms ranked by commission income is high, and the analysts' brokerage firms are shareholders. However, analyst-level tests find that analysts' ability helps to reduce the impact of additions to stock index on earnings forecast optimism. Furthermore, additions to stock index significantly increase analyst coverage and forecast divergence. Economic consequences tests find additions to stock index significantly increases stock price synchronization, which is partly mediated by analysts' earnings forecast optimism. This study enriches the literature on the impact of basic capital market systems and analyst behavior. The findings suggest that investors should rationally evaluate analysts' earnings forecasts for stocks added to the stock index and obtain further information from various channels to improve asset allocation efficiency.

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1. Introduction

Improvements in the capital market system have promoted the rapid development of China's capital market. In the Report on the Work of the Government 2019, Premier Li Keqiang stated that the Chinese government "will reform and improve the basic systems of the capital market to promote the healthy and steady development of multi-tiered capital markets." In recent years, scholars have begun to examine various basic systems of the capital market, such as capital market liberalization and securities margin trading. As the stock market includes large numbers of stocks, stock price fluctuations make it challenging for investors to fully grasp the overall changes in the stock market. Thus, the primary purpose of a stock index is to reflect the changes in the overall stock market or a particular section of it. Examples of stock indexes include S&P 500 Index, Russell 1000 Index, Hang Seng Index, SSE 50 Index, and CSI 300 Index. As a stock index serves as a barometer of the economy and the stock market, the issuer of the index regularly adjusts the constituent stocks in the index to accurately reflect changes in the overall market. These are known as stock index adjustments. Whether the capital market is international or domestic, most stock index adjustment methods are based on liquidity and market capitalization. Stocks with higher liquidity and market capitalization in the previous period are added to the stock index. Each stock index adjustment receives extensive attention from all participants in the capital market. Taking the CSI 300 Index as an example, each adjustment of the CSI 300 Index causes a wide range of reactions in the Chinese capital market. When a firm's stock is added to the index, the firm disseminates this information through an announcement or investor conference. Brokerage firms then make predictions and judgments about the future trends of the added stock, and the media report the stock index adjustment.[1]

As the Chinese capital market ranks among the highest in the world in terms of liquidity and market capitalization, it has gradually established and improved its stock index systems. Simultaneously, financial derivatives have appeared, such as index funds and futures based on stock indexes. Compared with the capital markets in Europe and the U.S., the Chinese economy and stock markets are developing rapidly, leading to frequent and wide-ranging stock index adjustments. Taking the research sample for this study as an example, for the 23 adjustments of the CSI 300 Index from June 2007 to June 2018, the market capitalization of the stocks after each adjustment represents more than 60% of the total market capitalization of A-shares on the Shanghai Stock Exchange (SSE) and Shenzhen Stock Exchange (SZSE). The CSI 300 Index adjusted 531 stocks from 2007 to 2018, and 98 stocks remained constituent stocks throughout that period, giving an adjustment rate of 67.33%.[2]

Market analysts, as participants and information intermediaries in the capital market, have the professional ability to collect, analyze, and process market information. Some studies have found that analysts' earnings forecasts are more accurate than those obtained using time-series models, indicating that analysts' earnings forecasts contain valuable information (O'Brien, 1988). Analysts transmit information to other capital market participants through earnings forecasts and investment suggestions to help alleviate the information asymmetry between external investors and firms (Brown and Rozeff, 1978; Schipper, 1991; Chu and Cang, 2008; Xu et al., 2012). However, other studies have found that analysts tend to be optimistic when making earnings forecasts (McNichols and O'Brien, 1997). There is evidence that cognitive bias (McNichols and O'Brien, 1997), analyst overconfidence (Hilary and Menzly, 2006), commission income (Agrawal and Chen, 2008), brokerage firm stock trading business (Cao and Zhu, 2011), and management preferences (Zhao et al., 2013) contribute to analysts' earnings forecast optimism. This optimism significantly reduces the efficiency of information transmission about firms, causing stock prices to deviate from their real values (Scherbina, 2008). In addition to the aforementioned reasons for optimistic earnings forecasts, scholars have begun to pay attention to the influence of the basic systems of the capital market on analyst optimism. For example, Chu et al. (2019) find that margin trading in China has led to optimism among analysts. As stock index adjustments are an

[1] http://www.cninfo.com.cn/new/disclosure/detail?orgId=gssz0002044&announcementId=1206100214&announcementTime=2019-04-26; http://stock.finance.sina.com.cn/stock/go.php/vReport_Show/kind/search/rptid/626465019660/index.phtml; http://finance.sina.com.cn/stock/marketresearch/2018-12-27/doc-ihqhqcis0638084.shtml.

[2] Further excluding repeatedly added and excluded stocks, just 73 stocks have been constituent stocks since June 2007, and the adjustment rate of the constituent stocks over the past 11 years is as high as 75.67%.

important basic system of the capital market and a key event that generally concerns all market participants, studying the influence of these adjustments on analysts' optimistic earnings forecasts may help to explain analysts' forecast behavior at the capital market level.

Using the CSI 300 Index as the research object, this study examines the impact of additions to stock index on analysts' earnings forecast optimism. Most studies of stock index adjustments have taken the S&P 500 as the research object. However, due to the index adjustment method of the S&P 500, the net effect of stock index adjustments cannot be accurately identified due to endogeneity problems. The CSI 300 Index, co-created by the SSE and SZSE in 2005 and managed by China Securities Index Co., ltd. (CSI), provides a preferable setting for the study of stock index adjustments. Each time the CSI 300 Index is adjusted, the CSI simultaneously announces 15 backup stocks for temporary adjustments, which are chosen by the same stock selection method used for the constituent stocks of the CSI 300 Index. Therefore, there are no systematic differences between the constituent and backup stocks at a given period, and the backup stocks provide a control group for studying the stock index adjustments.

Additions to stock index affect analysts' earnings forecast optimism mainly by influencing the analysts' margin income and cost. As information intermediaries in the capital market, analysts' income are affected by commission income, and their reputation and forecast accuracy also affect their future career development. From the income perspective, retail and institutional investors have a strong need to invest in high-quality constituent stocks. Analysts may release optimistic earnings forecasts to cater to investors, which help increase their commission income and ensure support from institutional investors during the selection of the best analysts by New Fortune.[3] From the cost perspective, newly added stocks are more likely to be held by investors than other stocks. After additions, the external supervision for added stocks improves, which alleviates opportunistic management behavior and improves firm earnings quality. Thus, the analysts' optimistic earnings forecasts are less likely to be wrong, which prevents reputational damage. The empirical results show that compared with backup stocks, stocks that have recently been added to the CSI 300 Index attract increased analyst earnings forecast optimism. Cross-sectional tests show that this impact is more significant when the stock market is bullish, institutional ownership is low, the ratio of listed brokerage firms is low, star analyst coverage is low, firms show seasoned equity offering (SEO) activity, the ratio of analysts from the top five brokerage firms (ranked by commission income) is high, and shareholders include the brokerage firms. Using analyst-level data, this study finds that analysts' ability can help to alleviate the impact of additions to stock index on analysts' earnings forecast optimism; additionally, additions to stock index significantly increase analysts' coverage and divergence. Economic consequences tests find that additions to stock index significantly increase stock synchronization by affecting analysts' optimistic earnings forecasts.

This study makes several contributions to the literature. First, it enriches the understanding of the determinants of analyst' earnings forecast optimism. The ability of analysts to collect and analyze professional information means that they can provide investors with valuable information about firms, thereby improving the pricing efficiency and resource allocation efficiency of the capital market (O'Brien, 1988; Brown and Rozeff, 1978; Schipper, 1991; Chu and Cang, 2008; Xu et al., 2012). However, many studies find that analysts' optimistic earnings forecasts reduce information transmission efficiency, leading to mispricing and lower efficiency in the stock market (Scherbina, 2008). Studies show that cognitive bias (McNichols and O'Brien, 1997), analyst overconfidence (Hilary and Menzly, 2006), commission income (Agrawal and Chen, 2008), stock trading by brokerage firms (Cao and Zhu, 2011), and management preferences (Zhao et al., 2013) result in optimistic analyst earnings forecasts. This study provides a new explanation from the perspective of the basic system of capital market, specifically, that additions to stock index decrease the cost of analysts' earnings forecast optimism and increase their income, thus increasing analysts' earnings forecast optimism.

Second, this study enriches the literature on the economic consequences of the basic capital market system. The rapid development of the Chinese capital market is associated with forming and improving the underlying system. Scholars have conducted extensive empirical studies, mainly from the perspectives of margin trading (Li et al., 2015; Chu and Fang, 2016) and capital market liberalization (Zhong and Lu, 2018; Lian et al., 2019).

[3] New Fortune creates the first and most influential market-oriented analyst ranking in China (https://www.xcf.cn/zhuanti/2021/fxs/index.html).

Although stock index adjustments have received extensive attention from several participants in the capital market, there is little related research on it. This study provides evidence of the economic consequences of the basic capital market system by analyzing the impact of stock index adjustments on analysts' earnings forecasts.

Third, this study enriches the research on the economic consequences of stock index adjustments. After a stock index adjustment, index funds adjust their asset portfolios according to the constituent stocks. Retail and other institutional investors pay greater attention to newly added stocks, and earnings forecasts issued by analysts influence investors' asset allocations. Studying the impact of stock index adjustments on analysts' earnings forecast optimism can help to better understand the impact of stock index adjustments on analyst behavior and provide further evidence on information content and the economic consequences of stock index adjustments. It can also help investors to realize that after stock index adjustments, analysts' earnings forecasts for the adjusted stocks should be rationally evaluated.

Fourth, in the research design, the unique presence of backup stock during Chinese stock index adjustments provides control groups to construct a staggered difference-in-differences model to alleviate the endogeneity problems of prior studies and more accurately identify causality. Most studies of stock index adjustments use the S&P 500 and other indexes as research objects. Due to the lack of suitable control groups, there may be endogeneity issues due to omitted variables or causal inversion. By setting the industry, year, and firm fixed effects and using backup stocks as control groups, this study helps to alleviate the abovementioned endogeneity issues and improve the reliability of the findings.

2. Background, literature review, and hypothesis development

2.1. Background

Stock indexes can be traced back to the Dow Jones Industrial Average compiled by Charles Dow in 1884. Subsequently, the development of the capital market in the 20th century further promoted the compilation and application of stock indexes. Indexes such as the S&P 500 Index, NASDAQ Composite Index, FTSE 100 Index, Nikkei 225 Index, DAX Index, CAC 40 Index, and Hang Seng Index have gradually increased in number. These stock indexes provide investors with information about dynamic changes in the global capital market, and simultaneously promote the development of financial derivatives such as funds and futures that are based on these indexes.

Compared to the stock markets in developed countries, the Chinese capital market was established relatively late, and the Chinese stock index is rapidly developing and improving. After the establishment of the SSE and SZSE, the Shanghai Composite Index and Shenzhen Component Index became China's first two stock indexes. With the development and expansion of the stock market, however, these stock indexes no longer met investors' needs. In 2005, therefore, the SSE and SZSE co-established CSI, China's first financial service firm specializing in index compilation and index derivative product development. The establishment of CSI provided a foundation for the systematic development of indexes in China. In addition to indexes reflecting the overall market, CSI has compiled a series of indexes based on scale, industry, theme, strategy, and debt and fund markets.

The CSI 300 is the most representative of the Chinese stock indexes. It was co-created by the SSE and SZSE in April 2005, and has been managed by CSI since September 2005. The CSI 300 Index comprises the 300 stocks with the greatest liquidity and market capitalization on the SSE and SZSE. Thus, the CSI 300 represents both Chinese stock exchanges, and its high-quality constituent stocks attract many investors, in turn reflecting the overall status of Chinese mainstream investors.

According to the Rules for Compilation of the CSI 300 Index, management of the CSI 300 Index involves three main processes: sample selection, stock index adjustment, and backup stock selection. The sample selection process requires CSI to first determine the sample space from all A-share firms on the SSE and SZSE.[4] Subsequently, 300 stocks are selected from the sample space based on the stock liquidity and market capital-

[4] The stocks in the sample space must meet certain criteria, such as non-*GEM* stocks that have been listed for more than one quarter or *GEM* stocks that have been listed for more than three years, and these stocks cannot have ST, *ST, or suspension of listing.

ization ranking of the firms.[5] Due to the dynamic nature of the stock market, CSI updates the index biannually in June and December[6] to ensure that it remains representative of the stock market, similar to the S&P 500 Index. The adjustment process in June is mainly based on stock liquidity and market capitalization from May 1 of the previous year to April 30 of the adjustment year, and the process in December is mainly based on stock liquidity and market capitalization from November 1 of the previous year to October 31 of the adjustment year.

The stock index adjustment process is consistent with the sample selection method. Thus, in each adjustment, firms with average daily trading volumes in the top 50% are first identified, after which the top 300 firms are selected based on their average daily market capitalization ranking. As the constituent stocks are often subject to special events,[7] CSI creates a backup stock list to prevent such events from influencing the representativeness of the CSI 300 and to ensure the transparency and predictability of temporary adjustments. Specifically, CSI selects the firms ranked 301 to 315 based on their average daily market capitalization as backup stocks in the same adjustment. When there is a need to adjust the CSI 300 temporarily due to delisting, M&A, or other reasons, these backup stocks are used as substitutes. According to this method, the backup stocks for each adjustment differ slightly from the constituent stocks in terms of average daily market capitalization. Therefore, it is challenging for a firm selected as a constituent stock to predict whether its stock will be selected the following year. Simultaneously, as the CSI 300 Index is ranked according to the average daily market capitalization for the entire year, it is also challenging for firms to manage market capitalization purposefully. Therefore, constituent stocks and backup stocks are mainly selected randomly.

Nevertheless, the CSI 300 Index, a stock index reflecting the overall trend of the SSE and SZSE, represents the high-quality assets of Chinese listed firms and attracts widespread attention from investors. Furthermore, compared with other stock index adjustment methods, the unique backup stock method of the CSI 300 Index provides a setting that alleviates endogeneity problems and improves the reliability of empirical results.

2.2. Literature review

The literature on stock index adjustments is focused mainly in two areas: the "index effect" and its causes, and the economic consequences of stock index adjustments. Harris and Gurel (1986) and Shleifer (1986) are the first to study the index effect. They find that there are significantly positive abnormal returns and larger trading volumes for stocks added to stock index. The "price pressure hypothesis" of Harris and Gurel (1986) ascribes this index effect to rapid changes in the investment portfolios of index funds, which in turn create large stock trading volumes and a resulting short-term imbalance between supply and demand, leading to changes in stock returns. Shleifer (1986) proposes that imperfect substitutability among stocks lead to a downward demand curve slope leading to stock price changes, called the "incomplete substitution hypothesis." The difference between these two hypotheses is that the price pressure hypothesis predicts that stock price increases caused by stock index adjustments will decrease, whereas the incomplete substitution hypothesis predicts that the stock price changes after the adjustments will be long-lasting. Pruitt and Wei (1989) test the changes in institutional ownership when stocks were added to and deleted from the S&P 500 index, and find that changes in institutional ownership are related to changes in stock prices. Beneish and Whaley (1996) and Lynch and Mendenhall (1997) examine the index effect of the S&P 500 index and find that stock prices and trading volumes increase significantly during the lag period between the date an index adjustment is announced and the date of its implementation. Hegde and McDermott (2003) find a significant decrease in the transaction cost of adjusted stocks, thus improving liquidity and ultimately increasing abnormal stock returns, called the "liquidity hypothesis". All of these studies indicate that stock index adjustments do not con-

[5] The specific rules are: first, in the sample space, rank the stocks by the average daily trading volume for the entire past year and remove the bottom 50% of stocks; next, rank the remaining stocks by the average daily market capitalization and select the top 300 stocks; finally, the CSI also considers the firm's operating conditions, violations, earnings quality, stock price fluctuations, and manipulation.

[6] The implementation dates prior to December 2013 were the first trading day of July each year and the first trading day of January in the following year. After December 2013 the implementation dates were changed to the next trading day after the second Friday in June or December.

[7] Such events include IPOs by other firms, mergers and acquisitions, suspension of listing or delisting, and bankruptcy or risk warnings.

tain new information. In contrast, Dhillon and Johnson (1991) suggest that stocks added to the index receive more attention from analysts and institutional investors. They test the index effect of adjusted stocks and their effect on stock options and debt, finding that stock index adjustments are informative events. The "performance improvement hypothesis" of Denis et al. (2003) proposes that the future performance of added firms increase significantly, leading in turn to higher stock returns. Chen et al. (2004) find an asymmetric change in the returns of added versus deleted stocks, such that the price increase of added stocks is permanent, whereas the price decline of deleted stocks is not. They ascribe this phenomenon to the asymmetry of investor attention, known as the "investor attention hypothesis." There is no consensus on these five hypotheses in the literature (Elliott et al., 2006; Cai, 2007; Mase, 2007; Chan et al., 2013).

In addition to research on the index effect and its causes, other scholars have focused on the economic consequences of stock index adjustments. Becker-Blease and Paul (2006) regard adjustments to the S&P 500 as an exogenous shock to stock liquidity. They find that firm investment opportunities and expenditure increase significantly after their stock is added to the S&P 500. Baran and King (2012) further test the impact of additions to stock index on the cost of equity capital. They find that increased stock liquidity and investor attention are the main reasons for the decrease in the equity capital cost of added stocks. Additionally, after a stock is added to the index, supervision from external investors and the media improves corporate governance and encourages management to disclose higher quality earnings information (Platikanova, 2008). However, Chattopadhyay et al. (2020) argue that to improve a firm's reputation, management will increase earnings to promote the firms' addition to the stock index. In addition to management behavior, scholars have studied the impact of additions to stock index on cash holdings and financing constraints (Brisker et al., 2013; Liang et al., 2020). Regarding stock market efficiency, Ye et al. (2018) examine the impact of additions to the CSI 300 Index on stock crash risk. They find that additions to stock index significantly increase the crash risk and reduce stock market efficiency.

It is clear that the literature remains undecided on whether stock index adjustments contain information, and research on the economic consequences of stock index adjustments is gradually increasing. Compared with the capital markets of developed countries, the rapid establishment of stock index in the Chinese capital market and the unique stock index adjustment method provide an ideal background for the study of stock index adjustments.

2.3. Hypothesis development

When analysts make earnings forecasts, optimistic forecasts increase investor trading volumes in the short term, thereby increasing the analysts' commission income (Fang and Yasuda, 2009). However, analysts' long-term career development is directly affected by their reputation (Li et al., 2017). Blindly forecasting optimistic earnings can damage analysts' reputations, cause them to lose investor's trust, and affect their careers (Chu and Fang, 2016; Chu et al., 2019). Therefore, analysts must weigh their commission income and reputation cost when forecasting. In this study, we argue that additions to stock index affect the optimistic bias of analysts' earnings forecasts from two perspectives.

First, issuing optimistic earnings forecasts for firms added to the stock index increase analysts' income. In China, most analysts are employed by brokerage firms. When forecasting firms' future earnings, there is a conflict of interest with the other business of brokerage firms, which impairs the analysts' independence; thus, they tend to issue more optimistic forecast earnings (Cao and Zhu, 2011; Li et al., 2016). Specifically, analysts' commission income is an important part of their compensation (Xu et al., 2012). Studies have shown that analysts can increase investor trading volumes by issuing optimistic earnings forecasts (Irvine, 2004; Jackson, 2005), thereby increasing their commission income (Ljungqvist et al., 2007). According to the CSI 300 Index adjustment method, addition of a stock to the index is based on the firm's market capitalization and liquidity over the previous year. By adding these stocks to the index, the index compiler plays a "certification role" for these stocks (Baran and King, 2012) and helps investors identify high-quality stocks (Cai, 2007). After additions, optimistic earnings forecasts issued by analysts are in line with the general perceptions of mainstream investors, which can encourage more investors to trade, thereby increasing the analysts' commission income. In addition to analysts' consideration of their commission, institutional investors, as the main clients of brokerage firms, also influence the independence of analysts by prompting them to issue optimistic earnings

forecasts to maintain or even increase stock prices. Lin and McNichols (1998) found that institutional investors are the most important source of income for brokerage firms. To meet the needs of institutional investors and obtain more commission income, brokerage firms exert pressure on analysts' earnings forecasting. A major factor influencing the promotion of analysts is the selection of the best analysts by New Fortune. Once selected as star analysts, their income and reputation increase significantly (Stickel, 1992). However, this selection process is determined mainly by institutional investors. After stocks are added to the index, institutional investors, such as index funds, will gradually buy these stocks (Zhu et al., 2017). By hiding adverse news, analysts release more optimistic earnings forecasts, which caters to the needs of institutional investors, as they increase their holdings of the stock. At the same time, optimistic earnings forecasts help to prevent the prices of stocks held by institutional investors from falling, and eventually guarantee the interests of institutional investors. Therefore, analysts can promote stock trading and increase their commission income by issuing optimistic earnings forecasts for added stock.

Second, additions to stock index reduce analysts' cost of issuing optimistic earnings forecasts. Analysts' reputations directly determine their influence on the capital market. Fang and Yasuda (2009) found that analysts' optimism can help increase commission income in the short term. Simultaneously, it can cause investors to lose trust in analysts' future forecasts, affecting long-term career development. However, for stocks that have been added to the stock index, analysts are less likely to be wrong when issuing optimistic earnings forecasts, and may thus suffer less reputational damage. According to relevant research on stock index adjustments, after stocks are added to the stock index, investor attention and external supervision improve significantly (Chen et al., 2004), helping to curb opportunistic management behavior (Platikanova, 2008), lower financing costs (Baran and King, 2012), and improve firms' future performance (Denis et al., 2003). Analysts are therefore less likely to err when issuing optimistic earnings forecasts for newly added stocks. Compared with other stocks, their rankings based on liquidity and market capitalization will have received extensive attention from the market before the adjustment. In addition to index funds that quickly adjust their portfolios, other institutional investors will also buy stocks that have been added to the index (Pruitt and Wei, 1989; Zhu et al., 2017). Therefore, analysts who release optimistic earnings forecasts align with the need of institutional investors to increase their stock holdings and raise stock prices (Chu et al., 2019). Even if there is a forecast deviation, the adverse effects are still limited to selecting the best analysts for New Fortune. Consequently, even if analysts wrongly issue optimistic earnings forecasts for added stocks, they may suffer less reputational damage. Based on the above analysis, our hypothesis is as follows:

Hypothesis. After a stock is added to the stock index, optimistic analyst earnings forecasts for the stock increase significantly.

3. Research design

3.1. Model specification and variable definitions

Because the CSI 300 Index is adjusted biannually, this study follows the model of Bertrand and Mullainathan (2003) and Beck et al. (2010). The following staggered difference-in-differences model is constructed to test the hypothesis:

$$Optimism_{i,t} = \beta_0 + \beta_1 Treat_{i,t} \times Post_{i,t} + \Sigma Controls + \Sigma Year + \Sigma Industry + \delta_i + \varepsilon_{it} \quad (1)$$

The dependent variable *Optimism* in Model (1) is analysts' optimistic earnings forecasts calculated using the following formula:

$$Optimism = (Mean(Feps) - Meps)/\mathrm{Price} \quad (2)$$

Mean(Feps) is the mean value of all analysts' earnings forecasts, *Meps* is the actual earnings per share, and *Price* is the stock price at the beginning of the year. In this study, we only consider the first time the stock is added to the stock index. Additionally, CSI adjusts its CSI 300 Index in June and December each year; therefore, the adjustment in June is the adjustment for the current year, and the adjustment in December is the

adjustment for the following year. *Treat* is a dummy variable equal to 1 if the firm has been selected as a constituent stock during the sample period, and 0 otherwise; *Post* is a dummy variable equal to 1 if the firm is added to the CSI 300 Index, and 0 otherwise.

Controls denotes the control variables (see Table 1 for a specific definition). Model (1) controls for the year fixed effect (*Year*), industry fixed effect (*Industry*), and firm fixed effect (δ_i). To avoid the influence of extreme values in this study, we winsorize all continuous variables at the 1% level. This study focuses on the coefficient β_1 in Model (1). If β_1 is significantly positive, the hypothesis is verified. Table 1 presents the definitions and descriptions of the variables.

3.2. Data sources and sample selection

This study has the CSI 300 Index as the research object. Compared with the SZSE Component Index, SSE 50 Index, SME Board Index, ChiNext Index, and other indexes that reflect only a single stock market, the CSI 300 covers stocks listed on the SSE and the SZSE. In addition, the CSI 300 Index is ranked by market capitalization in terms of influence. Therefore, compared with the CSI 500 and other indexes, the total market capitalization of the CSI 300 Index is the largest, and adjustments to the CSI 300 have the greatest impact on the capital market. Because new accounting standards were implemented in China in 2007, the sample period for this study is from 2007 to 2018. During this period, the CSI 300 Index was adjusted 24 times. To test the impact of stock index adjustments on analyst behavior, the adjustment in December 2018 was removed, leaving 23 adjustments during the sample period and 4429 firm-year observations. The screening process for the samples is shown in Table 2.

4. Empirical results

4.1. Descriptive statistics and univariate tests

Table 3 Panel A shows the descriptive statistics of the variables. The mean of analysts' optimistic earnings forecasts (*Optimism*) is 0.013 and the standard deviation is 0.050; the mean of the interaction (*Treat* × *Post*) is 0.559, indicating that the proportion of the samples affected by adjustments is 55.9%.

Univariate tests of the variables are shown in Table 3 Panel B, including mean comparisons between constituent stocks before and after adjustments, between constituent stocks and backup stocks before adjustments, and between analysts' optimistic earnings forecasts under different windows. The comparisons between constituent stocks before and after adjustments show that the mean of analysts' optimistic earnings forecasts is significantly larger at the 1% level after adjustments than before adjustments, and there are significant differences in firm size(*Size*), leverage(*Lev*), return on assets(*Roa*), independent director ratio(*Indep*), ownership concentration(*Top*), sales growth rate(*Growth*), market to book ratio(*MB*), operating cash flow (*Cfo*), Big 4 audit firm(*Big4*), audit opinion(*Opinion*). Comparisons between constituent and backup stocks before adjustments show significant differences in firm size (*Size*), return on assets (*Roa*), and the independent director ratio (*Indep*) at the 1%, 10%, and 5% levels, respectively, while most other variables show no significant differences. Therefore, backup stocks are a suitable control group for constituent stocks and can be used in a difference-in-differences model. Additionally, the above variables are controlled in Model (1), and the firm fixed effect is also controlled to alleviate the endogeneity problems caused by omitted variables. By comparing analysts' optimistic earnings forecasts under different windows, it is evident that analysts' earnings forecast optimism increases significantly for the year after the stock was added to the index compared with that of the previous year.

4.2. Main regression results

Table 4 shows the regression results for Model (1). Columns (1) and (2) show the regression results before and after adding the control variables, respectively. In column (1), the coefficient of interaction (*Treat* × *Post*) is significantly positive at the 1% level, indicating a significant increase in analysts' earnings forecast optimism for a stock after its addition to the stock index. In column (2), the coefficients for return

Table 1
Definition of the variables.

Type	Name	Symbol	Definition
Dependent Variable	Optimism	*Optimism*	Ratio of the difference between the mean of analysts' earnings forecasts and actual earnings per share to the stock price at the beginning of year *t*
Independent Variables	Constituent stock	*Treat*	Dummy variable that equals 1 if the firm is selected as a constituent stock during the sample period, and 0 otherwise
	Stock index adjustment	*Post*	Dummy variable that equals 1 if the firm is added to the CSI 300 Index, and 0 otherwise
	Difference-in-differences variable	*Treat* × *Post*	Interaction between *Post* and *Treat*
Control Variables	Firm size	*Size*	Log (Total assets)
	Leverage	*Lev*	Total debt/Total assets
	Return on assets	*Roa*	Profit/Total assets
	Board size	*Board*	Log (Total number of board members)
	Independent director ratio	*Indep*	Total number of independent directors/Total number of board members
	Ownership concentration	*Top*	Shareholding ratio of the largest shareholder
	Sales growth rate	*Growth*	Ratio of the difference between the revenues of years *t* and *t-1* to total revenue at year/t
	Market to book ratio	*MB*	Ratio of market capitalization of equity to book value
	Operating cash flow	*Cfo*	Operating cash flow/total assets
	Big 4 audit firm	*Big4*	Dummy variable that equals 1 if the auditor is from the *Big4*, and 0 otherwise
	Audit opinion	*Opinion*	Dummy variable that equals 1 if the annual report is issued by an auditor with an unqualified opinion, and 0 otherwise

Table 2
Sample selection process.

	Constituent stock	Backup stock	All
Begin	531	345	876
Exclude stocks that have been in the CSI 300 for less than 6 months	3	0	3
Exclude stocks added to the CSI 300 index more than once	77	127	204
Exclude backup stocks selected as constituent stocks	0	128	128
Exclude financial industry	34	1	35
Exclude ST or *ST stocks	1	0	1
Exclude observations with missing data	12	0	12
End	404	89	493
Firm-year observations	3638	791	4429

on assets (*Roa*) and sales growth rate (*Growth*) are significantly negative at the 1% level, and the coefficient of the market to book ratio (*MB*) is significantly positive at the 1% level. These results are consistent with those of Chu et al. (2019), Li et al. (2016), and Wang and Ran (2019). The coefficient of interaction (*Treat* × *Post*) is still significantly positive at the 1% level, indicating that, after controlling for other variables, analysts' earnings forecast optimism increases significantly after a stock is added to the stock index, verifying the hypothesis.

4.3. Robustness tests

4.3.1. Common trend assumption

To test whether constituent stocks and backup stocks satisfy the common trend assumption before stock index adjustments, we construct a dynamic model based on Bertrand and Mullainathan (2003). For Model (1) to satisfy the common trend assumption, compared with backup stocks, the effect of additions to stock

Table 3
Descriptive statistics and univariate tests.

Panel A: Descriptive Statistics

Variable	N	Mean	SD	Min	p25	p50	p75	Max
Optimism	4429	0.013	0.050	−0.167	−0.005	0.007	0.026	0.238
Treat × Post	4429	0.559	0.497	0	0	1	1	1
Size	4429	23.17	1.340	19.75	22.28	23.11	23.95	26.81
Lev	4429	0.475	0.203	0.047	0.322	0.484	0.633	0.892
Roa	4429	0.056	0.057	−0.157	0.022	0.047	0.083	0.231
Board	4429	2.206	0.211	1.609	2.079	2.197	2.398	2.708
Indep	4429	0.375	0.058	0.286	0.333	0.357	0.417	0.571
Top	4429	0.413	0.173	0.0650	0.271	0.409	0.544	0.891
Growth	4429	0.229	0.435	−0.529	0.016	0.149	0.322	2.789
MB	4429	1.991	1.993	0.136	0.613	1.348	2.589	10.49
Cfo	4429	0.073	0.098	−0.218	0.020	0.067	0.120	0.422
Big4	4429	0.156	0.363	0	0	0	0	1
Opinion	4429	0.986	0.117	0	1	1	1	1

Panel B: Univariate Tests

Mean comparisons between constituent stocks before and after adjustment

Variable	After adjustments	Mean	Before adjustments	Mean	MeanDiff
Optimism	2476	0.018	1162	0.002	0.016***
Size	2476	23.71	1162	22.42	1.289***
Lev	2476	0.492	1162	0.444	0.048***
Roa	2476	0.052	1162	0.065	−0.014***
Board	2476	2.213	1162	2.210	0.003
Indep	2476	0.381	1162	0.367	0.013***
Top	2476	0.423	1162	0.402	0.021***
Growth	2476	0.163	1162	0.365	−0.202***
MB	2476	1.657	1162	2.708	−1.051***
Cfo	2476	0.068	1162	0.088	−0.020***
Big4	2476	0.206	1162	0.106	0.101***
Opinion	2476	0.985	1162	0.992	−0.008*

Mean comparisons of constituent and backup stocks before the adjustments

Variable	Constituent stocks	Mean	Backup stocks	Mean	MeanDiff
Optimism	1162	0.002	302	0.002	0
Size	1162	22.42	302	22.10	0.320***
Lev	1162	0.444	302	0.447	−0.004
Roa	1162	0.065	302	0.072	−0.007*
Board	1162	2.210	302	2.189	0.021
Indep	1162	0.367	302	0.360	0.007**
Top	1162	0.402	302	0.407	−0.005
Growth	1162	0.365	302	0.373	−0.008
MB	1162	2.708	302	2.748	−0.040
Cfo	1162	0.088	302	0.084	0.004
Big4	1162	0.106	302	0.093	0.013
Opinion	1162	0.992	302	0.997	−0.004

Mean comparisons of analysts' earnings forecast optimism under different windows

Windows	−1	0	1	2	3	4	5
Mean	−0.016	0.004	0.019	0.020	0.021	0.029	0.028
Diff		0.020***	0.034***	0.035***	0.037***	0.045***	0.043***

index on analysts' optimistic earnings forecasts can only exist after adjustments and cannot be observed before adjustments. Based on this logic, we construct six dummy variables. *Pre2* is a dummy variable that equals 1 for the second year before adjustments, and 0 otherwise. *Pre1* is a dummy variable that equals 1 for the first year before adjustments, and 0 otherwise. *Current* is a dummy variable that equals 1 for the year the adjustments

Table 4
Stock index adjustments and analysts' earnings forecast optimism.

	(1)	(2)
DepVar=	*Optimism*	*Optimism*
Treat* × *Post	***0.018******	***0.013******
	(6.21)	***(5.28)***
Size		−0.001
		(−0.60)
Lev		−0.010
		(−1.00)
Roa		−0.591***
		(−18.44)
Board		−0.007
		(−1.01)
Indep		0.004
		(0.18)
Top		−0.005
		(−0.41)
Growth		−0.021***
		(−10.29)
MB		0.002***
		(3.03)
Cfo		−0.020*
		(−1.92)
BIG4		0.003
		(0.72)
Opinion		−0.034***
		(−3.17)
Cons	−0.050*	0.089
	(−1.85)	(1.60)
Industry FE	Yes	Yes
Year FE	Yes	Yes
Firm FE	Yes	Yes
Observations	4429	4429
R-squared	0.11	0.48

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

took effect, and 0 otherwise. *Post1* is a dummy variable that equals 1 for the first year after adjustments, and 0 otherwise. *Post2* is a dummy variable that equals 1 for the second year after adjustments, and 0 otherwise. *Post2more* is a dummy variable that equals 1 for the third year and subsequent years after adjustments, and 0 otherwise. We interact these six dummy variables with *Treat* and replace *Treat* × *Post* in Model (1) for the regression. The regression results are shown in column (1) of Table 5. The coefficients of *Treat* × *Pre2* and *Treat* × *Pre1* are insignificant, indicating that the constituent stocks and the backup stocks satisfy the common trend assumption, and the coefficients of *Treat* × *Post0*, *Treat* × *Post1*, *Treat* × *Post2*, and *Treat* × *Post2more* are all significantly positive at the 1% level, indicating a significant increase in analysts' earnings forecast optimism after additions to stock index.

4.3.2. Placebo test

Following Wang and Liu (2019), we also conduct a placebo test. We randomly change the adjustment time of the constituent stocks and then use Model (1) to obtain the estimated coefficient of *Treat* × *Post* and P-value. We repeat this process 500 times to obtain 500 estimated coefficients and P-values, and show their distribution in Fig. 1. The mean of the 500 estimated coefficients is 0.0000389. All of the estimated coefficients are lower than those of the regression results in Table 4, indicating that Model (1) has no obvious omitted variable issue.

Table 5
Robustness test: Part one.

	(1)	(2)	(3)	(4)
DepVar=	*Optimism*	*Optimism*	*Optimism*	*Optimism*
Treat × Post		***0.015******	***0.015******	***0.012******
		(6.05)	***(3.60)***	***(4.85)***
Treat × Pre2	***−0.005***			
	(−1.57)			
Treat × Pre1	***−0.002***			
	(−0.67)			
Treat × current	***0.007******			
	(2.59)			
Treat × Post1	***0.013******			
	(4.41)			
Treat × Post2	***0.016******			
	(4.88)			
Treat × Post2more	***0.014******			
	(3.86)			
Size	−0.001	0.000	−0.005*	−0.002
	(−0.46)	(0.05)	(−1.72)	(−0.75)
Lev	−0.010	−0.017**	0.031**	−0.009
	(−1.57)	(−2.03)	(2.26)	(−0.94)
Roa	−0.590***	−0.610***	−0.600***	−0.593***
	(−35.84)	(−22.91)	(−13.70)	(−18.48)
Board	−0.007	0.002	−0.000	−0.008
	(−1.30)	(0.38)	(−0.05)	(−1.13)
Indep	0.004	0.006	0.056*	0.003
	(0.25)	(0.30)	(1.95)	(0.15)
Top	−0.004	−0.009	−0.042*	−0.002
	(−0.46)	(−0.84)	(−1.91)	(−0.21)
Growth	−0.021***	−0.018***	−0.018***	−0.021***
	(−14.99)	(−9.98)	(−7.38)	(−10.17)
MB	0.002***	0.002***	0.002**	0.002***
	(4.43)	(3.74)	(2.56)	(3.08)
Cfo	−0.019***	−0.016**	−0.026*	−0.019*
	(−2.63)	(−2.00)	(−1.82)	(−1.82)
BIG4	0.003	−0.000	−0.005	0.004
	(0.87)	(−0.08)	(−0.79)	(0.84)
Opinion	−0.033***	−0.017**	−0.033**	−0.035***
	(−6.48)	(−2.05)	(−2.48)	(−3.23)
RZRQ				0.006***
				(2.77)
Cons	0.073*	−0.004	0.136*	0.096*
	(1.74)	(−0.09)	(1.80)	(1.74)
Industry FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Observations	4429	4731	2174	4429
R-squared	0.48	0.49	0.55	0.48

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

4.3.3. The propensity score matching (PSM) method

To further alleviate possible endogeneity problems, this study uses the PSM method to match adjusted stocks and then applies the Model (1) regression. In addition to the control variables in Model (1), we add stock market capitalization, stock turnover, and a dummy variable indicating that whether the registered address is in Beijing, Tianjin, Chongqing, Shanghai, or Shenzhen as control variables. We use a logit model to obtain the propensity score and use one-to-one nearest neighbor matching to obtain the control group. The

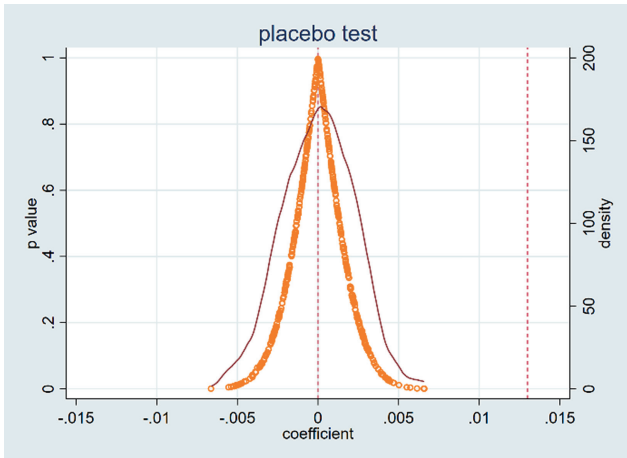

Fig. 1. Placebo test.

result is shown in column (2) of Table 5. It can be seen that the coefficient of interaction (*Treat* × *Post*) is significantly positive at the 1% level.

4.3.4. Excluding the effects of margin trading and short selling

China began to implement margin trading and short selling (RZRQ) in 2010. There is a certain connection between the constituent stocks of the CSI 300 Index and the stocks of margin trading and short selling. Therefore, to exclude the effect of margin trading and short selling, this study uses the following method. First, we exclude the firm-year observations with a margin balance in the sample period. The regression result is shown in column (3) of Table 5. Second, we construct a dummy variable, *RZRQ*, which equals 1 if there is a margin balance, and 0 otherwise. The regression result is shown in column (4) of Table 5. Both coefficients of interaction (*Treat* × *Post*) are significantly positive at the 1% level and the coefficient of *RZRQ* is significantly positive at the 1% level, which is consistent with Chu et al. (2019).

4.3.5. Other robustness tests

In addition, we conduct the following robustness tests. First, because some analysts may stop following stocks, we recalculate the analysts' optimistic earnings forecasts by removing the forecasts if the period between the last earnings forecast date and the actual financial report disclosure date is longer than 180 days or 90 days. The regression results are shown in columns (1) and (2), respectively, of Table 6. Second, we use net assets per share instead of the stock price in formula (2) to generate *Optimism1*, the median of all analysts' most recent earnings forecasts as the numerator in formula (2) to generate *Optimism2*, and the proportion of analysts who released optimistic earnings forecasts to generate *Optimism3*. The regression results are shown in columns (3), (4) and (5), respectively, of Table 6. Third, because the sample period is from 2007 to 2018, some stocks were already constituent stocks in 2007. To ensure that all stocks have pre-adjustment observations, we reset the sample period from 2005 to 2018. The regression result is shown in column (6) of Table 6. Fourth, we use the control variables lagged by one period, and the regression results are shown in column (7) of Table 6.

5. Further tests

5.1. Cross-sectional tests

According to the above logic, additions to stock index affect analysts' earnings forecast optimism by affecting their compensation and reputational cost. From the perspective of compensation, after additions to stock index, analysts are more likely to increase their commission income by releasing optimistic earnings forecasts for the stock; from the perspective of cost, additions to stock index reduce the probability and reputational

Table 6
Robustness test: Part two.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
DepVar=	*Optimism*	*Optimism*	*Optimism1*	*Optimism2*	*Optimism3*	*Optimism*	*Optimism*
Treat × Post	***0.014******	***0.011******	***0.055******	***0.016******	***0.141******	***0.013******	***0.010******
	(3.71)	***(2.74)***	***(5.15)***	***(3.95)***	***(6.42)***	***(5.21)***	***(3.42)***
Size	−0.019***	−0.014***	−0.044***	−0.015***	−0.003	−0.001	0.020***
	(−3.78)	(−2.77)	(−2.71)	(−2.68)	(−0.17)	(−0.47)	(6.35)
Lev	0.017	0.023**	−0.026	0.006	−0.171**	−0.012	−0.055***
	(1.25)	(1.97)	(−0.43)	(0.36)	(−2.45)	(−1.19)	(−4.72)
Roa	−0.225***	−0.138***	−0.703***	−0.683***	−3.000***	−0.597***	−0.064**
	(−5.52)	(−4.40)	(−5.68)	(−11.44)	(−16.51)	(−18.60)	(−2.29)
Board	−0.001	−0.004	0.002	−0.015	−0.025	−0.007	−0.009
	(−0.05)	(−0.32)	(0.06)	(−1.12)	(−0.44)	(−0.92)	(−0.85)
Indep	−0.022	0.020	−0.053	−0.051	−0.066	0.009	−0.006
	(−0.60)	(0.85)	(−0.74)	(−0.99)	(−0.37)	(0.46)	(−0.23)
Top	−0.019	−0.035*	−0.093	0.001	0.022	0.002	0.024
	(−0.96)	(−1.84)	(−1.02)	(0.04)	(0.22)	(0.20)	(1.27)
Growth	−0.031***	−0.033***	−0.103***	−0.034***	−0.169***	−0.022***	−0.011***
	(−4.79)	(−4.49)	(−4.49)	(−5.82)	(−12.40)	(−10.55)	(−5.78)
MB	−0.000	0.001	−0.008	0.001	−0.012***	0.002***	−0.004***
	(−0.00)	(1.51)	(−1.41)	(0.52)	(−2.65)	(2.96)	(−5.07)
Cfo	−0.022	−0.018	−0.229***	−0.018	−0.371***	−0.021**	−0.052***
	(−0.88)	(−0.56)	(−2.88)	(−0.73)	(−5.92)	(−2.07)	(−5.02)
BIG4	0.002	−0.008	−0.022	0.000	0.064	0.004	0.002
	(0.20)	(−0.72)	(−0.71)	(0.03)	(1.51)	(0.86)	(0.33)
Opinion	−0.018*	−0.015	−0.081**	−0.057***	0.042	−0.033***	−0.059***
	(−1.72)	(−1.56)	(−2.07)	(−3.02)	(1.03)	(−3.19)	(−3.08)
Cons	0.484***	0.365***	1.219***	0.460***	0.810*	0.081	−0.323***
	(3.73)	(2.61)	(3.05)	(3.26)	(1.70)	(1.56)	(−3.85)
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3781	2762	4429	4429	4429	4586	3876
R-squared	0.23	0.23	0.27	0.37	0.38	0.48	0.18

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

cost of analysts' forecast errors, motivating analysts to release optimistic forecasts. To further support this theoretical logic, this study examines whether the effects of additions to stock index differ under various circumstances, specifically from the perspective of the market situation, institutional ownership, the ratio of listed brokerage firms, star analyst coverage, SEO activity, the ratio of analysts from the top five brokerage firms ranked by commission income, and shareholding by brokerage firms.

5.1.1. Market situation

According to the stock index adjustment method of the CSI 300 Index, the constituent stocks added to the index are stocks with larger market capitalization and higher liquidity, and thus receive more investor attention. Therefore, issuing optimistic earnings forecasts aligns with the investment direction and cognition of most investors. Depending on the situation in the stock market, there are significant differences in investor sentiment. When the stock market is bullish, investment sentiment is high and investors are more motivated to invest in stocks added to the stock index. Analysts issue optimistic earnings forecasts and suffer less reputational damage when stock prices fall. Furthermore, analysts are more likely to stimulate investors to trade and increase their commission income by issuing optimistic earnings forecasts. However, when the stock market is bearish, investor sentiment is depressed, and analysts who issue optimistic earnings forecasts may suffer greater reputational damage and lower commission income. Therefore, additions to stock index have a greater impact on analysts' earnings forecast optimism when the market is bullish.

Table 7
Cross-sectional test: Market situation.

	(1)	(2)	(3)	(4)	(5)
DepVar=	*Optimism*	*Optimism*	*Optimism*	*Optimism*	*Optimism*
	Bear	Bull	Bear	Bull	Full sample
Treat × Post	***0.009******	***0.017******	***0.011******	***0.017******	***0.012******
	(4.34)	***(5.46)***	***(3.79)***	***(2.92)***	***(5.59)***
Treat × Post × Bull					***0.005****
					(2.11)
Bull					−0.012***
					(−2.75)
Size	−0.005***	−0.005***	−0.001	−0.002	−0.001
	(−5.08)	(−2.63)	(−0.24)	(−0.42)	(−0.85)
Lev	−0.014**	−0.014	−0.019*	−0.006	−0.010
	(−2.13)	(−1.32)	(−1.67)	(−0.26)	(−1.50)
Roa	−0.443***	−0.512***	−0.552***	−0.677***	−0.592***
	(−13.77)	(−10.19)	(−15.74)	(−9.27)	(−35.99)
Board	0.001	−0.012*	−0.010	−0.012	−0.007
	(0.24)	(−1.75)	(−1.10)	(−0.80)	(−1.28)
Indep	−0.002	−0.010	−0.004	0.011	0.005
	(−0.09)	(−0.40)	(−0.15)	(0.28)	(0.28)
Top	0.003	0.010	−0.008	0.000	−0.005
	(0.41)	(1.04)	(−0.54)	(0.00)	(−0.59)
Growth	−0.021***	−0.031***	−0.018***	−0.027***	−0.021***
	(−8.22)	(−9.39)	(−7.18)	(−6.55)	(−15.12)
MB	0.001	0.001	0.003***	0.001	0.002***
	(1.55)	(0.59)	(3.18)	(0.67)	(4.02)
Cfo	−0.017*	−0.005	−0.017	−0.028	−0.020***
	(−1.70)	(−0.30)	(−1.63)	(−1.18)	(−2.65)
BIG4	−0.002	−0.012**	0.004	0.001	0.003
	(−0.43)	(−2.35)	(0.90)	(0.06)	(0.93)
Opinion	−0.036***	−0.053**	−0.030***	−0.054**	−0.034***
	(−3.92)	(−2.55)	(−3.00)	(−2.05)	(−6.59)
Cons	0.196***	0.220***	0.085	0.140	0.097**
	(6.68)	(4.83)	(1.40)	(1.27)	(2.28)
Industry FE	Yes	Yes	Yes	Yes	Yes
Year FE	No	No	Yes	Yes	Yes
Firm FE	No	No	Yes	Yes	Yes
Observations	3108	1321	3108	1321	4429
R-squared	0.37	0.45	0.45	0.56	0.48
Difference in Treat × Post	***−0.00778***		——		——
P-value	***0.0118****		——		

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

We define 2007, 2009, 2014, and 2015 as bull market years, following Chu et al. (2019), and the rest of the sample period as bear market years, and set a dummy variable *bull*, which equals 1 if the market situation is bullish, and 0 otherwise. The regression results are presented in Table 7. Columns (1) and (2) are regressions without the firm fixed effect grouped by market situation, columns (3) and (4) are regressions with the firm fixed effect grouped by market situation, and column (5) is a full-sample regression with a three-term interaction.[8] From the regression results in columns (1) and (2), the two coefficients of interaction (*Treat × Post*) are significantly positive at the 1% level, and the difference between the coefficients of the interaction (*Treat × Post*) of the two regressions is significant at the 5% level; from column (5), the coefficient of the three-term

[8] As the bootstrapping method cannot be used to test the difference in coefficients for the bull and bear market groups in the fixed-effect model, pooled OLS regression is added here and used for this purpose. The following cross-sectional tests use the bootstrapping method to test the difference in coefficients between groups.

interaction (*Treat* × *Post* × *Bull*) is significantly positive at the 5% level. These results indicate that additions to stock index have a greater impact on analysts' optimistic earnings forecasts when the market is bullish.

5.1.2. Institutional ownership

After additions to stock index, both index funds and other institutional investors increase their shareholdings (Zhu et al., 2017). Therefore, when institutional ownership is low, issuing optimistic earnings forecasts generates more commission income and attracts more institutional investment, helping to raise the stock price. This is consistent with the perceptions of retail investors, and eventually reduces analysts' reputational damage from forecast errors.[9] Therefore, additions to stock index have a greater impact on analysts' earnings forecast optimism when institutional ownership is low.

We separate the observations into two groups based on institutional ownership, and create the dummy variable *Institution*, which equals 1 if an observation's institutional ownership is lower than the median institutional ownership of the full sample, and 0 otherwise. The regression results are shown in Table 8. Columns (1) and (2) are regressions grouped by institutional ownership, and column (3) is a full-sample regression with a three-term interaction (*Treat* × *Post* × *Institution*). From the regression results in columns (1) and (2), the two coefficients of interaction (*Treat* × *Post*) are positive and significant at the 5% and 1% levels, respectively, and the difference between the coefficients of interaction (*Treat* × *Post*) of the two regressions is significant at the 10% level; from column (3), the coefficient of the three-term interaction (*Treat* × *Post* × *Institution*) is significantly positive at the 5% level. These results indicate that additions to stock index have a greater impact on analysts' earnings forecast optimism when institutional ownership is low.

5.1.3. The ratio of listed brokerage firms

Clarke et al. (2007) find that brokerage firms can affect analysts' earnings forecasts. Going public is an important strategy for brokerage firms to expand their capital and business scope (Ma, 2019). After a brokerage firm goes public, it is supervised not only by its customers but also by investors and regulatory agencies, which raises its reputational cost. Analysts' earnings forecast reports are issued in the name of their brokerage firm and reviewed by the brokerage firm before being issued. Forecasting errors in these reports thus affect the reputation of both the analyst and the brokerage firm. As listed brokerage firms are more sensitive to analysts' earnings forecast optimism, their forecasts are more cautious to prevent reputational damage. Therefore, additions to stock index have a greater impact on analysts' earnings forecast optimism when the ratio of listed brokerage firms is low.

We separate the observations into two groups based on the ratio of listed brokerage firms, and add the dummy variable *List*, which equals 1 if an observation's ratio of listed brokerage firms is lower than the median ratio for the full sample, and 0 otherwise. The regression results are shown in Table 9. Columns (1) and (2) show the regressions grouped by the ratio of listed brokerage firms, and column (3) shows the full-sample regression with a three-term interaction (*Treat* × *Post* × *List*). From the results in columns (1) and (2), the two coefficients of interaction (*Treat* × *Post*) are positive and significant at the 5% and 1% levels, respectively, and the difference between the two coefficients of interaction (*Treat* × *Post*) of the two regressions is significant at the 1% level; from the results in column (3), the coefficient of the three-term interaction (*Treat* × *Post* × *List*) is significantly positive at the 1% level. These results indicate that additions to stock index have a greater impact on analysts' optimistic earnings forecasts when the ratio of listed brokerage firms is low.

5.1.4. Star analyst coverage

Earnings forecasts by star analysts are more accurate than those of other analysts (Fang and Yasuda, 2009), and the reputational cost for star analysts is higher (Chu et al., 2019; Lu et al., 2020). Studies have shown that star analysts are more likely to find a firm's idiosyncratic information and thus issue more accurate

[9] On the contrary, institutional investors are the main source of profit for brokerage firms and the main customers of analyst reports (Xu et al., 2012). After additions to stock index, analysts' optimistic earnings forecasts for stocks with higher institutional ownership help to stabilize and raise the stock price, and also influence the selection of the best analysts in New Fortune in the future. Therefore, the effect of additions to stock index on analysts' earnings forecast optimism may also be more significant when institutional investors hold more shares.

Table 8
Cross-sectional test: Institutional ownership.

	(1)	(2)	(3)
DepVar=	*Optimism*	*Optimism*	*Optimism*
	High	Low	Full sample
Treat × Post	***0.007****	***0.020*****	***0.010*****
	(2.35)	***(5.57)***	***(3.48)***
Treat × Post × Institution			***0.006****
			(2.14)
Institution			0.003
			(1.27)
Size	−0.000	−0.003	−0.001
	(−0.15)	(−0.98)	(−0.63)
Lev	−0.030**	0.019	−0.011
	(−2.38)	(1.33)	(−1.09)
Roa	−0.543***	−0.603***	−0.585***
	(−11.25)	(−14.20)	(−18.34)
Board	−0.002	−0.014	−0.007
	(−0.24)	(−1.19)	(−0.92)
Indep	0.000	0.007	0.002
	(0.01)	(0.18)	(0.10)
Top	0.021	−0.054***	−0.010
	(1.51)	(−2.62)	(−0.86)
Growth	−0.020***	−0.016***	−0.021***
	(−7.37)	(−5.41)	(−10.07)
MB	0.003***	0.002*	0.002***
	(2.96)	(1.69)	(3.18)
Cfo	−0.032**	−0.003	−0.019*
	(−2.25)	(−0.21)	(−1.82)
BIG4	0.006	−0.012	0.003
	(1.13)	(−1.47)	(0.67)
Opinion	−0.043***	−0.029**	−0.033***
	(−2.77)	(−2.33)	(−3.09)
Cons	0.036	0.156**	0.088
	(0.48)	(2.12)	(1.62)
Industry FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes
Observations	2195	2201	4396
R-squared	0.43	0.52	0.48
Difference in Treat × Post	***−0.0128***		——
P-value	***0.076****		——

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

earnings forecasts (Xu et al., 2013). According to the above logic, the higher the reputation of the analyst, the higher the cost of issuing optimistic earnings forecasts. Therefore, additions to stock index have a greater impact on analysts' earnings forecast optimism when star analyst coverage is low.

We separate the observations into two groups based on star analyst coverage, and add the dummy variable *Star*, which equals 1 if the star analyst coverage is lower for the observation than the median of the full sample, and 0 otherwise. The regression results are shown in Table 10. Columns (1) and (2) show the regressions grouped by star analyst coverage, and column (3) shows the full-sample regression with a three-term interaction (*Treat* × *Post* × *Star*). From the regression results of columns (1) and (2), the coefficients of interaction (*Treat* × *Post*) in column (2) are significantly positive at the 1% level, and the difference between the two coefficients of interaction (*Treat* × *Post*) of the two regressions is significant at the 5% level. From the results in column (3), the coefficient of three-term interaction (*Treat* × *Post* × *Star*) is significantly positive at the 5%

Table 9
Cross-sectional test: Ratio of listed brokerage firms.

	(1)	(2)	(3)
DepVar=	*Optimism*	*Optimism*	*Optimism*
	High	Low	Full sample
Treat × Post	***0.007****	***0.021*****	***0.009*****
	(2.39)	***(5.48)***	***(3.36)***
Treat × Post × List			***0.009*****
			(3.13)
List			−0.008***
			(−3.86)
Size	−0.002	−0.007**	−0.002
	(−0.47)	(−2.23)	(−0.85)
Lev	−0.013	−0.005	−0.009
	(−1.10)	(−0.28)	(−0.94)
Roa	−0.472***	−0.655***	−0.593***
	(−12.39)	(−14.99)	(−18.53)
Board	−0.008	−0.012	−0.007
	(−0.76)	(−1.36)	(−0.95)
Indep	0.013	0.003	0.005
	(0.55)	(0.11)	(0.23)
Top	−0.005	−0.015	−0.004
	(−0.23)	(−0.85)	(−0.37)
Growth	−0.022***	−0.016***	−0.021***
	(−6.97)	(−6.81)	(−10.18)
MB	0.002***	0.001	0.002***
	(3.21)	(0.83)	(2.85)
Cfo	−0.020	−0.029*	−0.021**
	(−1.63)	(−1.89)	(−2.03)
BIG4	0.008*	−0.009	0.004
	(1.72)	(−1.04)	(0.77)
Opinion	−0.021	−0.039***	−0.034***
	(−1.15)	(−3.18)	(−3.22)
Cons	0.062	0.230***	0.106*
	(0.83)	(3.21)	(1.89)
Industry FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes
Observations	1976	2453	4429
R-squared	0.45	0.53	0.48
Difference in Treat × Post	***−0.0144***		——
P-value	***0.009*****		——

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

level. These results indicate that additions to stock index have a greater impact on analysts' earnings forecast optimism when star analyst coverage is low.

5.1.5. SEO activity

The underwriting business is an important source of income for brokerage firms. With increasing competition, analyst's reports have become an important resource for brokerage firms to obtain underwriting business (Lin and McNichols, 1998; Yuan and Huang, 2007). Lin and McNichols (1998) find that analysts from brokerage firms that also offer underwriting issue more optimistic earnings forecasts. Mola and Guidolin (2009) also find that during the period of an SEO, analysts issue more optimistic forecasts. Due to conflicts of interest, analysts' optimistic earnings forecasts are more likely to help their brokerage firms obtain underwriting business (Yuan and Huang, 2007). Therefore, we expect additions to stock index have a greater impact on analysts' optimistic earnings forecasts when firms are undergoing an SEO.

Table 10
Cross-sectional test: Star analyst coverage.

	(1)	(2)	(3)
DepVar=	*Optimism*	*Optimism*	*Optimism*
	High	Low	Full sample
Treat* × *Post	***0.005***	***0.018******	***0.010******
	(1.50)	***(4.67)***	***(3.69)***
Treat* × *Post* × *Star			***0.006****
			(2.01)
Star			−0.006***
			(−3.06)
Size	0.006	−0.005	−0.002
	(1.54)	(−1.55)	(−0.65)
Lev	−0.015	−0.016	−0.010
	(−1.31)	(−1.04)	(−0.97)
Roa	−0.516***	−0.641***	−0.583***
	(−11.86)	(−13.36)	(−17.12)
Board	−0.004	−0.000	−0.002
	(−0.41)	(−0.02)	(−0.20)
Indep	0.011	0.010	0.010
	(0.47)	(0.30)	(0.49)
Top	0.023	−0.039**	−0.005
	(1.14)	(−2.18)	(−0.42)
Growth	−0.024***	−0.018***	−0.022***
	(−8.54)	(−6.20)	(−10.33)
MB	0.003***	−0.000	0.002**
	(3.49)	(−0.00)	(2.31)
Cfo	−0.035**	−0.015	−0.018*
	(−2.43)	(−0.90)	(−1.65)
BIG4	0.010*	−0.009	0.002
	(1.76)	(−1.29)	(0.45)
Opinion	−0.038	−0.031**	−0.032**
	(−1.16)	(−2.41)	(−2.53)
Cons	−0.102	0.167**	0.090
	(−1.07)	(2.17)	(1.44)
Industry FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes
Observations	1976	2453	4429
R-squared	0.45	0.53	0.48
Difference in Treat* × *Post	***−0.013***		——
P-value	***0.032****		——

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

We separate our observations into two groups based on SEO activity, and set a dummy variable *Seo*, which equals 1 if a firm has SEO activity, and 0 otherwise. The regression results are shown in Table 11. Columns (1) and (2) show the regression results grouped by SEO activity, and column (3) shows the results of a full-sample regression with a three-term interaction (*Treat* × *Post* × *Seo*). From the regression results in columns (1) and (2), the two coefficients of interaction (*Treat* × *Post*) are significantly positive at the 1% level, and the difference between the two coefficients of the interaction (*Treat* × *Post*) of the two regressions is significant at the 1% level; in column (3), the coefficient of the three-term interaction (*Treat* × *Post* × *Seo*) is positive but not significant. These results indicate that additions to stock index have a greater effect on analysts' earnings forecast optimism when firms are undergoing SEO activity.

Table 11
Cross-sectional test: SEO activity.

	(1)	(2)	(3)
DepVar=	*Optimism*	*Optimism*	*Optimism*
	No SEO	SEO	Full sample
Treat × Post	***0.009******	***0.023******	***0.011******
	(3.41)	***(2.71)***	***(4.34)***
Treat × Post × Seo			***0.005***
			(1.45)
Seo			−0.017***
			(−6.75)
Size	0.004*	−0.002	0.001
	(1.86)	(−0.24)	(0.63)
Lev	−0.030**	0.005	−0.021**
	(−2.54)	(0.19)	(−2.08)
Roa	−0.611***	−0.710***	−0.606***
	(−17.47)	(−5.11)	(−18.81)
Board	−0.014*	0.012	−0.008
	(−1.89)	(0.33)	(−1.16)
Indep	−0.006	−0.036	0.001
	(−0.29)	(−0.33)	(0.05)
Top	0.003	−0.110**	−0.009
	(0.23)	(−2.54)	(−0.73)
Growth	−0.018***	−0.014***	−0.018***
	(−6.75)	(−3.08)	(−9.07)
MB	0.003***	0.003	0.003***
	(3.74)	(1.18)	(3.63)
Cfo	−0.008	−0.015	−0.018*
	(−0.71)	(−0.44)	(−1.76)
BIG4	0.003	−0.024	0.003
	(0.71)	(−1.11)	(0.60)
Opinion	−0.032***	−0.013	−0.033***
	(−2.67)	(−0.49)	(−3.16)
Cons	0.019	0.106	0.074
	(0.34)	(0.53)	(1.31)
Industry FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes
Observations	3814	428	4420
R-squared	0.412	0.437	0.436
Difference in Treat × Post	***−0.014***		
P-value	***0.000*****		

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

5.1.6. Ratio of analysts from the top five brokerage firms ranked by commission income

Commission income is an important source of analysts' income. Studies have shown that more optimistic earnings forecasts can stimulate stock trading and bring higher commission income (Irvine, 2004; Jackson, 2005). Further, analysts at brokerage firms with higher commission income are under greater pressure to increase commission income and are thus more likely to issue optimistic earnings forecasts (Ljungqvist et al., 2007; Xu et al., 2012). Therefore, we expect additions to stock index to have a greater effect on analysts' earnings forecast optimism when there is a high ratio of analysts from the top five brokerage firms ranked by commission income.

We separate our observations into two groups based on the ratio of analysts from the top five brokerage firms ranked by commission income,[10] and set a dummy variable *BrokerTop5* that equals 1 if the ratio of ana-

[10] The Wind database provides data on brokerage firm commission income.

lysts from the top five brokerage firms is higher for the observation than the median ratio of the full sample, and 0 otherwise. The regression results are shown in Table 12. Columns (1) and (2) show the regressions grouped by the ratio of analysts from the top five brokerage firms, and column (3) shows a full-sample regression with a three-term interaction (*Treat* × *Post* × *BrokerTop5*). From the regression results of columns (1) and (2), the two coefficients of interaction (*Treat* × *Post*) are significantly positive at the 1% level, and the difference between the coefficients of interaction (*Treat* × *Post*) of the two regressions is significant at the 5% level; in column (3), the coefficient of the three-term interaction (*Treat* × *Post* × *BrokerTop5*) is significantly positive at the 5% level. These results indicate that additions to stock index have a greater effect on analysts' earnings forecast optimism if there is a high ratio of analysts from the top five brokerage firms ranked by commission income.

Table 12
Cross-sectional test: Ratio of analysts from top five brokerage firms ranked by commission income.

	(1)		(2)	(3)
DepVar=	*Optimism*		*Optimism*	*Optimism*
	Low		High	Full sample
Treat* × *Post	***0.012******		***0.016******	***0.010*****
	(3.05)		***(4.94)***	***(3.39)***
Treat* × *Post* × *BrokerTop5				***0.006****
				(2.35)
BrokerTop5				−0.003*
				(−1.76)
Size	−0.002		0.000	−0.001
	(−0.57)		(0.05)	(−0.58)
Lev	−0.006		−0.007	−0.010
	(−0.43)		(−0.55)	(−0.99)
Roa	−0.608***		−0.579***	−0.591***
	(−14.56)		(−13.85)	(−18.47)
Board	−0.007		0.001	−0.007
	(−0.69)		(0.09)	(−0.95)
Indep	−0.012		0.016	0.005
	(−0.36)		(0.75)	(0.24)
Top	−0.005		−0.019	−0.004
	(−0.27)		(−1.18)	(−0.35)
Growth	−0.020***		−0.020***	−0.021***
	(−6.77)		(−7.36)	(−10.34)
MB	0.004***		0.002*	0.002***
	(4.01)		(1.96)	(3.09)
Cfo	−0.027**		−0.021*	−0.020*
	(−2.02)		(−1.75)	(−1.91)
BIG4	0.000		0.012**	0.004
	(0.06)		(2.22)	(0.77)
Opinion	−0.026**		−0.033*	−0.034***
	(−2.33)		(−1.83)	(−3.16)
Cons	0.131		0.069	0.124**
	(1.61)		(0.98)	(2.29)
Industry FE	Yes		Yes	Yes
Year FE	Yes		Yes	Yes
Firm FE	Yes		Yes	Yes
Observations	2169		2171	4420
R2	0.436		0.433	0.426
Difference in Treat* × *Post		***−0.004***		
P-value		***0.047****		

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

5.1.7. Brokerage firm shareholdings

Brokerage firms can buy and sell stocks in the secondary market. The shareholdings of brokerage firms may thus affect the independence of their analyst's earnings forecasts. Studies have found that analysts issue more optimistic earnings forecasts for stocks when their brokerage firms are shareholders (Cao and Zhu, 2011). Therefore, we expect additions to stock index have a greater influence on analysts' earnings forecast optimism when brokerage firms are shareholders.

We separate our observations into two groups based on shareholding by the brokerage firms, and set a dummy variable *BrokerHold* that equals 1 if the brokerage firms are shareholders, and 0 otherwise. The regression results are shown in Table 13. Columns (1) and (2) show the regressions grouped by brokerage firm shareholdings, and column (3) shows a full-sample regression with a three-term interaction (*Treat* × *Post* × *BrokerHold*). From the regression results in columns (1) and (2), the two coefficients of interaction (*Treat* × *Post*) are significantly positive at the 1% level, and the difference between the coefficients of

Table 13
Cross-sectional test: Shareholding by brokerage firms.

	(1)		(2)	(3)
DepVar=	*Optimism*		*Optimism*	*Optimism*
	No Holding		Holding	Full sample
Treat* × *Post	***0.013******		***0.018******	***0.012******
	(4.76)		***(2.87)***	***(4.73)***
Treat* × *Post* × *BrokerHold				***0.005****
				(1.87)
BrokerHold				−0.003
				(−1.56)
Size	−0.001		−0.002	−0.001
	(−0.48)		(−0.35)	(−0.62)
Lev	−0.012		−0.002	−0.011
	(−1.07)		(−0.07)	(−1.05)
Roa	−0.571***		−0.714***	−0.591***
	(−16.86)		(−10.60)	(−18.46)
Board	−0.012		0.010	−0.007
	(−1.47)		(0.56)	(−1.01)
Indep	0.008		0.063	0.004
	(0.36)		(1.16)	(0.18)
Top	−0.010		0.019	−0.004
	(−0.79)		(0.58)	(−0.37)
Growth	−0.021***		−0.022***	−0.021***
	(−9.23)		(−4.64)	(−10.30)
MB	0.002**		0.004**	0.002***
	(2.43)		(2.12)	(3.04)
Cfo	−0.010		−0.036	−0.020*
	(−0.98)		(−1.43)	(−1.95)
BIG4	0.007		−0.005	0.003
	(1.27)		(−0.57)	(0.69)
Opinion	−0.035***		0.023	−0.034***
	(−2.87)		(0.74)	(−3.19)
Cons	0.133**		0.009	0.128**
	(2.30)		(0.06)	(2.32)
Industry FE	Yes		Yes	Yes
Year FE	Yes		Yes	Yes
Firm FE	Yes		Yes	Yes
Observations	3446		850	4420
R2	0.495		0.525	0.479
Difference in Treat* × *Post		***−0.005***		
P-value		***0.000*****		

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

interaction (*Treat* × *Post*) of the two regressions is significant at the 1% level. In column (3), the coefficient of the three-term interaction (*Treat* × *Post* × *BrokerHold*) is significantly positive at the 10% level. These results indicate that additions to stock index have a greater effect on analysts' earnings forecast optimism when their brokerage firms are shareholders.

5.2. Analyst-level tests

In this section, firm-year-analyst observations are used to test the relationship between additions to stock index and analysts' earnings forecast optimism. We analyze the influence of analysts' ability and expect that analysts with greater ability are less likely to issue optimistic earnings forecasts and are less affected by additions to stock index. Therefore, we predict that the greater the analyst's ability, the lower the effect of additions stock index on the analyst's optimistic earnings forecasts.

Following Cao and Zhu (2011), we reset the dependent variable to equal the ratio of the difference between analysts' earnings forecasts and actual earnings to the stock price at the beginning of year *t*, and keep the control variables the same as in Model (1). We use the analysts' educational background and work experience to proxy for ability and set the dummy variables *Degree* and *Experience*. *Degree* equals 1 if the analyst has a master's degree, and 0 otherwise; *Experience* equals 1 if the analyst's work experience is higher than the median of all samples, and 0 otherwise. The regression results are presented in Table 14.

Column (1) in Table 14 shows the regression results for analysts' earnings forecast optimism regarding additions to stock index using analyst-level data. The coefficient of interaction (*Treat***Post*) is significantly positive at the 1% level, which is consistent with the main result. Columns (2), (3), and (4) of Table 14 present the results of cross-sectional tests for different educational backgrounds. Columns (2) and (3) show the regression results using the two groups of observations, and column (4) shows the full-sample regression results with a three-term interaction. From columns (2) and (3), the coefficients of interaction (*Treat* × *Post*) are significantly positive at the 1% level, and the difference between these two coefficients is significant at the 10% level. In column (4), the coefficient of the three-term interaction (*Treat* × *Post* × *Degree*) is significantly negative at the 5% level. These results indicate that for analysts with a master's degree, the effect of additions to stock index on analysts' earnings forecast optimism is lower.

Columns (5), (6), and (7) in Table 14 show cross-sectional tests of the effects of analysts' work experience. Columns (5) and (6) show the regression results using the two observation groups, and column (7) shows the full-sample regression results with a three-term interaction. In columns (5) and (6), the coefficients of interaction (*Treat* × *Post*) are significantly positive at the 1% level, and the difference between these two coefficients is significant at the 1% level. In column (7), the coefficient of the three-term interaction (*Treat* × *Post* × *Experience*) is significantly negative at the 5% level. These results indicate that additions to stock index have less effect on earnings forecast optimism among analysts with more work experience.

5.3. Other analyst behavior

From the perspective of completeness, the dependent variable in Model (1) is replaced with analyst coverage (*Num*), analyst forecast bias (*Ferr*), and analyst forecast divergence (*Disper*) to test the effect of additions to stock index on other behavior by analysts. We predict that analyst coverage and divergence will increase significantly after additions to stock index, and that analysts' forecast bias will not change significantly. Following Huang et al. (2018), we define analysts' coverage (*Num*), analysts' forecast bias (*Ferr*), and analysts' divergence (*Disper*) are as follows:

$$Num = ln(1 + number) \tag{3}$$

$$Ferr = |MeanFeps) - Meps|/Price \tag{4}$$

$$Disper = Sd(Feps)/Price \tag{5}$$

where the definitions of *Mean(Feps)*, *Meps*, and *Price* remain the same; *number* is the total number of analysts who made earnings forecasts for firm *i* in year *t*; and *Sd*(*Feps*) is the standard deviation of all analysts' earnings forecasts.

Table 14
Stock index adjustments and analysts' earnings forecast optimism using analyst-level data.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
DepVar=	*Optimism*	*Optimism*	*Optimism*	*Optimism*	*Optimism*	*Optimism*	*Optimism*
	Full sample	High	Low	Full sample	More	Less	Full sample
Treat × Post	***0.006******	***0.005******	***0.007******	***0.008******	***0.005******	***0.006******	***0.007******
	(11.84)	***(9.64)***	***(7.39)***	***(7.80)***	***(7.34)***	***(9.84)***	***(9.73)***
Treat × Post × Degree				***−0.003****			
				(−2.39)			
Treat × Post × Experience							***−0.002****
							(−2.08)
Experience							0.001
							(0.92)
Size	−0.005***	−0.005***	−0.003***	−0.005***	−0.005***	−0.005***	−0.005***
	(−13.17)	(−12.75)	(−4.68)	(−13.19)	(−9.37)	(−9.28)	(−13.19)
Lev	−0.013***	−0.012***	−0.015***	−0.013***	−0.013***	−0.012***	−0.013***
	(−7.28)	(−6.28)	(−3.63)	(−7.26)	(−5.08)	(−4.77)	(−7.28)
Roa	−0.250***	−0.245***	−0.266***	−0.249***	−0.252***	−0.247***	−0.250***
	(−27.24)	(−23.45)	(−13.79)	(−27.24)	(−19.44)	(−17.85)	(−27.22)
Board	0.002	0.003	0.001	0.002	0.003	0.000	0.002
	(1.50)	(1.63)	(0.27)	(1.51)	(1.42)	(0.09)	(1.49)
Indep	−0.001	0.001	−0.010	−0.001	−0.003	−0.002	−0.001
	(−0.31)	(0.26)	(−1.19)	(−0.33)	(−0.45)	(−0.30)	(−0.31)
Top	0.019***	0.019***	0.018***	0.019***	0.020***	0.017***	0.019***
	(8.17)	(7.43)	(3.80)	(8.18)	(6.54)	(6.12)	(8.17)
Growth	−0.019***	−0.019***	−0.017***	−0.019***	−0.020***	−0.018***	−0.019***
	(−18.51)	(−17.87)	(−7.78)	(−18.52)	(−14.54)	(−12.04)	(−18.53)
MB	0.002***	0.002***	0.003***	0.002***	0.002***	0.002***	0.002***
	(11.67)	(9.89)	(7.17)	(11.66)	(8.33)	(7.91)	(11.69)
Cfo	−0.009***	−0.012***	0.001	−0.009***	−0.009**	−0.006	−0.009***
	(−3.24)	(−3.99)	(0.18)	(−3.27)	(−2.08)	(−1.47)	(−3.24)
BIG4	−0.003**	−0.004**	−0.003	−0.003**	−0.005***	−0.001	−0.003**
	(−2.55)	(−2.35)	(−1.05)	(−2.56)	(−2.82)	(−0.75)	(−2.55)
Opinion	−0.019***	−0.019***	−0.017**	−0.019***	−0.021***	−0.014**	−0.019***
	(−5.33)	(−4.72)	(−2.17)	(−5.35)	(−4.95)	(−2.51)	(−5.34)
Cons	0.129***	0.136***	0.103***	0.129***	0.135***	0.133***	0.129***
	(14.69)	(13.45)	(5.55)	(14.71)	(10.89)	(10.11)	(14.63)
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Analyst FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	31,318	24,595	6723	31,318	15,730	15,299	31,318
R2	0.165	0.164	0.175	0.166	0.170	0.160	0.166
Difference in Treat × Post		***0.001***			***0.001***		
P-value		***0.075****			***0.003*****		

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

Table 15 Panel A shows the regression results. Column (1) shows that the coefficient of interaction (*Treat* × *Post*) is significantly positive at the 1% level, indicating that analyst coverage increases significantly after stocks are added to the stock index. Column (2) shows that the coefficient of interaction (*Treat* × *Post*) is positive but not significant, suggesting that additions to stock index do not affect analysts' forecast bias. Column (3) shows that the coefficient of interaction (*Treat* × *Post*) is significantly positive at the 1% level, indicating that analysts' forecast divergence increases significantly after stocks are added to the stock index.

Additionally, to further explore the impact of additions to stock index on analyst behavior, we divide the sample into an optimistic group (Optimism > 0) and a pessimistic group (Optimism<=0) according to whether the analysts' earnings forecast optimism is greater than 0. The regression results are presented in Table 15 Panel B.

In Table 15 Panel B, in columns (1) and (2), it can be seen that for the optimistic group (*Optimism* > 0), the coefficient of interaction (*Treat* × *Post*) is significantly positive at the 10% level, whereas for the pessimistic

Table 15
Stock index adjustments and other analyst behavior.

Panel A

	(1)	(2)	(3)
DepVar=	*Num*	*Ferr*	*Disper*
Treat × Post	***0.134******	***0.000***	***0.003******
	(3.22)	***(0.07)***	***(2.74)***
Size	0.466***	0.008***	0.003**
	(10.32)	(3.36)	(2.55)
Lev	−0.479***	−0.008	−0.005
	(−3.29)	(−0.67)	(−0.85)
Roa	2.452***	−0.403***	−0.127***
	(8.13)	(−11.08)	(−9.36)
Board	−0.031	−0.008	−0.009**
	(−0.26)	(−1.08)	(−1.99)
Indep	−0.130	0.025	−0.012
	(−0.39)	(1.01)	(−1.01)
Top	−0.053	0.012	−0.008
	(−0.23)	(0.74)	(−1.17)
Growth	−0.086***	0.009***	−0.003***
	(−3.95)	(3.30)	(−3.62)
MB	0.041***	0.003***	−0.000
	(3.72)	(2.98)	(−0.14)
Cfo	−0.084	0.050***	0.003
	(−0.70)	(4.10)	(0.61)
BIG4	−0.001	−0.004	0.001
	(−0.01)	(−0.82)	(0.42)
Opinion	0.036	−0.046***	−0.008
	(0.36)	(−3.59)	(−1.47)
Cons	−7.558***	−0.104*	−0.011
	(−7.22)	(−1.80)	(−0.41)
Industry FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes
Observations	4429	4429	4429
R-squared	0.38	0.22	0.23

Panel B

	(1)	(2)	(3)	(4)	(5)	(6)
DepVar=	*Num Optimism>0*	*Num Optimism<=0*	*Ferr Optimism>0*	*Ferr Optimism<=0*	*Disper Optimism>0*	*Disper Optimism<=0*
Treat×Post	***0.110****	***0.052***	***0.012*****	***−0.009****	***0.006*****	***−0.003****
	(1.83)	***(0.97)***	***(3.97)***	***(−2.21)***	***(3.30)***	***(−2.18)***
Size	0.515***	0.460***	0.002	0.007**	0.002	0.001
	(8.70)	(8.53)	(0.69)	(2.16)	(1.20)	(1.62)
Lev	−0.514***	−0.425**	−0.002	0.005	−0.004	0.008*
	(−2.65)	(−2.09)	(−0.11)	(0.42)	(−0.49)	(1.83)
Roa	2.274***	3.928***	−0.626***	0.261***	−0.165***	0.052***
	(5.75)	(7.17)	(−14.26)	(5.66)	(−8.59)	(3.11)
Board	−0.021	−0.038	−0.006	−0.004	−0.006	−0.010***
	(−0.14)	(−0.24)	(−0.91)	(−0.38)	(−1.03)	(−2.72)
Indep	−0.066	0.283	0.016	0.028	−0.015	−0.018*
	(−0.16)	(0.60)	(0.76)	(1.09)	(−0.91)	(−1.74)
Top	0.158	−0.463	−0.010	0.011	−0.011	−0.007
	(0.55)	(−1.57)	(−0.61)	(0.58)	(−1.23)	(−1.27)
Growth	−0.074**	−0.068**	−0.014***	0.028***	−0.003**	−0.000
	(−2.27)	(−2.22)	(−4.85)	(6.32)	(−2.12)	(−0.35)
MB	0.066***	0.022	0.002*	−0.000	−0.000	−0.000
	(4.80)	(1.22)	(1.89)	(−0.13)	(−0.91)	(−1.63)

(*continued on next page*)

Table 15 (*continued*)

Panel B						
	(1)	(2)	(3)	(4)	(5)	(6)
Cfo	0.079	−0.054	0.026*	0.036*	0.004	0.005
	(0.48)	(−0.33)	(1.93)	(1.88)	(0.46)	(1.11)
BIG4	0.030	0.016	−0.001	−0.008	−0.002	−0.000
	(0.36)	(0.19)	(−0.26)	(−1.41)	(−0.54)	(−0.40)
Opinion	0.071	−0.044	−0.038***	0.015***	−0.005	0.002
	(0.71)	(−0.15)	(−3.12)	(3.33)	(−0.92)	(0.62)
Cons	−8.326***	−8.030***	0.041	−0.119	0.001	0.005
	(−6.57)	(−6.60)	(0.71)	(−1.58)	(0.02)	(0.21)
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2871	1558	2871	1558	2871	1558
R-squared	0.35	0.55	0.43	0.39	0.26	0.22

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

group (*Optimism*<=0), the coefficient of interaction (*Treat* × *Post*) is positive but not significant; the results of columns (1) and (2) indicate that after additions to stock index, analyst coverage increases mainly among optimistic analysts. In columns (3) and (4) of Panel B, the coefficients of interaction (*Treat* × *Post*) have opposite signs and are significant at the 1% and 5% levels, respectively, indicating that the earnings forecasts of optimistic analysts are more optimistic. As confirmed by the results in Table 3, pessimistic analysts are more optimistic after additions to stock index, further reducing forecast errors among the pessimistic analyst group (*Optimism*<=0).

In column (5) of Panel B, in the optimistic group (*Optimism* > 0), the coefficient of interaction (*Treat* × *Post*) is significantly positive at the 1% level, indicating that analysts' divergence is significantly greater after additions to stock index. In column (6) of Panel B, for the pessimistic group (*Optimism*<=0), the coefficient of interaction (*Treat* × *Post*) is significantly negative at the 5% level, indicating that analyst divergence is reduced after additions to stock index. Combining the results of columns (5) and (6), it is evident that the increase in analyst divergence after additions to stock index derives mainly from the optimistic group (*Optimism* > 0).

5.4. Economic consequences of additions to stock index

According to the above theoretical logic and empirical tests, analysts' earnings forecasts become more optimistic after additions to stock index. This effect is primarily due to the change in analysts' cost and income caused by issuing optimistic earnings forecasts, and this optimistic bias reduces stock information efficiency (Xu et al., 2012). Therefore, we predict that additions to stock index significantly increase analysts' optimistic earnings forecasts and subsequently increase stock price synchronization.

Following Xu et al. (2013), the following model is used to calculate stock price synchronicity.

$$R_{i,w} = \alpha_{i,w} + \beta_{i,w} R_{m,w} + \lambda_{i,w} R_{ind,w} + \varepsilon_{i,w} \tag{6}$$

$$SYN = Ln[R_{sq}/(1 - R_{sq})] \tag{7}$$

where $R_{i,w}$ represents the stock return of firm i in *week w*, $R_{m,w}$ represents the market return in *week w*, and $R_{ind,w}$ represents the industry return in *week w*. R_{sq} is obtained by regressing Model (6) and is logarithmically transformed to SYN using Model (7).

In this study, we use the mediation effect model of Wen et al. (2004), and present the results in Table 16. Column (1) shows that stock index synchronization increases significantly after additions to stock index; column (2) shows that analysts' earnings forecast optimism increases significantly after additions to stock index; and column (3) shows that after controlling for the effect of additions to stock index, analysts' earnings forecast optimism is significantly positive. The Sobel test z-score is significant at the 1% level, supporting the partial mediation effect of analysts' earnings forecast optimism. The proportion of the mediation effect is 23.82%.

Table 16
Stock index adjustments, analysts' earnings forecast optimism and stock price synchronization.

	(1)	(2)	(3)
DepVar=	*SYN*	*Optimism*	*SYN*
Treat × Post	***0.154******	***0.013******	***0.137******
	(3.67)	***(5.28)***	***(3.25)***
Optimism			***1.308******
			(3.52)
Size	0.061*	−0.001	0.063*
	(1.72)	(−0.60)	(1.78)
Lev	−0.605***	−0.010	−0.592***
	(−4.33)	(−1.00)	(−4.30)
Roa	0.472	−0.591***	1.246***
	(1.34)	(−18.44)	(3.08)
Board	0.261**	−0.007	0.271**
	(2.03)	(−1.01)	(2.12)
Indep	0.686*	0.004	0.681*
	(1.77)	(0.18)	(1.74)
Top	−0.472**	−0.005	−0.465**
	(−2.41)	(−0.41)	(−2.39)
Growth	−0.088***	−0.021***	−0.060**
	(−3.04)	(−10.29)	(−2.08)
MB	−0.088***	0.002***	−0.091***
	(−7.02)	(3.03)	(−7.23)
Cfo	−0.180	−0.020*	−0.154
	(−1.14)	(−1.92)	(−0.99)
BIG4	−0.085	0.003	−0.089
	(−1.12)	(0.72)	(−1.18)
Opinion	0.184	−0.034***	0.229
	(1.13)	(−3.17)	(1.38)
Cons	−2.142**	0.089	−2.258**
	(−2.37)	(1.60)	(−2.50)
Industry FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes
Observations	4429	4429	4429
R-squared	0.31	0.48	0.31
SobelZ		***3.368*****	
Proportion of mediation effect		***23.82***%	

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

6. Conclusion

Capital market development is inseparable from constructing and improving the basic market system. In recent years, scholars have paid increasing attention to the basic system of the Chinese capital market. Studying the impact of the basic system of capital market can help provide a theoretical basis and policy recommendations for the healthy development of the capital market. In this study, stock index adjustments, which are common in the capital market, comprise the research object, and their effect on analysts' earnings forecast optimism is discussed. This study finds that additions to stock index increase analysts' earnings forecast optimism for the stock. Cross-sectional tests show that this effect is more significant when the market is bullish, institutional ownership is low, the listed brokerage firm ratio is low, star analyst coverage is low, firms show SEO activity, the ratio of analysts from the top five brokerage firms ranked by brokerage commission is high, and the brokerage firms are shareholders. Analyst-level tests indicate that analysts' ability helps to reduce the influence of additions to stock index on their earnings forecast optimism. Furthermore, additions to stock index significantly increases analyst coverage and divergence. Economic consequences tests show additions

to stock index significantly increase stock price synchronization, which is partly mediated by analysts' earnings forecast optimism.

This study enriches the literature on analyst behavior, and provides evidence of the effect of stock index adjustments as an important basic system of the capital market. Stock index adjustments can dynamically and accurately reflect the overall changes in the market and the investment preferences of mainstream investors. They are helpful in reflecting the return of high-quality asset portfolios and the development of industries in the economy, thus assisting investors to analyze future economic development and make reasonable asset allocation decisions. Based on the conclusions of this study, investors should rationally evaluate analysts' earnings forecasts, especially when the market is bullish, institutional ownership is low, the listed brokerage firm ratio is low, star analyst coverage is low, firms are undergoing an SEO, the ratio of analysts from the top five brokerage firms ranked by brokerage commissions is high, and the analysts' brokerage firms are shareholders. Additionally, investors should strengthen their information gathering to help them make rational investment decisions.

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Market misvaluation and corporate innovation: "Catering" or "risk aversion"?—Empirical evidence from China capital market

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ABSTRACT

This paper tests how market misvaluation affects corporate innovation. Unlike the "catering effect" observed in the US, we find that estimated stock overvaluation in China is strongly negatively associated with corporate innovation, conforming to our "risk-aversion" hypothesis. In China, misvaluation affects innovation via finance and management behavior channels. The effect is more significant in non-state-owned corporations than in state-owned corporations. Stock turnover rate and ownership concentration play moderating roles in the effect. The evidence sheds light on the relationship between market risks and corporate innovation in an emerging market.

1. Introduction

The capital market is the core of the modern financial system. Thus, building a standardized, transparent, open, dynamic and resilient capital market is an important goal of China's comprehensive and deepening reform. On 21 October 2020, Chairman of the Securities Regulatory Commission Yi Huiman said at the annual meeting of the Financial Street Forum, that improving the basic system of the capital market is conducive to comprehensively strengthen its role as a pivot, which mobilizes and guides various factor resources more efficiently and promotes the formation of innovative capital.

In an ideal capital market, high-quality companies can obtain high-quality resources, which promotes their innovation and further development. However, in reality, the irrational behaviors of capital market investors

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often lead stock prices to deviate from their intrinsic value; this mispricing of stocks affects the effective allocation of market resources and the formation of innovation capital. 2012 American Finance Association Annual Conference Chair, Sheridan Titman, pointed out that changes in external factors unrelated to company fundamentals are likely to trigger participation shocks in the capital market, ultimately affecting the real economy, which has been often ignored by investors and company managers. Titman (2013) constructs two models to analyze the mechanism of financial market shocks' effect on the real economy in the equity and debt financing markets. He finds that although U.S. high-tech firms generated a stock price bubble that eventually burst in the 1990 s, they absorbed a large amount of investment driven by high stock prices, accelerating technological progress and the development of the real economy. Lu et al. (2017) find that asset overvaluation attracts capital investment and generates a capital change effect, which triggers industrial expansion, while stock undervaluation does not have a significant effect. The above studies indicate the crucial role of stock misvaluation's impact on the decision-making behavior of firms.

In the long-term, investments related to innovation are vital to development of a company. Innovation can substantially promote a company's sustainable development, allowing it to continuously change and become a pioneer in its industry. This potential for a company's future growth is often linked to its ability to innovate. However, although innovation activities may seem glamorous, they carry a high degree of uncertainty, a high failure rate and a long payback period. Therefore, successful innovation activities requires internal and external environments that tolerate short-term failures and risks (Manso, 2011; Ferreira et al., 2014; Tian and Wang, 2014) Among the internal factors affecting innovation, managers' characteristics act as an important role. For instance, prudent and conservative executives are averse to investment risk and have a low tolerance for failure. Firms with these managers tend to have lower levels of innovation than other firms (Tang and Zhen, 2009). The potential risks and economic losses caused by stock misvaluation can have a significant effect on managers' behavior, financing institutions' judgment of corporation risk level and their willingness to lend, all of which ultimately affect corporations' innovation behavior by influencing the risk level of their operations. Therefore, it is important to study the factors that affect corporate innovation from the perspective of stock misvaluation.

Empirical studies related to stock mispricing often have endogeneity problems to some extent. Commonly, stock mispricing tends to be measured based on fundamental conditions such as a firm's financial information[1] in an attempt to isolate the part of the stock price that is divorced from the fundamentals, which generally raises a serious reverse-causality problem. Specifically, it is difficult to determine whether a firm's innovative activity has affected the firm's fundamental conditions and thus the degree of stock mispricing.

Based on the discussion above, we adopt Edmans et al.'s (2012) and Dong et al.'s (2020) method, constructing the variable *MFFlow* (for "mutual fund flow pressure"), which measures the level of stock mispricing. *MFFlow* is a function of a firm's average public fund outflow rate, which is exogenous to the fundamental value of the firm and not directly related to the firm's research and development (R&D) innovation, effectively mitigating the endogeneity problem and helping us to more rigorously and comprehensively evaluate the effect of stock overvaluation on firm innovation.

Using a sample of Chinese A-share listed companies from 2006 to 2019, this paper draws the following conclusions from the empirical study: (1) Other things being equal, stock overvaluation inhibits firm innovation and reduces firm innovation output, which is consistent with a "risk-aversion" hypothesis, rather than "catering" hypothesis. (2) Managerial shareholding selling and tighter financing constraints are two important channels through which stock overvaluation inhibits firm innovation. (3) Other things being equal, the higher the concentration of equity in the firm and the lower the stock turnover rate, the more the inhibiting effect of stock overvaluation is mitigated. The above conclusions hold in robustness tests such as changing the model estimation method, changing the variable measurement method, quantile regression and addressing sample selection problems.

The possible contributions of this paper are as follows. First, following the relevant literature, this paper constructs a variable, *MFFlow*, to measure levels of stock market mispricing in China. This variable measures the degree of stock mispricing by using the theoretical change in fund positions because there is correlation

[1] Including the residual income valuation model, book-to-market ratio solution, Tobin's Q decomposition method, etc.

between fund market and stock market. We also verifies the reliability of this variable in the Chinese market with relevant data. The resulting information enriches the literature on stock mispricing in the Chinese market.

Second, we find that in the Chinese market, stock overvaluation has an inhibiting effect on firm innovation, contrary to the findings of studies based on the U.S. market, and we provide a plausible explanation for this from the perspectives of internal managers' behavior and external financing, in line with the current state of the Chinese capital market. This explanation suggests that different institutional environments and capital market characteristics have different effects on firms' innovative behavior, thus also enriching the innovation-related literature.

Third, the research results in this paper show that preventing and resolving major financial risks, regulating the behavior of corporate managers and forming positive market expectations can promote the high-quality development of the capital market and corporations. The research in this paper can help researchers to better understand the relationship between capital markets and corporate finance in China.

2. Theoretical analysis and research hypothesis

"Stock Mispricing" refers to the deviation of stock prices from the fundamental value of stocks, a phenomenon that is common in capital markets. Shiller (2001) uses the feedback-amplification mechanism to explain the process by which continuous stock overvaluation causes speculative bubbles. He describes this mechanism as a spontaneous Ponzi process whereby past prices enhance investors' confidence and expectations. These investors further inflate the stock price, thus attracting more investors and driving the cycle forward. The conventional view is therefore that stock mispricing is caused by the spontaneous behavior of market investors, affects market efficiency and interferes rational allocation of resources.

The phenomenon of stock misvaluation can directly affect managers' behavior; Schnatterly et al. (2018) note that when a firm's stock is overvalued, i.e., when investors have excessive expectations of the firm, its executives are under psychological pressure to maintain stock price levels and to bring the firm's value up to market expectations. Driven by this pressure, firm managers may resort earning management to embellish the firm's short-term financial data; Johnson, Ryan and Tian (2009) show that managers are generally under pressure to make excellent achievements and maintain high stock prices, leading some managers to engage in financial and legal misconduct. Burns and Kedia (2006) find that even managers motivated by long-term options use more aggressive accounting policies to improve their individual performance during their tenure.

Furthermore, stock mispricing can directly affect corporate investment. Previous studies analyze the relationship between stock mispricing and corporate investment, considering the impacts of managers' behavior and financing conditions. To align the value of a firm with market expectations, managers cater to short-term investors by increasing innovation inputs and outputs to send positive signals to the market (i.e., the catering hypothesis; Stein, 1996; Jensen, 2005; Polk and Sapienza, 2009). Hirshleifer, Subrahmanyam and Titman (2006) further argue that the catering hypothesis holds even when managers' characteristics are considered; overly optimistic irrational managers mistakenly believe that an overvalued stock is consistent with the firm's true value and spontaneously maintain the same expectations as investors, which increases the firm's R&D and innovation activities. Rational managers, are although able to recognize the fact that stocks are mispriced, also recognize that overvaluation of a firm's stock indicates a favorable time for the firm to issue new shares; financing institutions are willing to provide financing when stock prices are high, making it easier to secure funds through equity and debt financing, ultimately driving investment through the finance channel (Baker et al., 2003; Gilchrist et al., 2005; Lu et al., 2017). Innovation is an investment that drives the long-term growth of a firm, and therefore, stock overvaluation promotes firm innovation (Dong et al., 2020).

Based on the theoretical framework outlined above, we propose the following hypothesis, i.e., the "catering" hypothesis:

H1. The overvaluation of stocks promotes corporate innovation.

However, we argue that in emerging markets, managers' behavior and corporate finance may not be consistent with the catering hypothesis, and managers may be inclined to choose risk-averse strategies if overvaluation of the stock increases uncertainty for the firm (Schwartz, 2003). As there are many irrational investors in such markets and strong uncertainty in the capital market, managers engage in *ex ante* risk management

and make investment decisions cautiously to maintain the stock price. Innovative investments with high upfront investments, unstable returns and long payback periods are difficult to be favored under conditions of high uncertainty. Furthermore, anticipating that the stock price will correct after overvaluation, managers may choose to sell their personal holdings to avoid risks, thus further separating managerial interests from the long-term interests of the company, in which case the firm's long-term projects are more likely to be put on hold (Jensen, 2005). In terms of the external financing environment, when a firm's stock price is overvalued, there is a higher risk of stock price collapse due to the deviation of the stock price from the true value of the firm. An inflated stock price also indicates that the firm may have a higher level of risk; thus, financing institutions may reduce their lending to firms with overvalued stock to avoid risk, reducing available funds for the firm's innovation activities and rendering it difficult for managers to make innovation investments.

In China capital market, the effect of stock overvaluation on corporate innovation is likely to align with the risk-aversion hypothesis. First, 97% of the whole investors have shareholdings worth less than 500,000 yuan according to formal vice chairman of CSRC Yan Qingmin Compared relative to insiders, the retail investor has less access to corporate information and immature investment skills and is more prone to irrational emotions, factors that are likely to lead to stock misvaluation. This, in turn, increases stock price volatility and risk levels for the company in question, and the increased uncertainty hinders corporate innovation (Schwartz, 2003). Therefore, managers in the Chinese market are cautious in their decision-making when their companies' stock is overvalued, and they choose to avoid risk rather than catering to investors, thus reducing innovation investment.

Second, as managers expect a high level of risk when their companies' stock is overvalued, it is likely that when a company's stock is overvalued, its managers will choose to sell their personal shares to profit from the overvaluation. Such a reduction in personal shareholding separates the interests of the managers from the long-term interests of the company, such that activities that are consistent with the long-term interests of the company but potentially detrimental to the managers' personal interests, such as investment in innovation, are often put on hold.

Third, the main financing method for Chinese companies is indirect financing; thus, it is difficult to raise funds through the issuance of new shares, as is done in the U.S. capital market. Like managers, creditors, as represented by banks and other financing institutions, also perceive an increase in risk for a company when its stock is overvalued because of irrational sentiment concerning the A-Share stock price. When the stock is overvalued, the risk of stock price collapse is increased by the heightened risk of equity pledges by major shareholders (Sun et al., 2017). Therefore, when a company's stock is overvalued, creditors also choose a risk-averse strategy; they issue loans cautiously to companies with overvalued stocks to avoid the risk of debt default brought by the companies' future risk exposure. This further tightens financing constraints on such companies, which limits their R&D and other innovation activities.

Fourth, there are many non-state-owned enterprises (non-SOEs) among China's listed companies, which are important subjects of market innovation; however, these companies have long been deemed to be less important than state-owned enterprises (SOEs) in China's financing system and have gained less policy support (Li and Yu, 2012, 2015). Compared with the U.S. market, which relies more on companies' spontaneous innovation, R&D innovation in China requires strong policy support in terms of financing and taxation. Against this background, the majority of non-SOEs are at a disadvantage; they are more affected than SOEs by stock overvaluation, which eventually affects the innovation of the entire market.

Based on the above discussions, we propose the following "risk-aversion" hypothesis:

H2: In the Chinese market, the overvaluation of stocks inhibits firm innovation.

3. Research design

3.1. Sample selection and data sources

In this paper, we select sample data from 2006 to 2019. The choice of 2006 as a starting date is made to avoid the impact of Equity Share Reform in 2005, Chinese stock market has experienced several bull and bear markets during the 2006–2019 period which allows a robust test for our research. Data related to the variable *MFFlow*, which portrays the level of stock mispricing, and other control variables are obtained from the China

Stock Market & Accounting Research (CSMAR) database, and data on firm innovation are obtained from the Chinese Research Data Services Platform (CNRDS) database.

We process the collected data by (1) excluding the data of financial sector companies and companies with ST or *ST during the sample period, (2) excluding insolvent companies and (3) excluding listed companies that have never been held by any mutual fund in any year of our sample period. Finally, we winsorize at the 1% and 99% levels for ratio-based variables. A total of 16,527 valid observations are obtained.

3.2. Variable construction

3.2.1. Level of stock misvaluation

Many variables are proposed in the literature to measure the level of stock mispricing, including the residual income model (RIM), Tobin's Q decomposition and book-to-market decomposition methods.[2] However, these models have a serious endogeneity problem; a firm's increased level of innovation can have an impact on the firm's fundamental situation, which creates a reverse-causality problem. For this reason, this paper follows Edmans et al. (2012) and Dong et al. (2020) to construct the variable *MFFlow*, which measures the level of stock misvaluation based on the hypothetical outflow level of mutual fund, which is directly correlated with the level of stock misvaluation and uncorrelated with firm fundamentals. Therefore, this variable is not directly related to firms' R&D innovation, which alleviates the aforementioned endogeneity problem and improves the accuracy of the study.

Our variable representing mutual fund flow pressure, *MFFlow*, also known as "mutual fund liquidity pressure," measures the degree of stock mispricing by using the assumed level of outflows from fund holdings. This measure is based on the Price Pressure Hypothesis proposed by Scholes (1972), who stated that similar to other commodities, the price of stocks and the demand for stocks are negatively correlated and that the equilibrium price of stocks is determined by the stocks supply and demand. When a company's stock is sold on a large scale, the supply of stocks in circulation suddenly increases and the market supply exceeds the market demand, causing the stock price to suddenly fall, thus leading to undervaluation of the stock.

Scholes argues that this type of undervaluation due to market pressure serves as compensation for the liquidity provider. Harris and Gurel (1986) and Shleifer (1986) support this theory with empirical research based on statistics from the U.S. market. Coval and Stafford (2007) develop the theory by suggesting that when a stock is sold by a mutual fund on a large scale, it can put pressure on the price of that stock. Edmans et al. (2012) further refine Coval and Stafford's study by constructing a new variable, *MFFlow*.

The variable *MFFlow* is calculated in the following two steps:

$$Netflow_{j,t} = \frac{TA_{j,t} - TA_{j,t-1} * \left(1 + R_{j,t}\right)}{TA_{j,t-1}} \tag{1}$$

$$QMFFlow_{i,t} = \sum_{j=1}^{m} \frac{Netflow_{j,t} * share_{i,j,t} * price_{i,t}}{vol_{i,t}} \tag{2}$$

In equation (2), we define *QMFFlow* as variable *MFFlow* measured quarterly. "Q" means the quarter. In equation (1), *Netflow* is calculated as the average outflow rate of a particular fund, *j*.We define subscript *t* as the proxy of some quarter in one year. The average outflow rate of a fund refers to the rate of change in the fund's size. As fund managers cannot directly decide how much investors in the market put into a fund, the rate of change in fund size is determined by investors (fund owners) in the market and it represents the sentiment of the market. Equation (1) indicates that if the value of Netflow become higher, more retail investors emerge into mutual fund market and more investors display optimistic expectations about the fund's stock holdings. Equation (2) assumes that stock i is held by m funds. *Netflow* is weighted summed by the stock's market value of each fund's stock holdings Finally, *QMFFlow* is divided by the total trading volume of that stock in that quarter.

[2] For specific construction methods, see Goyal and Yamada (2004), Ohlson (2001) and Lu et al. (2017).

To calculate the variable *Netflow*, we follow Dong et al. (2020) by using only observations with *Netflow* ≤ -0.05, excluding the effect of small, reasonable fluctuations in stock prices to ensure that *MFFlow* indeed measures the level of stock mispricing and does not include reasonable fluctuations in stock prices.

The level of stock mispricing, as measured by *MFFlow*, is independent of the fundamental value of the company. If all of the investors in the market have access to news that indicates growth in the company's fundamental value, such as technological innovation, or if the company develops innovations in the previous period that released favorable signals to the investors would buy stocks of the company directly rather than long mutual funds holding shares of the companies, because they would receive higher return by buying the stock directly. In a word, the expansion and contraction of fund size and changes in the average fund outflow rate are spontaneously determined by fund investors and are directly related to market sentiment. An example of the correlation between market sentiment and fund size occurred at the end of 2020 and the beginning of 2021, when overly optimistic retail investors in the A-share market spontaneously emerged into mutual fund market, resulting in the expansion of the fund holding size. At the same time, the prices of blue chips stock crashed down. We assume that maybe there are some relationships between mutual fund market and stock market. It is reasonable to use *MFFlow* as a proxy of mispricing of stocks to some extent.

Second, *MFFlow* is calculated by using the average outflow rate of a fund, not the actual outflow rate of a particular stock in a fund. The average outflow rate of a fund is used to estimate the actual outflow rate of each stock and is weighted by the market value of the stock as a percentage of the fund. The advantage of this approach is that in the case of incomplete information disclosure, even if a fund manager increases his holdings in a stock and obtains a higher rate of return by virtue of his access to insider information about a company's fundamentals, such as corporate technological innovation, the impact of this change can be smoothed out by the calculation of the average outflow rate, without significantly changing the value of *MFFlow*. In addition, this paper measures the level of corporate innovation in the baseline regression model by the number of patent applications. In many industries, patent applications are not necessarily the primary consideration in a fund manager's decisions (although, in certain industries, such as pharmaceuticals, the number of patent applications is an important factor). In this case, the problem of reverse causality caused by the fund manager's insider information can be better mitigated.

Finally, we also winsorize *MFFlow* values at the 1% and 99% levels to further exclude the effect of extreme values.

Based on the above method, a high *MFFlow* value indicates investors' exceedingly optimistic expectations of a stock, high demand for the stock and overvaluation of the stock when the basic value of the company is unchanged; conversely, a low *MFFlow* value indicates that market investors do not have optimistic expectations of the stock when the basic value of the company is unchanged. The lower the *MFFlow* value, the lower the demand for the stock and the more the stock is undervalued.

3.2.2. Corporate innovation level

Drawing on Kogan et al. (2017), Dong et al. (2020) and Tian and Meng (2018), this paper adopts the number of a company's patent applications as an important indicator of the innovation output of the corporation. There are three types of patents in China: invention-type patents, utility-type patents and appearance patents. Appearance design patents mainly involve the improvement of product shapes and patterns and have a low technological content; therefore, following Tian and Meng (2018), this paper omits appearance patents and selects only invention-type patents and utility-type patents, using the number of such patent applications to measure the level of innovation in the baseline regression model.

3.2.3. Other variables

Other control variables mainly comprise the size of the corporation (*Size*), calculated as the logarithm of the total assets of the corporation; Leverage; *SOE*, a dummy variable representing the nature of the ownership of the company, which equals 1 for SOEs and 0 for non-SOEs; the age of the listed company in logarithmic form (*Age*); the ratio of net cash flow from operating activities to total assets (*CFO*); the growth rate of the main business income (*Sales_rate*); Turnover; return on total assets (*ROA*); the internal control quality of the corporation (Internal) and the shareholding ratio of the largest shareholder (*Holding 1*).

Table 1
Definition of variables.

Variable Type	Variable Name	Definition	Calculation method
Explained variables	*Lnpatent_inv*	Invention-type patent	The number of invention-type patent applications plus 1 is taken as a logarithm.
	Lnpatent_use	Utility patent	The number of utility patent applications plus 1 is taken as a logarithm.
	Lnpatent_all	Total of invention-type patents and utility patents	The total number of patent applications plus 1 is taken as a logarithm.
Explanatory variables	*MFFlow*	Stock misvaluation level	See equations (1) and (2) in Section 3.2.1 and the associated explanations.
Intermediate variables	*CredLoan*	Financing constraints	The ratio of credit loan to the loan in all.
	Mana_stock	Shareholding ratio of company executives	Executive shareholding/total shares outstanding
Control variables	*Size*	Company size	Total company assets are taken as a logarithm.
	Leverage	Corporate gearing ratio	Total company liabilities/total company assets
	SOE	Nature of company ownership	Equals 1 for SOEs and 0 for non-SOEs
	CFO	Company's net cash flow produced by operating activities at the end of the period as a percentage of asset	Net cash flow at the end of the period/total assets of the company at the end of the period
	Sales_rate	Growth rate of main business revenue	Increase in revenue from main business/main business at the end of the previous year
	Turnover	Change of hands rate	Arithmetic average of annual trading day turnover rates
	ROA	Return on total assets	Net profit/total assets
	Internal	Internal quality control	Database provided; a higher value indicates higher quality of internal control
	Holding1	Largest shareholder holdings	Percentage of shareholding of the largest shareholder

In the test of mediating effects, this paper also uses the variable *CredLoan* which measures a firm's finance constraints, and *Mana_stock*, which measures the average shareholding of the firm's executives to the whole shareholding. All of the variables are defined in Table 1.

Based on the above variables, we construct the following baseline model:

$$Lnpatent_{i,t} = \beta_0 + \beta_1 MFFlow_{i,t-1} + \beta_2 X_{i,t-1} + \gamma_i + t_{t-1} + \varepsilon_{i,t-1} \quad (1)$$

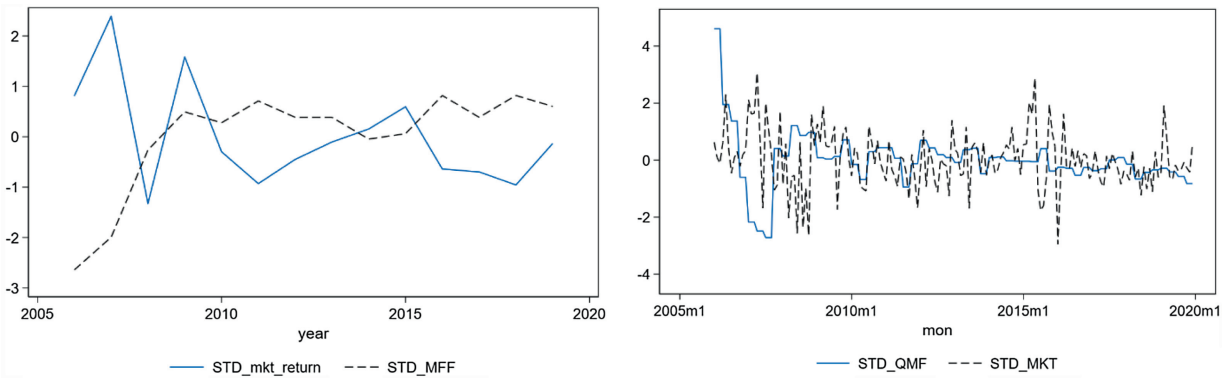
where, for convenience, $\text{Lnpatent}_{i,t}$ is used to represent $\text{Lnpatent\_inv}_{i,t}$, $\text{Lnpatent\_use}_{i,t}$ and $\text{Lnpatent\_all}_{i,t}$, the three variables that measure the firm's innovation output. We define the subscript t as the proxy of year. $X_{i,t}$ stands for all of the control variables (see Table 1). γ_i and t_t denote the industry and year fixed effects of the controls, respectively.[3] As applying for a patent is a long-time process, we lag all of the independent variables by one period. If the empirical results show a positive coefficient β_1 of *MFFlow*, the catering hypothesis is supported; conversely, if the coefficient is negative, the risk-aversion hypothesis is supported.

4. Empirical results and analysis

4.1. MFFlow validity test

MFFlow has been shown to be an effective measure in mature markets (e.g., the U.S.) because of these markets' substantial share of institutional investors, whose buying and selling can significantly influence market volatility. However, in emerging capital markets, such as the Chinese market, the institutional investors' level of development and behavioral characteristics are significantly different from those in mature markets. There-

[3] $X_{i,t}, \gamma_i$ and t_t in the model carry the same meaning as the corresponding variables in model①.



Yearly Monthly

Fig. 1. Relationship between *MFFlow* and stock price return.

fore, before conducting the empirical study, we test whether *MFFlow* can effectively measure stock mispricing in the Chinese capital market. Fig. 1 illustrates the annual and monthly changes of *MFFlow* and the A-share market return. In most cases, a lower value of *MFFlow* corresponds to a higher market return, and a higher market return tends to indicate that the stock is undervalued during this period. Similarly, a higher value of *MFFlow* corresponds to a lower market return, while a lower market return tends to imply that the stock is overvalued during this period.

Fig. 1 illustrates visually the opposite directional movement of *MFFlow* and stock price returns, on the basis of which we propose that *MFFlow* can effectively portray the level of stock misvaluation. Next, we follow Edmans et al. (2012) in adopting an event study approach to verify the validity of *MFFlow* for the Chinese market rigorously.

The event study method is as follows. When a company's *MFFlow* value is very high, we define it as "event occurrence." We find that the company's stock price shows the following characteristics before and after the event. First, the abnormal return of the stock price changes abruptly and even reverses at the time of the event. After the event, the abnormal return of the stock price rises at a very fast rate and continues for a period of time, as the event implies over-optimistic market sentiment. This is followed by a sudden reversal, where abnormal return falls at a faster rate and for a longer period of time than those observed for the price rises.

The event study method is performed as follows. First, the *QMFFlow* data are calculated according to the method described above. We then define the event date as the quarter in which the *QMFFlow* value corresponds to the upper 90th percentile of the overall data (i.e., the quarter in which overoptimistic market sentiment are most pronounced), the event window as (–2, 12), and the estimation window of the event as (–12, –2). The longer period of event reflects the fact that stock mispricing's effect on corporate innovation involves a long-time transmission process. Therefore, the abnormal returns in this paper are based on the buying and holding abnormal returns (BHAR). Market returns are the quarterly market returns of the integrated A-share Market and Second Board Market and Sci-Tech innovation board, and individual stock returns are the monthly individual stock returns, considering the reinvestment of cash dividends. The above data are collected from the CSMAR stock market series database. The results obtained from the event study method are shown in Fig. 2.

Fig. 2 clearly shows that the abnormal return of the stock quickly reverses from a gradual decline before the event to a steep rise after the event (which occurs at $t = 0$). This proves that the exogenous shock, rather than fundamental factors, influences the stock price, as the abnormal return in the latter case would grow more smoothly than in the former case. In the year following the event ($0 \leq t \leq 4$), the abnormal returns of the stock rise rapidly, coinciding with overvaluation of the stock. One year after the event (i.e., $t > 4$), a clear turning point is evident; the abnormal returns of the stock fall abruptly again, and the downward trend continues to the end of the event window. This proves that when quarterly *MFFlow* values are high, stocks are often

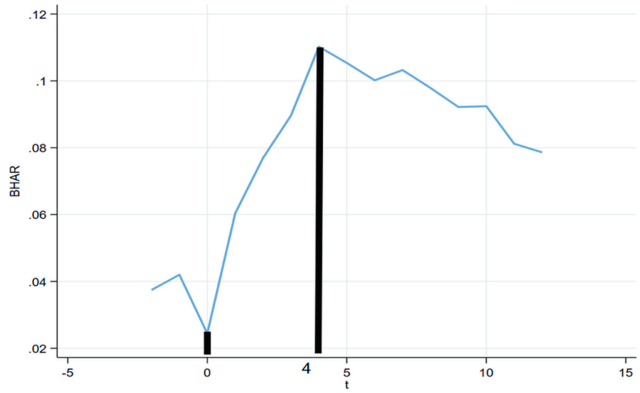


Fig. 2. Results of event study.

overvalued for the following year, and thus the change in stock abnormal returns reverses and rises at a rapid rate. Furthermore, when the bubble formed by overvalued bursts, it causes stock prices to fall, resulting in a sudden drop in abnormal returns. Therefore, based on the historical data of China capital market performance, it is reasonable and valid to use *MFFlow* to measure the level of stock misvaluation in China A-share market.

4.2. Descriptive statistics of variables

As shown in Table 2, the mean value of *MFFlow* is –0.012 and the standard deviation is 0.027, which is similar to the findings of Dong et al. (2020). The standard deviation of *MFFlow* is relatively small, which indicates that many companies' *MFFlow* does not vary much among 2006-2019. This means that the variation is mainly found between companies rather than within individual company. Based on this data feature, our subsequent baseline regression model does not control for individual company fixed effects.

Table 2 also shows dependent variable *Lnpatent_inv, Lnpatent_use and Lnpatent_all,* which measure innovation output, have relatively large standard deviations, indicating that the levels of innovation and innovation capacity vary widely across companies.

Table 2
Descriptive statistics results.

Variables	*Obs.*	*Mean*	*Std.*	*Min.*	*Max.*
Lnpatent_inv	16527	1.912	1.650	0	8.918
Lnpatent_use	16527	1.805	1.721	0	8.904
Lnpatent_all	16527	2.472	1.846	0	9.604
MFFlow	16527	−0.012	0.027	−0.221	0
SOE	16527	0.432	0.495	0	1
Age	16527	2.859	0.343	1.099	3.932
CFO	16527	0.065	0.091	−0.234	0.358
Sales rate	16527	0.110	0.256	−1.381	0.768
Size	16527	22.507	1.343	17.813	28.636
Leverage	16527	0.442	0.204	0.054	0.972
ROA	16527	0.048	0.058	−0.283	0.197
Turnover	16527	0.025	0.019	0.002	0.115
Holding1	16527	0.357	0.152	0.088	0.749
Internal	16527	665.651	128.67	0	995.360
Mana_stock	16527	0.087	0.083	0	0.214
CredLoan	12312	0.521	0.328	0.001	1

Table 3
Baseline regression results: Industry, year bivariate fixed effects.

	(1) Lnpatent_inv	(2) Lnpatent_use	(3) Lnpatent_all
MFFlow	–2.595***	–1.339***	–2.259***
	(0.547)	(0.289)	(0.498)
SOE	0.143***	0.047	0.090**
	(0.039)	(0.040)	(0.042)
Age	–0.500***	–0.517***	–0.577***
	(0.059)	(0.063)	(0.059)
CFO	–0.476**	–0.666***	–0.673**
	(0.210)	(0.228)	(0.252)
Sales_rate	0.022	0.070	0.060
	(0.069)	(0.089)	(0.085)
Size	0.471***	0.443***	0.507***
	(0.047)	(0.054)	(0.046)
Leverage	–0.079	0.319	0.065
	(0.202)	(0.228)	(0.220)
ROA	0.759*	0.293	0.725*
	(0.386)	(0.321)	(0.383)
Turnover	2.051***	3.501**	3.253***
	(0.348)	(1.551)	(0.668)
Holding1	–0.373**	–0.052	–0.285
	(0.165)	(0.122)	(0.179)
Internal	0.001***	0.001***	0.001***
	(0.000)	(0.000)	(0.000)
Industry	Y	Y	Y
Year	Y	Y	Y
N	16,527	16,527	16,527
R^2	0.350	0.349	0.388

Note: Robust standard errors for clustering adjusted at the industry level are in parentheses.[6] *, ** and *** represent 10%, 5% and 1% significance levels, respectively.

4.3. Baseline model regression

We apply the ordinary least squares (OLS) method for the baseline model regression and add regional fixed effects in the subsequent regressions. The regression results for model *(1)* are presented in Table 3, showing the results with industry and year fixed effects. In addition, we also control industry, year and region fixed effects, presenting the results in Table 4.

In Tables 3 and 4, the regression coefficients of invention patents, utility patents and the sum of the two types of patents on *MFFlow* are all significantly negative at the 1% level. These results show that the higher the *MFFlow* is, the more overvalued the company's stock is and the less the company's innovation is, while other conditions remain unchanged. This supports the risk-aversion hypothesis (H2) to a certain extent.

The results of the baseline model regressions are in contrast to Dong et al.'s (2020) finding, which supports the catering hypothesis. They explain this in terms of the finance channel; specifically, when a firm's stock is overvalued, the firm can take advantage of this favorable market expectation to issue new equity and debt and use new funds to promote innovation. However, we find that in China, the overvaluation of stocks decreases firms' innovation. This is because the investor structure in China is dominated by individual investors, and the retail investors lack rational sentiment. Therefore, a high stock price may not necessarily send a favorable signal to managers and financing institutions, however it may instead increase the risk level of the company, resulting in such adverse effects as managers' selling their holdings and financing institutions reducing their

[6] [6] Following Cameron and Miller's (2015) proposition, we unify the hierarchy of fixed effects and the hierarchy of clustered robust standard errors into a single hierarchy. The clustering robust standard errors are still significant at the firm level. This is discussed in Section 6, which covers robustness testing.

Table 4
Baseline regression results: Industry, year, region effects.

	(1) Lnpatent_inv	(2) Lnpatent_use	(3) Lnpatent_all
MFFlow	–2.226***	–1.099***	–1.913***
	(0.459)	(0.205)	(0.415)
Controls	Y	Y	Y
Industry	Y	Y	Y
Year	Y	Y	Y
Region	Y	Y	Y
N	16,527	16,527	16,527
R^2	0.376	0.370	0.413

Note: Robust standard errors for clustering adjusted at the industry level are in parentheses. *, ** and *** represent 10%, 5% and 1% significance levels, respectively.

lending, because they are more cautious. Furthermore, in China, debt financing from financial institutions is discriminatory against non-SOEs; therefore, since there is a fact that the vast number of non-SOEs are more motivated than SOEs to conduct R&D and innovation, corporate innovation is rather inhibited when a company's stock is overvalued.

4.4. Test of sample selection problem

Although this paper mitigates reverse causality by constructing *MFFlow*, an indicator exogenous to the fundamental value of the firm, there may be a sample selection problem. First, a self-selection problem exists in that there may be systematic differences between firms with overvalued stock and those with undervalued stock, and it is possible that these factors contribute to the difference in innovation output. To mitigate the effect of systematic differences between overvalued and undervalued firms, this paper applies the propensity score matching (PSM) method to test robustness. For this, the full sample is divided into two groups based on the median *MFFlow* of listed companies in each year and in each industry, which is portrayed by the dummy variable Overvaluation. Overvaluation = 1 if the value of *MFFlow* of a company in a given year is higher than the annual median, and otherwise 0. For each year, listed companies with an Overvaluation value of 1 are sorted into the overvalued stock group, and those with a value of 0 belong to the undervalued group. We then use control variables as covariates to perform PSM; to ensure that there is no significant difference in the above variables between the overvaluation and undervaluation groups, the radius of difference of PSM values between the two groups is limited to 0.01. Finally, we conduct regressions according to the baseline model based on the successfully matched samples of overvalued and undervalued stocks, and the findings remain the same. The regression results of the matched samples are shown in Table 5.

The second potential problem involves sample selection and omission. In constructing the baseline regression, we exclude stocks in the sample interval that are not held by any fund because these stocks cannot be calculated for *MFFlow*. However, this presents a sample selection problem, as the reason that the excluded

Table 5
Sample regression results after PSM.

	(1) Lnpatent_inv	(2) Lnpatent_use	(3) Lnpatent_all
Over-valuation	–0.160**	–0.101**	–0.158***
	(0.060)	(0.039)	(0.051)
Controls	Y	Y	Y
Industry	Y	Y	Y
Year	Y	Y	Y
N	10,146	10,146	10,146
R^2	0.328	0.334	0.375

stocks are not held by funds is not a random factor. This exclusion affects the generality of our conclusions and potentially biases the sample regression results. To address this problem, we construct the dummy variable *Fund*; *Fund* = 1 if the stock is held by a fund in the sample interval, and 0 otherwise.

In this study, we use the Heckman two-stage model to test the sample-selection problem. In the first stage, we run a probit regression. In addition to the variable in baseline regression, we add the exclusion constraint variable, *OtherFund*. *OtherFund* is the proportion of other corporations held by a mutual fund in the same industry. We use the results of the probit regression to calculate the inverse Mills ratio, and in the second stage, we add the inverse Mills ratio as the control variable for the regression. The results of the two-stage regression are shown in Table 6.

As shown in Table 6, Panel A, we find that the coefficient of OtherFund is significantly positive, which meets the condition of an exclusion constraint variable. The proportion of other companies in the same industry held by funds is not directly related to the innovation output of corporations. Furthermore, as shown in Table 6, Panel B, we find that the inverse Mills ratio variable (IMR) is significantly negative, which proves that there is indeed a sample-selection problem. In particular, we note that the variance inflation factors of IMR are all below 5, indicating that the collinearity problem is not serious and the model selection is appropriate to a certain extent. However, even after considering the sample-selection problem, the regression coefficient of the number of coporation patent applications on *MFFlow* is still significantly negative, which shows that the findings of the baseline regression in this paper are creditable.

Table 6
Results of Heckman two-stage model test for sample selection problem.

Panel A. First-stage results
Fund

	Coefficient		*Std-Error*
SOE	–0.147***		0.052
Age	–0.218***		0.045
CFO	0.809***		0.118
Sales_rate	0.218***		0.048
Size	0.552***		0.022
leverage	–0.856***		0.106
ROA	3.439***		0.539
Turnover	0.256		0.760
Holding1	–0.610***		0.059
Internal	0.000***		0.000
OtherFund	2.048***		0.498
Year	0.057***		0.004
Industry	0.001		0.009
N		27,856	
R^2		0.223	

Panel B. Second-stage results

	(1) *Lnpatent_inv*	*(2)* *Lnpatent_use*	*(3)* *Lnpatent_all*
MFFlow	–1.752***	–0.676**	–1.375***
	(0.473)	(0.248)	(0.453)
IMR	–0.931***	–0.771***	–1.005***
	(0.201)	(0.158)	(0.176)
Controls	Y	Y	Y
Year	Y	Y	Y
Industry	Y	Y	Y
N	16,302	16,302	16,302
R^2	0.373	0.365	0.410
VIF of IMR	1.83	1.78	1.83

5. Further research

5.1. Intermediary effect analysis

Certain studies argue that changes in managerial behavior due to catering mechanisms and the convenience of financing are the main reasons why stock overvaluation promotes investment (Stein, 1996; Jensen, 2005; Dong et al., 2020), and these two channels are in fact explained in terms of internal managerial behavior and external financing, respectively. Following above research, this study attempts to investigate the channels through which stock overvaluation affects corporate innovation from managerial behavior channel and finance channel.

5.1.1. Managers shareholding selling channel

Changes in managers' shareholdings tend to affect firms' long-term investment behavior. The relationship between executive incentives and constraints and the level of corporate innovation appears in the literature. Wang et al. (2017) point out that equity and option incentives for executives are conducive to increasing corporate innovation, i.e., the behavior of a company's executives in increasing their stock holdings is conducive to the company's long-term investment activities, such as R&D and innovation. Jensen and Meckling (1976) and other scholars argue that increasing the shareholding of executives can better synergize the interests of executives and external shareholders and encourage executives to take action to increase corporate value. Conversely, if a company's managers choose to sell their shareholding, this likely indicates that the managers are not willing to increase the company's long-term investment, impeding the company's long-term increase in value. Finally, Yang et al.'s (2018) research shows that managers often become cautious when stocks are overvalued. Based on this, we propose that when a firm's stock is overvalued, managers behave more cautiously than in other situations and choose to sell their stock holdings, thus discouraging their firms from undertaking R&D and innovation activities. Thus, we use the following models to test whether there is a mediating effect of changes in executive shareholding.

$$Mana\_stock_{i,t} = \alpha_0 + \alpha_1 MFFlow_{i,t-t} + \alpha_2 X_{i,t-t} + \gamma_i + t_{t-t} + \varepsilon_{i,t-t} \tag{2}$$

$$Lnpatent\_all_{i,t} = \theta_0 + \theta_1 MFFlow_{i,t-1} + \theta_2 Mana\_stock_{i,t-1} + \theta_3 X_{i,t-1} + \gamma_i + t_{t-1} + \varepsilon_{i,t-1} \tag{3}$$

Model *(2)* tests the effect of *MFFlow* on executive shareholding percentage (*Mana_stock*), and model (3) tests the effect of Mana_stock on the number of a firm's patent applications (*Lnpatent_all*).

Panel B of Table 7 shows that when a company's *MFFlow* is high and its stock is overvalued, the share of managers' holdings decreases, indicating that managers are inclined to lock in personal gains by selling their stock when the stock is overvalued; this behavior significantly reduces the innovation output of the company. Thus, managers' shareholding selling behavior is an important influence on firms' innovation, and improving the corporate governance structure and strengthening supervision of managers are important means to improve firms' level of innovation.

5.1.2. Financing constraint path

Innovation, as a long-term investment, requires sufficient financial support; therefore, the higher the financing constraint, the greater the restriction on corporate innovation. Equity financing and debt financing are the two most common means of financing for firms. In China, listed companies do not issue new shares on the secondary market frequently; thus, financing for R&D innovation is often done via the debt financing route.

We use *CredLoan* to measure the financial constraint. CredLoan is calculated by the ratio of credit loan to loan in all. The data for the *CredLoan* are obtained from the CSMAR database. We construct models (4) and (5), which, combined with the baseline model (1), can test the channel effect.

$$\text{Index} \quad SA_{i,t} = \partial_0 + \partial_1 MFFlow_{i,t-t} + \partial_2 X_{i,t-t} + \gamma_i + t_{t-t} + \varepsilon_{i,t-t} \tag{4}$$

$$Lnpatent\_all_{i,t} = \theta_0 + \theta_1 MFFlow_{i,t-1} + \theta_2 CredLoan_{i,t-1} + \theta_3 X_{i,t-1} + \gamma_i + t_{t-1} + \varepsilon_{i,t-1} \tag{5}$$

Table 7
Results of the test of managers' shareholding channel.

Panel A. *Joint effect of MFFlow and Mana_stock*		Panel B. *Separate effects of MFFlow on total number of patent applications and Mana_stock*		
Variable	Lnpatent_all	Variable	Lnpatent_all	Mana-stock
MFFLOW	−2.194***	MFFLOW	−2.259***	−0.136***
	(0.499)		(0.498)	(0.019)
Mana_stock	0.570**			
	(0.239)			
Controls	Y	Controls	Y	Y
N	16527	N	16527	16527
R^2	0.389	R^2	0.388	0.371

Panel C. Channel Effect Analysis

Path Effect	Coefficient	Sd-Error
(1) Directly effect of MFFlow on Patent		
MFFlow→Lnpatent_all	−2.194	0.499
(2) Channel of Mana_stock		
MFFlow→Mana_stock	−0.136	0.019
Mana_stock→Lnpatent_all	0.570	0.239

Table 8
Test of financing constraints channel.

Panel A. Joint effect of MFFlow and CreditLoan		*Panel B. Separate effects of MFFlow on total number of patent applications and CreditLoan*		
Variable	Lnpatent_all	Variable	Lnpatent_all	*Cred_loan*
MFFlow	−3.463***	MFFlow	−3.514***	−0.269**
	(0.825)		(0.813)	(0.102)
CredLoan	0.181***			
	(0.049)			
Controls	Y	Controls	Y	Y
N	12312	N	12312	12312
R^2	0.416	R^2	0.415	0.125

Panel C. Channel Analysis

Path	Coefficient	Sd-Error
(1) Directly effect of MFFlow on Patent		
MFFlow→Lnpatent_all	−3.514	0.813
(2) Channel of CredLoan		
MFFlow→Credloan	−0.269	0.102
Credloan→Lnpatent_all	0.181	0.049

Model (4) tests the effect of *MFFlow* on *CredLoan*, and model (5) tests the effect of *CredLoan* on the number of patent applications (*Lnpatent_all*). The combination of model (4), model (5) and the baseline regression model *(1)* tests the channel effect. The regression results are shown in Table 8.

As shown in Panel B of Table 8, *CredLoan* increases when value of *MFFlow* rises, indicating that when the company's stock is overvalued, the company's financing constraint tightens. This paper proposes that this is because when a company's stock is overvalued, the stock price rises rapidly and that creditors, by observing the historical data of the A-share market, may expect a bubble to form after a short-term rise in stock price. The company is likely to accumulate risk, which in turn is likely to trigger a debt default. Moreover, creditors may also predict that managers will take actions that are detrimental to the long-term development of the

company, such as selling their own holdings when the stock is overvalued. Therefore, creditors reduce their loan to companies with overvalued stocks.

5.2. Heterogeneity analysis and moderating effects

The heterogeneous elements examined in this paper are mainly SOEs and non-SOEs. Managers of SOEs and those of non-SOEs have different goals; the managers of non-SOEs are mainly concerned with performance, while the managers of SOEs consider not only performance but also social responsibility and political performance (e.g., tax contribution, firm size). The two types of firms also differ in their status in the credit market due to historical reasons. As a result, SOEs and non-SOEs differ in their levels of risk-taking and corporate innovation (Li and Yu, 2012, 2015).

We explain the differences in these two aspects as follows. Compared with non-SOE managers, SOE managers are less concerned about short-term performance and therefore do not adopt a risk-averse strategy in response to the overvaluation of their companies' stock, and they are less likely to sell their shareholding frequently. Furthermore, as SOEs receive favorable treatment in the credit market, creditors do not restrict their loans to them even if stocks of SOEs are overvalued in the short term. Therefore, we predict that the inhibiting effect of stock overvaluation on firm innovation is more evident in non-SOEs than in SOEs. We divide the sample into two groups according to the dummy variable (SOE) measuring the natural of enterprises, run regressions respectively and use the Suest Test to investigate whether there is a significant difference between the regression coefficients of the two groups. The empirical results are shown in Table 9.

The results in Table 9 show that for SOEs, the inhibitory effect of stock overvaluation on firm innovation is not significant, while for non-SOEs, stock overvaluation has a significant inhibitory effect on firm innovation. After the Suest Test, the above findings still hold.

Further, we analyze the moderating effect in terms of equity concentration (*Holding1*) and turnover. *Holding1* is the percentage of shares held by the company's largest shareholder. The data are taken from the CSMAR database.

Based on the agency problem that arises when stock is overvalued, namely that managers choose to sell their holdings, further separating their personal interests from the firm's long-term interests and thus discouraging firm innovation, we speculate that while an appropriate degree of equity concentration is conducive to firm innovation (Feng and Wen, 2008), A higher stock turnover rate always means that there are more short-term investors in the market, which always means that there are a more irrational sentiment concerning the stock (Li and Wang, 2006). Therefore, the inhibitory effect of stock overvaluation on firm innovation is enhanced for firms with a high turnover rate. We construct models to test the moderating effect:

$$\begin{aligned} Lnpatent\_use_{i,t} = {} & \theta_0 + \theta_1 MFFlow_{i,t-1} + \theta_2 Holding1_{i,t-1} + \theta_3 MFFlow \\ & \times Holding1_{i,t-1} + \theta_4 Controls_{i,t-1} + \gamma_i + t_{t-1} + \varepsilon_{i,t-1} \end{aligned} \tag{6}$$

Table 9
Heterogeneity test.

	(1) SOEs Lnpatent_all	(2) Non-SOEs Lnpatent_all
MFFlow	–0.489	–3.196***
	(0.815)	(0.591)
Controls	Y	Y
Industry	Y	Y
Year	Y	Y
N	7,142	9,385
R^2	0.3084	0.1608
Suest test	P = 0.0066	

Table 10
Moderating effects of shareholding concentration and turnover ratio.

	(1) Lnpatent_use	(2) Lnpatent_use
MFFlow	–3.300***	–0.672*
	(0.463)	(0.334)
Holding1	–0.001	
	(0.122)	
MFFlow × *Holding1*	4.191**	
	(1.887)	
Turnover		3.274**
		(1.451)
MFFlow × *Turnover*		–33.339*
		(17.965)
Controls	Y	Y
Industry	Y	Y
Year	Y	Y
N	16,527	16,527
R^2	0.350	0.349

$$Lnpatent\_use_{i,t} = \theta_0 + \theta_1 MFFlow_{i,t-1} + \theta_2 Turnover_{i,t-1} + \theta_3 MFFlow \times Turnover_{i,t-1} + \theta_4 Controls_{i,t-1} + \gamma_i + t_{t-1} + \varepsilon_{i,t-1} \quad (7)$$

Model (6) tests the moderating effect of *Holding1*, and model (7) tests the effect of *Tunrover*. The regression results are shown in Table 10.

The results in Table 10 show that the cross term of *Holding1* and *MFFlow* is only positively correlated to utility patents, which verifies our speculation. It also shows that equity concentration does not moderate the relationship between stock overvaluation and invention patent applications. In addition, high turnover rates strengthen the inhibiting effect of stock overvaluation on patent applications, which also confirms that in emerging markets, overly high market sentiment does not have a positive effect on firm innovation, further supporting the conclusion obtained from the baseline model regression.

6. Robustness test

6.1. Changing the estimation method of the regression model

As the variables used in this paper to portray firm innovation are continuous truncated variables with a lower bound of 0, following Tian and Meng's (2018) practice, we use Tobit estimation for robustness testing. The initial variables, Patent_all, Patent_inv and Patent_use, are discrete truncated variables with a lower bound of 0. We also follow Jiang (2021) by using Poisson regression to test robustness. The regression results after changing the regression model are shown in Tables 11 and 12. The coefficients of *MFFlow* keep the same sign as those of the baseline OLS regression, and the results are significantly negative, except for the nonsignificant coefficient of utility patent application on *MFFlow* in the Tobit estimation model, indicating that the baseline regression results are robust.

Considering that the baseline regression specifies clustering robust standard errors at the industry level, which may have an impact on statistical inference, we estimate clustering robust standard errors at the individual firm level in the robustness test. The estimation results are shown in Table 13. As observed in Table 13, the results of the baseline regression remain significant even when we cluster the standard errors at the firm level.

Table 11
Results of the Tobit regression model.

	(1) Lnpatent_inv	(2) Lnpatent_use	(3) Lnpatent_all
MFFlow	–2.446***	–1.121	–1.989**
	(0.812)	(0.728)	(0.905)
Controls	Y	Y	Y
Industry	Y	Y	Y
Year	Y	Y	Y
N	16,527	16,527	16,527
Pseudo R^2	0.0627	0.0574	0.0642

Table 12
Results of the Poisson regression model.

	(1) Lnpatent_inv	(2) Lnpatent_use	(3) Lnpatent_all
MFFlow	–4.803***	–3.065***	–4.014***
	(0.722)	(0.605)	(0.668)
Controls	Y	Y	Y
Industry	Y	Y	Y
Year	Y	Y	Y
N	16,527	16,527	16,527
Pseudo R^2	0.4659	0.4567	0.4886

Table 13
Estimation results of the standard errors of the changes.

	(1) Lnpatent_inv	(2) Lnpatent_use	(3) Lnpatent_all
MFFlow	–2.595***	–1.339**	–2.259***
	(0.572)	(0.609)	(0.620)
Controls	Y	Y	Y
Industry	Y	Y	Y
Year	Y	Y	Y
N	16,527	16,527	16,527
Pseudo R^2	0.4659	0.4567	0.4886

Table 14
Regression results for other variables of firm innovation.

	(1) RD_Income	(2) Cited1	(3) Cited2	(4) Lnpatent_out
MFFlow	–0.059***	–2.836***	–2.866***	–0.272**
	(0.020)	(0.507)	(0.364)	(0.101)
Controls	Y	Y	Y	Y
Industry	Y	Y	Y	Y
Year	Y	Y	Y	Y
N	11,556	10,644	10,389	10,389
R^2	0.244	0.242	0.240	0.042

6.2. Changes in variables measuring firm innovation

In this section, corporate R&D investment, corporate patent applications cited and appearance-type patents are used individually as variables to measure corporate innovation. In Table 14, the dependent vari-

able RD_Income in column (1) measures the ratio of corporate R&D investment to the total revenue of the year, the dependent variable Cited1 in column (2) measures the number of corporate patents cited and the explanatory variable in column (3), Cited2, measures the number of cited patents granted to the firm. In addition, we test the effect of stock mispricing on the number of appearance-type patent applications, and the explanatory variable Lnpatent_out in column (4) is the logarithmic form of the number of appearance-type patent applications filed by the firm. We change the explanatory variables several times, and the coefficients of the regression results remain consistent with the sign of the regression coefficients of the baseline model, further enhancing the robustness of the initial study findings. Table 14 presents the regression results adjusted for firm innovation variables.

6.3. Long-term effects and extreme value cases

In terms of the time horizon, corporate innovation projects tend to be long-term; therefore, it is necessary to test whether the inhibiting effect of stock overvaluation is also long-term. Referring to Dong et al. (2020), this paper regresses the core explanatory variable *MFFlow* and all of the control variables with a three-period lag on the number of invention patent applications, utility patent applications and both of the patent applications by firms to observe whether stock mispricing has a long-term effect on firms' innovation. The results of the final regressions are consistent with those of the baseline model. Table 15 presents the corresponding regression results.

In addition, it is important to consider that economic fluctuations happen from time to time. During the 2006–2019 period, China experienced two large bull and bear markets, occurring in 2008 and 2015. The stock prices experienced significant volatility in these two years, which may influence our estimates. Therefore, we also run robustness tests for estimation excluding the data from these two years. The results are shown in Table 16, which shows that the regression coefficients are still estimated to be significantly negative.

Table 15
Results of lagged three-period regression of independent variables.

	(1) *Lnpatent_inv*	*(2)* *Lnpatent_use*	*(3)* *Lnpatent_all*
MFFlow	–1.500***	–0.945***	–1.299***
	(0.351)	(0.231)	(0.289)
Controls	Y	Y	Y
Industry	Y	Y	Y
Year	Y	Y	Y
N	16,527	16,527	16,527
R^2	0.350	0.349	0.388

Table 16
Regression results, excluding extreme years.

	(1) *Lnpatent_inv*	*(2)* *Lnpatent_use*	*(3)* *Lnpatent_all*
MFFlow	–2.721***	–1.195***	–2.294***
	(0.524)	(0.258)	(0.428)
Controls	Y	Y	Y
Industry	Y	Y	Y
Year	Y	Y	Y
N	14,361	14,261	14,361
R^2	0.342	0.345	0.381

Table 17
Quantile regression results.

	Q(0.25)	*Q(0.5)*	*Q(0.75)*
Lnpatent_inv	–1.667***	–2.633***	–2.648***
	(0.389)	(0.614)	(0.512)
Lnpatent_use	–0.034	–0.785	–0.905
	(0.236)	(0.564)	(0.600)
Lnpatent_all	–1.463***	–2.025***	–1.810***
	(0.535)	(0.743)	(0.655)
Controls	Y	Y	Y
Industry	Y	Y	Y
Year	Y	Y	Y

6.4. Quantile regression test

In the baseline regression model, we use an OLS estimation method, excluding the effects of outliers by tailoring at the 1% and 99% levels. However, the distribution of stock mispricing levels and firm innovation levels is uneven in the A-share market. We also examine the effect of stock mispricing on firm innovation more comprehensively, with particular attention on the relationship between stock mispricing and firm innovation at different quantile levels. Therefore, we follow Dong et al. (2020) to run the quantile regressions, in which the quantile values taken are 0.25, 0.5 and 0.75, with all of the independent variables still lagged by one period, and the final regression results are consistent with the sign of the coefficient of *MFFlow* in the benchmark model. Table 17 displays the results of the quantile regression, which indicates that the negative effect of stock overvaluation on firms' invention patent applications and total patent applications remains significant for firms with different levels of misvaluation, after considering the distribution imbalance as well as the outlier problem. It shows that this problem is generalizable to firms with different characteristics.

7. Conclusion and insights

Stock prices tend to deviate from their true value, because there exists investors' irrational emotions. As a representative emerging market, China has a large proportion of retail investors, seriously asymmetric market information and a regulatory system that requires further improvement; as a result, there are many irrational sentiment factors in this market, leading to prevalent stock mispricing. Stock misvaluation reflects investors' wrong expectations of a company and has an impact on the company's investment and financing levels, corporate governance and M&A behavior.

This paper measures the level of stock mispricing by using the variable *MFFlow*, which is exogenous to the fundamental value of a firm. First, we show empirically that stock overvaluation inhibits firm innovation, supporting the risk-aversion hypothesis. Second, we find that managerial stock's cutbacks and tight financing constraints are two important channels through which firm innovation is inhibited. These results remain significant under several endogeneity and robustness tests.

Improving the ability of financial services for the real economy and building a "regulated, transparent, open, dynamic and resilient" capital market are the long-term goals of China's capital market construction. This study provides the following relevant insights.

First, as compared with developed Western countries, China capital market is immature; as a result, the phenomenon of stock misvaluation is more common. To develop the ability of financial services for the real economy, it is necessary to further improve institutional construction and reduce information asymmetry and other harmful factors, so that a company's stock price better reflects the true value of the company, promoting the efficient allocation of funds and the high-quality development of the capital market. In addition, it is necessary to strengthen the supervision of institutional investors' management to guard against the "herding effect" of institutional investors, take measures such as publicity supervision and education for retail investors

to improve the investment ability retail investors and enhance the stability of the market to improve their expectations of capital market.

Second, the principal–agent problem plays an important role in inhibiting effect of stock overvaluation on corporate innovation. Therefore, a better corporate governance structure and comprehensive supervision of managers and major shareholders are important to capital market construction. We must improve the laws and regulations related to managers' trading behavior and the disclosure system of listed companies.

Third, financing constraints clearly restrict the R&D innovation of Chinese companies. Under the financing system dominated by indirect financing, it is important to understand how to deepen the reform of financial intermediaries and allocate more funds to real economy. Last but not least, developing more means of direct financing is important to address the financing difficulty of corporations. These questions must be considered in the construction of emerging capital markets.

Declaration of Competing Interest

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

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Government R&D spending, fiscal instruments and corporate technological innovation

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ABSTRACT

Using panel data from 242 cities in China, we examine the impact of government research and development (R&D) spending on corporate technological innovation. We find that listed firms located in cities with higher government R&D expenditures are more innovative than firms in other cities. Further, the positive effect of government R&D spending depends on fiscal instruments and factor allocation. Through subsidies and tax incentives, government R&D spending enhances firm innovation by alleviating financing constraints, improving employee creativity and ensuring efficient operations. We demonstrate that subsidies are more effective than taxes in spurring corporate technological innovation. We also show that the impact of government R&D spending is stronger for state-owned and high-tech enterprises than for other enterprises. Overall, our findings suggest that government R&D spending can substantially improve corporate technological innovation through fiscal instruments.

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1. Introduction

Innovation is critical for a country's economic development (Schumpeter, 1980). As public policies have great impacts on the private sector, an extensive literature studies the causal relationship between government spending and corporate technological innovation (Wallsten, 2000; Toole, 2007; Cohen et al., 2011; Howell, 2017). Recent evidence suggests that government spending dampens companies' innovation activities. For example, Kong (2020) shows that an increase in government expenditures reduces innovation output at the firm level. Using China's unique data on government R&D spending and patent applications by firms, this paper aims to supplement the literature with empirical evidence from the Chinese setting.

The Chinese government has emphasized the importance of national innovation for decades. According to Freeman (1987), government policies, such as fiscal instruments, are used to spur innovation in countries such as Germany, Japan and the Soviet Union. National systems of innovation are a topic of interest in economic research because most of the premises are still valid, and such systems can help developing countries overcome the middle-income trap. Increasingly, the literature explores the incentives of innovation associated with government decisions. Studies in innovation economics suggest that government support can efficiently and effectively encourage the research and development (R&D) of cutting-edge technologies (David et al., 2000; Wade, 2017; Liu et al., 2017).

Due to institutional differences between developed and developing countries, it remains uncertain whether previous findings on government spending and innovation apply to China. As a decision-maker, plan-executor and strategy-setter for national innovation, the Chinese government has an ambitious goal to foster corporate technological innovation across different industries (Băzăvan, 2019). The Chinese setting enables us to focus on government R&D spending, which has the obvious intention of facilitating innovation activities in the private sector. The extant literature suggests that public R&D support can improve companies' cost structure, stock performance and R&D budgets (Lichtenberg, 1984; Nadiri and Mamuneas, 1994; Chen et al., 2020). Therefore, we predict that government R&D spending can boost firm innovation in China.

Although government R&D spending is an important part of regional fiscal support, it is not widely investigated because most innovation studies focus on other types of government policies, such as industrial policies. The main challenge facing empirical research is that the impact of government R&D spending cannot be directly observed at the corporate level. To overcome this challenge, this paper uses fiscal instruments as a channel to connect government R&D spending with corporate innovation. An empirical design is used because government R&D spending, as a fiscal expenditure choice, enables manifestation of public preferences for innovation, which can be seen as an institutional arrangement implemented via government subsidies and tax incentives.[1]

To examine whether government R&D spending affects corporate technological innovation through fiscal instruments, we use R&D spending data from the Chinese municipal government and patent data of A-share public firms listed in the Shanghai and Shenzhen Stock Exchanges between 2007 and 2018. Our analyses establish the following results. First, government R&D spending substantially increases corporate technological innovation as measured by the number of patent applications. This relationship is robust to a series of additional tests that address potential endogeneity concerns. Second, government subsidies encourage companies to engage in innovation by alleviating the financing constraints associated with monetary capital factors, improving the creativity of human capital and ensuring the efficient operation of management institution. In addition, the channel effect of tax incentives applies only to the factor of management institution. Third, the relationship is mostly concentrated among state-owned and high-tech enterprises. We further evaluate the inverted U-shaped relation between government R&D spending and corporate technological innovation.

This paper contributes to the extant literature in three ways. First, our findings enrich the relevant research on government R&D spending (Nadiri and Mamuneas, 1994; Kong, 2020; Chen et al., 2020) and supplement studies on technological innovation (David et al., 2000; Hirshleifer et al., 2012; Chen et al., 2016; Cai et al.,

[1] Government R&D spending is different from fiscal instruments. First, government R&D spending is a formal institutional arrangement related to fiscal policies, whereas fiscal instruments are joint decisions of the government and companies. Second, government R&D spending is a policy objective, whereas fiscal instruments are policy measures. Third, government R&D spending reflects the allocation of macroeconomic resources. In contrast, fiscal instruments represent the use of individual companies' resources.

2018; Mann, 2018). Second, we empirically test the causal impact of government R&D spending on innovation through the channels of government subsidies and tax incentives, two common fiscal instruments. We particularly focus on factor allocation related to financial constraints, human capital and capital allocation efficiency. Third, we study the granular components of government investments and policies. Previous textual analyses of industrial and government policies do not distinguish between national capital and regional innovation support. Further, studies that directly use government subsidies and tax incentives as independent variables may compare the two fiscal instruments using inconsistent standards, leading to controversial research conclusions due to instrument heterogeneity. Using a specific setting based on government R&D spending and corporate technological innovation, we rely on consistent standards to compare government subsidies and tax incentives.

The rest of the paper is organized as follows. Section 2 outlines our study background and develops hypotheses about government R&D spending, corporate technological innovation and the underlying channels. Section 3 details our research design and statistical analyses. We present empirical tests and results in Section 4. Section 5 provides further evidence on the inverted U-shaped relationship and reports our cross-sectional analyses. Section 6 concludes the paper.

2. Research background and hypothesis development

2.1. Research background

2.1.1. Government R&D spending in China

In China, government R&D spending is determined both by the government's fiscal spending structure and its preference for innovation (Nasierowski and Arcelus, 2003; Lee, 2011). China's National Medium- and Long-Term Plan for Science and Technology Development (2006–2020) (国家中长期科学和技术发展规划纲要 *2006-2020* 年), issued by the State Council in 2006, specifies government R&D spending as the national strategy to construct an innovation system. In 2019, the State Council's Reform Plan for Dividing the Responsibility of Central and Local Fiscal Authorities and Expenditures in the Field of Science and Technology (科技领域中央与地方财政事权和支出责任划分改革方案) emphasizes that the council will "...continue to increase R&D spending, and ensure that government R&D spending increases and does not decrease." The Outline of the 14th Five-Year Plan for National Economic and Social Development and Long-Range Objectives for 2035 (国民经济和社会发展第十四个五年规划和*2035*年远景目标纲要), which took effect in 2021, proposes that the government will improve the national innovation system by promoting the concentration of various innovative factors in Chinese companies. Studies show that government R&D spending can drive the allocation of resources by guiding firms' R&D investments (Levy and Terleckyj, 1983; Chang et al., 2002; Howell, 2017). Thus, high-level development of the Chinese economy is likely to depend on government R&D spending, which can help firms improve their innovation capabilities.

2.1.2. Fiscal instruments

Fiscal instruments that can influence technological innovation include government subsidies (David et al., 2000), tax incentives (Shao and Xiao, 2019), government procurement (Aschhoff and Sofka, 2009; Bruce et al., 2019) and government investment (Borisova et al., 2015; Zheng et al., 2018). We choose to study government subsidies and tax incentives because they tend to be the most effective channels supporting firm innovation (Aghion et al., 2015). By providing whole-process incentives, government-owned, project-based subsidies can motivate companies to engage in R&D investment by imposing strict supervision and evaluation. Meanwhile, tax incentives can resolve deficiencies in innovation systems and compensate companies for the cost of technology spillover (Hu and Jefferson, 2009). However, tax incentives tend to be less effective than government subsidies in promoting innovation for four reasons. First, the two fiscal instruments have different qualification thresholds. Government subsidies have a higher threshold than tax incentives. Companies eligible to receive government subsidies should be active in innovation, have a strong tendency to incur technology spillover and comply with national policies intended to guide development. In contrast, companies can obtain tax incentives if the proportion of their R&D expenditures exceeds a target ratio. Second, the two fiscal instruments have different future contingencies. Once awarded government subsidies, companies can secure

unconditional government support. Conversely, tax incentives are a type of outcome-oriented benefit and depend on the profits of successful projects; accordingly, such incentives generate high uncertainty for applicant companies. Third, these two fiscal instruments have different timings. Through whole-process supervision and evaluation, government subsidies provide *ex ante* incentives for firms to enhance innovation. By contrast, tax incentives compensate companies after they have engaged in innovation. Fourth, the two fiscal instruments differ in terms of the discretion given to companies regarding the proceeds. The government typically specifies strict requirements for the use of government subsidies, whereas companies have more discretion when managing the proceeds of tax incentives. Therefore, government subsidies are more effective than tax incentives because companies that receive such subsidies have strong innovation capabilities, deal with limited financial uncertainty, receive *ex ante* incentives and need to comply with stringent guidance.

2.1.3. Corporate factor allocation

Based on economic growth theory, the focus of factor allocation research has shifted from tangible factors such as capital, labor and natural resources (Ramsey, 1928; Solow, 1956; Cass, 1965; Diamond, 1965) to intangible factors such as technology and management institution (North, 1981; Romer, 1986, 1990; Lucas, 1988; Acemoglu et al., 2001, 2002). In recent years, China has adopted a series of guidelines to improve market-based allocation of production factors. Although capital, labor and technology are the main factors driving economic growth, intangible factors are likely to become increasingly important as the economy reaches the middle-income stage. Therefore, we choose to study monetary capital, human capital and management institution to investigate whether factor allocation influences the effects of government R&D spending on innovation.

2.2. Hypothesis development

2.2.1. Government R&D spending and corporate technological innovation

R&D spending is the basic channel through which government influences firm innovation. Although the government can use industrial policies or direct subsidies to improve corporate innovation capabilities, the most efficient approach to support innovation is through government R&D spending (Lee, 2011). In addition to direct support for corporate R&D activities, government R&D spending mainly provides financial grants to support fundamental research conducted within universities and other research institutes (Adams and Griliches, 1998; Salter and Martin, 2001). This fundamental research, especially in the scientific field, can create cutting-edge technologies. Hence, long-term public investment into fundamental scientific research is crucial to yield advanced theories and core technologies (Adams, 1990; Zeira, 2011).

As long as industrial competition relies on corporate technological development, companies need to cope with the potential cost of technology spillover. As it can be costly for firms to adjust their allocation of innovative resources (Szczygielski et al., 2017), the government can play the role of innovation leader in certain risky areas where technological innovation faces high uncertainty. In addition, the government can reduce the direct cost of R&D activities, alleviate information asymmetry between firm managers and stakeholders and promote the innovation of high-end technology (Wade, 2017). Government R&D spending can also lead to an innovation-friendly environment by facilitating research management, R&D services and scientific communication and cooperation. The environment can further help regulators to enforce laws that protect technology and intellectual property (Buesa et al., 2010).

Based on the above analysis, we present Hypothesis 1 in the alternative form:

Hypothesis 1. *Ceteris paribus*, government R&D spending can effectively increase corporate technological innovation.

2.2.2. The channel of government subsidies

Fiscal instruments such as government subsidies and tax incentives constitute the channels through which government R&D spending can influence corporate technological innovation. The effects of these instruments depend on the allocation of certain production factors. We use Fig. 1 to illustrate a framework delineating the

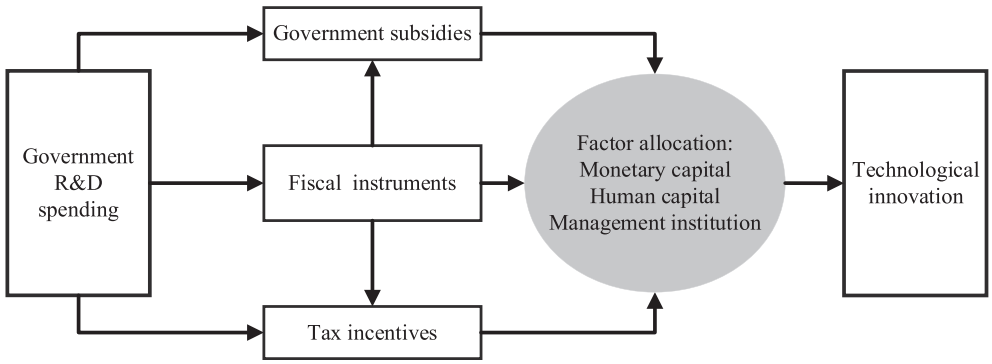

Fig. 1. Channels between Government R&D Spending and Technological Innovation.

channel effects of the two fiscal instruments and their associations with factor allocation. As Fig. 1 shows, we focus on three factors: monetary capital, human capital and management institution.

2.2.2.1. Effect of the channel of government subsidies on monetary capital. First, government subsidies can alleviate the financing constraints associated with monetary capital factors. According to the resource-based viewpoint (Teece et al., 1997), government subsidies can directly mitigate the shortage of corporate innovation resources (Tether, 2002). Project-oriented government subsidies are a form of cost-free, low-contingency compensation supervised by state officials. Such subsidies can also transmit a favorable policy signal, which can reduce the marginal costs of companies' innovation efforts, lower the risk of innovation uncertainty (Lach, 2002; Almus and Czarnitzki, 2003; Hussinger, 2008) and promote corporate R&D investment (Carboni, 2011; Kang and Park, 2012). In addition, the favorable policy signal can alter the perceptions of capital market investors and financial institutions because companies with government subsidies are considered industry leaders and have full government endorsement. As a result, this valuable signal can help companies to obtain necessary resources in order to enhance innovation efficiency (Lerner, 1999; Feldman and Kelley, 2006; Kleer, 2010).

2.2.2.2. Effect of the channel of government subsidies on human capital. Second, government subsidies can increase the creativity of human capital (e.g. through highly skilled employees) because they can directly address the labor costs of projects regulated by the government. Increased investment in high-quality human capital enhances corporate innovation (Takalo and Tanayama, 2010). When government subsidies allow companies to recruit talented employees, the companies can shift human capital investment from conventional operations to innovation activities. By making raises in employee compensation possible, government subsidies can also induce skilled human capital to increase their effort and, consequently, labor productivity. In addition, according to the knowledge spillover theory (Arrow, 1962; Romer, 1986), highly skilled employees (i.e., human capital) can indirectly improve the productivity of other employees.

2.2.2.3. Effect of the channel of government subsidies on management institution. Third, government subsidies can amplify the effect of institutional factors, such as efficient operations, on innovation. As innovation transformation between inputs and outputs is risky due to the possibility of technology spillover (Nelson, 1959), the government can play a more supportive role when capital operations are more (vs. less) efficient. When combined with low operating efficiency, government subsidies may lead to low-quality innovation due to high transaction costs; such innovation may not generate incentives for valuable technological breakthroughs.

Based on the above analysis, we propose Hypothesis 2 in the alternative form:

Hypothesis 2. *Ceteris paribus*, government subsidies can strengthen the positive correlation between government R&D spending and corporate technological innovation through factor allocation channels such as monetary capital, human capital and management institution.

2.2.3. The channel of tax incentives

Tax incentives are also an important fiscal instrument. By providing *ex post* incentives to companies, this instrument should improve corporate technological innovation by increasing factor allocation efficiency. Nevertheless, considering the differences between government subsidies and tax incentives, we expect the latter to be a less effective channel than the former for advancing corporate technological innovation.

2.2.3.1. Effect of the channel of tax incentives on monetary capital. First, tax incentives can support firm innovation by providing *ex post* outcome-based compensation (Becker, 2015). Moll (2014) argues that, since the tax burden is a rigid cost for companies, tax incentives can significantly relieve corporate financial distress. Auerbach (1989) finds that tax incentives can encourage companies to expand R&D investment by reducing their cost of capital. Nonetheless, as tax incentives are sensitive to the outcome of innovation, companies whose R&D projects are managed by venture capitalists prefer external financing to tax incentives (Nakano and Nguyen, 2012). In addition, companies may modify their R&D activities to exploit tax credits, an activity not intended to facilitate technological innovation (Mansfield, 1986). Therefore, the effect of the tax incentive channel on monetary capital is likely to offer a weaker instrument than the channel of government subsidies.

2.2.3.2. Effect of the channel of tax incentives on human capital. Second, tax incentives can enhance the effect of human capital factors (e.g. through highly skilled employees) on innovation. As companies have high levels of discretion in applying tax proceeds to their operations, tax credits can reduce the labor costs of highly skilled employees, incentivizing companies to upgrade their human capital structures. This improvement enables companies to seize profitable investment opportunities (Aghion et al., 2015). Therefore, tax incentives can facilitate complementarity between labor and capital, especially in terms of investment in high-tech assets (Krusell et al., 2000; Duffy et al., 2004). The high level of discretion in using tax incentives, however, may also allow managers to achieve other goals. For example, the theory of tax preference allocation demonstrates that managers use these incentives to maximize the interests of shareholders rather than to recruit high-quality human capital (Harberger, 1962).

2.2.3.3. Effect of the channel of tax incentives on management institution. Third, management institution (e.g. efficient operations) can strengthen the positive effect of tax incentives on firm innovation. Companies that receive government subsidies are strictly supervised and evaluated. In contrast, tax incentives provide discretionary funds not subject to the capital management rules imposed on government subsidies. Efficient operations can direct companies to take full advantage of tax incentive proceeds by curbing opportunistic behavior. For example, under efficient operations, tax credits can be effectively used to reduce the adjustment costs of R&D investment, which include equipment, recruiting and training expenses of expert staff (Groth and Khan, 2010).

Based on the above analysis, we present Hypothesis 3 in the alternative form:

Hypothesis 3. *Ceteris paribus*, tax incentives can increase the positive correlation between government R&D spending and corporate technological innovation through the allocation of factors such as monetary capital, human capital and management institution.

3. Research design and statistical analyses

3.1. Sample and data source

Our initial sample comprises China's A-share non-financial public firms. The sample period ranges from 2007 to 2018. Data on the main independent variable, government R&D spending, are collected from the China City Statistical Yearbook between 2008 and 2019 published by China Statistics Press. The other financial data are obtained from two databases: China Stock Market & Accounting Research (CSMAR) and Chinese Research Data Services (CNRDS).

We screen the initial sample according to the following two criteria: (1) financial or ST firms are excluded, and (2) observations with missing data are removed. The screening procedure leads to a final sample of 18,796 firm–year observations. To reduce the effect of potential outliers, we winsorize all continuous variables at the 1st and 99th percentiles.

3.2. Variable definition

3.2.1. Technological innovation

The CNRDS database includes three types of patents: invention innovation, utility model innovation and design innovation. It further identifies patent applications and patent grants. We choose to study invention patents because these are a better proxy for technological innovation than utility model or design patents (Tong et al., 2014; Yuan and Wen, 2018). We mainly focus on patent applications rather than on patent grants because the former type has a high signaling effect (Faria and Barbosa, 2014). Although the literature uses R&D expenditures as a proxy for corporate technological innovation, patent applications can provide better insights than R&D expenditures by reducing noise in measures of technological innovation capability (Atanassov, 2013; Kong, 2020). In addition, R&D expenditures are determined by discretionary accounting choices regarding capitalization of R&D inputs (Koh and Reeb, 2015). We therefore use the natural logarithm of the number of invention patent applications (*Innovation*) to measure corporate technological innovation.

3.2.2. Government R&D spending

To obtain city-level government R&D spending (*GRDS*), we divide each city's R&D spending by its total fiscal expenditure (Easterly and Rebelo, 1993; Devarajan et al., 1996). There are three main components of government R&D spending. The first part comprises financial grants for studies conducted within universities and other research institutes. The second part refers to the funds offered to advance companies' technological growth. Ultimately, the third part aims to improve research management, the R&D environment and services and scientific communication and cooperation. Given these three types of government support, we regard government R&D spending as an institutional arrangement that represents the government's resource allocation structure and preferences for technological innovation.[2]

3.2.3. Fiscal instruments

We construct the variable that measures government subsidies (*Sub*) and divide it by the operating income. Consistent with Shevlin (1987), we use the actual income tax rate to measure tax incentives (*Tax*), dividing the income tax expense by earnings before interest and taxes (*EBIT*). As the usual tax measure is inversely related to the intensity of tax incentives, the variable we use takes the opposite sign of the original measure.

3.2.4. Factor allocation

We use the SA index proposed by Hadlock and Pierce (2010) to measure financial constraint (*Fin*), a monetary capital factor, which is calculated using the following formula: $SA = |-0.737 \times Size + 0.043 \times Size^2 - 0.04 \times Age|$. To construct a proxy for highly skilled employees (*Skill*), a human capital factor, we calculate the natural logarithm of the number of employees who have a postgraduate degree. We also use total asset turnover, which is defined as the ratio of sales revenue over total assets, to measure operating efficiency (*Turn*) with respect to management institution.

[2] For example, while Guangdong province has the highest proportion of government R&D spending (6.59% in 2018), the provinces with the fastest increase in government R&D spending during the sample period are Anhui and Hubei in central China. These two provinces' economies are less developed than those in eastern China: Government R&D spending in Anhui Province has grown from 1.28% in 2007 to 4.49% in 2018, an increase of 3.51 times; government R&D spending in Hubei Province has grown from 1.2% in 2007 to 3.7% in 2018, an increase of 3.08 times. In contrast, government R&D spending in Guangdong province has increased only by 1.75 times during the same period.

3.2.5. Control variables

Following previous work (e.g. Zhong, 2018), we include a series of control variables. Our analyses control for *Size* (natural logarithm of total assets), *Age* (natural logarithm of years during which a firm has been operating), *Cashflow* (cash flow from operation divided by total assets), *Leverage* (total debt divided by total assets), *Tangibility* (net property, plant and equipment divided by total assets), *ROA* (net income before extraordinary items divided by total assets), *Growth* (difference between current and previous year's sales revenue, scaled by previous year's sales revenue), *TobinQ* (equity value plus nominal debt value divided by total assets), *RE* (real earnings management as defined by Roychowdhury, 2006) and *PCGDP* (city per capita GDP). Definitions of these variables are provided in Appendix A.

3.3. Methods

3.3.1. Main regression

As our dataset has a panel structure, we use the firm fixed-effect regression model (FE) to explore the impact of government R&D spending on technological innovation. Our baseline model is:

$$Innovation_{ipt} = \beta_0 + \beta_1 GRDS_{pt} + \beta_k Controls + T_t + \varepsilon_{ipt} \tag{1}$$

where $Innovation_{ipt}$ is the technological innovation of firm i in city p and year t. $GRDS_{pt}$ measures the government R&D spending of city p in year t. *Controls* is a vector of control variables that include *Size*, *Age*, *Cashflow*, *Leverage*, *Tangibility*, *ROA*, *Growth*, *TobinQ*, *RE* and *PCGDP*. T_t denotes year fixed effects, and ε_{ipt} is the residual term.

3.3.2. Testing channels

We add *Sub*, *Tax* and their interaction terms with *GRDS* to the model to examine channels based on fiscal instruments. Our channel model is:

$$\begin{aligned} Innovation_{ipt} = {} & \beta_0 + \beta_1 GRDS_{pt} + \beta_2 Sub_{ipt}\left(Tax_{ipt}\right) + \beta_3 GRDS_{pt} \times Sub_{ipt}\left(GRDS_{pt} \times Tax_{ipt}\right) \\ & + \beta_k Controls + T_t + \varepsilon_{ipt} \end{aligned} \tag{2}$$

where coefficient β_3 on $GRDS \times Sub$ ($GRDS \times Tax$) indicates whether fiscal instruments strengthen the impact of government R&D spending on corporate technological innovation.

To study whether factor allocation explains the effect of fiscal instruments, we use the triple-interaction models specified below:

$$\begin{aligned} Innovation_{ipt} = {} & \beta_0 + \beta_1 GRDS_{pt} + \beta_2 Sub_{ipt} \\ & + \beta_3 Fin_{ipt}\left(Skill_{ipt}\right)\left(Turn_{ipt}\right) + \beta_4 GRDS_{pt} \times Sub_{ipt} + \beta_5 GRDS_{pt} \\ & \times Fin_{ipt}\left(GRDS_{pt} \times Skill_{ipt}\right)\left(GRDS_{pt} \times Turn_{ipt}\right) + \beta_6 Sub_{ipt} \\ & \times Fin_{ipt} Sub_{ipt} \times Skill_{ipt} Sub_{ipt} \times Turn_{ipt} + \beta_7 GRDS_{pt} \times Sub_{ipt} \\ & \times Fin_{ipt}\left(GRDS_{pt} \times Sub_{ipt} \times Skill_{ipt}\right)\left(GRDS_{pt} \times Sub_{ipt} \times Turn_{ipt}\right) \\ & + \beta_k Controls + T_t + \varepsilon_{ipt} \end{aligned} \tag{3-1}$$

$$\begin{aligned} Innovation_{ipt} = {} & \beta_0 + \beta_1 GRDS_{pt} + \beta_2 Tax_{ipt} \\ & + \beta_3 Fin_{ipt}\left(Skill_{ipt}\right)\left(Turn_{ipt}\right) + \beta_4 GRDS_{pt} \times Tax_{ipt} + \beta_5 GRDS_{pt} \\ & \times Fin_{ipt}\left(GRDS_{pt} \times Skill_{ipt}\right)\left(GRDS_{pt} \times Turn_{ipt}\right) + \beta_6 Tax_{ipt} \\ & \times Fin_{ipt} Tax_{ipt} \times Skill_{ipt} Tax_{ipt} \times Turn_{ipt} + \beta_7 GRDS_{pt} \times Tax_{ipt} \\ & \times Fin_{ipt}\left(GRDS_{pt} \times Tax_{ipt} \times Skill_{ipt}\right)\left(GRDS_{pt} \times Tax_{ipt} \times Turn_{ipt}\right) \\ & + \beta_k Controls + T_t + \varepsilon_{ipt} \end{aligned} \tag{3-2}$$

Coefficient β_7 on the triple-interaction terms reflects whether government subsidies (tax incentives) enhance the association between government R&D spending and corporate technological innovation through factor allocation (e.g. monetary capital, human capital and management institution).

3.4. Statistical analyses

3.4.1. Summary statistics

Table 1 summarizes the main variables used in this study. Ranging from 0 to 5.509, the variable *Innovation* has a mean, standard deviation and median of 1.537, 1.514 and 1.386, respectively, with a 25th percentile of 0 and 75th percentile of 2.639. Such results demonstrate that the sample firms have a large variation in the number of patent applications filed. The average city–year *GRDS* is 0.036, indicating that, on average, city-level government R&D spending is 3.6% of the city-level total fiscal expenditure. This variable ranges from 0.2% to 15.5% with a standard deviation of 2.3%. The variable distribution suggests that government R&D spending varies considerably across cities and some cities may need to improve their R&D spending. Summary statistics of our control variables are also included in Table 1.

3.4.2. Graphical evidence

To explore the impact of government R&D spending on corporate technological innovation, we divide the sample observations into seven groups according to the value of *GRDS*. For each group, we calculate the average value of *GRDS* and plot it in Fig. 2. Below we show that when the headquarter city's government R&D spending increases (e.g. higher group rank), firms engage in more innovation activities. This preliminary evidence is supportive of our first hypothesis. To control for the effects of other factors, we conduct further analyses to examine the positive association between government R&D spending and corporate technological innovation.

4. Empirical tests and results

4.1. Baseline results

We examine the influence of government R&D spending on corporate technological innovation in Table 2. Column (1) does not include control variables. The coefficient of *GRDS* in Column (1) is positive and statistically significant (2.587, p-value < 0.01). In Column (2), which includes control variables, the coefficient of *GRDS* remains positive and statistically significant (1.837, p-value < 0.05). Consistent with our first hypothesis, these results suggest that government R&D spending has a positive impact on corporate innovation.

4.2. Robustness test

Three distinct institutional features in China suggest that reverse causality may not be a serious concern. First, the characteristics of an individual company can hardly affect the planning of macroeconomic policies

Table 1
Summary statistics.

Variable	N	Mean	SD	Min	P25	Median	P75	Max
Innovation	18,796	1.537	1.514	0.000	0.000	1.386	2.639	5.509
GRDS	18,796	0.036	0.023	0.002	0.017	0.034	0.051	0.155
Age	18,796	2.759	0.350	1.099	2.565	2.773	2.996	3.434
Size	18,796	21.981	1.276	19.074	21.067	21.811	22.707	25.754
Cashflow	18,796	0.047	0.074	−0.186	0.007	0.046	0.089	0.260
Leverage	18,796	0.462	0.211	0.052	0.299	0.462	0.622	0.994
Tangibility	18,796	0.240	0.175	0.002	0.102	0.206	0.345	0.744
ROA	18,796	0.036	0.060	−0.269	0.013	0.034	0.063	0.202
Growth	18,796	0.467	1.401	−0.740	−0.042	0.127	0.429	9.900
TobinQ	18,796	2.086	1.295	0.900	1.249	1.651	2.417	7.611
RE	18,796	−0.016	0.229	−0.838	−0.111	−0.004	0.094	0.758
PCGDP	18,796	11.159	0.603	8.786	10.808	11.244	11.593	12.153

Note: Table 1 reports the summary statistics of key variables. Variable definitions are presented in Appendix A.

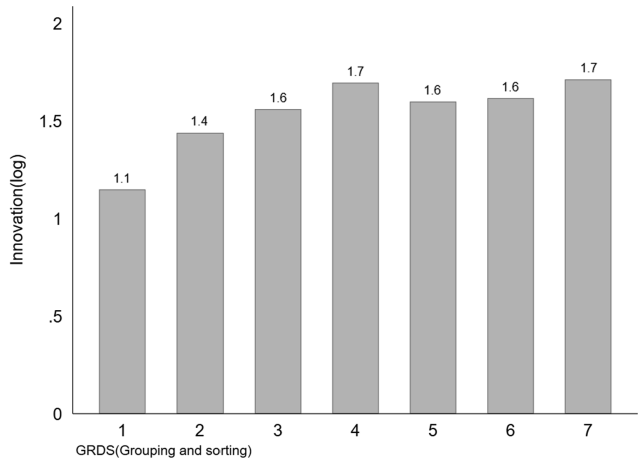

Fig. 2. Relationship between Government R&D Spending and Corporate Technological Innovation.

related to government spending. Second, unlike the profit-seeking financial institutions in the market, the Chinese government intends to optimize the regional industrial structure, which implies that government R&D spending attempts to support all the industries within a region. Third, the Chinese government presents its R&D initiative as a means to exploit current strengths and correct weaknesses. The initiative aims to increase market efficiency by improving market failures. The government has no stated preference for supporting particular companies. We also conduct a series of robustness tests to rule out any endogenous factors that may confound our results.

4.2.1. IV regression results

A major challenge of this study is the difficulty in identifying changes in government R&D spending that are truly exogenous to corporate technological innovation. This challenge arises because government R&D spending can be an endogenous choice associated with economic growth, which in turn may affect corporate technological innovation. The positive relationship between government R&D spending and corporate technological innovation may be confounded by changes in the level of economic growth. Therefore, we use river length as an instrumental variable to address this endogeneity concern.

We choose this instrumental variable for two reasons. First, as rivers are generally used as borders between administrative divisions, cities with a high river density generally have more administrative divisions than other cities. Hoxby (2000) proposes that a river does not directly affect local economic and social development, but it can increase the number of administrative divisions.[3] According to the promotion tournament model (Li and Zhou, 2005), cities with more administrative divisions have more intense political competition than other cities, due to the limited number of employee promotions. When GDP growth is the major criterion for the evaluation of political performance, government R&D spending is a suboptimal choice because innovation investment tends to be long-term and unpredictable, with a high failure probability (Holmstrom, 1989). Officials living close to many rivers may have a self-interested investment preference for "emphasizing production and neglecting innovation" (Jia et al., 2014) and thus reduce the amount of government R&D spending. Second, river length is not reasonably related to corporate technological innovation. Therefore, the exogenous topological features of physical geography make river length a proper instrumental variable to satisfy the exclusivity requirement.

River length (*River*) is defined as the length of a river divided by its land area in a city (Hoxby, 2000; Hatfield and Kosec, 2013). Based on Columns (1) and (2) of Table 3, we find that river length is associated with a significant decrease in government R&D spending. The result is in line with our prediction. Columns

[3] We also use the number of municipal cities in each province, a proxy for the number of administrative divisions, as our instrumental variable. The results, displayed in Appendix 4, are consistent with our main findings.

Table 2
FE estimates: Impact of government R&D spending on innovation.

Dependent variable	(1) Innovation	(2) Innovation
GRDS	2.587***	1.837**
	(2.91)	(2.14)
Age		0.712***
		(4.84)
Size		0.295***
		(10.16)
Cashflow		0.000
		(0.00)
Leverage		0.072
		(0.74)
Tangibility		−0.166
		(−1.38)
ROA		0.718***
		(4.27)
Growth		0.001
		(0.25)
TobinQ		−0.006
		(−0.71)
RE		0.043
		(1.04)
PCGDP		0.057
		(0.76)
Constant	0.618***	−7.887***
	(15.32)	(−7.88)
Observation	18,796	18,796
Year FE	YES	YES
Firm FE	YES	YES
Adj.R^2	0.23	0.26

Note: Table 2 presents FE regression results of the impact of government R&D spending on corporate technological innovation. T-values are reported in parentheses and are calculated with robust standard errors clustered at the firm level.
* Statistical significance at the 10 % level.
*** Statistical significance at the 1% level.
** Statistical significance at the 5% level.

(3) and (4) of Table 3 report the results of the second-stage regression of the instrumental variable method, in which the regression coefficient on government R&D spending is significantly positive. Meanwhile, the weak IV test shows that the F-statistic in the first stage is 72.617 without control variables or 81.68 with control variables. These values are far above the critical value of 10 for the weak instrument hypothesis (Stock et al., 2002). Based on the rule of thumb for one instrument (e.g. for one endogenous variable), we reject the null hypothesis that our instrument is weak. Further, the overidentification test shows that the Hansen J-statistic is 0.00 in columns with and without controls. This supports the null hypothesis that our model is not overidentified.

4.2.2. Test of reverse causality

If changes in government R&D spending are affected by corporate technological innovation, our findings are subject to the problem of reverse causality. To examine the possible endogeneity, we follow the method of Jiang et al. (2016) and use model (3) to examine whether city-level corporate innovation can predict changes in government R&D spending:

$$\Delta GRDS = \beta_0 + \beta_1 Innovation_{t-1}(Innovation_{t-2}) + \beta_k \sum Controls + CityFE + YearFE + \varepsilon \quad (3)$$

Table 3
IV estimates: Impact of government R&D spending on innovation.

Dependent variable	(1) GRDS	(2)	(3) Innovation	(4)
River	−0.037***	−0.039***		
	(−4.13)	(−4.50)		
GRDS			46.876**	42.996**
			(2.48)	(2.45)
Age		0.005		0.414*
		(1.63)		(1.95)
Size		0.001**		0.273***
		(2.32)		(7.31)
Cashflow		−0.000		−0.071
		(−0.09)		(−0.44)
Leverage		0.003**		−0.078
		(2.16)		(−0.63)
Tangibility		−0.002		−0.152
		(−1.21)		(−1.02)
ROA		0.001		0.631***
		(0.60)		(3.00)
Growth		−0.000*		0.015*
		(−1.76)		(1.95)
TobinQ		0.000		−0.012
		(0.47)		(−1.03)
RE		0.001		−0.004
		(0.87)		(−0.08)
PCGDP		0.006***		−0.179
		(5.44)		(−1.29)
Constant	0.038***	−0.058***	−0.615	−5.295***
	(14.45)	(−3.85)	(−1.22)	(−3.19)
Observation	14,875	14,875	14,875	14,875
Year FE	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES
Adj.R^2	0.23	0.24	0.05	0.07

Note: Table 3 presents IV regression results that use river length as an instrumental variable. T-values are reported in parentheses in Columns (1) and (3). Z-values are reported in parentheses in Columns (2) and (4).
*** Statistical significance at the 1% level.
** Statistical significance at the 5% level.
* Statistical significance 10% level.

ΔGRDS is the change in government R&D spending. $Innovation_{t-1}$ ($Innovation_{t-2}$) is the city-level corporate innovation during the *t-1* (*t-2*) period, measured by the mean or median value of corporate technological innovation in a city. Control variables include the following period *t-1* variables: GDP growth rate (*RGDP*), natural logarithm of per capita GDP (*PCGDP*), employment rate (*Emp*, the ratio of the number of employees to the total population), industrial structure (*Structure*, the ratio of the added value of the tertiary industry to GDP), fixed asset investment (*Invest*, the total ratio of fixed asset investment to GDP), household savings rate (*Saving*, the ratio of household savings to GDP) and proportion of primary school students (*Primary*, the ratio of the number of students in primary schools to the total population). The model also controls for city and year fixed effects. Regression results are presented in Table 4, Columns (1) to (4). Although the coefficient on $Innovation_{t-2}$ in Column (2) is negative and statistically significant, lagged *Innovation* variables generally cannot predict increases in government R&D spending. Thus, the results of Table 4 do not support the hypothesis that increases in corporate innovation lead to a surge in government R&D spending.

4.2.3. Different model designs

As some innovation activities need more than a year to complete, we use the independent and control variables measured at period *t-1* to examine the robustness of our model. Regression results are reported in

Table 4
Test of reverse causality.

	(1) Mean	(2)	(3) Median	(4)
Dependent variable	△GRDS	△GRDS	△GRDS	△GRDS
$Innovation_{t-1}$	−0.063		−0.031	
	(−1.17)		(−0.60)	
$Innovation_{t-2}$		−0.104**		−0.073
		(−2.34)		(−1.61)
RGDP	0.023**	0.024**	0.023**	0.024**
	(2.08)	(2.14)	(2.05)	(2.13)
PCGDP	0.537	0.526	0.530	0.526
	(1.46)	(1.40)	(1.43)	(1.40)
Emp	−1.550***	−1.558***	−1.548***	−1.543***
	(−3.03)	(−3.01)	(−3.04)	(−3.00)
Structure	−3.685***	−3.665***	−3.681***	−3.652***
	(−3.05)	(−3.03)	(−3.06)	(−3.03)
Invest	0.720***	0.694***	0.708***	0.680***
	(3.49)	(3.29)	(3.42)	(3.24)
Saving	0.878**	0.909**	0.865**	0.897**
	(2.45)	(2.50)	(2.40)	(2.47)
Primary	−7.678**	−8.178**	−7.818**	−8.257**
	(−2.27)	(−2.35)	(−2.31)	(−2.37)
Constant	0.231	0.384	0.306	0.381
	(0.06)	(0.10)	(0.08)	(0.10)
Observation	2,435	2,400	2,435	2,400
Year FE	YES	YES	YES	YES
City FE	YES	YES	YES	YES
Adj.R^2	0.56	0.56	0.56	0.56

Note: Table 4 presents the regression results of the test of reverse causality. T-values are reported in parentheses and are calculated with robust standard errors clustered at the city level.
* Statistical significance at the 10% level.
*** Statistical significance at the 1% level.
** Statistical significance at the 5% level.

Column (1) of Table 5 and show that our findings still hold. We also use the Tobit model to account for the fact that the dependent variable is censored from below at the value zero. The regression output is summarized in Column (2) of Table 5 and shows no contradiction with our previous results.

4.2.4. Different Dependent variables

With respect to the dependent variable, we replace invention patent applications with invention patent citations. Because some researchers argue that the overall quality of Chinese companies' patents is low (Li, 2012; Hu et al., 2017), we use citation data as the dependent variable to capture the patent quality (Nagaoka et al., 2010). Raw citation counts have truncation biases due to the fixed length of the sample horizon. Patents filed in later sample years are likely to have fewer citations than those filed in earlier years because more recent patents have less time to accumulate citations. Therefore, we use the number of times a patent has been cited in a three-year period to measure the quality of the patent (*Cite1*). Companies tend to cite their own patents which are more relevant to their innovation projects. However, self-citation does not provide an objective judgement about a patent's quality and cannot indicate the technical impact of the patent. Any number that includes self-citation may overestimate a patent's quality. Accounting for this potential source of measurement error, we exclude self-citations to construct a new measure (*Cite2*). Reported in Columns (3) and (4) of Table 5, the regression results based on these new dependent variables show that our findings are robust.

Table 5
Different model designs and variables.

Dependent variable	(1) Innovation	(2) Innovation	(3) Cite1	(4) Cite2	(5) Innovation
GRDS	1.501*	2.275***	2.178*	2.182*	1.515*
	(1.75)	(4.30)	(1.71)	(1.71)	(1.71)
Age	0.910***	−0.149***	−0.413	−0.411	0.779***
	(5.49)	(−2.66)	(−1.53)	(−1.53)	(5.10)
Size	0.215***	0.315***	0.246***	0.246***	0.302***
	(7.57)	(25.23)	(4.91)	(4.92)	(10.19)
Cashflow	0.163	0.045	0.236	0.232	0.002
	(1.35)	(0.41)	(1.06)	(1.04)	(0.01)
Leverage	0.057	−0.010	0.148	0.147	0.063
	(0.61)	(−0.18)	(1.01)	(1.01)	(0.63)
Tangibility	−0.074	−0.220***	−0.071	−0.070	−0.148
	(−0.65)	(−3.28)	(−0.36)	(−0.36)	(−1.14)
ROA	0.771***	0.741***	0.494*	0.492*	0.728***
	(4.23)	(5.66)	(1.88)	(1.88)	(3.90)
Growth	0.001	−0.005	−0.030**	−0.030**	0.005
	(0.12)	(−1.07)	(−2.11)	(−2.11)	(0.77)
TobinQ	−0.009	0.005	0.010	0.010	−0.005
	(−0.98)	(0.65)	(0.71)	(0.72)	(−0.55)
RE	0.094**	0.054	0.105	0.103	0.054
	(2.32)	(1.48)	(1.14)	(1.12)	(1.12)
PCGDP	0.083	0.077**	−0.098	−0.098	0.086
	(1.12)	(2.12)	(−0.90)	(−0.89)	(1.15)
Constant	−6.806***	−6.443***	−2.405	−2.419	−8.473***
	(−6.77)	(−13.63)	(−1.44)	(−1.45)	(−8.42)
Observation	17,184	18,796	8,180	8,180	16,250
Year FE	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES
Adj.R^2	0.24		0.30	0.30	0.26
Model Chi^2		6,065.34			

Note: Table 5 presents the results of a robustness test of different model designs and variables. T-values are reported in parentheses and calculated with robust standard errors clustered at the firm level. The independent and the control variables in Column (1) are measured at period *t*-1, whereas those in other columns are measured at period *t*.

*** Statistical significance at the 1% level.

** Statistical significance at the 5% level.

* Statistical significance at the 10% level.

4.2.5. Financial crisis impact

Some economic shocks may disrupt companies' innovation plans. Considering the possible estimation bias caused by the recent financial crisis, we delete the sample observations whose year spans from 2009 and 2010. The results in Column (5) are consistent with our previous findings.

4.2.6. Difference-in-differences method

Published in 2016, the Outline of the 13th Five-Year Plan for National Economic and Social Development emphasizes the importance of innovation. For example, although the innovation chapter had originally been placed in Section 7 and had not been modified for the 11th Five-Year Plan and 12th Five-Year Plan, it was moved to Section 2 in the 13th Five-Year Plan. This change suggests that national innovation has become increasingly important to the central government. Given the recent policy change, local governments should expect companies to engage in quality innovation activities. Moreover, increases in R&D spending can help the local government gain the support of the central government, because this change would be in line with the national strategy.

We use a difference-in-differences design, defined as model (4), to test the impact of this policy change on corporate technological innovation. *Post* is a dummy variable that equals 1 for the 2016–2018 period, when

Table 6
Difference-in-differences method.

Dependent variable	(1) Innovation	(2) Innovation
Post	0.194**	0.075
	(2.15)	(0.78)
Treat × Post	0.204**	0.141*
	(2.23)	(1.69)
Age		0.097
		(0.40)
Size		0.295***
		(7.22)
Cashflow		−0.418**
		(−1.97)
Leverage		0.215
		(1.63)
Tangibility		−0.291
		(−1.50)
ROA		1.011***
		(4.36)
Growth		0.002
		(0.29)
TobinQ		−0.005
		(−0.44)
RE		−0.031
		(−0.34)
PCGDP		0.034
		(0.40)
Constant	1.852	−5.356***
	(147.67)	(−3.73)
Observation	9,856	9,856
Year FE	YES	YES
Firm FE	YES	YES
Adj.R^2	0.11	0.14

Note: Table 6 presents the robustness test of difference-in-differences method. T-values are reported in parentheses and are calculated with robust standard errors clustered at the firm level.
*** Statistical significance at the 1% level.
** Statistical significance at the 5% level.
* Statistical significance at the 10% level.

the 13th Five-Year Plan was in effect, and 0 for the 2013–2015 period before the Plan. Because our independent variable measuring government R&D spending is a continuous variable, it is impossible to directly identify natural treatment and control groups. Following Yu et al. (2016), we use specific criteria to divide our sample firms into two groups. In model (4), *Treat* is a dummy variable that equals 1 for cities whose mean government R&D spending during 2013–2015 and 2016–2018 is high[4], and 0 for cities that have a high mean value of government R&D spending during 2013–2015 and a lower mean value during 2016–2018. Our DID test focuses only on the cities with a high mean value of government R&D spending before the 13th Five-Year Plan to follow the parallel trend assumption. The model does not consider the variable *Treat* separately due to multicollinearity concerns. We predict that the interaction term between *Treat* and *Post* has a significantly positive coefficient.

$$Innovation_{ipt} = \beta_0 + \beta_1 Post_t + \beta_2 Post_t \times Treat_{ipt} + \beta_k Controls + T_t + \varepsilon_{ipt} \quad (4)$$

[4] If the mean value of a city's government R&D spending during 2013–2015 (2016–2018) is greater than the median of the sample, the city's government R&D spending is considered high. Otherwise, we regard it as low.

Table 7
Channel of government subsidies.

Dependent variable	(1) Innovation	(2) Innovation	(3) Innovation	(4) Innovation
GRDS	1.938**	2.253**	1.288	2.540***
	(2.23)	(2.31)	(1.23)	(2.86)
Sub	0.125	0.120	0.372**	2.069***
	(1.18)	(1.44)	(2.39)	(2.65)
GRDS × Sub	15.771**	6.850	18.100**	105.967***
	(2.11)	(1.03)	(2.39)	(3.60)
Fin		−0.488***		
		(−2.61)		
GRDS × Fin		−0.279		
		(−0.12)		
Sub × Fin		2.597**		
		(2.01)		
GRDS × Sub × Fin		138.991**		
		(2.46)		
Skill			0.082***	
			(8.85)	
GRDS × Skill			0.311	
			(1.13)	
Sub × Skill			0.301**	
			(2.44)	
GRDS × Sub × Skill			10.938**	
			(2.07)	
Turn				−0.097*
				(−1.82)
GRDS × Turn				3.904***
				(2.61)
Sub × Turn				3.696***
				(2.67)
GRDS × Sub × Turn				177.096***
				(3.34)
Age	0.728***	0.755***	0.749***	0.724***
	(4.92)	(5.07)	(5.14)	(4.89)
Size	0.300***	0.308***	0.255***	0.299***
	(10.18)	(10.18)	(8.84)	(10.23)
Cashflow	−0.042	−0.063	−0.009	0.012
	(−0.35)	(−0.53)	(−0.08)	(0.10)
Leverage	0.098	0.066	0.086	0.111
	(1.01)	(0.67)	(0.90)	(1.15)
Tangibility	−0.193	−0.202*	−0.190	−0.182
	(−1.60)	(−1.69)	(−1.61)	(−1.51)
ROA	0.655***	0.691***	0.572***	0.740***
	(3.92)	(4.17)	(3.48)	(4.41)
Growth	0.001	0.002	0.000	−0.000
	(0.11)	(0.38)	(0.07)	(−0.01)
TobinQ	−0.006	−0.012	−0.004	−0.001
	(−0.66)	(−1.38)	(−0.45)	(−0.16)
RM	0.030	0.020	0.035	0.027
	(0.71)	(0.47)	(0.84)	(0.63)
PCGDP	0.054	0.060	0.056	0.060
	(0.71)	(0.79)	(0.77)	(0.80)
Constant	−7.910***	−8.242***	−6.931***	−7.950***
	(−7.84)	(−7.98)	(−7.05)	(−7.91)
Observation	18,445	18,445	18,445	18,410
Firm FE	YES	YES	YES	YES

Year FE	YES	YES	YES	YES
Adj.R^2	0.27	0.27	0.28	0.27

Note: Table 7 presents regression results of the interaction model that examines the channel of government subsidies through which government R&D spending affects corporate technological innovation. Government subsidies can have an influence directly or through factor allocation, such as financial constraints, highly skilled employees and efficient operations. T-values are reported in parentheses and calculated with robust standard errors clustered at the firm level.

*** Statistical significance at the 1% level.

** Statistical significance at the 5% level.

* Statistical significance at the 10% level.

Table 6 presents our test results. The coefficient on the interaction term between *Treat* and *Post* is positive and statistically significant. These results indicate that the increased importance of the innovation section in the 13th Five-Year Plan compared with earlier Plans is associated with an increase in corporate patent applications.

4.3. Channel tests

4.3.1. Government subsidies channel

We first examine whether government R&D spending influences corporate technological innovation through government subsidies. Column (1) of Table 7 shows the overall effect of government subsidies. The coefficient on $GRDS \times Sub$ is positive and statistically significant (15.711, p-value < 0.05), indicating that government subsidies enhance the effect of government R&D spending on innovation. We further test the factor allocation effect with respect to financial constraints, highly skilled employees and efficient operations in Columns (2)–(4). The coefficient on $GRDS \times Sub \times Fin$ in Column (2) is positive and statistically significant (138.991, p-value < 0.05). This suggests that government subsidies can improve the positive relationship between government R&D spending and corporate technological innovation by alleviating firms' financial distress. The coefficient on $GRDS \times Sub \times Skill$ in Column (3) is positive and statistically significant (10.938, p-value < 0.05). In this case, government subsidies can strengthen the creativity of human capital through highly skilled employees. The coefficient on $GRDS \times Sub \times Turn$ in Column (4) is positive and statistically significant (177.096, p-value < 0.01). This result implies that government subsidies can enhance innovation by firms with good management institution factors, such as operating efficiency. These results support our second hypothesis that government subsidies are an effective channel and can support government R&D spending to promote firm innovation.[5]

4.3.2. Tax incentives channel

We check the channel effect of tax incentives. Column (1) in Table 8 summarizes the overall effect of tax incentives. The coefficient on $GRDS \times Tax$ is positive and statistically significant (5.133, p-value < 0.1). The result suggests that tax incentives enhance the positive impact of government R&D spending on innovation. Columns (2), (3) and (4) account for factor allocation, which includes financial constraints, highly skilled employees and efficient operations. Both the coefficients on $GRDS \times Tax \times Fin$ in Column (2) and on $GRDS \times Tax \times Skill$ in Column (3) are positive but not statistically significant. This suggests that tax incentives are not as effective as government subsidies when exploiting monetary and human capital factors. Nevertheless, Table 8 reports that the coefficient on $GRDS \times Tax \times Turn$ in Column (4) is positive and statistically significant (10.518, p-value < 0.1). This result demonstrates that tax incentives enable firms with efficient operations to gain more benefits from the innovation effect of government R&D spending. Overall, these findings are partially consistent with our third hypothesis, which postulates that government R&D spending can facilitate firm innovation through the channel of tax incentives.[6]

[5] Considering that government subsidies may interact with tax incentives, we include the latter as an additional control variable in the Appendix B′s tests in which our regression results still hold.

[6] If we include government subsidies as an additional control variable to account for the interaction with tax incentives, our findings do not change (see Appendix 3).

Table 8
Channel of tax incentives.

Dependent variable	(1) Innovation	(2) Innovation	(3) Innovation	(4) Innovation
GRDS	1.834**	2.222**	1.127	1.792**
	(2.14)	(2.32)	(1.11)	(2.11)
Tax	0.157**	0.048	0.150**	0.149**
	(2.54)	(0.70)	(2.16)	(2.41)
GRDS × Tax	5.133*	2.824	4.232	5.421**
	(1.87)	(0.90)	(1.28)	(1.99)
Fin		−0.531***		
		(−2.86)		
GRDS × Fin		−1.129		
		(−0.48)		
Tax × Fin		0.651***		
		(2.82)		
GRDS × Tax × Fin		12.504		
		(1.17)		
Skill			0.081***	
			(8.78)	
GRDS × Skill			0.275	
			(1.01)	
Tax × Skill			−0.016	
			(−0.55)	
GRDS × Tax × Skill			1.027	
			(0.76)	
Turn				−0.153***
				(−2.97)
GRDS × Turn				1.343
				(0.98)
Tax × Turn				−0.199
				(−1.58)
GRDS × Tax × Turn				10.518*
				(1.83)
Age	0.698***	0.728***	0.724***	0.703***
	(4.74)	(4.91)	(4.99)	(4.77)
Size	0.295***	0.302***	0.249***	0.295***
	(10.15)	(10.13)	(8.76)	(10.21)
Cashflow	−0.001	−0.021	0.031	0.059
	(−0.00)	(−0.18)	(0.26)	(0.49)
Leverage	0.053	0.029	0.039	0.077
	(0.55)	(0.30)	(0.42)	(0.80)
Tangibility	−0.171	−0.183	−0.166	−0.156
	(−1.42)	(−1.53)	(−1.42)	(−1.30)
ROA	0.778***	0.808***	0.688***	0.879***
	(4.53)	(4.71)	(4.07)	(5.04)
Growth	0.002	0.003	0.001	0.001
	(0.29)	(0.60)	(0.21)	(0.14)
TobinQ	−0.005	−0.011	−0.004	−0.002
	(−0.58)	(−1.29)	(−0.44)	(−0.19)
RE	0.043	0.035	0.049	0.042
	(1.03)	(0.85)	(1.19)	(1.00)
PCGDP	0.055	0.054	0.059	0.059
	(0.73)	(0.71)	(0.80)	(0.78)
Constant	−7.766***	−8.012***	−6.790***	−7.820***
	(−7.72)	(−7.80)	(−6.92)	(−7.80)
Observation	18,744	18,744	18,744	18,736
Year FE	YES	YES	YES	YES

Firm FE	YES	YES	YES	YES
Adj.R^2	0.26	0.26	0.27	0.26

Note: Table 8 presents the regression results of the interaction model that examines the tax incentives channel through which government R&D spending affects corporate technological innovation. Tax incentives can have an influence directly or through factor allocation, such as financial constraints, highly skilled employees and efficient operations. T-values are reported in parentheses and are calculated with robust standard errors clustered at the firm level.

*** Statistical significance at the 1% level.

** Statistical significance at the 5% level.

* Statistical significance at the 10% level.

4.3.3. Channel comparison

4.3.3.1. Comparison between fiscal instruments. We further compare government subsidies and tax incentives to analyze which fiscal instrument is more effective. To facilitate the comparison, following Yu et al. (2012) and Liang et al. (2020), we standardize the two variables and add *Sub*, *Tax* and the interaction terms $GRDS \times Sub$ and $GRDS \times Tax$ to the baseline model (1). Our channel comparison model is specified as.

$$Innovation_{ipt} = \beta_0 + \beta_1 GRDS_{pt} + \beta_2 Sub_{ipt} + \beta_3 Sub_{ipt} \times GRDS_{pt} + \beta_4 Tax_{ipt} + \beta_5 Tax_{ipt} \times GRDS_{pt} + \beta_k Controls + T_t + \varepsilon_{ipt} \quad (5)$$

Because we use standardized variables for government subsidies and tax incentives, we can directly compare coefficients β_3 and β_5 to gauge which channel is more effective. If only coefficient β_3 is positive, government subsidies provide a more effective channel than tax incentives; conversely, if coefficient β_5 remains to be positive, tax incentives are the main channel used to promote innovation; ultimately, if the two coefficients are positive, both fiscal instruments provide adequate policy effects. Further, the magnitudes of the two coefficients indicate which channel is more important. Table 9 reports that, in Column (1), the coefficients on $GRDS \times Sub$ (3.598, p-value < 0.05) and on $GRDS \times Tax$ (0.671, p-value < 0.05) are both positive and statistically significant. The result suggests that both government subsidies and tax incentives are effective policy channels. Besides, the magnitude of the coefficient on $GRDS \times Sub$ is 5.36 times greater ($3.598/0.671 \approx 5.36$) than the magnitude of the coefficient on $GRDS \times Tax$. This difference implies that the channel of government subsidies is more effective than the channel of tax incentives.

4.3.3.2. Relationship between fiscal instruments. We further analyze whether government subsidies and tax incentives replace or complement each other. Following Jiang et al. (2020), we use the median of the tax incentives variable to divide the sample into two groups: the weak and strong tax incentives groups. Within each group, we examine the effect of the channel of government subsidies, interacted with government R&D spending, on firm innovation. Columns (2) and (3) of Table 9 display the regression results for the weak and strong tax incentives groups, respectively. The coefficient on $GRDS \times Sub$ in Column (3) is positive and statistically significant, whereas the coefficient on $GRDS \times Sub$ in Column (2) is not significant. Therefore, the channel effect of government subsidies is stronger when tax incentives are higher (vs. lower). The contrast suggests that the two channels complement each other.

The complementarity between government subsidies and tax incentives can be explained from three perspectives. First, to account for heterogeneity across different regions and industries, government R&D spending needs a variety of policy instruments to provide flexible support. As government subsidies and tax incentives have distinct effects, it is critical for the government to use both policy instruments to achieve the incentive goals of individual companies. Through the complementary use of different instruments, the government can also relinquish responsibility for debating the merits of each channel. Second, to incentivize companies to engage in innovation, the government can exploit the characteristics of both government subsidies and tax incentives. The two policy instruments have complementary differences with respect to the qualification threshold, future contingency, timing and firms' latitude to use the proceeds. For example, tax incentives require only the R&D expenditure ratio to reach the threshold, provide *ex post* outcome-oriented incentives and allow companies to use incentive proceeds at their discretion; in contrast, government subsidies alleviate companies' current financial distress, offer *ex ante* incentives, provide detailed guidance on how to use the subsidies and require strict supervision. Third, companies can demand different policy instruments over their

Table 9
Channel comparison.

Dependent variable	(1) Innovation	(2) Innovation (Weak Tax Incentives)	(3) Innovation (Strong Tax Incentives)
GRDS	1.935**	0.439	2.637**
	(2.23)	(0.38)	(2.20)
Sub	0.029	−0.056	0.927**
	(1.20)	(−0.41)	(2.07)
GRDS × Sub	3.598**	9.041	48.591**
	(2.12)	(0.37)	(2.53)
Tax	0.018**		
	(2.40)		
GRDS × Tax	0.671**		
	(2.04)		
Age	0.714***	0.889***	0.405*
	(4.81)	(4.76)	(1.75)
Size	0.300***	0.242***	0.373***
	(10.17)	(6.22)	(9.47)
Cashflow	−0.043	0.098	−0.207
	(−0.36)	(0.66)	(−1.04)
Lev	0.079	0.029	0.140
	(0.81)	(0.22)	(1.11)
Tangibility	−0.198	−0.107	−0.441***
	(−1.64)	(−0.65)	(−2.83)
ROA	0.712***	0.438	0.699***
	(4.18)	(1.22)	(3.37)
Growth	0.001	0.000	0.008
	(0.13)	(0.02)	(0.80)
TobinQ	−0.005	−0.002	−0.017
	(−0.54)	(−0.14)	(−1.41)
RE	0.030	0.052	0.014
	(0.70)	(1.09)	(0.18)
PCGDP	0.051	0.054	0.018
	(0.68)	(0.52)	(0.18)
Constant	−7.850***	−7.213***	−8.138***
	(−7.76)	(−5.21)	(−5.97)
N	18,393	9,217	9,176
Year FE	YES	YES	YES
Firm FE	YES	YES	YES
Adj.R^2	0.27	0.23	0.29

Note: Table 9 presents the regression results of the channel comparison test. T-values are reported in parentheses and are calculated with robust standard errors clustered at the firm level.
*** Statistical significance at the 1% level.
** Statistical significance at the 5% level.
* Statistical significance at the 10% level.

life cycles (Miller and Friesen, 1984). The complementary use of government subsidies and tax incentives can help companies improve the innovation activities critical to their growth. Chen et al. (2019) find that government subsidies can incentivize innovation in both growth and value firms, whereas tax incentives are only effective in value firms.

5. Further analyses

5.1. Inverted U-shaped relation test

The specification of the baseline model requires the relationship between government R&D spending and corporate technological innovation to be linear. However, Fig. 2 indicates that this relation may have an

inverted U-shape. To explore this possible nonlinear relation, we construct a polynomial equation and include the squared value of government R&D spending (*GRDS2*). The model is specified below:

$$Innovation_{ipt} = \beta_0 + \beta_1 GRDS_{pt} + \beta_2 GRDS2_{pt} + \beta_k Controls + T_t + \varepsilon_{ipt} \quad (6)$$

The regression results are reported in Column (1) and Column (2) of Table 10. The variable *GRDS* has a positive coefficient (9.511, p-value < 0.01 in Column (1) and 9.283, p-value < 0.01 in Column (2)), whereas the squared term *GRDS2* has a negative coefficient (-51.065, p-value < 0.01 in Column (1) and -54.727, p-value < 0.01 in Column (2)). These results suggest that although corporate technological innovation changes proportionately with changes in government R&D expenditures, increases in government R&D spending beyond a certain threshold can diminish innovation output. Based on our calculation, the effect of government R&D spending becomes negative once it exceeds 8.48% of total government expenditures. Our findings about the positive role of government R&D spending are valid because only 2.55% of our sample observations reach such a high level. Notwithstanding, our analyses imply that when a local government allocates fiscal resources,

Table 10
Test of inverted U-shaped relation.

Dependent variable	(1) Innovation	(2) Innovation
GRDS	9.511***	9.283***
	(3.79)	(3.85)
GRDS2	−51.065***	−54.727***
	(−3.00)	(−3.36)
Age		0.722***
		(4.91)
Size		0.295***
		(10.15)
Cashflow		0.001
		(0.01)
Leverage		0.077
		(0.80)
Tangibility		−0.162
		(−1.35)
ROA		0.711***
		(4.22)
Growth		0.001
		(0.21)
TobinQ		−0.007
		(−0.79)
RE		0.043
		(1.03)
PCGDP		0.024
		(0.32)
Constant	0.471***	−7.724***
	(7.21)	(−7.74)
Observation	18,796	18,796
Year FE	YES	YES
Firm FE	YES	YES
Adj.R^2	0.24	0.26

Note: Table 10 presents the results of analysis of the inverted U-shaped relation between government R&D spending and corporate technological innovation. T-values are reported in parentheses and are calculated with robust standard errors clustered at the firm level.
** Statistical significance at the 5% level.
* Statistical significance at the 10% level.
*** Statistical significance at the 1% level.

there should be coordination between regional innovation support and basic production capacities. Fiscal support for innovation should be compatible with economic development. If government R&D spending is too high to be absorbed by the local innovation infrastructure, its positive effect would be diminished.

5.2. Cross-sectional analysis

5.2.1. Ownership status

We then conduct a cross-sectional analysis with respect to ownership status and industry effects to study under which circumstances the effect of government R&D spending increases. Column (1) of Table 11 comprises state-owned enterprises (SOEs). The coefficient on $GRDS \times SOE$ is positive and statistically significant (2.794, p-value < 0.1). The result suggests that government R&D spending has a stronger innovation effect on SOEs than on other firms. Because SOEs have close ties with local governments (Kornai, 1979), the

Table 11
Cross-sectional analysis of ownership status and industry effects.

	(1)	(2)
Dependent variable	Innovation	Innovation
GRDS	0.506	−0.240
	(0.47)	(−0.24)
SOE	−0.012	
	(−0.13)	
GRDS × SOE	2.794*	
	(1.81)	
GRDS × Hightech		6.855***
		(4.09)
Age	0.735***	0.687***
	(4.96)	(4.67)
Size	0.294***	0.296***
	(9.93)	(10.23)
Cashflow	0.021	−0.002
	(0.17)	(−0.02)
Leverage	0.071	0.061
	(0.74)	(0.63)
Tangibility	−0.162	−0.163
	(−1.34)	(−1.37)
ROA	0.740***	0.723***
	(4.32)	(4.32)
Growth	0.002	0.001
	(0.34)	(0.23)
TobinQ	−0.005	−0.006
	(−0.61)	(−0.72)
RE	0.043	0.041
	(1.05)	(0.99)
PCGDP	0.045	0.064
	(0.60)	(0.85)
Constant	−7.713***	−7.905***
	(−7.65)	(−7.91)
Observation	18,556	18,796
Year FE	YES	YES
Firm FE	YES	YES
Adj.R^2	0.26	0.26

Note: Table 11 presents the cross-sectional analysis of ownership status and industry effects. T-values are reported in parentheses and are calculated with robust standard errors clustered at the firm level.
** Statistical significance at the 5% level.
*** Statistical significance at the 1% level.
* Statistical significance at the 10% level.

government has an incentive to increase their allocation of innovation resources to SOEs. Furthermore, SOEs are required to assume important modernization responsibilities, especially when the central government encourages the development of an innovative economy (Lin and Tan, 1999). Non-SOEs allocate factors in accordance with the rules of the market economy and are therefore less responsive than SOEs to government policies.[7]

5.2.2. Industry effects

We also divide all sample firms into two groups based on their industries. Specifically, we distinguish between high-tech and non-high-tech companies.[8] Column (2) in Table 11 reports the regression results, showing that the coefficient on $GRDS \times Hightech$ is positive and statistically significant (6.855, p-value < 0.01). Government R&D spending more effectively promotes innovation by high-tech companies than by non-high-tech companies, because the high-tech industry is knowledge-intensive and faces a competitive market environment (Acemoglu, 2010). To survive against fierce competition, high-tech companies have to increase investment of resources in technological innovation and thus react to government R&D spending rapidly.[9]

6. Conclusion

Using unique data from the Chinese setting, we reveal new evidence on the relationship between government R&D spending and corporate technological innovation. Unlike previous works, this study investigates the effect of government R&D spending in consideration of both fiscal instruments and factor allocation. In place of firm R&D expenditure, we use invention patent applications to measure corporate innovation output. Our findings show that companies located in cities where government R&D spending is higher file more invention patent applications than companies located in other cities. This relationship is robust to tests using river length as an instrumental variable and a series of additional tests. Further, our results demonstrate that fiscal instruments such as government subsidies and tax incentives constitute the main channels through which government R&D spending promotes innovation. The positive effect of government R&D spending also depends on factor allocation, including monetary capital (e.g. financial constraints), human capital (e.g. highly skilled employees) and management institution (e.g. efficient operations).

Our analysis sheds light on the efficacy of national innovation strategies. We show that government R&D spending has the real effect of encouraging companies to increase their filing of invention patent applications. Policy makers in emerging economies should take advantage of government R&D spending to support long-term innovative growth. The effects on invention patent applications also suggest that government R&D spending can facilitate the accumulation of cutting-edge technology, gradually reducing companies' reliance on lower-end product manufacturing. Hence, the government can use its policies to guide microeconomic activities and foster firm innovation.

One possible limitation of our paper is that knowledge spillover effects may reduce the impact of government R&D spending. If a company increases its engagement in innovation activities, its competitors are likely to increase their own R&D investments in response to the pressure. Aside from having direct effects on local companies' innovation plans, government R&D spending can exert a spillover effect on companies headquartered in adjacent cities. Future research should account for this consequence, thus distinguishing between the direct and indirect effects of government R&D spending.

[7] We further examine the difference between the effects of government subsidies and tax incentives, conditional on ownership status. The results are presented in Appendix 5. The channel of government subsidies does not have significantly different impacts on SOEs and non-SOEs, whereas the channel of tax incentives has a marginally stronger effect on SOEs. Our results suggest that SOEs are more responsive than non-SOEs to tax incentives which promote innovation.

[8] According to the industry classification standard of the National Bureau of Statistics (GB/T4754), the high-tech industry comprises firms producing general equipment, special equipment, transportation equipment, electrical machinery and equipment, computers and other electronic equipment, communication equipment, instrumentation and culture or office machinery.

[9] We compare government subsidies and tax incentives according to their effects on high-tech companies. Appendix 6 reports our results. We find that the channel of government subsidies amplifies innovation effects for high-tech companies, whereas the channel of tax incentives reduces innovation output. This difference suggests that tax incentives are more useful for non-high-tech companies than for high-tech companies.

Appendix A. Variable definition

Variable	Definition
Innovation	Natural logarithm of the number of invention patent applications
GRDS	Government R&D spending divided by government total spending in a city
River length	Length of the river divided by land area of the city
Sub	Government subsidies divided by operating income
Tax	Actual income tax rate proposed by Shevlin (1987), calculated by dividing the income tax expense by EBIT and then taking the opposite of the rate
Fin	SA index proposed by Hadlock and Pierce (2010), calculated using the formula SA = $\lvert -0.737 \times \text{Size} + 0.043 \times \text{Size}^2 - 0.04 \times \text{Age} \rvert$
Skill	Natural logarithm of the number of employees who have a postgraduate degree
Turn	Total assets turnover, calculated by dividing sales revenue by total assets
Size	Natural logarithm of total assets
Age	Natural logarithm of a firm's age
Cashflow	Cash flow from operations divided by total assets
Leverage	Total debt divided by total assets
Tangibility	Net property, plant and equipment divided by total assets
ROA	Net income before extraordinary items divided by total assets
Growth	Difference between current year's sales revenue and last year's sales revenue, scaled by last year's sales revenue
TobinQ	Equity value plus nominal debt value divided by total assets
RE	Real earnings management, defined by Roychowdhury (2006)
PCGDP	Natural logarithm of per capita GDP

Appendix B. Channel of government subsidies controlling for tax incentives

Dependent variable	(1) Innovation	(2) Innovation	(3) Innovation	(4) Innovation
GRDS	1.960**	2.290**	1.318	2.519***
	(2.26)	(2.35)	(1.26)	(2.84)
Sub	0.129	0.124	0.375**	2.067***
	(1.23)	(1.48)	(2.41)	(2.65)
GRDS × Sub	16.051**	7.198	18.279**	106.229***
	(2.15)	(1.09)	(2.39)	(3.61)
Fin		−0.489***		
		(−2.61)		
GRDS × Fin		−0.344		
		(−0.15)		
Sub × Fin		2.563**		
		(1.97)		
GRDS × Sub × Fin		137.608**		
		(2.42)		
Skill			0.082***	
			(8.85)	
GRDS × Skill			0.308	
			(1.12)	

Sub × Skill			0.300**	
			(2.43)	
GRDS × Sub × Skill			10.730**	
			(2.02)	
Turn				−0.097*
				(−1.82)
GRDS × Turn				3.879***
				(2.60)
Sub × Turn				3.688***
				(2.66)
GRDS × Sub × Turn				177.385***
				(3.35)
Age	0.722***	0.750***	0.743***	0.722***
	(4.87)	(5.03)	(5.10)	(4.88)
Size	0.302***	0.310***	0.256***	0.301***
	(10.23)	(10.22)	(8.89)	(10.29)
Cashflow	−0.041	−0.062	−0.009	0.011
	(−0.34)	(−0.52)	(−0.07)	(0.09)
Leverage	0.076	0.043	0.065	0.096
	(0.78)	(0.44)	(0.68)	(0.99)
Tangibility	−0.200*	−0.210*	−0.196*	−0.191
	(−1.65)	(−1.75)	(−1.66)	(−1.57)
ROA	0.705***	0.740***	0.617***	0.781***
	(4.15)	(4.39)	(3.70)	(4.58)
Growth	0.001	0.002	0.001	0.000
	(0.16)	(0.44)	(0.13)	(0.03)
TobinQ	−0.004	−0.011	−0.002	−0.001
	(−0.52)	(−1.23)	(−0.27)	(−0.14)
RE	0.030	0.020	0.035	0.027
	(0.71)	(0.47)	(0.84)	(0.63)
PCGDP	0.051	0.057	0.054	0.058
	(0.68)	(0.75)	(0.74)	(0.77)
Tax	0.137**	0.135**	0.121**	0.132**
	(2.22)	(2.21)	(1.99)	(2.15)
Constant	−7.881***	−8.208***	−6.904***	−7.939***
	(−7.80)	(−7.94)	(−7.02)	(−7.89)
Observation	18,393	18,393	18,393	18,386
Year FE	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES
Adj.R^2	0.27	0.27	0.28	0.27

Note: Appendix B presents the regression results of the interaction model that examines the channel of government subsidies through which the government R&D spending affects corporate technological innovation. We include tax incentives as an additional control variable. Government subsidies can have an influence directly or through factor allocation, including financial constraints, highly skilled employees and efficient operations. T-values are reported in parentheses and are calculated with robust standard errors clustered at the firm level.

*** Statistical significance at the 1% level.

** Statistical significance at the 5% level.

* Statistical significance at the 10% level.

Appendix C. Channel of tax incentives controlling for government subsidies

Dependent variable	(1) Innovation	(2) Innovation	(3) Innovation	(4) Innovation
GRDS	1.857**	2.168**	1.250	1.808**
	(2.15)	(2.24)	(1.19)	(2.10)
Tax	0.148**	0.039	0.145**	0.138**
	(2.39)	(0.57)	(2.06)	(2.23)
GRDS × Tax	5.700**	3.231	5.040	5.990**
	(2.07)	(1.04)	(1.50)	(2.19)
Fin		−0.500***		
		(−2.68)		
GRDS × Fin		−0.825		
		(−0.35)		
Tax × Fin		0.653***		
		(2.80)		
GRDS × Tax × Fin		13.316		
		(1.24)		
Skill			0.081***	
			(8.73)	
GRDS × Skill			0.233	
			(0.85)	
Tax × Skill			−0.018	
			(−0.63)	
GRDS × Tax × Skill			0.900	
			(0.66)	
Turn				−0.148***
				(−2.87)
GRDS × Turn				1.362
				(0.98)
Tax × Turn				−0.250**
				(−2.00)
GRDS × Tax × Turn				9.904*
				(1.72)
Age	0.716***	0.745***	0.742***	0.721***
	(4.82)	(4.98)	(5.08)	(4.86)
Size	0.300***	0.307***	0.254***	0.299***
	(10.17)	(10.12)	(8.78)	(10.22)
Cashflow	−0.044	−0.064	−0.011	0.019
	(−0.36)	(−0.53)	(−0.09)	(0.16)
Leverage	0.077	0.054	0.064	0.101
	(0.79)	(0.55)	(0.67)	(1.05)
Tangibility	−0.194	−0.204*	−0.191	−0.179
	(−1.61)	(−1.70)	(−1.63)	(−1.48)
ROA	0.709***	0.734***	0.626***	0.809***
	(4.16)	(4.31)	(3.73)	(4.69)
Growth	0.000	0.002	0.000	−0.000
	(0.06)	(0.36)	(0.00)	(−0.07)
TobinQ	−0.005	−0.010	−0.003	−0.002
	(−0.55)	(−1.19)	(−0.38)	(−0.18)

RE	0.029	0.021	0.036	0.030
	(0.69)	(0.51)	(0.87)	(0.70)
PCGDP	0.050	0.050	0.051	0.054
	(0.66)	(0.66)	(0.70)	(0.72)
Sub	−0.023	−0.034	−0.016	−0.046
	(−0.72)	(−1.05)	(−0.52)	(−1.40)
Constant	−7.843***	−8.093***	−6.834***	−7.896***
	(−7.76)	(−7.84)	(−6.93)	(−7.84)
Observation	18,393	18,393	18,393	18,386
Year FE	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES
Adj.R^2	0.27	0.27	0.28	0.27

Note: Appendix C reports the regression results of the interaction model that tests the tax incentives channel through which government R&D spending affects corporate technological innovation. We include government subsidies as an additional control variable. Tax incentives can exert impact directly or through factor allocation, including financial constraints, highly skilled employees and efficient operations. T-values are reported in parentheses and are calculated with robust standard errors clustered at the firm level.

*** Statistical significance at the 1% level.

** Statistical significance at the 5% level.

* Statistical significance at the 10% level.

Appendix D. IV regression using the number of prefecture-level cities

Dependent variable	(1) GRDS	(2) GRDS	(3) Innovation	(4) Innovation
City_number	−0.003***	−0.003***		
	(−5.53)	(−6.20)		
GRDS			35.328**	35.324**
			(2.08)	(2.38)
Age		0.005*		0.449**
		(1.65)		(2.24)
Size		0.001**		0.280***
		(2.46)		(7.64)
Cashflow		−0.000		−0.064
		(−0.13)		(−0.42)
Leverage		0.003**		−0.052
		(2.20)		(−0.44)
Tangibility		−0.002		−0.159
		(−1.04)		(−1.10)
ROA		0.002		0.641***
		(0.67)		(3.21)
Growth		−0.000*		0.014*
		(−1.85)		(1.91)
TobinQ		0.000		−0.010
		(0.66)		(−0.94)
RE		0.000		0.005
		(0.82)		(0.10)

PCGDP		0.006***		−0.144
		(5.53)		(−1.17)
Constant	0.062***	−0.031**	−0.311	−5.705***
	(9.86)	(−1.99)	(−0.69)	(−3.70)
Observation	14,901	14,901	14,901	14,901
Year FE	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES
Adj.R^2	0.23	0.24	0.06	0.08

Note: Appendix D presents IV regression results that use the number of prefecture-level cities in each province as the instrumental variable. T-values are reported in parentheses for Columns (1) and (3), while Z-values are reported in parentheses for Columns (2) and (4).

*** Statistical significance at the 1% level.

** Statistical significance at the 5% level.

* Statistical significance at the 10% level.

Appendix E. Cross-sectional analysis of ownership status under fiscal instruments

Dependent variable	(1) Innovation	(2) Innovation
GRDS	0.616	0.617
	(0.57)	(0.58)
Sub	0.897**	
	(2.00)	
GRDS × Sub	37.885	
	(1.64)	
SOE	−0.025	−0.023
	(−0.27)	(−0.25)
GRDS × SOE	2.793*	2.625*
	(1.78)	(1.70)
Sub × SOE	−0.815*	
	(−1.79)	
GRDS × Sub × SOE	−20.517	
	(−0.82)	
Tax		0.223**
		(2.52)
GRDS × Tax		0.938
		(0.23)
Tax × SOE		−0.078
		(−0.64)
GRDS × Tax × SOE		8.320
		(1.54)
Age	0.745***	0.722***
	(4.99)	(4.86)
Size	0.300***	0.294***
	(10.02)	(9.95)
Cashflow	−0.018	0.018
	(−0.15)	(0.15)

Leverage	0.097	0.054
	(0.98)	(0.55)
Tangibility	−0.191	−0.168
	(−1.57)	(−1.39)
ROA	0.670***	0.803***
	(3.94)	(4.59)
Growth	0.001	0.002
	(0.16)	(0.36)
TobinQ	−0.005	−0.005
	(−0.53)	(−0.53)
RE	0.030	0.043
	(0.70)	(1.03)
PCGDP	0.042	0.044
	(0.56)	(0.58)
Constant	−7.832***	−7.675***
	(−7.73)	(−7.59)
Observation	18,213	18,505
Year FE	YES	YES
Firm FE	YES	YES
Adj.R^2	0.27	0.26

Note: Appendix E presents the cross-sectional analysis of ownership status under fiscal instruments. T-values are reported in parentheses and are calculated with robust standard errors clustered at the firm level.

*** Statistical significance at the 1% level.

** Statistical significance at the 5% level.

* Statistical significance 10% level.

Appendix F. Cross-sectional analysis of industry effects under fiscal instruments

Dependent variable	(1) Innovation	(2) Innovation
GRDS	−0.113	−0.188
	(−0.11)	(−0.19)
Sub	0.030	
	(0.54)	
GRDS × Sub	6.719	
	(1.39)	
GRDS × Hightech	6.585***	7.057***
	(3.88)	(4.24)
Sub × Hightech	1.183	
	(1.43)	
GRDS × Sub × Hightech	58.753**	
	(2.03)	
Tax		0.184***
		(2.63)
GRDS × Tax		7.123**
		(2.31)
Tax × Hightech		−0.059
		(−0.36)

GRDS × Tax × Hightech		−11.868*
		(−1.79)
Age	0.701***	0.674***
	(4.73)	(4.58)
Size	0.301***	0.296***
	(10.22)	(10.22)
Cashflow	−0.050	−0.004
	(−0.42)	(−0.03)
Leverage	0.091	0.043
	(0.94)	(0.45)
Tangibility	−0.188	−0.167
	(−1.56)	(−1.40)
ROA	0.665***	0.789***
	(4.01)	(4.61)
Growth	0.000	0.001
	(0.06)	(0.27)
TobinQ	−0.006	−0.005
	(−0.65)	(−0.62)
RE	0.028	0.042
	(0.65)	(1.01)
PCGDP	0.061	0.060
	(0.81)	(0.79)
Constant	−7.949***	−7.781***
	(−7.90)	(−7.77)
Observation	18,445	18,744
Year FE	YES	YES
Firm FE	YES	YES
Adj.R^2	0.27	0.26

Note: Appendix F presents the cross-sectional analysis of industry effects under fiscal instruments. T-values are reported in parentheses and are calculated with robust standard errors clustered at the firm level.

*** Statistical significance at the 1% level.

** Statistical significance at the 5% level.

* Statistical significance at the 10% level.

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Non-actual controllers and corporate innovation: Evidence from China

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ABSTRACT

As the number of "ownerless" enterprises in China's capital market increases, so does the importance of paying attention to their behavior. From the perspective of enterprises' control rights allocation, we find that non-actual controllers can inhibit corporate innovation by intensifying agency conflicts, reducing corporate risk-taking and strengthening financing constraints. We also find that a larger proportion of independent directors, higher audit quality, greater managerial ownership and less environmental uncertainty weaken the negative effect of non-actual controllers on corporate innovation. In contrast, multiple large shareholders strengthen the inhibitory effect of non-actual controllers on corporate innovation, but this inhibitory effect comes from over-supervision rather than from collusion. We further divide non-actual controllers into real and hidden types and find that real non-actual controllers still have a significant inhibitory effect on corporate innovation. Finally, we rule out the competitive explanation of equity dispersion, whereby non-actual controllers inhibit corporate innovation. This study enriches the literature on the factors influencing corporate innovation and provides evidence of the adverse impact of non-actual controllers.

1. Introduction

At the executive meeting of the State Council of China held on 23 September 2020, arrangements were made for improving the governance of listed companies, including strengthening their governance system and rules and enforcing the statutory duties and responsibilities of controlling shareholders, actual controllers,

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directors, supervisors and senior managers. The behavior of actual controllers, who have the greatest influence on the operation and management activities of listed companies, is increasingly emphasized by the Chinese government. The ownership structure of most listed companies in China has long been that of a single large shareholder, which enables actual controllers to entrench the interests of minority shareholders (Ma et al., 2018). It is thus necessary to supervise and restrict actual controllers' behavior. However, studies find that an actual controller can improve corporate governance by directly holding shares in an enterprise, which can increase the value of the enterprise (Shao and Lyu, 2015) and improve the management incentive mechanism (Lin et al., 2013). The actual controller has thus become an important factor in the effectiveness of the corporate governance of listed companies in China.

With the completion of China's split share structure reform, the A-share market has gradually begun to show a trend of decentralization (Li et al., 2021). In particular, the 2015 equity dispute between Baoneng Group and Vanke Group indicates that China's capital market has entered a "dispersed equity era" (Zheng, 2019). A large number of listed companies now declare in their annual reports that they have no actual controller, thus appearing to be "ownerless" enterprises. For example, in December 2019, Gree Electric stated in "Explanation of the Reply to the Comment Letter of the Shenzhen Stock Exchange" that the company had no controlling shareholder or actual controller. According to the statistics of the sample, the percentage of companies with non-actual controllers listed as A-shares on the Shanghai and Shenzhen stock exchanges increased from 1.81% in 2004 to 6.22% in 2019 (Fig. 1), which indicates that non-actual controllers were increasingly accepted by listed companies as a control rights allocation mode in this period.

The emergence of "ownerless" enterprises is mainly due to the dissolution of acting-in-concert agreements, the dilution of equity by private placement, management turnover caused by general elections and the dispersion of equity before IPOs (Fang, 2020). Although it is increasingly common for companies to adopt the control rights allocation mode of a non-actual controller in the dispersed equity era, this does not mean that the non-actual controller mode can be directly equated with dispersed equity; nor can we simply equate the presence of actual controllers with centralized ownership. Through preliminary statistical analysis of the sample, we find that in China's capital market, the proportion of companies with dispersed equity but an actual controller is about 35%; thus, such companies are relatively common. In addition, China's "Company Law" stipulates that the actual controller cannot be directly defined as a shareholder. For enterprises with actual controllers but with relatively dispersed equity, although the actual controllers do not have absolute control over the companies, they can still control the companies by controlling the board of directors. Therefore, studying actual controllers can better reflect the essence of control than studying controlling shareholders (Zhang et al., 2013; Xu et al., 2019). In the case of dispersed equity, the actual controller can entrench the

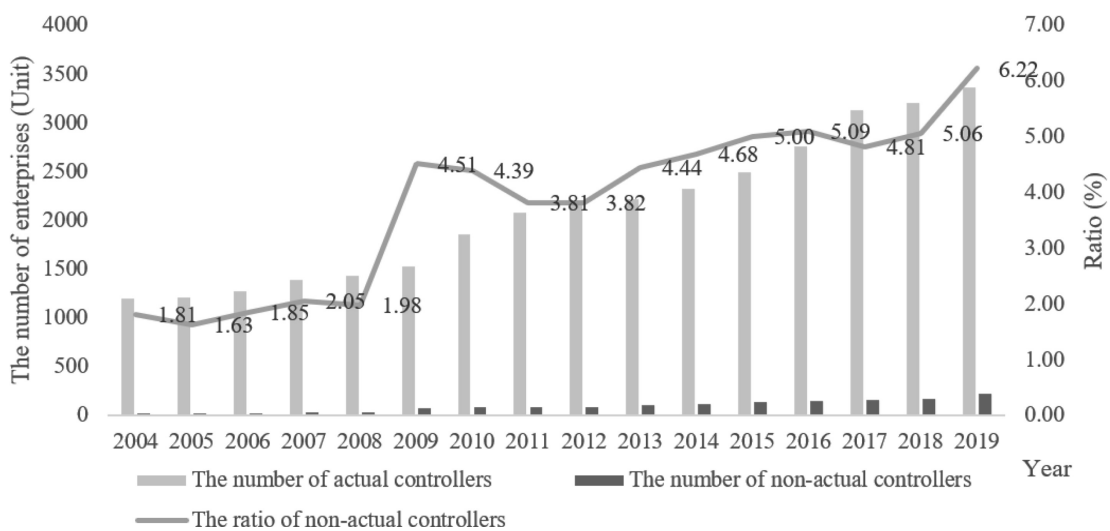

Fig. 1. Trend of enterprises with non-actual controllers (created by the authors).

interests of minority shareholders (Jiang et al., 2018a; Ma et al., 2018), and protecting the rights and interests of minority shareholders is critical (Zheng et al., 2016a). In contrast, for enterprises with non-actual controllers but relatively concentrated equity, the insider control of management and the entrenchment behavior of major shareholders coexist, resulting in severe damage to the companies' value (Forst and Hettler, 2019). The ownership structure and the actual controller are not equivalent, which is one reason why it is valuable to study how non-actual controllers affect enterprises' strategic decision-making. Although China's capital market features many excellent listed companies with non-actual controllers, such as Vanke Group, Gree Electric and PingAn Insurance Group, recent events such as the equity dispute between Baoneng Group and Vanke Group and the "Bloodwashing of China Southern Glass Group" show that even mature enterprises with non-actual controllers, such as Vanke Group, face the risk of barbarian invasion. For most enterprises in China with non-actual controllers, "ownerless" enterprises become subject to disputes over control rights, which reduce decision-making efficiency and delay the companies' development (Zheng, 2019). Therefore, how to accurately view the phenomenon of non-actual controllers is an important topic in the study of the strategic decision-making of listed companies in China's capital market (Gan et al., 2020; Liu and Zhou, 2021).

Among enterprises' many strategic decisions, innovation strategy is becoming prominent. The Chinese government has vowed to maintain a focus on innovation in China's modernization efforts and to pursue scientific and technological self-reliance as strategic support for the country's development. As the micro units that implement this innovation strategy, enterprises are the key driving force in enhancing China's independent innovation. Because the actual controller controls the enterprise's resources (Ma et al., 2018), it can directly affect the enterprise's corporate innovation strategy via foreign residency rights and the over-appointment of directors (Wang, 2019; Li et al., 2021). Especially when the ownership structure of an enterprise is centralized, the controlling shareholder and the actual controller can control and supervise management through internal and external governance mechanisms to ensure that management fulfills its responsibilities (Zhu and Wang, 2012). However, for enterprises with non-actual controllers, after eliminating the control of the actual controller and the controlling shareholder, management often engages in collusion, controls the board of directors and uses other means to pursue its own interests, thus establishing insider control (Rajan and Wulf, 2006; Barclay et al., 2007), which can have a negative impact on corporate innovation (Wang and He, 2020). Therefore, the approach of enterprises with non-actual controllers to innovation strategy merits further exploration.

Based on the above analysis, we select 2003–2017 non-financial A-share listed companies in China as a sample to examine the impact of non-actual controllers on corporate innovation. We find that non-actual controllers inhibit corporate innovation, not only reducing innovation willingness by aggravating agency conflicts and corporate risk-taking but also reducing innovation ability by strengthening financing constraints. We also find that a better corporate governance mechanism and external development environment can weaken the negative influence of non-actual controllers on corporate innovation—that is, a larger proportion of independent directors, a higher level of managerial ownership, higher audit quality and less environmental uncertainty can alleviate the negative effects of non-actual controllers on corporate innovation. In addition, enterprises with non-actual controllers may have multiple large shareholders, whose over-supervision effect can strengthen the negative relationship between the non-actual controller and corporate innovation. Furthermore, we divide non-actual controllers into real and hidden types, and we find that real non-actual controllers inhibit corporate innovation. Finally, we exclude the competitive explanation of equity dispersion, whereby non-actual controllers inhibit corporate innovation.

The contributions of this study are as follows. First, we provide a framework for analyzing how enterprises with non-actual controllers make strategic decisions. In light of the increase in enterprises with non-actual controllers in China's capital market and innovation strategies reflecting enterprises' long-term development orientation, we discuss the influence of non-actual controllers on corporate innovation and divide non-actual controllers into real and hidden types. We explore whether different types of non-actual controllers have heterogeneous influences on corporate innovation, thus enriching the literature on the influence of non-actual controllers on corporate strategic decisions. Second, most previous studies regard the concept of equity dispersion as the same as that of non-actual controllers (Liu and Zhou, 2021; Song and Hua, 2020). However, they are not equivalent; enterprises with non-actual controllers also have a centralized ownership structure. We further distinguish the boundary between the ownership structure and the actual controller and rule out the possible competitive explanation of equity dispersion in corporate innovation strategies with non-

actual controllers, thus expanding the literature on actual controllers. Third, we analyze the dynamic mechanism of corporate innovation from the perspective of control rights allocation. Corporate governance is the institutional basis of corporate innovation (O'Sullivan, 2000; Belloc, 2012), and control rights allocation is the core of corporate governance (Fama and Jensen, 1983). We examine the influence of the control rights allocation mode of non-actual controllers on corporate innovation. We thus enrich the literature on the factors that influence corporate innovation in the field of corporate governance, and we clarify enterprises' internal motivation to carry out innovation activities. Finally, against the background of China's strategic development, which focuses on innovation to promote the optimization and upgrading of the national economic structure, it is of great practical significance to strengthen the corporate governance of enterprises with non-actual controllers. We find that non-actual controllers have an inhibitory effect on corporate innovation, and this result holds when the types of non-actual controllers are distinguished. We also find that a better governance mechanism and external environment can effectively alleviate the negative effect of non-actual controllers on corporate innovation. This study's findings may thus help enterprises with non-actual controllers to improve their corporate governance mechanisms and realize sustainable and healthy development in China's capital market, thereby increasing the effectiveness of China's innovation-driven strategy.

2. Literature review and hypothesis development

2.1. Literature on non-actual controllers

With China's capital market gradually entering a ''dispersed equity era'' (Zheng, 2019), increasing numbers of enterprises are adopting the control rights allocation mode of non-actual controllers. A number of scholars discuss the important economic effects of non-actual controllers from an academic perspective. Taking listed companies with non-actual controllers as a sample, Gan et al. (2020) find that executive compensation in listed companies with non-actual controllers can significantly improve corporate performance. Fang (2020) analyzes the change trends, characteristics and potential problems of listed companies with non-actual controllers and proposes suggestions for improving the regulatory policies of listed companies with non-actual controllers. Song and Hua (2020) conduct a multi-case study to explore the agency conflicts of listed companies with non-actual controllers. They identify four types of agency problems in listed companies with non-actual controllers: abnormal executive compensation, abnormal perquisites, insufficient efforts of senior executives and poor investment efficiency. Liu and Zhou (2021) examine the impact of non-actual controllers on audit fees and find that non-actual controllers aggravate the agency conflict and increase the violation risk, thus increasing audit fees.

2.2. Literature on corporate innovation from the perspective of actual controllers

The actual controller can legally control the voting results of shareholder meetings to elect directors and appoint senior executives by controlling the resources of the enterprise, and can thus control the board of directors and management (Ma et al., 2018). In such cases, the board of directors and management show an obvious attachment to the actual controller (Zheng et al., 2016b). Based on the key position of actual controllers in enterprises, scholars explore the relationship between the specific characteristics of actual controllers and corporate strategy from various perspectives. Focusing on corporate innovation strategy, relevant studies mainly discuss the influence of actual controllers on corporate innovation from the perspectives of the external environment and individual behavior. We review this body of research.

The external environment profoundly affects the formation of actual controllers' preferences and beliefs (Becker, 1992). A developed growth environment can strengthen actual controllers' adventurous spirit and innovativeness and enhance their ability to acquire and integrate resources, thus leading to better innovation performance (Zhai and Zhou, 2020). Actual controllers' foreign residency rights also have an important effect on corporate innovation (Chen et al., 2018a; Wang, 2019). Foreign residency rights indicate that the actual controller is likely to discover and seize overseas research and development opportunities and thus actively carry out overseas innovation (Chen et al., 2018a). However, when individuals believe that their future selves will be less similar to their present selves, they find it easier to pursue short-term benefits through immoral

behaviors, giving less consideration to their long-term interests (Bartels and Urminsky, 2011; Hershfield et al., 2012). The actual controllers of private enterprises with foreign residency rights perceive less similarity between their future selves and their present selves and exhibit more short-sighted behaviors, which are not conducive to corporate innovation (Wang, 2019).

2.3. Literature summary

Although some scholars examine the impact of the internal and external characteristics of actual controllers on corporate innovation (Chen et al., 2018a; Wang, 2019; Zhai and Zhou, 2020), they do not examine non-actual controllers' effects on corporate innovation. Most research on non-actual controllers is theoretical; there are few large-sample empirical studies on the economic effects of non-actual controllers. As enterprises with non-actual controllers are becoming increasingly common in China's capital market, we explore the effect of non-actual controllers on corporate innovation, thereby providing a deeper understanding of the causes of corporate innovation and expanding research on the factors influencing corporate innovation and the economic effects of non-actual controllers.

2.4. Hypothesis development

Corporate innovation depends on the continuous investment of various resources, and its characteristics of long return periods, high investment risks and high failure probability indicate that corporate innovation requires high failure tolerance and substantial decision-making space (Aghion et al., 2013; Luong et al., 2017; Quan et al., 2019). Whether an enterprise can effectively carry out its innovation strategy is influenced by its willingness and ability to innovate (Zhu et al., 2018). Most related studies analyze innovation willingness from the perspectives of agency cost and risk-taking (He and Tian, 2013; Chen et al., 2017; Meng et al., 2018), and most studies on innovation ability focus on the effects of financing constraints on corporate innovation (Hall, 2002). Therefore, we analyze the influence of non-actual controllers on corporate innovation in terms of innovation willingness (agency cost and risk-taking) and innovation ability (financing constraints).

2.4.1. Analysis of the relationship between non-actual controllers and corporate innovation from the perspective of innovation willingness

Enterprises with non-actual controllers often experience a separation of ownership and management rights. To pursue personal interests, management has the motivation and ability to entrench shareholders' interests (Jensen and Meckling, 1976), which exacerbates the agency conflict. In addition, non-actual controllers necessitate stricter requirements for the legal protection and supervision of the rights and interests of investors in China's capital market (Fang, 2020). However, China still has a transition economy, and its capital market is not yet fully developed. There are great differences in the reform process between different regions of the country (Wang et al., 2018; Yan et al., 2019), and given the external institutional environment, supervision of management is challenging. With the deepening of agency conflict, private costs, career concerns and other issues motivate managers to pursue their personal interests, which reduces innovation willingness (He and Tian, 2013; Zhong et al., 2017). In addition, innovation requires enterprises to be willing to take risks (Aghion et al., 2013; Luong et al., 2017). Research also shows that an actual controller can improve corporate governance by directly holding shares (Shao and Lyu, 2015) and can improve corporate innovation by appointing directors (Li et al., 2021). In addition, the more developed the growth environment of the actual controller, the better the enterprise's innovation performance is likely to be (Zhai and Zhou, 2020). In contrast with non-actual controllers, shareholders may lose actual control over the enterprise, which not only reduces the consistency of board decisions but also strengthens the short-term pressure and over-supervision imposed by a hostile board of directors on managers (Chemmanur and Tian, 2018; Baran et al., 2019), thus reducing managers' willingness to take risks, which is not conducive to corporate innovation.

2.4.2. Analysis of the relationship between non-actual controllers and corporate innovation from the perspective of innovation ability

Corporate innovation requires enterprises to continuously invest a large amount of capital, so in reality, innovation activities are generally restricted by financial constraints (Meng et al., 2018). Actual controllers can improve the consistency and stability of the decisions of the board of directors by appointing directors and through other means (Zheng et al., 2019; Li et al., 2021) to transmit positive signals to the capital market and reduce the information asymmetry between external investors and enterprises, thereby alleviating financing constraints (Majluf and Majluf, 1984). However, for enterprises with non-actual controllers, the high risk associated with innovation reduces the consistency of the decisions of the board of directors, affecting the stability and continuity of the enterprises' operating policies (Fang, 2020; Li et al., 2021) and thus transmitting negative signals to the capital market. If an enterprise does not have an actual controller, shareholders' control over the operation of the company will be weaker than that of management, which is not conducive to alleviating information asymmetry and which exacerbates the financing constraint dilemma, making it difficult for the company to obtain sufficient resources to support corporate innovation. In addition, when the actual controller directly holds the shares, the ownership information of the enterprise is highly transparent and it is relatively difficult for the actual controller to "exit in advance," thus inhibiting speculation in the capital market and giving the actual controller longer-term control over the operation of the company (Shao and Lyu, 2015). In addition, when the enterprise does not have an actual controller, information transparency and the quality of information disclosure are reduced, and it is more difficult for banks to make credit decisions by comprehensively evaluating the enterprise's operating conditions, which increases the enterprise's debt financing cost (LaFond and Watts, 2008; Zhou et al., 2017; Meng et al., 2018) and strengthens its financing constraints. When management faces a shortage of funds, it makes more conservative strategic decisions, which reduces corporate innovation.

Based on the above analysis, non-actual controllers not only reduce innovation willingness by intensifying agency conflicts and reducing risk-taking but also decrease innovation ability by strengthening financing constraints, thus inhibiting corporate innovation. Therefore, we propose the following hypothesis:

H1: Ceteris paribus, non-actual controllers inhibit corporate innovation.

3. Research design

3.1. Sample and data

Our sample includes all A-share firms listed on the Shanghai and Shenzhen stock exchanges between 2003 and 2017. We use 2003 as the first year of the sample period because the China Securities Regulatory Commission (CSRC) has required listed companies in China to disclose information on their actual controllers since 2003. We use 2017 as the end of the research period because data on the number of patent applications, which is used to measure corporate innovation, are obtained from the China Stock Market and Accounting Research (CSMAR) database, which is currently updated to 2017. We exclude firms in the financial services industry, as they use different accounting standards and performance measures. We obtain the firms' financial and governance data from the CSMAR and Chinese Research Data Services databases. Matching all of the variables of interest yields 13,375 firm-year observations, excluding firms with missing data, special treatment firms and firms issuing debt exceeding their asset value. To reduce the influence of outliers, we winsorize all of the continuous variables at the 1st and 99th percentiles.

3.2. Dependent variable

The dependent variable is corporate innovation (*Inno*). The main measures of corporate innovation are innovation input and innovation output. The former is usually measured by R&D expenditure (He and Wintoki, 2016; Xie et al., 2019) and the latter is usually measured by the number of patent applications (He and Tian, 2013; Li and Zheng, 2016; Yu et al., 2016; Zhu et al., 2018). Because there are many missing values for R&D expenditure in annual reports (He and Tian, 2013), measuring corporate innovation by the number of patent applications can more accurately and comprehensively reflect corporate innovation. Fur-

ther, according to China's Patent Law, patents include invention patents, practical new-type patents and design patents. Practical new-type patents and design patents are easier to obtain, with relatively low technical requirements, while invention patents are new technical solutions proposed for products, methods or their improvements, which are more difficult to obtain and have higher technical requirements, and better represent innovation capability (Li and Zheng, 2016; Yu et al., 2016). Therefore, we use the number of applications for invention patents to measure corporate innovation.

3.3. Independent variable

The independent variable is non-actual controllers (*Codum*). The identification of non-actual controllers requires various conditions to be met (Fang, 2020), and disputes remain over how to clearly define non-actual controllers. Since 2003, the CSRC has required listed companies in China to publicly disclose relevant information on actual controllers in their annual reports, which provides a relatively robust indicator of whether an enterprise has an actual controller. Because in reality, non-actual controllers are difficult to clearly define, we rely on the annual reports of listed companies and manually query the relevant information on shareholders and actual controllers and on the announcement charts of shareholders' control relationship chains disclosed by the listed companies in their annual reports. When an enterprise clearly states in its annual report that it does not have an actual controller, *Codum* takes a value of 1, and 0 otherwise.

3.4. Control variables

Following relevant research on the factors influencing corporate innovation (He and Tian, 2013; Quan et al., 2019; Quan et al., 2020), we control for a number of variables. Firm size (*Size*) is measured as the logarithm of total assets. Leverage (*Lev*) is measured as the ratio of debt to total assets. We control for accounting performance (*ROA*), measured as return on assets. Firm growth (*Growth*) is measured as the growth rate of sales revenue. Cash flow (*CF*) is measured as the net cash flows from operating activities to total assets. We also control for firm age (*Age*), measured as the logarithm of the firm's establishment year plus 1. Market performance (*TobinQ*) is measured as the ratio of a firm's market value to its book value of total assets. Institutional investor (*Inst*) is measured as the ratio of institutional investor shares to the total number of shares. The largest shareholder (*Top*) is measured as the ratio of the number of shares held by the largest shareholder to the total number of shares. We also control for equity balance (*Balance*), measured as the ratio of the second to fifth largest shareholders' shareholding to the first largest shareholder's shareholding. Finally, we control for individual fixed effects (*Firm*) and year fixed effects (*Year*).

3.5. Model specification

To test the impact of non-actual controllers on corporate innovation, we establish regression model (1). Because of the lag characteristics of corporate innovation, we lag the independent variable and the control variables by one period. If α_1 is significant and negative, non-actual controllers inhibit corporate innovation, and H1 is supported.

$$Inno_{i,t} = \alpha_0 + \alpha_1 Codum_{i,t-1} + \sum \alpha_i Control_{i,t-1} + Firm + Year + \varepsilon \quad (1)$$

where *Control* represents the control variables.

4. Empirical results

4.1. Summary statistics

The sample and summary statistics are shown in Table 1. The mean of *Inno* is 2.020, which is close to the results in prior research (Quan et al., 2020). There is a substantial difference between the maximum (5.964) and the minimum (0) of *Inno*, which indicates that there is a substantial difference in the innovation levels of the

Table 1
Summary statistics.

	N	Mean	Median	SD	Max	Min
Inno	13,375	2.020	1.946	1.400	5.964	0
Codum	13,375	0.038	0	0.192	1	0
Size	13,375	22.130	21.940	1.294	26.400	19.240
Lev	13,375	0.433	0.434	0.196	0.991	0.027
ROA	13,375	0.044	0.040	0.061	0.245	−0.415
Growth	13,375	0.191	0.129	0.394	4.806	−0.737
CF	13,375	0.050	0.048	0.068	0.282	−0.235
Age	13,375	2.705	2.773	0.414	3.555	0.693
TobinQ	13,375	1.936	1.538	1.229	17.68	0.799
Inst	13,375	0.357	0.352	0.245	0.889	0
Top	13,375	0.357	0.338	0.152	0.758	0.084
Balance	13,375	0.671	0.499	0.594	2.961	0.005

sample enterprises. The mean of *Codum* is 0.038, indicating that 3.8% of the enterprises in the sample do not have actual controllers, and the mean of *Codum* (0.038) is higher than the median value (0), indicating that the enterprises are gradually inclined to adopt the control rights allocation mode of non-actual controllers. The values of other variables are similar to those in prior Chinese studies.

4.2. Difference tests of the corporate characteristic variables

To compare the differences between enterprises with actual controllers and those with non-actual controllers and to determine which company characteristic variables are significantly different between the two types of enterprises, we conduct difference tests of the company characteristic variables for the two types of enterprises. According to the results of the mean difference test shown in Panel A in Table 2, there are signif-

Table 2
Difference test of corporate characteristic variables.

Panel A Mean difference test

	Number of actual controllers	Mean1	Number of non-actual controllers	Mean2	Mean-Diff
Size	12,861	22.120	514	22.380	−0.257***
Lev	12,861	0.433	514	0.427	0.007
ROA	12,861	0.044	514	0.042	0.002
Growth	12,861	0.192	514	0.165	0.027
CF	12,861	0.050	514	0.047	0.003
Age	12,861	2.700	514	2.830	−0.130***
TobinQ	12,861	1.926	514	2.167	−0.241***
Inst	12,861	0.358	514	0.337	0.021*
Top	12,861	0.362	514	0.227	0.135***
Balance	12,861	0.648	514	1.249	−0.601***

Panel B Median difference test

	Number of actual controllers	Median1	Number of non-actual controllers	Median2	Median-Diff
Size	12,861	21.934	514	22.070	2.344
Lev	12,861	0.434	514	0.441	0.204
ROA	12,861	0.040	514	0.041	0.033
Growth	12,861	0.129	514	0.111	1.364
CF	12,861	0.048	514	0.047	0.032
Age	12,861	2.773	514	2.890	49.642***
TobinQ	12,861	1.535	514	1.660	6.815***
Inst	12,861	0.353	514	0.322	2.617
Top	12,861	0.344	514	0.184	253.384***
Balance	12,861	0.481	514	1.178	212.446***

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

icant differences in *Size*, *Age*, *TobinQ*, *Inst*, *Top* and *Balance* between the two types of enterprises. According to the results of the median difference test shown in Panel B in Table 2, there are significant differences in *Age*, *TobinQ*, *Top* and *Balance* between the two types of enterprises. Therefore, it is necessary to control the above variables in the regression. Other key variables affecting corporate innovation should also be controlled.

4.3. Baseline regression results

Table 3 shows the regression results for non-actual controllers and corporate innovation. Column (1) shows the results of the regression containing only the independent variable (*Codum*). Column (2) shows the regression results for the control variables that do not contain the equity variables (*Top* and *Balance*) added to those shown in column (1). Column (3) shows the regression results for the equity variables (*Top* and *Balance*) added to those shown in column (2). As shown in column (1), the coefficient of *Codum* is negative and statistically significant. The coefficient of –0.135 indicates that with the mean of *Codum* as the starting point, when *Codum* increases by 1%, corporate innovation decreases by 3.55%. As shown in column (2), when the control variables except for *Top* and *Balance* are added, the coefficient of *Codum* is negative and statistically significant. The coefficient of –0.132 indicates that with the mean of *Codum* as the starting point, when *Codum* increases by 1%, corporate innovation decreases by 3.47%. As shown in column (3), with all of the control variables added, the coefficient of *Codum* is negative and statistically significant. The coefficient of –0.133 indicates that with the mean of *Codum* as the starting point, when *Codum* increases by 1%, corporate innovation decreases by 3.5%. At the same time, when the equity variables are included, the coefficient of *Codum* changes little, which indicates that the concepts of actual controllers and controlling shareholders are not equivalent. In summary, non-actual controllers significantly inhibit corporate innovation, which supports H1.

Table 3
Baseline regression results for non-actual controllers and corporate innovation.

	(1)	(2)	(3)
Codum	−0.135**	−0.132**	−0.133**
	(−2.30)	(−2.24)	(−2.26)
Size		−0.028	−0.032*
		(−1.53)	(−1.75)
Lev		−0.147*	−0.137*
		(−1.85)	(−1.72)
ROA		0.063	0.054
		(0.35)	(0.30)
Growth		0.019	0.016
		(0.92)	(0.78)
CF		0.016	0.016
		(0.11)	(0.12)
Age		0.058	0.090*
		(1.36)	(1.93)
TobinQ		−0.016*	−0.014*
		(−1.86)	(−1.67)
Inst		−0.001	−0.013
		(−0.02)	(−0.25)
Top			0.241*
			(1.68)
Balance			0.032
			(1.02)
Firm	Y	Y	Y
Year	Y	Y	Y
Cons	0.585***	1.132***	1.036***
	(11.73)	(3.50)	(3.15)
N	13,375	13,375	13,375
R2	0.341	0.341	0.341

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

4.4. Endogeneity tests

Although this study controls for variables that affect corporate innovation, there may be some missing variables. Because the instrumental variable method can effectively correct the endogeneity caused by missing variables, we conduct a two-stage regression using the instrumental variable method to alleviate possible endogeneity. We use the annual divorce rate (*Divorce*) in the province where the enterprise is located as an instrumental variable. A higher annual divorce rate in the province where the enterprise is located indicates that family relationships in this area are less harmonious. The family is the basic unit of society (Poza and Messer, 2010; Ning et al., 2020), and turbulent family relationships also indicate disharmony in broader interpersonal relationships. Disharmonious interpersonal relationships may lead to control rights disputes, of which non-actual controllers are an important manifestation (Zheng et al., 2019). Thus, the regional divorce rate may be related to the number of enterprises adopting the control rights allocation mode of non-actual controllers. However, there is no correlation between marital status at the regional level and the financial decisions of listed companies (Jiang et al., 2017). Thus, the instrumental variable meets the requirements of correlation and exogeneity. The results are shown in columns (1) and (2) of Table 4. As shown in column (1), we find that the coefficient of *Divorce* is positive and statistically significant, indicating that there is no problem of a weak instrumental variable. It also indicates that there are more enterprises with non-actual controllers in regions with high divorce rates, indicating that disharmonious interpersonal relationships enhance management's motivation to adopt the control rights allocation mode of non-actual controllers. As shown in column (2), when we control for endogeneity, the coefficient of *Codum* is negative and statistically significant, indicating that the baseline conclusion is robust.

We conduct further analysis using the propensity score matching method. We use the sample of enterprises with non-actual controllers as the experimental group and the sample of enterprises with actual controllers as the control group. To eliminate any potential selection error, we first match the control group and the experimental group based on the sum of the squares of the shareholding proportions of the top 10 largest shareholders. The matching variables include the control variables in model (1), board size (*Board*) and CEO duality (*Dual*). We calculate the corresponding propensity score and adopt one-to-one matching to alleviate the selection error of the samples. The results are shown in columns (3) to (7) of Table 4. As shown in column (5) of Table 4, there is no significant difference between the experimental group and the control group. As shown in column (7), the coefficient of *Codum* is negative and statistically significant, indicating that the baseline conclusion is still robust.

4.5. Other robustness tests

In the baseline regression, the number of invention patent applications is used to measure corporate innovation. Based on Zhu et al. (2018) and Quan et al. (2019), we use the sum of the numbers of applications for invention patents, practical new-type patents and design patents to measure corporate innovation. As shown in column (1) of Table 5, the coefficient of *Codum* is negative and statistically significant, which indicates that the baseline conclusion remains robust after we replace the measurement method for the dependent variable.

We convert the unbalanced panel data into balanced panel data and conduct the regression test again. The result is shown in column (2) of Table 5. The coefficient of *Codum* is negative and statistically significant, which is consistent with the baseline regression result. This indicates that the baseline conclusion remains valid after we convert the unbalanced panel data into balanced panel data.

The Driscoll–Kraay (D–K) standard deviation is an unbiased, consistent and effective way to estimate standard errors, so we use the D–K standard error method to conduct the regression. The result is shown in column (3) of Table 5. The coefficient of *Codum* is negative and statistically significant, consistent with the baseline regression result, providing further support that the baseline conclusion is robust.

We run another test in which we shorten the observation period. Because the new accounting standards have been in effect in China since 2007, we take 2007 as the starting year for the regression. As shown in column (4) of Table 5, the coefficient of *Codum* is negative and statistically significant, indicating that the baseline conclusion is still valid when we shorten the observation period.

Table 4
Endogeneity test results.

	(1)	(2)		Match	Mean		t-test		(7)
					(3) Experimental	(4) Control	(5) t-value	(6) p-value	
Codum		–1.272***	*Codum*						–0.403*
		(–23.25)							(–1.78)
Divorce	0.410***		*Size*	Before	22.395	22.145	4.24***	0.000	0.076
	(3.62)			After	22.400	22.368	0.35	0.723	(0.52)
Size	0.351***	0.408***	*Lev*	Before	0.423	0.430	–0.79	0.428	–1.075*
	(6.80)	(13.51)		After	0.424	0.421	0.26	0.792	(–1.96)
Lev	–0.492	–0.752***	*ROA*	Before	0.042	0.044	–0.71	0.475	0.449
	(–1.64)	(–7.96)		After	0.043	0.043	–0.09	0.927	(0.55)
ROA	–0.084	–0.151	*Growth*	Before	0.163	0.189	–1.43	0.154	0.473***
	(–0.09)	(–0.68)		After	0.163	0.179	–0.70	0.486	(3.48)
Growth	–0.215	–0.252***	*CF*	Before	0.047	0.050	–1.06	0.290	–2.080***
	(–1.46)	(–8.96)		After	0.047	0.051	–0.94	0.347	(–2.80)
CF	–1.041	–1.336***	*Age*	Before	2.855	2.721	7.27***	0.000	0.174
	(–1.26)	(–7.65)		After	2.854	2.823	1.31	0.191	(0.50)
Age	0.227	0.370***	*TobinQ*	Before	2.201	1.958	4.25***	0.000	–0.129***
	(1.50)	(6.63)		After	2.154	2.259	–0.97	0.331	(–2.83)
TobinQ	0.164***	0.186***	*Inst*	Before	0.345	0.369	–2.15**	0.031	–0.142
	(5.71)	(14.31)		After	0.346	0.349	–0.28	0.783	(–0.41)
Inst	–0.137	–0.200***	*Top*	Before	0.218	0.359	–20.74***	0.000	0.397
	(–0.51)	(–3.24)		After	0.218	0.221	–0.35	0.730	(0.38)
Top	–5.675***	–6.814***	*Balance*	Before	1.273	0.655	23.05***	0.000	0.054
	(–6.69)	(–19.24)		After	1.265	1.321	–1.16	0.246	(0.49)
Balance	0.594***	0.804***	*Board*	Before	2.140	2.156	–1.75*	0.081	
	(6.25)	(16.18)		After	2.141	2.131	0.74	0.462	
Firm	Y	Y	*Dual*	Before	0.243	0.240	0.14	0.885	
Year	Y	Y		After	0.242	0.259	–0.59	0.556	
Cons	–10.698***	–10.898***	*Firm/Year*						*Y*
	(–9.51)	(–14.98)	*Cons*						–1.103
N	13375	13375							(–0.43)
Pseudo R2/R2	0.146	0.067	*N*						937
			R2						0.458

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

5. Mechanism test and extended analysis

5.1. Mechanism test

We further test whether non-actual controllers can influence corporate innovation through the paths of innovation willingness (agency cost and risk-taking) and innovation ability (financing constraint).

Because enterprises with non-actual (vs. actual) controllers are more likely to face agency conflicts between shareholders and management, we use the principal-agent conflicts to measure the agency conflicts faced by enterprises with non-actual controllers. Most previous studies use the management fee rate to measure the principal-agent conflicts, but the management fee covers too much content, which may cause it to contain noise (Chen, 2019). In contrast, perquisites can better reflect management's self-interested behavior (Chen et al., 2010). Therefore, we refer to Chen et al. (2010) and use the ratio of perquisites to total assets to measure the agency cost.

The literature uses two main measures of corporate risk-taking: profit volatility (Boubakri et al., 2013; He et al., 2019; Zhou et al., 2019) and stock return volatility (Zhang et al., 2015). Because of the volatility of China's stock market, profit volatility is widely used to measure the risk-taking of Chinese enterprises (He et al., 2019). Therefore, we use profit volatility to measure risk-taking.

Specifically, we measure the volatility of return on total assets (*ROA*) during the observation period. The greater the volatility of *ROA*, the greater the risk-taking. The models are as follows:

$$Adj\_ROA_{it} = \frac{EBIT_{it}}{ASSET_{it}} - \frac{1}{X}\sum\nolimits_{k=1}^{X}\frac{EBIT_{it}}{ASSET_{it}} \tag{2}$$

$$RiskT = \sqrt{\frac{1}{T-1}\sum_{t=1}^{T}\left(Adj\_ROA_{it} - \frac{1}{T}\sum_{t=1}^{T}Adj\_ROA_{it}\right)^{2}} \mid T = 5 \tag{3}$$

where *Adj_ROA* is *ROA* after the mean of industry and annual adjustment, *EBIT* is earnings before interest and tax, *Asset* is the mean value of total assets, *i* and *t* respectively indicate the company and the year and $T = 5$ represents the rolling 5 periods used to calculate corporate risk-taking.

According to Almeida et al. (2004), if a company is not constrained in obtaining external capital, it does not need to set aside cash reserves for its future investment needs. Conversely, if the company expects to face financing constraints in the future, it must increase its precautionary cash reserve. Therefore, we refer to previous studies (Almeida et al., 2004; Ning et al., 2022) and use the cash-cash flow sensitivity model to explore the impact of non-actual controllers on the financing constraints. The model is as follows:

$$\Delta Cash_{it} = \beta_0 + \beta_1 Codum_{i,t-1} + \beta_2 CF_{it} + \beta_3 Codum_{i,t-1} \times CF_{it} + \sum \beta_i Control_{i,t} + Firm + Year + \varepsilon \tag{4}$$

Table 5
Other robustness test results.

	(1)	(2)	(3)	(4)
Codum	−0.123**	−0.197**	−0.133**	−0.108***
	(−2.15)	(−2.49)	(−2.28)	(−2.60)
Size	−0.034*	0.005	−0.032**	−0.007
	(−1.92)	(0.19)	(−2.30)	(−0.39)
Lev	−0.068	−0.206*	−0.137	−0.194**
	(−0.88)	(−1.85)	(−1.60)	(−2.16)
ROA	0.131	−0.373	0.054	−0.142
	(0.74)	(−1.34)	(0.36)	(−1.47)
Growth	0.007	0.034	0.016	0.024
	(0.37)	(1.15)	(1.12)	(1.33)
CF	0.046	0.166	0.016	−0.213
	(0.34)	(0.83)	(0.11)	(−1.45)
Age	0.087*	0.014	0.090***	0.056
	(1.93)	(0.21)	(2.61)	(1.47)
TobinQ	−0.015*	0.002	−0.014***	−0.006
	(−1.78)	(0.18)	(−4.58)	(−0.88)
Inst	0.024	0.036	−0.013	−0.027
	(0.49)	(0.46)	(−0.35)	(−0.46)
Top	0.150	0.208	0.241**	0.098
	(1.08)	(1.12)	(2.10)	(0.54)
Balance	0.002	0.012	0.032	−0.034
	(0.08)	(0.29)	(0.99)	(−0.85)
Firm	Y	Y	Y	Y
Year	Y	Y	Y	Y
Cons	2.049***	0.579	1.036***	1.315***
	(6.45)	(1.31)	(3.41)	(3.43)
N	13,375	6223	13,375	6975
R2	0.342	0.395	0.341	0.299

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

In model (4), $\Delta Cash$ represents the change in the cash holdings of the company, which is equal to the annual change in the ratio of cash and cash equivalents to total assets. *Control* is consistent with the control variables in model (1). *Codum* × *CF* is the core variable in model (4): when the coefficient (β_3) of *Codum* × *CF* is positive and statistically significant, the enterprise faces severe financing constraints.

We refer to the research method of Hirshleifer et al. (2012) and Chen et al. (2014) to test the impact of non-actual controllers on agency costs, risk-taking and financing constraints. If non-actual controllers can significantly increase agency costs, reduce risk-taking and strengthen financing constraints, then the mechanism test is supported. The regression results of the mechanism tests are shown in Table 6. As shown in column (1), the coefficient of *Codum* is positive and statistically significant, indicating that non-actual controllers exacerbate agency conflict, which also supports the establishment of the agency cost path. As shown in column (2), the coefficient of *Codum* is negative and statistically significant, indicating that non-actual controllers reduce corporate risk-taking; thus, the risk-taking path is established. As shown in column (3), the coefficient of *Codum* × *CF* is positive and statistically significant, indicating that non-actual controllers strengthen financing constraints; thus, the financing constraint path is established. In summary, non-actual controllers can inhibit corporate innovation by increasing agency conflict, weakening risk-taking and strengthening financing constraints.

5.2. Situational factor analysis

The above analysis reveals that non-actual controllers are a key factor affecting corporate innovation. However, the relationship between non-actual controllers and corporate innovation may also be affected by

Table 6
Mechanism test results.

	(1)	(2)	(3)
Codum	0.002*	−0.004**	0.012
	(1.66)	(−2.26)	(0.04)
Codum × *CF*			0.291***
			(2.63)
Size	−0.011***	−0.004***	0.013
	(−25.76)	(−6.61)	(1.28)
Lev	0.002	−0.007***	−0.487***
	(1.49)	(−2.74)	(−3.65)
ROA	−0.023***	−0.068***	0.406***
	(−13.67)	(−11.63)	(3.21)
Growth	0.003***	0.002***	−0.056
	(7.04)	(2.92)	(−5.63)
CF	0.023***	0.001	0.108*
	(9.10)	(0.31)	(1.93)
Age	0.012***	0.015***	−0.602***
	(4.86)	(3.41)	(−3.10)
TobinQ	0.002***	0.001***	−0.037***
	(13.11)	(3.89)	(−2.98)
Inst	−0.005***	−0.012***	0.103***
	(−4.61)	(−6.94)	(3.00)
Top	−0.000	0.015***	0.214***
	(−0.04)	(3.34)	(3.12)
Balance	−0.001*	0.003***	0.071***
	(−1.70)	(2.88)	(5.54)
Firm	Y	Y	Y
Year	Y	Y	Y
Cons	0.261***	0.081***	1.318***
	(26.71)	(5.21)	(2.66)
N	11,787	10,541	11,023
R2	0.156	0.067	0.107

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

internal and external situational factors. How to improve the corporate governance of enterprises with non-actual controllers and alleviate the negative effect of non-actual controllers on corporate innovation is an important issue. However, enterprises are embedded in the external environment, and their strategic decisions are bound to be affected by changes in that environment. Therefore, we select independent directors, managerial ownership and audit quality, which reflect the level of corporate governance, and environmental uncertainty, which reflects the external environment, as situational factors, and we test how these situational factors affect the relationship between non-actual controllers and corporate innovation.

5.2.1. Independent directors

Independent directors can play supervisory and advisory roles in the corporate decision-making process. A board of directors with greater independence is more likely to dismiss managers with poor performance, so managers' strategic decisions will be more in line with the goal of maximizing shareholder value (Hermalin and Weisbach, 2001). More independent directors pay more attention to their own market reputation (Laux, 2008), which reduces the likelihood of their colluding with management (Fama and Jensen, 1983). In addition, independent directors can not only issue negative opinions on the resolutions of the board of directors but also safeguard their own interests while ensuring that rational strategic decisions are made (Zhu et al., 2018; Jiang et al., 2018b). They can also provide relevant advice on and suggestions for companies' strategic decision-making by virtue of their rich experience (Adams and Ferreira, 2007; Brickley and Zimmerman, 2010), thereby decreasing strategic conservatism, reducing agency conflicts, promoting risk-taking and weakening the inhibitory effect of non-actual controllers on corporate innovation. In addition, an increase in the proportion of independent directors can signal to the capital market that a listed company's corporate governance mechanism is improving and thereby enhance the credibility of its information disclosure (Zheng, 2016), thus alleviating the financing constraints caused by non-actual controllers and further improving corporate innovation. Therefore, we believe that an increase in the proportion of independent directors weakens the negative impact of non-actual controllers on corporate innovation.

Column (1) of Table 7 reports the effect of independent directors on the relationship between non-actual controllers and corporate innovation. There are a large number of listed companies in China's capital market, and the proportion of independent directors on the board of directors is required to be 1/3 (Zhu et al., 2018). We therefore refer to Zhu et al. (2018) and assign *Indep* a value of 1 when the proportion of independent directors is larger than 1/3, and 0 otherwise. From column (1), the coefficient of $Codum \times Indep$ is positive and statistically significant, indicating that independent directors can weaken the negative effect of non-actual controllers on corporate innovation.

5.2.2. Managerial ownership

As an important corporate governance mechanism, managerial ownership has a significant effect on corporate strategy (Shen et al., 2012b). According to the literature, this effect takes two main forms: the alignment effect and the entrenchment effect (Jensen and Meckling, 1976; Fama and Jensen, 1983). In the Chinese context, managerial ownership is more likely to reflect the alignment effect than the entrenchment effect (Jiang et al., 2016). Managerial ownership can align the interests of management and shareholders (Chen et al., 2018b), alleviate agency conflicts caused by insider control in enterprises with non-actual controllers, and motivate management to actively carry out innovation activities. Moreover, managerial ownership enables management to share the risks with the enterprise, encourages management to make decisions that will increase shareholders' wealth (Shen et al., 2012b) and increases risk-taking by enterprises with non-actual controllers, which promote the development of innovation activities. Furthermore, the alignment effect of managerial ownership can improve corporate performance, making external capital suppliers more willing to provide capital for such enterprises (Fan and Zhou, 2020) and thus easing the financing constraints of enterprises with non-actual controllers and promoting corporate innovation. Therefore, we expect managerial ownership to weaken the negative impact of non-actual controllers on corporate innovation.

Column (2) of Table 7 reports the results regarding the impact of managerial ownership on the relationship between non-actual controllers and corporate innovation. For our measure of managerial ownership, we refer to Shen et al. (2012b): when the level of managerial ownership is higher than the median, *Mshare* takes a value of 1, indicating that managerial ownership is high, and when managerial ownership is below the median,

Mshare takes a value of 0, indicating that managerial ownership is low. From column (2), the coefficient of *Codum* × *Mshare* is positive and statistically significant, indicating that an increase in managerial ownership can weaken non-actual controllers' negative impact on corporate innovation.

5.2.3. Audit quality

External audits, an important part of external governance, are usually considered an effective mechanism for alleviating companies' agency conflict (Jensen and Meckling, 1976; Ma et al., 2018). A high-quality external audit can effectively identify the entrenchment effect (Fan and Wong, 2005), alleviate the agency conflict caused by non-actual controllers and enhance corporate innovation. A high-quality external audit can also increase the trustworthiness of relevant information, including financial information, which can improve the quality of accounting information and reduce information risks (Wang and Zhang, 2014), thus enhancing management's willingness to take risks and helping enterprises to carry out innovative activities. In addition, large accounting firms with high audit quality can give audit opinions with high information content (Weber and Willenborg, 2003; Li et al., 2018), alleviating the financing constraints caused by information asymmetry. Moreover, high-quality audits can help enterprises with non-actual controllers to improve their internal governance mechanisms and transmit signals of improved enterprise development to the capital market, thus attracting more external investors, alleviating the enterprises' financing constraints and providing sufficient resource support for corporate innovation. Therefore, we expect high-quality external audits to weaken the negative effect of non-actual controllers on corporate innovation.

Column (3) of Table 7 reports the effect of audit quality on the relationship between non-actual controllers and corporate innovation. We refer to Wang and Zhang (2014) to measure audit quality. Specifically, according to *Information of the Top 100 Accounting Firms with Comprehensive Evaluation* published by the Chinese Institute of Certified Public Accountants, if the income of an accounting firm ranks among the top 10 in the current year, *Audit* takes a value of 1, and 0 otherwise. As shown in column (3), the coefficient of *Codum* × *Audit* is positive and statistically significant, indicating that high audit quality can weaken the negative effect of non-actual controllers on corporate innovation.

5.2.4. Environmental uncertainty

In recent years, against the background of dramatic economic growth and macroeconomic policy adjustments, China's external development environment has become increasingly dynamic and complex. Environmental uncertainty has become an important external factor affecting enterprises' strategic decision-making (Yuan et al., 2015). Environmental uncertainty may lead management to be more cautious in making investments (Bloom et al., 2007; Dong et al., 2017). Especially in situations with non-actual controllers, management's decisions may be more conservative, thus reducing corporate risk-taking, which is not conducive to innovation activities. Environmental uncertainty also increases the difficulty faced by shareholders in supervising management and increases the likelihood that management will use funds to pursue its own interests (Shen et al., 2012a; Yang and Li, 2018). In contrast, a lower degree of environmental uncertainty can increase management's willingness to take risks and facilitate shareholders' supervision of management. In addition, environmental uncertainty can affect the volatility and sustainability of corporate earnings and increase financing costs (Lin et al., 2015), thus strengthening the financing constraints faced by enterprises with non-actual controllers and leading to greater difficulty in carrying out innovation activities. If environmental uncertainty is reduced, enterprises with non-actual controllers can transmit information to the external market more accurately and alleviate financing constraints, thus improving corporate innovation. Therefore, we expect a reduction in environmental uncertainty to weaken the negative impact of non-actual controllers on corporate innovation.

Column (4) of Table 7 reports the impact of environmental uncertainty on the relationship between non-actual controllers and corporate innovation. We refer to Shen et al. (2012a) and Dong et al. (2017) to measure environmental uncertainty. Specifically, we take the sales revenue of the company from year t–4 to year t as the dependent variables, and we take 5, 4, 3, 2 and 1 as the respective independent variables for regression. We then measure the standard error of the regression coefficient of the model divided by the average value of the sales revenue of the company in these 5 years. Because we focus on the impact of low environmental uncertainty, we multiply the calculated environmental uncertainty by –1 to obtain *Anti-EU*, for which a higher value

indicates lower environmental uncertainty. As shown in column (4), the coefficient of *Codum* × *Anti-EU* is positive and statistically significant, indicating that reducing environmental uncertainty can weaken the negative impact of non-actual controllers on corporate innovation.

5.3. The effect of multiple large shareholders

Enterprises with non-actual controllers are likely to gradually develop a structure in which multiple large shareholders coexist. Because the presence of a non-actual controller usually means that shareholders have

Table 7
Situational factor analysis results.

	(1)	(2)	(3)	(4)
Codum	−0.129**	−0.137**	−0.118**	−0.170**
	(−2.18)	(−2.32)	(−1.98)	(−2.54)
Indep	0.109			
	(1.62)			
Codum × *Indep*	0.796***			
	(2.59)			
Mshare		−0.016		
		(−0.53)		
Codum × *Mshare*		0.233**		
		(2.11)		
Audit			0.037	
			(1.55)	
Condum × *Audit*			0.204**	
			(2.18)	
Anti-EU				−0.855***
				(−3.41)
Codum × *Anti-EU*				2.467*
				(1.89)
Size	−0.032*	−0.032*	−0.032*	−0.017
	(−1.73)	(−1.73)	(−1.75)	(−0.84)
Lev	−0.139*	−0.135*	−0.136*	−0.161*
	(−1.74)	(−1.69)	(−1.71)	(−1.79)
ROA	0.061	0.056	0.056	−0.219
	(0.34)	(0.31)	(0.31)	(−1.02)
Growth	0.015	0.016	0.017	0.022
	(0.73)	(0.77)	(0.81)	(0.94)
CF	0.021	0.017	0.015	−0.018
	(0.15)	(0.12)	(0.11)	(−0.11)
Age	0.088*	0.090*	0.090*	0.074
	(1.90)	(1.93)	(1.95)	(1.41)
TobinQ	−0.014*	−0.014	−0.014*	−0.012
	(−1.69)	(−1.64)	(−1.66)	(−1.18)
Inst	−0.012	−0.016	−0.013	−0.005
	(−0.23)	(−0.31)	(−0.26)	(−0.09)
Top	0.241*	0.246*	0.242*	0.195
	(1.68)	(1.71)	(1.68)	(1.24)
Balance	0.030	0.033	0.032	0.011
	(0.96)	(1.05)	(1.01)	(0.30)
Firm	Y	Y	Y	Y
Year	Y	Y	Y	Y
Cons	0.948***	1.035***	1.025***	1.014***
	(2.84)	(3.15)	(3.12)	(2.77)
N	13,375	13,375	13,375	9502
R2	0.342	0.342	0.342	0.323

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

lost actual control of the enterprise, which leads to management insider control, multiple large shareholders play a more important role in the enterprise's decision-making process. Multiple large shareholders may collude, strengthening the inhibitory effect of non-actual controllers on corporate innovation. Multiple large shareholders may not only entrench the interests of other shareholders (Zwiebel, 1995) but also use their private information advantages to pursue profits (Laeven and Levine, 2008; Cai et al., 2015), and in situations with non-actual controllers, they may also conspire with management to satisfy the private interests of both parties, which is not conducive to corporate innovation. Multiple large shareholders may also have an over-supervision effect, thus strengthening the inhibitory effect of non-actual controllers on corporate innovation. Multiple large shareholders can reduce entrenchment by supervising managers (Jiang et al., 2018b; Luo and Huang, 2020). However, when the enterprise has no actual controller, multiple large shareholders pay more attention to supervising management. Compared with other strategic decisions, when enterprises make decisions on innovation, supervisors give the decision-makers greater power, which enhances their participation and enthusiasm (Aghion and Tirole, 1997). However, under the pressure of strict audits and supervision, management's behavior may be more rigid, its work initiative may be reduced and its behaviors may be more conservative, resulting in an over-supervision effect (Edmans, 2014; Zhu et al., 2018). Based on the above analysis, we conclude that multiple large shareholders can strengthen the negative influence of non-actual controllers on corporate innovation, but whether this influence is due to the collusion effect or the over-supervision effect of multiple large shareholders requires further examination.

We refer to Zhu et al. (2018) and Luo and Huang (2020) and define shareholders holding more than 10% of the shares after the signing of acting-in-concert agreements as large shareholders. When the company has two or more large shareholders holding more than 10% of the shares, *Mul* is assigned a value of 1, and 0 otherwise. Column (1) in Table 8 shows the regression results for how multiple large shareholders affect the relationship between non-actual controllers and corporate innovation. From column (1), it can be seen that the coefficient of *Codum* × *Mul* is negative and statistically significant, indicating that multiple large shareholders strengthen the negative effect of non-actual controllers on corporate innovation.

To further verify whether the strengthening effect of multiple large shareholders on the negative relationship between non-actual controllers and corporate innovation originates from the collusion effect or the over-supervision effect, we conduct the following tests. First, we test the collusion effect of multiple large shareholders by groups. We measure the collusion effect using tunneling (other receivables/total assets, *Tunnel*) (Jiang et al., 2010) and divide it at the median into low-collusion and high-collusion groups. If multiple large shareholders show the collusion effect, the strengthening effect of multiple large shareholders on the negative relationship between non-actual controllers and corporate innovation should be easier to observe in the low-collusion-effect sample group than in the high-collusion-effect sample group. The regression results are shown in columns (2) and (3) of Table 8. As shown in column (2), in the low-collusion group, multiple large shareholders do not have a significant effect on the relationship between non-actual controllers and corporate innovation. As shown in column (3), in the high-collusion group, the coefficient of *Codum* × *Mul* is negative and statistically significant, which is not consistent with the expectation. Thus, the collusion effect of multiple large shareholders is not supported. Second, if multiple large shareholders have an over-supervision effect, then when other large shareholders have greater supervisory power, they will be more capable of exerting pressure on management, increasing the likelihood of over-supervision (Zhu et al., 2018). Referring to Attig et al. (2008) and Ben-Nasr et al. (2015), we measure supervision power as the ratio of the sum of the shareholding ratios of other large shareholders to the shareholding ratio of the first major shareholder (*MulBalance*). The higher *MulBalance* is, the greater the likelihood of the over-supervision effect is. As shown in column (4), the coefficient of *Codum* × *MulBalance* is negative and statistically significant, indicating that the over-supervision effect of multiple large shareholders occurs. In summary, multiple large shareholders strengthen the inhibitory effect of non-actual controllers on corporate innovation, but this effect comes from over-supervision rather than collusion.

5.4. Further distinguishing the types of non-actual controllers

Some enterprises state in their annual reports that they do not have an actual controller but in fact hide their ownership structure, seeking to create the illusion of having no actual controller to satisfy the private

interests of large shareholders or management. For example, Lu Keping was the actual controller of Sihuan Bioengineering (SZ 000518) as early as 2014. However, Sihuan Bioengineering disclosed having a non-actual controller in its annual reports from 2014 to 2018 and concealed transactions between itself and other enterprises under Lu Keping's control. It is thus clear that further distinguishing the types of non-actual controllers can provide a better understanding of the intrinsic motivations of corporate behavior.

For enterprises with real non-actual controllers, internal and external corporate governance mechanisms can be used to restrict management's behavior and weaken insider control, thus alleviating the inhibitory effect of real non-actual controllers on corporate innovation. In contrast, for enterprises that hide their ownership through shareholdings, their insider control may be more severe, as they may create the illusion of having no actual controller to avoid their legal obligations and the supervision of external regulatory authorities, prompting management and large shareholders to entrench the interests of minority shareholders and to use more funds to satisfy their own interests rather than investing in corporate innovation.

Table 8
Results for multiple large shareholders.

	Multiple large shareholders	Collusion effect		Over-supervision effect
	(1)	(2) Low	(3) High	(4)
Codum	−0.116*	−0.018	−0.180**	−0.117*
	(−1.95)	(−0.20)	(−2.18)	(−1.96)
Mul	0.022	0.060	0.009	
	(0.83)	(1.46)	(0.23)	
Codum × Mul	−0.262***	−0.093	−0.299**	
	(−2.76)	(−0.60)	(−2.33)	
MulBalance				0.015
				(0.47)
Codum × MulBalance				−0.170*
				(−1.80)
Size	−0.031*	−0.010	−0.015	−0.032*
	(−1.68)	(−0.35)	(−0.59)	(−1.72)
Lev	−0.139*	−0.144	−0.227**	−0.138*
	(−1.75)	(−1.24)	(−1.97)	(−1.74)
ROA	0.040	−0.163	−0.080	0.048
	(0.22)	(−0.61)	(−0.30)	(0.27)
Growth	0.016	−0.008	0.029	0.016
	(0.76)	(−0.26)	(0.98)	(0.77)
CF	0.017	−0.172	0.105	0.017
	(0.12)	(−0.82)	(0.53)	(0.12)
Age	0.086*	−0.023	0.140**	0.088*
	(1.85)	(−0.34)	(2.09)	(1.89)
TobinQ	−0.014*	−0.014	−0.003	−0.014*
	(−1.66)	(−1.05)	(−0.26)	(−1.65)
Inst	−0.011	−0.016	−0.057	−0.012
	(−0.22)	(−0.23)	(−0.75)	(−0.23)
Top	0.237*	0.147	0.334	0.239*
	(1.65)	(0.69)	(1.63)	(1.66)
Balance	0.030	0.022	−0.004	0.030
	(0.96)	(0.48)	(−0.10)	(0.97)
Firm	Y	Y	Y	Y
Year	Y	Y	Y	Y
Cons	1.006***	0.302	0.734	1.024***
	(3.06)	(0.59)	(1.61)	(3.12)
N	13,375	6,582	6,793	13,375
R2	0.342	0.314	0.348	0.342

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

Therefore, we use ownership information based on the definition of the actual controller in the annual report of the enterprise to identify types of non-actual controllers, which we divide into real non-actual controllers and hidden non-actual controllers. When an enterprise does not have an actual controller, it is classified as having a real non-actual controller. When an enterprise uses ownership information to hide ownership, it is considered to have a hidden non-actual controller. Further, we evaluate whether the effects on corporate innovation differ between real and hidden non-actual controllers.

Table 9 shows the regression results for the two types of non-actual controllers. In column (1), we classify hidden non-actual controllers as actual controllers and test the effects of real non-actual controllers on corporate innovation. Real non-actual controllers are assigned a value of 1 and actual controllers are assigned a value of 0. As shown in column (1), the coefficient of *Codum* is not significant, indicating that when hidden non-actual controllers are included as actual controllers, real non-actual controllers do not have a significant effect on corporate innovation. Column (2) shows the results of the test of the effects of real non-actual controllers on corporate innovation with hidden non-actual controllers excluded. Real non-actual controllers are assigned a value of 1 and actual controllers are assigned a value of 0. As column (2) shows, the coefficient of *Codum* is negative and statistically significant, indicating that when hidden non-actual controllers are excluded, real non-actual controllers have a significant inhibitory effect on corporate innovation.

In summary, when we distinguish the types of non-actual controllers, we find that real non-actual controllers have an inhibitory effect on corporate innovation. However, hidden non-actual controllers make it difficult to accurately judge the impact of non-actual controllers on corporate innovation. This finding indicates that not only is it necessary to design a corporate governance mechanism to counter the negative impact of non-actual controllers on corporate innovation, but regulatory authorities must also further strengthen the

Table 9
Results for the different types of non-actual controllers.

	(1)	(2)
Codum	−0.078	−0.220**
	(−0.61)	(−2.01)
Size	−0.034*	0.448***
	(−1.85)	(20.54)
Lev	−0.123	0.167**
	(−1.53)	(1.98)
ROA	0.087	0.565***
	(0.47)	(2.67)
Growth	0.016	−0.049**
	(0.77)	(−2.56)
CF	−0.023	0.097
	(−0.17)	(0.73)
Age	0.079*	0.093
	(1.76)	(1.12)
TobinQ	−0.014	−0.006
	(−1.61)	(−0.66)
Inst	−0.004	0.058
	(−0.09)	(1.17)
Top	0.168	−0.315**
	(1.44)	(−2.03)
Balance	0.071***	0.027
	(2.59)	(0.79)
Firm	Y	Y
Year	Y	Y
Cons	1.087***	−8.829***
	(3.26)	(−19.73)
N	13,375	13,261
R2	0.345	0.329

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

identification and supervision of enterprises with hidden non-actual controllers to reduce corporate governance risks and promote the sustainable and healthy development of China's capital market.

5.5. Excluding the competitive explanation of equity dispersion

In reality, the ownership of most enterprises with non-actual controllers is relatively dispersed. Therefore, the inhibitory effect of non-actual controllers on corporate innovation may be caused by equity dispersion. Previous studies focus on the effect of equity concentration, the opposite of equity dispersion, on corporate innovation (Francis and Smith, 1995; Zhu et al., 2018; Chemmanur et al., 2019; Chen et al., 2021). However, we believe that non-actual controllers cannot be completely equivalent to equity dispersion, as the inhibitory

Table 10
The results of excluding the competitive explanation.

	(1)	(2)	(3)
Codum	−0.132**		
	(−2.24)		
CodumCon		−0.250***	
		(−2.78)	
Non-CodumCon			0.026
			(0.78)
Size	−0.033*	−0.033*	−0.033*
	(−1.80)	(−1.78)	(−1.80)
Lev	−0.139*	−0.138*	−0.136*
	(−1.75)	(−1.74)	(−1.71)
ROA	0.059	0.056	0.065
	(0.33)	(0.31)	(0.36)
Growth	0.016	0.016	0.016
	(0.77)	(0.78)	(0.76)
CF	0.006	0.005	0.010
	(0.05)	(0.04)	(0.07)
Age	0.090*	0.084*	0.085*
	(1.93)	(1.82)	(1.82)
TobinQ	−0.014	−0.014*	−0.015*
	(−1.64)	(−1.69)	(−1.71)
Inst	−0.012	−0.009	−0.008
	(−0.24)	(−0.18)	(−0.15)
Top	0.232	0.230	0.229
	(1.61)	(1.60)	(1.59)
Balance	0.034	0.034	0.031
	(1.08)	(1.07)	(0.98)
Concen3	−0.006	−0.006	−0.005
	(−0.95)	(−0.84)	(−0.74)
Concen5	0.012	0.012	0.012
	(1.46)	(1.43)	(1.41)
Concen10	−0.002	−0.002	−0.002
	(−0.43)	(−0.43)	(−0.45)
H-index	2.095**	2.206**	2.330**
	(1.97)	(2.08)	(2.12)
H3	−2.807**	−2.940**	−3.074**
	(−2.09)	(−2.19)	(−2.22)
Firm	Y	Y	Y
Year	Y	Y	Y
Cons	1.013***	1.006***	0.985***
	(2.99)	(2.97)	(2.88)
N	13,375	13,375	13,375
R2	0.342	0.343	0.342

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

effect of non-actual controllers on corporate innovation does not originate from the dispersed ownership structure. Some enterprises in China's capital market have non-actual controllers but concentrated equity, while others have actual controllers but dispersed equity, which indicates that the control rights allocation mode dominated by actual controllers differs from the ownership allocation mode dominated by ownership structure. Therefore, we conduct further tests to rule out the possible competitive explanation of equity dispersion.

Although the above control variables (*Top* and *Balance*) related to the equity concentration are included in the regression, they may not fully reflect the ownership structure. To further control for the impact of equity concentration, we add *Concen3* (the sum of the shareholding proportions of the top three major shareholders), *Concen5* (the sum of the shareholding proportions of the top five major shareholders), *Concen10* (the sum of the shareholding proportions of the top 10 major shareholders), *H-index* (the sum of the squares of the shareholding proportions of the first major shareholder) and *H3* (the sum of the shareholding proportions of the top three major shareholders) to model (1). The regression results are shown in column (1) of Table 10. As shown in column (1), when we control for the variables of equity concentration, the coefficient of *Codum* is negative and statistically significant. In addition, the coefficient of *Codum* changes little relative to the regression results for the variables of equity concentration that are not included in columns (1) and (2) of Table 3, which provides further evidence that actual controllers are not equal to controlling shareholders.

We also consider the influence of the relationship between non-actual controllers and equity concentration on corporate innovation to exclude the competitive explanation of equity dispersion. We define equity concentration as the proportion of controlling shareholders holding more than 30% of shares, which is the tender offer line of listed companies in China, the exceeding of which often indicates the emergence of new controlling shareholders. We examine how corporate innovation is affected for firms with non-actual controllers but relatively concentrated equity. When an enterprise has no actual controller but relatively concentrated equity, *CodumCon* takes a value of 1, and 0 otherwise. The regression result is shown in column (2) of Table 10. As shown, the coefficient of *CodumCon* is negative and statistically significant, indicating that there is no actual controller but that concentrated equity can still inhibit corporate innovation. We also examine how corporate innovation is affected for enterprises with an actual controller but dispersed equity. When an enterprise has an actual controller but its equity is dispersed, *Non-CodumCon* takes a value of 1, and 0 otherwise. The regression result is shown in column (3) of Table 10. The coefficient of *Non-CodumCon* is not significant, indicating that actual controllers in firms with dispersed equity do not have a significant effect on corporate innovation.

Thus, the inhibitory effect of non-actual controllers on corporate innovation does not originate from equity dispersion. Therefore, the competitive explanation for equity dispersion that non-actual controllers affect corporate innovation can be ruled out.

6. Conclusions

With China's capital market gradually entering the dispersed equity era, the number of enterprises with non-actual controllers is increasing. However, prior studies pay insufficient attention to this important issue. We combine the important economic phenomenon of non-actual controllers with China's innovation-driven development strategy and take Shanghai and Shenzhen A-share listed companies from 2003 to 2017 as the research object to explore the effect of non-actual controllers on corporate innovation. This study finds that non-actual controllers can significantly inhibit corporate innovation. Non-actual controllers reduce enterprises' innovation willingness by exacerbating their internal agency conflicts and reducing risk-taking. Non-actual controllers also reduce innovation ability by strengthening enterprises' financing constraints. With increases in the proportion of independent directors, managerial ownership and audit quality and a decrease in environmental uncertainty, the negative influence of non-actual controllers on corporate innovation gradually weakens. In addition, multiple large shareholders can strengthen the negative effect of non-actual controllers on corporate innovation, but this effect is mainly due to over-supervision, rather than to collusion. We further divide non-actual controllers into real and hidden types and find that real non-actual controllers have an inhibitory effect on corporate innovation. Finally, the competitive explanation of equity dispersion is

excluded, which indicates that the inhibition of corporate innovation by non-actual controllers does not originate from dispersed ownership structure.

This study has important research implications. First, although the number of enterprises with non-actual controllers in China's capital market is increasing and some excellent enterprises with non-actual controllers, such as Yunnan Baiyao Group and Gree Electric, have achieved good development, most enterprises' internal governance mechanisms are not perfect. The blind adoption of the control rights allocation mode of non-actual controllers not only is conducive to the implementation of long-term development strategies such as innovation strategies but can also lead to barbarian invasions and equity disputes, thus hindering enterprises' long-term development. Therefore, having a non-actual controller is not the optimal control rights allocation mode for most enterprises. Second, for enterprises in which non-actual controllers and multiple large shareholders coexist, it is necessary to design a reasonable corporate governance mechanism to ensure that multiple large shareholders truly exert a governance effect. Enterprises with non-actual controllers should not only increase the proportion of independent directors on the board of directors and hire stricter independent audit institutions to strengthen supervision, but also design a more scientific and reasonable management incentive system to align the interests of management and shareholders to play an active role in formulating and implementing corporate innovation strategy. In addition, government departments should maintain the continuity and consistency of various economic policies to reduce the uncertainty of the external environment and create a more stable external development environment for corporate innovation. Some enterprises use their ownership structure to hide their actual controller to avoid external supervision and evade their legal obligations. Therefore, China's regulators should further strengthen the identification and supervision of enterprises with hidden non-actual controllers to facilitate the sustainable and healthy development of China's capital market. Finally, enterprises should further distinguish between control rights allocation and ownership allocation to avoid situations in which having a non-actual controller is directly equivalent to equity dispersion, thus realizing the synchronous and reasonable allocation of control rights and ownership.

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Do companies compare employees' salaries? Evidence from stated-owned enterprise group

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ABSTRACT

The mechanism by which enterprises set salaries is vitally important to employees and is especially relevant to the reform of state-owned enterprises (SOEs). This paper investigates the effect of comparing employee compensation based on a sample of A-share SOE groups from 2008 to 2018. We find that when employee compensation at one company sharply increases, the employee compensation of other companies controlled by the same group will increase sharply in the following year. Further analysis shows that when employees' sense of unfair compensation is stronger, when employees are less replaceable and when enterprises' ability to pay is stronger, the effect of employee pay comparison is stronger. Increased employee salary does not improve enterprise performance, however, suggesting that such salary adjustment is ineffective. This paper expands the research on employee compensation and provides useful insights for optimizing the design of compensation contracts and promoting compensation reform in SOEs.

1. Introduction

Improving the employee incentive mechanism of state-owned enterprises (SOEs) and stimulating their vitality are important issues for SOE reform and catalysts for their high-quality development. Employees are the direct creators and influencers of enterprise value. Formulating a reasonable and effective compensation system to incentivize employees is necessary for successful SOE reform. In this context, obtaining a deeper understanding of the characteristics of SOE employee compensation is of both practical and theoretical importance. The literature mainly examines the absolute income level of SOE employees in terms of average salary and

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employee stock ownership (Lu et al., 2012, Shen et al., 2018, Cao et al., 2021) rather than relative income. Because of the deep influence of Confucianism, Chinese culture values collectivism and the fair distribution of income and wealth (Li et al., 2019), especially in SOEs (Li and Hu, 2012). In 2018, the State Council issued "The Opinions on Reforming the Wage Deciding Mechanism for State-owned Enterprises" which states "We should uphold the unity of efficiency orientation and maintain fairness, and achieve a simultaneous increase in labor remuneration." Therefore, when relative income falls, is there an incentive to increase employee pay and strengthen pay equity? If so, what is the specific intrinsic mechanism?

Most SOEs in China exist in the form of groups, which means that they are subsidiaries in a larger corporation, and they are central to the smooth operation of the national economy (Khanna and Palepu, 2000; Han et al., 2018; Jiang and Kim, 2020). In China's underdeveloped external labor market and financial market, the subsidiaries of an enterprise group have close business contacts and frequent information exchange; these include related party transactions, capital lending and risk guarantees, which can reduce transaction costs and ensure efficient group resource allocation (Hoshi et al., 1991; Stein, 1997; Li et al., 2007; Yang et al., 2010, Cai et al., 2015; Li, 2017). Such close business connections also mean that any change in corporate behavior will have a significant impact on other subsidiaries within the group, including their financial performance, financial investments and stock price (Huang et al., 2013; Li et al., 2019; Liu et al., 2019). Therefore, the group structure of SOEs provides a natural scenario for studying issues related to employee compensation.

In this paper, we argue that when employee compensation at one company in the SOE group increases sharply, employee compensation at other companies controlled by the same group will increase sharply in the next year. We term this phenomenon "employee salary comparison". First, unlike the indirect network formed by auditors, directors and venture capital, frequent and close business contacts between subsidiaries within a group constitute a close internal relationship network (Xu et al., 2018; Xia et al., 2019). Because subsidiaries are under the control of the same group, they can easily perceive the work and return of other employees, which provides a basis for salary comparison. Second, unlike companies who are not in the same group have diverse assessment standards and salary systems, a SOE group has similar performance assessment indicators (Li et al., 2019), and the internal and external business environments are also similar, which means that employees have a stronger basis for comparison. According to the fairness theory in psychology, when employees observe a significant increase in the salary level at a member enterprise, they will perceive their lower income and feel a sense of injustice, which will affect their labor efficiency. To alleviate employees' sense of unfairness, enterprises have an incentive to increase their salaries. Finally, compared with non-SOEs, SOEs are more attentive to employee salary satisfaction because they have soft budget constraints and sufficient funds to pay higher salaries (Lu et al., 2012).

Based on the above analysis, this paper takes A-share state-owned group-controlled listed companies from 2008 to 2018 as a research sample to empirically test the effect of employee salary comparison and the specific impact mechanism. The results show that when the employee salary level of a member enterprise in the group increases significantly, the salary level of employees at other member enterprises in the group increases significantly the following year, indicating that the enterprises compare employee salaries. Further analysis shows that when an employee's salary is lower than that of comparable employees of other enterprises in the same region or industry (not part of the group), and the stronger the collectivist culture is in the area, the stronger the employee's sense of unfairness and the greater the enterprise's motivation to improve employee compensation. When enterprise's labor intensity is lower and employees' educational background is higher, employees are more important and the enterprise is more willing to improve employee compensation. When the scale of the enterprise is larger and the cash holding level is higher, the ability to pay is stronger and the employee salary comparison effect is more pronounced. The economic consequence test shows that employee salary comparison does not improve the enterprise's future financial performance and stock returns, suggesting that it results in ineffective salary adjustment. The above conclusions remain robust across multiple robustness tests.

This paper makes three major contributions to the literature. First, it complements the literature on the factors affecting employee compensation. Unlike previous studies that examine such factors from an economic perspective (Wang and Huang, 2017; Shen et al., 2019), this paper enriches the literature on relative income changes and provides a unique explanation for the rapid rise of employee pay in emerging economies. Second, this paper enriches the research on the financial activities of enterprise groups. In contrast to the literature on

the mutual influence of the financial behavior of companies within a group (Huang et al., 2013; Li et al., 2019), this paper expands the research from the perspective of employees' individual pursuit of fairness, which makes it a useful reference for analyzing the operating characteristics of enterprise groups. Finally, this paper provides useful guidelines for improving the employee compensation system. It shows that the salary increases that occur in state-owned groups are not necessarily due to improved performance, but may be due to comparisons between enterprises, and this comparison behavior makes it difficult to motivate employees. Therefore, in salary contract design, enterprises should strengthen the relationship between employee salary and enterprise operation efficiency, avoid employee salary comparison, improve the incentive role of salaries and reconcile fairness and efficiency.

2. Literature review and research hypotheses

2.1. Literature review

2.1.1. Interaction between a company's financial activities

In recent years, the mutual influence of intercorporate financial behaviors and their internal mechanism have become important research questions. Most research is conducted from the economic perspective, focusing on joint companies in the industry or joint companies in the same network and the customer–supplier network, or adopting the information transmission perspective, such as to examine co-directors. Gleason et al. (2008) find that a listed company's financial restatement will reduce the stock prices of other companies in the same industry. Kedia et al. (2015) show that after a company's financial restatement, listed companies in the same or a neighboring industry will also be affected and show an increased possibility of earnings management, but when the company with financial restatement is investigated or sued by the SEC, this phenomenon disappears. Liu et al. (2016) find that when a company in a guarantee network performs poorly, the performance level of other companies in the same network declines in the following year. There is also a negative impact on the guarantee network: better performing companies will be less willing to join it and will leave before the guarantee network disappears. The worse the quality of the network, the higher the likelihood that enterprises will exit. Cai et al. (2017) focus on the venture capital network and point out that when a company has consistent venture capital associations with listed companies that pay excess compensation, the company is also more likely to pay excess compensation. Kolay et al. (2016) show that the financial behaviors of customers and suppliers can have a mutual influence, mainly because of the close exchange of information, the possibility of credit losses and the sunk costs of changing the transaction object. When a company files for bankruptcy, its supplier's gross margin will temporarily decrease and its expenses will increase. In terms of co-directors, Chiu et al. (2013) note that companies with joint directors in other companies with financial restatements are more likely to have financial restatements. Brown and Drake (2014) show that listed companies with joint directors with lower effective tax rates also have lower effective tax rates and engage in more tax avoidance activities.

Some scholars examine the mutual influence of financial decisions within enterprise groups. Huang et al. (2013) show that when the performance of a subsidiary of the group declines significantly, the performance of the other subsidiaries also suffers a substantial decline. In addition, when the enterprises are all in the same region and industry, the negative impact of this performance decline is more obvious. Other research shows that the specific impact path includes the decline in cash flow of other member enterprises and the reduced fixed capital expenditure caused by declining performance. Na et al. (2017) test risk transmission within the group. Li et al. (2019) take listed companies of state-owned groups as a sample based on the institutional background of the performance assessment of SOEs and empirically find that the financial investment behaviors of group enterprises influence each other, especially in listed companies with poor internal and external supervision. Zhang and Gao (2019) show that executive perquisites within the group have a mutual effect. Liu et al. (2019) find that when a company in the group receives administrative punishment, not only does its own stock prices fall, but so do those of other companies in the group.

2.1.2. Review of employee compensation literature

Compensation is an important way to motivate employees. The traditional literature focuses on the impact of absolute pay levels on employee behavior, especially on labor economics, studying the relationship between

pay levels and performance (Akerlof, 1982; Lazear, 2000). In recent years, with the public disclosure of employee compensation data, more scholars are paying attention to the factors that influence employee compensation and their economic consequences. Lu et al. (2012) show that compared with private enterprises, Chinese SOEs have higher salaries. Chen et al. (2015) point out that when the company's total profits rise, the salary levels of both executives and employees rise, but the wages of employees increase less. Shen et al. (2017) test the impact of the implementation of the Labor Contract Law on employee pay and find that it does not lead to an increase in employee pay but only improves the environment for the protection of employees' rights and interests. Wang and Huang (2017) show that foreign direct investment can significantly increase employees' income; however, vertical foreign direct investment has no significant effect on promoting employee income. Shen et al. (2019) show that air quality is significantly negatively correlated with employees' salary level and that this correlation is stronger when there is stronger awareness of employee rights and in non-labor-intensive enterprises. In terms of economic consequences, Chen et al. (2010) show that in the enterprises whose employees wage have rigidity, there is no significantly relationship between wage growth and the enterprises performance. Xia and Dong (2014) test the impact of employee salary on enterprises' capacity for growth and find that employee compensation only in the state small listed companies can improve firms' growth. Lu et al. (2017) take the implementation of minimum wage policies in different regions as a research scenario and find that after the minimum wage rises, labor costs rise and profits fall, so companies increase their degree of earnings management.

2.2. Theoretical analysis and hypothesis

In psychology, fairness theory posits that employees consider the ratio of their input to their return when judging whether they are satisfied with their salary, and they often compare themselves to others (the reference object) to judge whether they are being treated fairly. The income level of the reference target is the main factor affecting employees' behavior (Bloom and Michel, 2002; Trevor et al., 2012; Bu and Bai, 2013; Li et al., 2019). When determining the reference target, employees favor convenient information acquisition and similarity. If employees have easier access to information about certain people who are similar to themselves, then employees are more likely to compare with them (Kulik and Ambrose, 1992; O'Neill and Mone, 2005; Goodman, 2007). When employees believe their input–income ratio is lower than comparable people, they will have a sense of dissatisfaction and unfairness, which will have a negative impact on their work input and output (Downes and Choi, 2014; Kong et al., 2017). For example, Cowherd and David (1992) show that a higher pay gap between executives and employees has a negative impact on the company's quality of goods. He and Long (2011) show that the absolute salary level of employees is not correlated with satisfaction, but within-department wage comparison is. Li and Hu (2012) find that when the income level of employees and senior executives in China's SOEs varies greatly, the salary satisfaction of employees decreases, which leads employees to neglect the enterprise's goals, affects overall cohesion and ultimately has a negative impact on the performance of the enterprise.

This paper argues that employees working for enterprises in the same group provide good references for each other. First, business communication between the group's enterprises is frequent, and information transmission is convenient. China's formal system under the transition economy is imperfect, and the enterprises within a group engage in close business associations, including related party transactions, risk sharing and internal lending (Han et al., 2018; Jiang and Kim, 2020). These frequent business activities enable subsidiaries within the group to observe the input and return of each other's employees, forming the basis for mutual comparison. Second, the similarity between the employees in the group's subordinate enterprises is relatively high. In contrast to other organizational forms, group subsidiaries have similar corporate cultures, management control systems and performance assessment standards (Pan and Yu, 2014; Du et al., 2018; Li et al., 2019; Zhang and Gao, 2019). Employees' input and return face similar assessment implementation methods and assessment environments, creating conditions for employees' mutual comparison. When the salaries of the employees of an enterprise in the group rise sharply and thus the relative income of employees of other subsidiaries decreases, employees will have a strong sense of unfairness and dissatisfaction, which will affect their work efficiency, and they may even have negative reactions such as slowdown and resignation, which will negatively affect the enterprise's production and operation. Therefore, to alleviate employees' sense of unfairness,

after observing the rise in employees' salary level in other enterprises in the group, the enterprise will improve its employees' salary level.[1]

Considering the above analysis, we propose Hypothesis 1:

H1: When employee compensation at one company increases sharply, employee compensation at other companies controlled by the same group will increase sharply in the next year. That is, there is employee salary comparison in the group.

3. Research design

3.1. Sample selection and data source

In this paper, we select state-owned group holding listed companies in Shanghai Stock Exchange and Shenzhen Stock Exchange from 2008 to 2018 as the initial research sample.[2] For the criteria for identifying group enterprises, this paper refers to previous research (He et al., 2013; Buchuk et al., 2014; Zhang and Gao, 2019), holding that if an actual controller simultaneously holds two or more listed companies in the same year, the listed company controlled by the actual controller belongs to the enterprise group.[3] The selection process is completed by manually sorting through the annual reports of listed companies. After financial industry samples, missing data samples and comparison objects are removed,[4] a final research sample of 3,186 firm-year observations is obtained. The financial and corporate governance data used in this paper are obtained from the CSMAR database.

3.2. Variables and regression models

This paper constructs the following model (1) to test for employee salary comparison:

$$Ln\_epay_{it} = \beta_{0+}\beta_1 Compare_{it} + \sum Control_{it} + \varepsilon_{it} \quad (1)$$

For employee compensation, this paper refers to the literature (Chen et al., 2015; Shen et al., 2017), using "Cash Paid to Employees" in the cash flow statement and deducting the total salary of enterprise executives in the current year, dividing it by the number of employees and taking the natural logarithm as the employee salary variable (*Ln_epay*). Employee compensation, as calculated from cash flow statement data, is a kind of broad salary that includes the actual salary, bonus, various allowances and subsidies paid to the employees, social insurance fund, supplementary endowment insurance, commercial insurance money, housing accumulation fund, housing hardship subsidies and various welfare expenses (Lu et al., 2012; Shen et al., 2019).

For employee salary comparison (*Compare*), we follow the literature (Li et al., 2019) by adopting the following measures. First, in year t, for company i, we define the dummy variable $Compare_{it}$. If the employee

[1] Salary is the main source of employee income rather than other income sources such as perquisites or shareholding (Shen et al., 2019).

[2] According to our previous research on state-owned group enterprises, the employee compensation system and management system of a group of enterprises differ from those of the same industry and region. Although the enterprises within the group belong to different industries, the salary system is relatively similar. In addition, in China, because of the strict control of the IPO system, there are large differences between unlisted companies and listed companies, including scale and profitability. Therefore, the comparability of listed companies is stronger, and an analysis based on listed companies is more practical.

[3] Consistent with Li et al. (2019) and Zhang and Gao (2019), if the largest shareholder is SASAC (State owned Assets Supervision and Administration Commission of the State Council) at all levels, a state-owned asset management company, a finance bureau or other government agency, or a company or individual that does not engage in industrial operations and only engages in investment holdings, the listed company is an independent enterprise.

[4] If the employee compensation of a company in the group increased by more than 10% in the previous year and the company's assets account for more than 25% of the group's total assets, then we define the company as a comparison object. Because this paper examines how to adjust the employee salary of the same group when an enterprise observes the significant increase in employee compensation, in the empirical analysis, we eliminate the comparison objects and only keep other enterprises in the group to accurately identify the employee salary comparison.

Table 1
Variable definitions.

Variable Name	Variable definitions
Ln_epay_{it}	The cash paid to employees minus the total salary of executives in the current year, divided by the number of employees, converted to natural logarithm form.
$Compare_{it}$	When the employee compensation of another company in the same group as company i increased by more than 10% in the previous year and the proportion of assets of this company exceeded 25% of the total assets of the group, the value is 1, and otherwise it is 0.
$Size_{it}$	Firm size, measured as the natural logarithm of total assets.
ROA_{it}	Firm's return on assets, calculated as net income divided by total assets.
Lev_{it}	Firm's financial leverage ratio, calculated as total debt divided by total assets.
Tq_{it}	Firm's Tobin's q, calculated as the market value divided by total assets.
$Growth_{it}$	Sales revenue in year t minus sales revenue in year t–1 divided by sales revenue in year t–1.
$Rind_{it}$	Number of independent directors divided by the total number of board directors.
H_share_{it}	The percentage of shares owned by the executives.
Gdp_p_{t}	Per-capita GDP (ten thousand yuan).

compensation of another company in the group containing company i increased by more than 10% in the previous year and the proportion of assets exceeded 25% of the total assets of the group,[5] the $Compare_{it}$ value of company i is 1; otherwise, it is 0. According to the regression results of model (1), if the coefficient of $Compare_{it}$ is significantly positive, then there is employee salary comparison. In the robustness test section, other methods are used to measure employee salary comparison.

Referring to the studies of Lu et al. (2012), Wang and Huang (2017) and Shen et al. (2019), we control company characteristic variables such as company size (*Size*) and the regional characteristic variable of the regional economic development level (*Gdp_p*). To eliminate the effects of extreme values, we winsorize all the continuous variables at the 1% and 99% levels. In addition, we add an annual dummy variable (*Year*) and industry dummy variable (*Industry*) to the model. Specific variable definitions are given in Table 1.

3.3. Descriptive statistics

The descriptive statistics for the variables presented in this paper are reported in Table 2. The average and median of employee salary (*Ln_epay*) are 11.500 and 11.471, respectively, and the mean and median are nearly the same, indicating that the distribution of employee salaries within enterprise groups presents a highly uniform distribution structure. The average value of employee salary comparison (*Compare*) is 0.373, indicating that approximately 37% of listed companies in enterprise groups are affected by employee salary comparison. The descriptive statistics of the other variables are reasonably close to those reported in the literature. Table 3 reports the correlation analysis of the main variables. The correlation coefficient of employee compensation (*Ln_epay*) and employee compensation comparison (*Compare*) is 0.044, which is significant at the 5% level. This result gives preliminary support for H1, which states that there is employee salary comparison in state-owned groups.

4. Empirical results

4.1. Employee salary comparison

Table 4 reports the results of testing H1. Column (1) shows that employee salaries are higher in larger and more profitable enterprises, which is consistent with the findings of Chen et al. (2015) and Wang and Huang (2017). In column (2), controlling control variables such as the financial characteristics of the company, the coefficient of employee salary comparison (*Compare*) is significantly positive at the 5% level, with a value of 0.045, which supports H1. From the economic perspective, the employee salary of comparison companies

[5] The total assets of the group refer to the total assets of all listed companies under the control of the same group in the current year.

Table 2
Descriptive statistics of the variables.

Variable	N	Mean	SD	Q25	Median	Q75
Ln_epay	3,186	11.500	0.664	11.115	11.471	11.839
Compare	3,186	0.373	0.484	0.000	0.000	1.000
Size	3,186	22.651	1.396	21.713	22.482	23.493
ROA	3,186	0.025	0.055	0.007	0.025	0.049
Lev	3,186	0.530	0.205	0.383	0.544	0.682
Tq	3,186	1.939	1.227	1.160	1.536	2.238
Growth	3,186	0.155	0.525	–0.042	0.082	0.228
Rind	3,186	0.367	0.055	0.333	0.333	0.375
H_share	3,186	0.001	0.007	0.000	0.000	0.000
Gdp_p	3,186	6.581	3.179	3.944	6.023	8.800

Table 3
Correlation analysis.

	Ln_epay	*Compare*	*Size*	*ROA*	*Lev*	*Tq*	*Growth*	*Rind*	*H_share*
Ln_epay	1.000								
Compare	0.044**	1.000							
Size	0.293***	–0.241***	1.000						
ROA	0.105***	–0.009	0.040**	1.000					
Lev	–0.006	–0.089***	0.360***	–0.365***	1.000				
Tq	–0.094***	0.103***	–0.525***	0.090***	–0.322***	1.000			
Growth	–0.021	–0.020	0.072***	0.144***	0.043**	–0.054***	1.000		
Rind	0.045**	–0.028	0.163***	–0.028	0.035**	–0.053***	0.002	1.000	
H_share	–0.009	–0.013	–0.065***	0.102***	–0.095***	0.081***	0.024	–0.048***	1.000
Gdp_p	0.401***	–0.057***	0.270***	0.074***	–0.041**	–0.057***	–0.009	0.072***	0.036**

Note: *, ** and *** indicate significance levels of 10%, 5% and 1%, respectively.

is 4.5% higher than that of no-comparison companies. Therefore, the results in Table 4 show that when the employee salary level of an enterprise of the group increases significantly, the salary levels of other enterprises under the control of the same group will also increase significantly in the following year; that is, the enterprise engages in employee salary comparison.

4.2. Robustness tests

4.2.1. Endogeneity tests

The results in Table 4 show that there are employee salary comparisons within enterprise groups, but these results may be affected by endogeneity issues. To ensure the robustness of our conclusions, this paper adopts the following two methods.

First, PSM matching is used to alleviate possible selection bias. Panel A in Table 5 reports the results of tests for differences in the control variables after matching.[6] It can be seen that there are no significant differences in the control variables after PSM matching. After matching, there are 769 observations in the treatment group and 769 observations in the control group. The regression results are shown in column (1) of Table 5, Panel B. They show that the coefficient of employee compensation comparison (*Compare*) is 0.068, which is significant at the 5% level.

Second, to avoid the influence of unobservable factors at the company level, we control for firm fixed effects. This results are presented in column (2). The coefficient of *Compare* is 0.037, which is significant at the 5% level. The results in Table 5 indicate that our main conclusions remain robust when controlling for possible endogeneity.

[6] The matching variables are all control variables (*Size*, *ROA*, *Lev*, *Tq*, *Growth*, *Rind*, *H_share*, *Gdp_p*), and the matching method is 1:1.

Table 4
Employee salary comparison.

Variable	(1) *Ln_epay*	(2) *Ln_epay*
Compare		0.045**
		(2.07)
Size	0.067***	0.072***
	(3.74)	(3.92)
ROA	0.934***	0.929***
	(3.30)	(3.28)
Lev	–0.162	–0.163
	(–1.43)	(–1.44)
Tq	0.018	0.019
	(1.35)	(1.40)
Growth	–0.032	–0.032
	(–1.23)	(–1.22)
Rind	–0.132	–0.134
	(–0.39)	(–0.40)
H_share	–3.510*	–3.428*
	(–1.76)	(–1.72)
Gdp_p	0.055***	0.055***
	(7.33)	(7.33)
Constant	9.433***	9.322***
	(20.26)	(19.68)
Year fixed effects	Yes	Yes
Industry fixed effects	Yes	Yes
Observations	3,186	3,186
F test	36.75***	35.90***
Adj-R^2	0.272	0.283

Note: The t-values adjusted at company level are reported in parentheses; *, ** and *** indicate significance levels of 10%, 5% and 1%, respectively.

4.2.2. Changing the variable measure

To further ensure the robustness of our main conclusions, we use other ways to measure employee salary comparison and employee salary. We define an employee salary increase of more than 10% as a significant increase. For robustness, we alternatively choose a threshold of 20% to define a significant increase in employee salary, and on this basis, we recalculate the employee salary comparison (*Compare*2). The corresponding test results are shown in Table 6. They show that the coefficient of employee salary comparison (*Compare*2) is 0.079, which is significant at 1%. Further, to examine the impact on the employee compensation growth rate, we replace the dependent variable with the variable value (Δ *Ln_epay*). The results are shown in column (2) of Table 6. The coefficients of *Compare* remain positive and are significant at the 1% level.

4.2.3. Other robustness tests

To further ensure the robustness of the main conclusion, the following robustness tests are conducted. First, to avoid the impact of the 2008 financial crisis, the samples from 2008 and 2009 are dropped. Second, to avoid the influence of heteroscedasticity, a double clustering adjustment at the firm and year levels is performed. Third, to avoid the influence of the change of the number of employees on the results, the number of employees is added as a control variable in the model, which is measured by the natural logarithm of the number of employees (*Employee*). Table 7 shows the results. The coefficients of employee salary comparison (*Compare*) remain positive and significant at the 5%, 1% and 5% levels for these three tests, respectively.

5. Further analysis

5.1. The influence of employees' sense of salary unfairness

According to the theoretical analysis, to maintain the fairness of employees' salaries, the enterprise will increase the employee salary level after observing the employee salary increase in other enterprises in the

Table 5
Endogeneity test.

Panel A: PSM matching

Variable	*Compare = 1*	*Compare = 0*	t-value of the difference
Size	22.215	22.208	0.14
ROA	0.025	0.026	–0.77
Lev	0.506	0.497	1.02
Tq	2.102	2.102	0.00
Growth	0.142	0.163	–1.14
Rind	0.365	0.364	0.22
H_share	0.001	0.002	–1.61
Gdp_p	6.346	6.439	–0.72
Observations	769	769	

Panel B: PSM and fixed-effects regression results

Variable	*Ln_epay*	
	(1) PSM	(2) Fixed Effect
Compare	0.068**	0.037**
	(2.58)	(2.27)
Size	0.110***	0.085***
	(3.84)	(3.95)
ROA	0.950**	0.537***
	(2.51)	(2.94)
Lev	–0.094	–0.026
	(–0.66)	(–0.30)
Tq	0.040**	0.009
	(2.28)	(0.82)
Growth	–0.082***	–0.057***
	(–2.65)	(–3.82)
Rind	0.226	–0.009
	(0.59)	(–0.04)
H_share	–2.483	–3.392
	(–0.94)	(–1.63)
Gdp_p	0.057***	–0.016
	(6.79)	(–1.63)
Constant	8.302***	9.298***
	(12.69)	(19.69)
Year fixed effects	Yes	Yes
Firm fixed effects	No	Yes
Industry fixed effects	Yes	No
Observations	1,538	3,186
F test	17.63***	39.56***
Adj-R^2	0.280	0.215

Note: The t-values adjusted at company level are reported in parentheses; *, ** and *** indicate significance levels of 10%, 5% and 1%, respectively.

group. According to this argument, when the sense of unfairness is higher, there will be a stronger incentive to raise pay. We next analyze and test the effects of regional relative salary, industry relative salary and regional collectivist culture.

From the perspective of regional relative compensation, the economic and commercial conditions in a region are similar, and enterprises' financial decisions have a strong similarity (Li et al., 2018). At the same time, the proximity of individuals in the same region makes it easier for them to perceive the relative decline in pay. The literature suggests that individuals have easier access to information that has close geographical proximity. For example, from an analyst's perspective, Malloy (2005) suggests that the closer the geographic proximity between analysts and public companies, the more accurate their forecasts and the less prone they are to optimistic forecast bias. From the perspective of auditors, Liu (2014) show that the closer the geographical distance between auditors and listed companies, the more they can supervise the company, and the higher the

Table 6
Changes in the variable measures.

Variable	(1) *Ln_epay*	(2) Δ *Ln_epay*
Compare		0.005***
		(3.68)
Compare2	0.079***	
	(3.39)	
Size	0.076***	–0.002***
	(4.70)	(–2.65)
ROA	0.818***	0.030**
	(3.15)	(2.12)
Lev	–0.071	0.008**
	(–0.73)	(2.01)
Tq	0.018	–0.000
	(1.55)	(–0.18)
Growth	–0.062***	0.001
	(–2.69)	(0.91)
Rind	–0.064	0.002
	(–0.21)	(0.15)
H_share	–2.507*	0.126
	(–1.89)	(1.10)
Gdp_p	0.051***	–0.000
	(7.48)	(–1.52)
Constant	9.178***	0.030*
	(23.43)	(1.71)
Year fixed effects	Yes	Yes
Industry fixed effects	Yes	Yes
Observations	4,278	2,249
F test	43.69***	2.187
Adj-R^2	0.270	0.0176

Note: The t-values adjusted at company level are reported in parentheses; *, ** and *** indicate significance levels of 10%, 5% and 1%, respectively.

audit quality. From the customer perspective, Tang and Li (2019) show that the closer the spatial proximity between customers and enterprises, the smaller the communication cost between them, which can significantly strengthen customer supervision and reduce the audit cost. Wan et al. (2019) show that key customers close to listed companies can reduce the likelihood of company violations. In addition, the geographical location of venture capital investors can affect their investment decisions. Huang et al. (2014) show that investors make lower investments in enterprises that are farther away. Therefore, we expect that when employee salaries are lower than those of employees in other companies in the same region, because of convenient information access, employees are more likely to have a strong sense of injustice and dissatisfaction. Thus, enterprises will have more incentive to improve employee salaries and maintain fairness, and the comparison effect will be more significant.

From the perspective of the relative salary in the industry, business and information exchanges between enterprises in the same industry are very frequent, and the financial behavior of such companies is highly comparable. For example, Leary and Roberts (2014) show that a company's financing decisions are significantly affected by other companies in the same industry. Wan et al. (2016) find that the merger and acquisition activities of other companies in the same industry can have a significant impact on the merger and acquisition behavior of listed companies. Lu et al. (2017) show that the capital structure of other companies in the same industry has a significant impact on the capital structure of enterprises. Unlike employees in other industries, employees working in the same industry face a similar external business environment and required skills, and they are more likely to choose each other as reference targets. Therefore, the income gap in the same industry will have a stronger psychological impact on employees compared to income gap within different industries (He and Long, 2011; Qi and Zou, 2014). Huang (2012) show that unfair salaries relative to the industry will damage a company's financial performance. Therefore, when salaries are lower than in other companies in the

Table 7
Other robustness tests.

Variable	*Ln_epay*		
	(1) Excluding samples in 2008 and 2009	(2) Double clustering standard error	(3) Controlling the number of employees
Compare	0.050**	0.045***	0.041**
	(2.24)	(2.81)	(2.13)
Size	0.067***	0.072***	0.360***
	(3.70)	(2.91)	(19.60)
ROA	0.869***	0.929**	0.842***
	(3.04)	(2.51)	(5.18)
Lev	–0.158	–0.163	–0.223***
	(–1.41)	(–0.98)	(–4.21)
Tq	0.022*	0.019*	0.010
	(1.67)	(1.87)	(1.19)
Growth	–0.030	–0.032	–0.069***
	(–1.11)	(–1.08)	(–2.84)
Rind	–0.080	–0.134	–0.210
	(–0.24)	(–0.31)	(–1.20)
H_share	–3.428*	–3.428**	–3.635***
	(–1.76)	(–2.29)	(–3.03)
Gdp_p	0.053***	0.055***	0.038***
	(7.23)	(9.71)	(11.19)
Employee			–0.358***
			(–17.84)
Constant	9.335***	9.322***	5.830***
	(19.58)	(18.34)	(19.96)
Year fixed effects	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes
Observations	2,995	3,186	3,186
F test	34.28***	35.90***	1855
Adj-R^2	0.280	0.283	0.475

Note: The t-values adjusted at company level are reported in parentheses; *, ** and *** indicate significance levels of 10%, 5% and 1%, respectively.

industry, employees' dissatisfaction with their salaries will rise further, and enterprises will be more motivated to increase employee compensation.

Finally, we analyze the influence of regional collectivist culture, which emphasizes a collective sense of honor and identity. When there is a stronger collectivist atmosphere, people expend more energy on social comparison (Chung and Mallery, 1999; Li et al., 2019). For example, White and Lehman (2005) show that compared with European Canadian students who belong to an individualist culture, Asian Canadian students who are part of a collectivist culture are more willing to ask other students for their scores after a test. Therefore, when the collectivist culture in the area where the company is located is stronger, the employees will be more motivated, the sense of injustice caused by the relative salary decline will be stronger and the company will be more motivated to improve the employee salary level.

To test the above logic, we create a dummy variable, *L_area_S*. When employees' salary is lower than the median salary of employees in the same region in the previous year, *L_area_S* is 1, and 0 otherwise. Next, we create the dummy variable *L_ind_S*. When the salary of employees is lower than the median salary of employees in the same industry in the previous year, *L_ind_S* is 1, and 0 otherwise. For collectivist culture, we draw on the social-oriented collectivism index constructed by Zhao et al. (2015) and set the virtual variable *H_Collec*. When the collectivist cultural index in the province where the company is located is greater than the median, *H_Collec* is 1, and 0 otherwise. The regression results are shown in Table 8. The coefficients of the interaction terms *Compare*L_area_S*, *Compare*L_ind_S* and *Compare*H_Collec* are 0.067, 0.080 and 0.116, and are significantly positive at the 10%, 5% and 1% levels, respectively. The results show that when employees perceive their relative salary to be lower, they have a stronger sense of unfairness, the enterprise has more motivation to improve the salary level and employees' salary comparison is stronger.

5.2. The influence of the enterprise's comparison motivation

We next analyze the impact of enterprise comparison motivation. According to previous research, compared to employees in labor-intensive enterprises, employees in non-labor-intensive enterprises usually have a higher skill level, stronger mobility and stronger ability to create value for enterprises (Zhou et al., 2012; Shen et al., 2019). Therefore, we expect that for non-labor-intensive enterprises, employee salary comparison will be more obvious. Similarly, a higher education level generally means a larger knowledge base, stronger knowledge acquisition ability and stronger value creation ability (Wang and Zhu, 2018). For example, Call et al. (2017) show that high-quality employees can improve the quality of accounting information in enterprises. Therefore, we expect that employee salary comparison will be stronger for enterprises with higher employee education.

To test the above logic, we draw on Shen et al. (2019) and distinguish the types of listed companies according to per-capita operating income. If the per-capita operating income of a listed company is greater than the annual industry median, indicating the stronger ability of employees to create value, it is considered a non-labor-intensive enterprise, the virtual variable *Nlabor* is assigned a value of 1, and the interaction item is added for testing. In addition, based on Wang and Zhu (2018), this paper takes the proportion of employees with a bachelor's degree or above of the total number of employees as a measure of employee education level. If the proportion of highly educated employees is greater than the annual industry median, the enterprise is considered to have highly educated employees, the dummy variable *H_Educ* is given the value 1 and the interaction item is added for inspection.

The regression results are shown in columns (1) and (2) of Table 9. The coefficient of the interaction term (*Compare*Nlabor*) is 0.113, which is significant at the 1% level. The interaction term (*Compare*H_Educ*) has a coefficient of 0.017, which is significant at the 1% level. The results in Table 9 thus show that when employees are better able to create value and are more educated, enterprises have more motivation to maintain employee salary fairness, and employee salary comparison is stronger.

5.3. The influence of enterprises' financial liquidity

Next, we analyze the impact of enterprises' financial liquidity. Employee compensation is an important labor cost of enterprises. Therefore, when enterprises have an incentive to improve employee pay and maintain

Table 8
The influence of employees' sense of salary unfairness.

Variable	*Ln_epay*		
	(1) The impact of employee compensation in the same area	(2) The impact of employee compensation in the same industry	(3) The impact of regional collectivist culture
Compare	–0.022	–0.030	–0.005
	(–0.88)	(–1.58)	(–0.23)
*Compare*L_area_S*	0.067*		
	(1.91)		
*Compare*L_ind_S*		0.080**	
		(2.44)	
*Compare*H_Collec*			0.116***
			(2.60)
L_area_S	0.652***		
	(7.90)		
L_ind_S		0.753***	
		(5.52)	
H_Collec			0.047*
			(1.81)
Size	0.029***	0.039***	0.069***
	(3.21)	(4.97)	(6.64)
ROA	0.545***	0.409***	0.969***
	(3.04)	(2.76)	(5.16)
Lev	–0.155***	–0.044	–0.146**
	(–2.86)	(–0.93)	(–2.39)
Tq	–0.007	0.001	0.019**
	(–0.80)	(0.22)	(2.18)
Growth	–0.001	–0.003	–0.035
	(–0.04)	(–0.15)	(–1.40)
Rind	–0.051	0.042	–0.142
	(–0.31)	(0.27)	(–0.72)
H_share	–0.837	–1.209	–3.317**
	(–0.66)	(–1.33)	(–2.51)
Gdp_p	0.057***	0.023***	0.048***
	(17.78)	(7.67)	(12.28)
Constant	10.171***	9.922***	9.362***
	(46.67)	(53.02)	(36.66)
Year fixed effects	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes
Observations	3,186	3,186	3,186
F test	80.55***	146.30***	80.50***
Adj-R^2	0.487	0.566	0.288

Note: The t-values adjusted at company level are reported in parentheses; *, ** and *** indicate significance levels of 10%, 5% and 1%, respectively.

Table 9
The influence of enterprise comparison motivation.

Variable	*Ln_epay*	
	(1) The impact of labor intensity	(2) The influence of employee education background
Compare	–0.010	0.040
	(–0.39)	(1.39)
*Compare*Nlabor*	0.113***	
	(2.81)	
*Compare*H_Educ*		0.017***
		(5.17)
Nlabor	0.367***	
	(14.72)	
H_Educ		0.135
		(0.41)
Size	0.032***	0.072***
	(3.15)	(6.94)
ROA	0.373**	0.930***
	(2.05)	(4.90)
Lev	–0.279***	–0.164***
	(–4.88)	(–2.66)
Tq	0.019**	0.019**
	(2.41)	(2.15)
Growth	–0.055**	–0.033
	(–2.18)	(–1.31)
Rind	–0.264	–0.108
	(–1.38)	(–0.55)
H_share	–3.166***	–2.763**
	(–2.69)	(–2.15)
Gdp_p	0.044***	0.056***
	(12.04)	(14.60)
Constant	10.067***	9.308***
	(42.69)	(36.33)
Year fixed effects	Yes	Yes
Industry fixed effects	Yes	Yes
Observations	3,186	3,186
F test	137.50***	67.71***
Adj-R^2	0.365	0.290

Note: The t-values adjusted at company level are reported in parentheses; *, ** and *** indicate significance levels of 10%, 5% and 1%, respectively.

pay fairness, their ability to pay is also crucial. Generally, when an enterprise is larger and the cash holding level is higher, capital is more abundant, so the enterprise is better able to improve employee welfare and increase employee salaries (Lu et al., 2012; Shen et al., 2019). Therefore, we expect that when the enterprise is larger and the cash holding level is higher, the employee salary comparison will be stronger.

To test the above logic, we create a dummy variable, *B_Size*. When the company size is larger than the median of the same industry company size in the same year, the *B_Size* value is 1, and 0 otherwise. Second, we define the dummy variable *H_Cash*. Cash holding level (*Cash*) is measured as the ratio of cash holding to total assets. When the cash holding level is higher than the median of the cash holding level in the same industry in the same year, *H_Cash* is 1, and 0 otherwise. The results of the regression are shown in Table 10. The coefficients of the interaction terms *Compare*B_Size* and *Compare*H_Cash* are 0.081 and 0.076, respectively, both of which are significantly positive at the 10% level. The results in Table 10 show that when the enterprise scale is larger and the cash holding level is higher, its financial liquidity is stronger, and the employee salary comparison is more obvious.

Table 10
The influence of enterprise financial liquidity.

Variable	*Ln_epay*	
	(1) The impact of enterprise size	(2) The impact of cash holding
Compare	0.010	0.012
	(0.37)	(0.43)
*Compare*B_Size*	0.081*	
	(1.90)	
*Compare*H_Cash*		0.076*
		(1.80)
B_Size	0.021	
	(0.59)	
H_Cash		0.019
		(0.61)
Size	0.058***	0.061***
	(4.05)	(4.70)
ROA	0.909***	0.897***
	(4.29)	(4.23)
Lev	–0.174***	–0.156**
	(–2.72)	(–2.44)
Tq	0.019*	0.019*
	(1.81)	(1.75)
Growth	–0.032*	–0.034*
	(–1.66)	(–1.72)
Rind	–0.127	–0.138
	(–0.66)	(–0.72)
H_share	–3.515**	–3.640**
	(–2.35)	(–2.43)
Gdp_p	0.056***	0.055***
	(14.61)	(14.49)
Constant	9.585***	9.536***
	(30.23)	(32.58)
Year fixed effects	Yes	Yes
Industry fixed effects	Yes	Yes
Observations	3,186	3,186
F test	34.25***	34.25***
Adj-R^2	0.284	0.284

Note: The t-values adjusted at company level are reported in parentheses; *, ** and *** indicate significance levels of 10%, 5% and 1%, respectively.

5.4. Excluding alternative explanations

The preceding theoretical analysis and empirical test support the hypothesis of employee salary comparison. Next, we exclude alternative explanations to further strengthen our theoretical logic.

First, better financial performance might result in increased employee salaries. For example, based on the tournament incentive theory (Downes and Choi, 2014), on the premise that there is an internal labor market within the group and employees can be transferred between companies within the group, when the salary level of an enterprise within the group rises, the employees of other enterprises will work hard to obtain the opportunity to transfer to a company with a higher salary level, which leads to a rise in overall performance of the focal enterprise, and ultimately to a rise in employee salary levels.

To exclude performance-driven alternative explanations, this paper divides the sample into a performance increase group (*ROA_I*) and performance decline group (*ROA_D*) based on whether the enterprise's net profit decreased from the previous year. We then define a dummy variable, *R_D*, which takes a value of 1 when the sample belongs to the performance decline group, and 0 otherwise. Panel A of Table 11 shows that the coefficient of the interaction term (*Compare*R_D*) is 0.001, which is not significant. The results show that com-

pany performance does not affect salary comparison, indicating that salary comparison is not performance-driven.[7]

Second, executives' political motivation for promotion could drive our results. Considering the quasi-official nature of state-owned enterprise executives, it is possible that senior executives might raise employee pay to assist in political promotion. However, it is not clear how political promotion motives might explain the main findings of the paper. With the goal of political promotion, state executives cater to major shareholders; however, employee satisfaction would seem unlikely to affect executive political promotion. At the same time, if executives' goal is just to maintain stability, they only need to avoid major negative events such as massive layoffs, which could lead to employee petitions; however, they would have no strong incentive to raise employee pay. To exclude this alternative explanation, we examine how the possibility of executive political promotion affects employee salary comparison. We draw on the literature and analyze the senior executives' political connections, age and educational background (Yang et al., 2013; Gu et al., 2020). When executives have political connections, lower age and higher education, their odds of political promotion are higher.

Because the chairmen of state-owned enterprises have stronger decision-making power compared to CEO or other executives (Jiang and Kim, 2020), we take the chairman as the object of our analysis. For political associations, we define the dummy variable *Pol*. When the chairman is a member of the CPPCC or a deputy to the National People's Congress, *Pol* is equal to 1, and 0 otherwise. For age, we define the dummy variable *Young*, which is equal to 1 when the chairman's age is below the annual-industry median, and 0 otherwise. For academic background, we define the dummy variable *Edu*, which is equal to 1 when the chairman has a PhD, and 0 otherwise. Next, the interaction terms are added separately in the model. The regression results are shown in Panel B of Table 6. The coefficients of the interaction terms *Compare*Pol*, *Compare*Young Compare*Edu* are 0.049, –0.041 and –0.032, respectively, and none are significant. Thus, the results preclude the alternative explanation based on the motivation for political promotion and further support the main logic of the paper.

Third, the results could be driven by the impact of specific industries. Because enterprises within a group may belong to different industries, the results of this paper could also be caused by the exogenous effects of different industries on the various enterprises. For example, one company in the group might be supported by national industrial policy in a particular year, and employee salaries would thus increase. Another company in the group might be supported by national industrial policy in the following year, and employee salaries will then increase.[8] To exclude this alternative explanation, two methods are used for a robustness test. First, we analyze how the degree of industry diversification at the group level affects employee salary comparison. The higher the industry diversification of subsidiaries within the group, the more likely it is they will be affected by industry policies, and the more likely it is that there will be synchronous changes in employee compensation. Therefore, if the main result of this paper is the result of industry impacts, then the higher the degree of industry diversification, the stronger the employee salary comparison. We calculate subsidiary industry standard deviations at the group level to measure industry diversification (*SD_Ind*). The larger the value of *SD_Ind*, the greater the industry diversification. Next, interaction terms are added to the model. In addition, to more directly exclude the influence of particular industries, we retain only some manufacturing samples. Specifically, we only retain the samples with industry code C3, including the non-metallic mineral products, ferrous metal smelting and processing, and non-ferrous metal smelting and processing industries,[9] to ensure representativeness, control the influence of the industry as much as possible, avoid the interference of other factors and more clearly identify employee salary comparison within the group.

[7] Unreported group tests show that in the performance decline group, the coefficient is 0.051, significant at the 10% level, and that in the performance rise group is 0.048, which is not significant. The p-value for the between-group difference test is 0.939.

[8] There may be another alternative explanation: in the face of industry impacts, different subsidiaries in the same industry have different response speeds, leading to asynchronous employee salary adjustments. However, we believe that under the control of the same group, subsidiaries of the same industry can not only learn information about the industry, but also exchange information within the group and have closer ties. At the same time, the parent company is generally assessed in accordance with the principle of "same industry, same rules" (e.g., "Business Performance Assessment Measures of Central Enterprises"). Therefore, in the face of industry impacts, the subsidiaries of the same industry have the ability and motivation to adjust simultaneously.

[9] Samples with the industry code C3 have the highest proportion.

Table 11
Ruling out alternative explanations.

Panel A: Excluding the alternative explanation of enterprise performance

Variable	*Ln_epay*
	(1) Full sample
Compare	0.045
	(1.40)
*Compare*R_D*	0.001
	(0.02)
R_D	0.005
	(0.18)
Size	0.072***
	(6.91)
ROA	0.942***
	(4.83)
Lev	–0.163***
	(–2.64)
Tq	0.019**
	(2.19)
Growth	–0.031
	(–1.19)
Rind	–0.134
	(–0.68)
H_share	–3.422***
	(–2.67)
Gdp_p	0.055***
	(14.49)
Constant	9.314***
	(36.52)
Year fixed effects	Yes
Industry fixed effects	Yes
Observations	3,186
F test	189.10***
Adj-R^2	0.282

Panel B: Excluding the alternative explanation of political promotion

Variable	*Ln_epay*		
	(1) The influence of political connection	(2) The influence of age	(3) The influence of education background
Compare	0.042*	0.071**	0.048**
	(1.79)	(2.07)	(2.02)
*Compare*Pol*	0.049		
	(0.72)		
*Compare*Young*		–0.041	
		(–0.95)	
*Compare*Edu*			–0.032
			(–0.53)
Pol	–0.016		
	(–0.42)		
Young		–0.036	
		(–1.45)	
Edu			0.009
			(0.28)
Size	0.072***	0.068***	0.071***
	(6.88)	(6.56)	(6.89)
ROA	0.925***	0.925***	0.930***
	(4.89)	(4.93)	(4.91)
Lev	–0.163***	–0.150**	–0.163***
	(–2.64)	(–2.45)	(–2.64)
Tq	0.019**	0.017**	0.018**

	(2.16)	(2.00)	(2.14)
Growth	–0.031	–0.032	–0.032
	(–1.22)	(–1.24)	(–1.24)
Rind	–0.133	–0.123	–0.134
	(–0.68)	(–0.63)	(–0.68)
H_share	–3.408***	–3.562***	–3.430***
	(–2.67)	(–2.77)	(–2.67)
Gdp_p	0.055***	0.055***	0.055***
	(14.49)	(14.47)	(14.52)
Constant	9.322***	9.410***	9.326***
	(36.86)	(36.93)	(37.01)
Year fixed effects	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes
Observations	3,186	3,186	3,186
F test	95.98***	114.89***	194.83***
Adj-R^2	0.282	0.284	0.282

Panel C: Excluding the alternative explanation of industry diversification

Variables	*Ln_epay*	
	(1) The impact of group industry diversification	(2) Only some manufacturing industries are retained
Compare	0.046*	0.047*
	(1.70)	(1.71)
*Compare*SD_Ind*	0.004	
	(0.33)	
SD_Ind	0.009	
	(1.17)	
Size	0.072***	0.101***
	(6.77)	(3.93)
ROA	0.925***	0.939**
	(4.37)	(2.02)
Lev	–0.159**	–0.144
	(–2.49)	(–0.92)
Tq	0.019*	0.013
	(1.80)	(0.69)
Growth	–0.032*	–0.072**
	(–1.65)	(–2.41)
Rind	–0.136	–0.232
	(–0.71)	(–0.58)
H_share	–3.479**	–3.146
	(–2.32)	(–1.29)
Gdp_p	0.055***	0.055***
	(14.41)	(5.19)
Constant	9.289***	8.785***
	(36.12)	(16.05)
Year fixed effects	Yes	Yes
Industry fixed effects	Yes	Yes
Observations	3,186	1,275
F test	34.10***	18.94***
Adj-R^2	0.283	0.270

Note: The t-values adjusted at the company level are reported in parentheses; *, ** and *** indicate significance levels of 10%, 5% and 1%, respectively.

The results are shown in Panel C of Table 11. Column (1) shows the impact of the diversification of subsidiary industries, and column (2) retains only part of the manufacturing industry. The coefficient of the interaction term (*Compare*SD_Ind*) is positive but not significant, and the coefficient of *Compare* in column (2) is significant at the 10% level. Therefore, we rule out the alternative explanation that industry diversification results in employee salary comparison.

[9] Samples with the industry code C3 have the highest proportion.

Table 12
The economic consequences of employee salary comparison.

Variable	*F_ROA*	*F_Ret*	*F2_ROA*	*F2_Ret*
Pay_I	–0.006	–0.010	0.003	0.021
	(–0.71)	(–0.61)	(0.65)	(1.03)
*Pay_I*Compare*	0.014	0.031	0.012	–0.043
	(1.18)	(1.13)	(0.84)	(–1.47)
Compare	–0.015	–0.022	–0.013	0.000
	(–1.22)	(–1.09)	(–0.92)	(0.00)
Size	0.008**	–0.036***	0.003	–0.024***
	(2.54)	(–4.65)	(1.08)	(–2.62)
ROA	0.157	0.284**	0.423***	–0.253
	(0.54)	(2.37)	(5.13)	(–1.32)
Lev	–0.003	0.060	–0.064**	0.020
	(–0.09)	(1.50)	(–2.16)	(0.47)
Tq	0.025	–0.032***	0.003*	–0.024**
	(1.38)	(–5.14)	(1.73)	(–2.31)
Growth	0.005**	–0.001	0.002	–0.038***
	(2.53)	(–0.09)	(0.94)	(–3.18)
Rind	–0.055	0.112	0.006	0.021
	(–1.58)	(1.01)	(0.21)	(0.18)
H_share	0.493**	2.006	0.184	–0.219
	(2.28)	(1.63)	(0.91)	(–0.25)
Gdp_p	–0.000	0.007***	0.002**	0.004
	(–0.30)	(3.30)	(2.03)	(1.55)
Constant	–0.190*	0.855***	–0.039	0.162
	(–1.94)	(4.94)	(–0.71)	(0.83)
Year fixed effects	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes
Observations	3,183	3,182	2,794	2,797
F test	3.39***	51.79***	4.44***	46.00***
Adj-R^2	0.0278	0.378	0.044	0.373

Note: The t-values adjusted at the company level are reported in parentheses; *, ** and *** indicate significance levels of 10%, 5% and 1%, respectively.

5.5. The economic consequences of employee salary comparison

Based on the main logic of this paper, employee salary comparison is intended to alleviate employees' sense of unfairness and dissatisfaction, but further analysis is needed to determine whether it can effectively motivate employees. If employee salary comparison is an effective incentive, raises will promote future performance and operating efficiency. However, if employee salary comparison can only alleviate unfair salary adjustment, raises will not affect future performance and operating efficiency.

To test whether giving raises that reflect salary increases in other companies in the same group is an efficient incentive, we use model (2):

$$Performance_i = \beta_0 + \beta_1 Pay\_I_i + \beta_2 Compare_i + \beta_3 Pay\_I_i * Compare + \sum Control_i + \varepsilon_i \quad (2)$$

Corporate performance (*Performance*) is measured by net profit margin (*ROA*) and annual stock return (*Ret*). To ensure the robustness of our conclusion, we test performance in the next year and the year after. We examine the coefficients of the interaction term (*Pay_I*Compare*). If β_3 is significantly positive, this means that giving raises in response to raises at other companies can improve enterprise performance and provide an effective incentive. If β_3 is not significant, this means that the incentives are ineffective. The results are shown in Table 12. The interaction *Pay_I*Compare* is not significant whether the dependent variable is accounting performance or market return of the next year and the year after. Therefore, the results in Table 12 show that giving raises in response to raises at other companies is not an efficient incentive.

6. Conclusion

This paper takes A-share state-owned group-controlled listed companies from 2008 to 2018 as a research sample to empirically test employee salary comparison and the specific impact mechanism. The results show that when the salary level of employees of a member enterprise in the group increases significantly, the salary level of employees of other member enterprises in the group will increase significantly in the next year, indicating that the enterprise engages in employee salary comparison. Further analysis shows that when employees have a stronger sense of salary unfairness, employees are more important and enterprises have stronger ability to pay, the effect of employee salary comparison is stronger. The economic consequence test shows that employee salary comparison does not improve an enterprise's future financial performance and market return, which indicates that the salary adjustment is ineffective. These conclusions remain robust across multiple robustness tests, including PSM, controlling firm fixed effects and ruling out alternative explanations.

The research conclusion of this paper has important theoretical value. Unlike previous research on the interactions between the financial behaviors of enterprise group subsidiaries, this paper analyzes employee salary comparison from the perspective of employees, thus expanding the research perspective on enterprise groups. In addition, unlike the literature, which focuses on the absolute salary level of employees, this paper enriches the research on the factors influencing employee salary from the perspective of psychology, which provides a useful reference for future research into employee salary motivation.

The findings also have practical significance in two areas. First, they provide insights into the business activities of enterprise groups in emerging economies. As an important organizational form in developing countries, enterprise groups play an important role in China's economic development. It is of value to explore their operating characteristics to improve their capital operation efficiency. Our research provides a unique perspective for understanding changes in labor costs within the group and gives a more comprehensive analysis of the internal operation mechanism of the enterprise group. Second, this paper provides guidance for the reform of the salary system in SOEs. An improved incentive mechanism will stimulate employees' creativity and strengthen SOEs. It is important to promote the healthy development of enterprise groups through well-considered salary design. Our research shows that increases in employee salaries in state-owned groups may be due to employee salary comparison, which does not play an incentive role. Therefore, in future salary reform, it is necessary to improve the linkage between salary and benefits and provide institutional support to improve the production and operation efficiency of SOEs.

Declaration of Competing Interest

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

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Standardization of the strategy translation process, procedural fairness in budgeting and firm performance

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ABSTRACT

This paper studies the effect of the standardization of the strategy translation process on procedural fairness in budgeting and firm performance. Analysis of 250 valid questionnaires using a structural equation model shows that the strategy translation process (STP) affects firm performance not only directly but also indirectly, through budget participation and procedural fairness in budgeting. This study enriches the literature on the economic consequences of strategic performance measurement systems and expands research on procedural fairness in budgeting and the factors influencing firm performance. This study shows that the standard translation and implementation of strategy will decrease managers' bias in the target-setting process, thus increasing manager's sense of fairness in the budget process and ultimately improving firm performance.

1. Introduction

Strategy translation is the process of translating strategy into an action plan for enterprises to guide their operation, coordinate organizational resources and realize strategy (Kaplan and Norton, 2008). According to Kaplan and Norton (2008), the standard strategy translation process can be divided into five steps: (1) establishing strategic themes and objectives (strategy formulation), (2) designing performance measures, (3) setting a target, (4) formulating an action plan and (5) budgeting (the process of transforming capital and business plans into accounting numbers). The strategy translation process is a key part of strategic performance

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measurement systems (Bisbe and Malagueño, 2012), which are management control systems that provide managers with financial and non-financial indicators covering various perspectives that enable them to transform organizational strategy into a coherent set of performance indicators (Chenhall, 2005). Bisbe and Malagueño (2012) state that strategic performance measurement systems (1) integrate long-term strategic and operational objectives, (2) provide multiple levels of performance measures, (3) ensure a coherent process of strategic translation, which provides goals, metrics, targets and action plans for each level of strategic performance measures, and (4) establisha clear causal relationship between goals and performance measures.

The concepts of strategic performance measurement systems and the strategy translation process are also applied in the design of institutional policy and guidelines. For example, the Ministry of Finance of the People's Republic of China issued the Guidelines for the Application of Management Accounting No. 101 – Strategic Map in 2017, dividing the work of strategy translation into strategic goal setting, strategic key performance indicator decomposition and responsibility signing. In an announcement,[1] Certified Management Accountant (CMA) emphasizes the consistency between top-level strategy and managers' adoption of action plans, and it regards the causal linkage between financial and non-financial measures as an important step in strategic translation. Studies focus on the impact of strategic performance measurement system on organizational performance (Burney and Widener, 2007; Gimbert et al., 2010; Bisbe and Malagueño, 2012), as well as on the characteristics of strategic performance measurement systems, such as the causal linkage of performance measures (Farrell et al., 2012; Li et al., 2020), However, no studies consider the application of the strategy translation process and its effects.

It is necessary to study the standardization of the strategy translation process. In the standard strategic translation process, each of the steps—goal, performance measure, target, action plan and budget—is the premise of the next step and has a positive effect on enterprise performance. First, the standard strategy translation process provides a unified communication framework for strategic information and helps to legitimate strategic decision-making within the organization (Langley, 1988; Chenhall, 2005). It can help managers establish internal information and technology networks and encourage them to think about future development and improve enterprise performance through communication and coordination on strategic issues (Langley, 1988). Second, as a part of the strategic performance management system, the standard strategy translation process can help organizations obtain multiple perspectives on performance, clearly express the cross-perspective relationships between performance measures, actions and expected results (such as market structure, the nature of customer needs, the deployment of organizational assets) and incorporate more comprehensive measures to improve performance (Vandenbosch and Huff, 1997). However, Grafton et al. (2010) find that when the superior pays attention to performance measures in the strategy translation process, the subsequent action plan and budget plan may focus too much on these performance measures, leading to management ignoring the improvement of some important aspects of strategy, which is ultimately harmful to the overall performance of the enterprise. How the standardization of the strategy translation process affects enterprise performance is an unanswered question.

It valuable to study the effect of the standardization of the strategy translation process on Chinese enterprises. Chinese enterprises do not have a fully comprehensive performance measurement system reflecting the growth of enterprise value because of many endogenous factors, such as the market environment and labor market (Wang, 2008). In strategic performance measurement systems, budgeting is often regarded as an important step (Chenhall, 2005). However, China is a traditional Confucian society, and Chinese enterprises are generally considered to have high power distance (Hofstede, 1991)—that is, the superior has considerable authority over the subordinate. In most Chinese enterprises' budgeting process, the subordinates simply receive the numbers assigned by their superiors (Yang, 2020). Subordinates rarely participate in the confirmation of budget objectives, which can lead them to doubt the procedural fairness of the enterprise's budget, and thus to reduce the enterprise's operating performance (Sun et al., 2017). The standardization of the strategy translation process would help subordinates better understand the relationship between strategy and budgeting and more actively participate in the budget, which would improve their perception of the fairness of budget procedures and their working effort, ultimately improving organizational performance.

[1] Announcement on Management Accounting, Strategic Alignment for Driving Superior Business Results, May 2018.

Budgeting is a widely used management accounting tool in Chinese enterprises (Gao and Tang, 2007). However, in Chinese enterprises, the disconnect between strategy-making and budgeting is severe (Yang, 2020). If the formulation of the budget cannot be organically combined with the enterprise's strategy, the enterprise's budgeting process will be based solely on data computing instead of the discussion on strategy, which leads to a lower level of trust in the budget. In Chinese enterprises, high power distance means that the superior decides the budget and the subordinate obeys, which can lead to the subordinate's pseudo-participative in budgeting (Argyris, 1952; Sun et al., 2017). The standard strategic translation process from strategic formulation to budgeting not only highlights the connection between strategy and budgeting but also requires the subordinate to determine the action plan according to the strategy and prepare the budget according to the action plan. In this way, the subordinate is not only the recipient of the budget but also an active participant in the budgeting process. Studies show that budget participation can improve subordinates' perceptions of budgeting fairness (Lau and Tan, 2006), and procedural fairness in budgeting is an important mechanism to prevent Chinese-style false budgets (Sun et al., 2017). The standard strategy translation process should be able to improve procedural fairness in budgeting and thus improve firm performance.[2]

This paper studies the effects of the standardization of the strategy translation process on procedural fairness in budgeting and firm performance. The results regarding the standardization of the strategy translation process are as follows. First, it has a positive direct effect on firm performance. Second, the relationship between standardization of strategy translation process and firm performance is positively mediated by budget participation and procedural fairness in budgeting. The above results hold when we use alternative measurement instruments for the degree of standardization of the strategy translation process.

This paper contributes to the literature in the following three ways. First, the paper provides empirical evidence regarding the consequences of strategy translation, thus enriching the literature on strategic performance measurement systems. Studies focus on strategic performance measurement systems (e.g., Burney and Widener, 2007; Gimbert et al., 2010; Bisbe and Malagueño, 2012) and the causality of performance measures (Farrell et al., 2012; Li et al., 2020), but no research focuses on the strategy translation process. This paper finds that the standardization of the strategy translation process affects firm performance both directly and indirectly through procedural fairness in budgeting, thus providing empirical evidence of the economic consequences of the strategy translation process and enriching the literature on strategic performance measurement systems.

Second, this paper expands related research on budgeting. Although the relationship between strategic management and budgeting is extensively researched (e.g., Kaplan and Norton, 2001, 2008; Gao and Tang, 2010; Yang, 2020), there are no empirical studies examine the impact of the strategy translation process on budgeting. This paper finds that the standardization of the strategy translation process has significant effects on budget participation and procedural fairness in budgeting, thus providing empirical evidence for the theoretical connection between strategic performance measurement systems and budgeting and expanding the literature.

Finally, this paper enriches the literature on the factors that influence procedural fairness in budgeting. Studies show that factors such as budget participation and information system integration affect the fairness of budget procedures (Lindquist, 1995; Wentzel, 2002; Lau and Tan, 2006; Sun et al., 2017). This paper finds that the standardization of the firm strategy translation process affects procedural fairness in budgeting, thus enriching the literature on the factors affecting procedural fairness in budgeting and providing practical implications for Chinese enterprises to improve their budget process.

2. Literature review

2.1. Strategic performance measurement systems and the strategy translation process

Strategic performance measurement systems collect, process and analyze quantitative performance information and report it to decision-makers in a concise form to support organizational decision-making

[2] "Budgeting" in the strategy translation process focuses on the budget preparation process, and "procedural justice" is managers' perception of the fairness of this process. The two are not subordinate or mechanically related, but are different constructs.

(Chenhall, 2005), and the balanced scorecard is considered a typical strategic performance measurement system (Bisbe and Malagueño, 2012). Strategic performance measurement systems help to transform strategy into objectives and performance measures, which can be clearly communicated within the organization to eliminate the gap between the company's strategic vision and its operational activities (Kaplan and Norton, 2008) and support the decentralization of power while maintaining strategic alignment within the organization.

Studies provide evidence of the effect of strategic performance measurement systems on firm performance. Burney and Wiener (2007) show that the application of a strategic performance measurement system can increase work-related information, reduce perceived responsibility conflict and ambiguity and improve performance. Gimbert et al. (2010) show that the application of a strategic performance measurement system will lead to more frequent strategy formulation and more comprehensive strategic agendas. Bisbe and Malagueño (2012) show that the application of a strategic performance measurement system positively affects organizational performance and find that when the variability of the environment is low, the comprehensiveness of the strategy planning process (e.g. the number of strategic objectives, performance measures, targets and areas involved in the action plan) positively affects firm performance.

According to Kaplan and Norton (2008), the standard strategy translation process can be divided into five steps: establishing strategic themes and objectives, designing performance measures, setting targets, formulating strategic action plans and budgeting. The first four steps are abstracted as the strategic execution sequence (proposed by Bisbe and Malagueño, 2012) in a strategic performance measurement system, which is composed of strategic objectives, performance measures, target values and action plans, and the fifth step is a form of strategic budgeting. As Chenhall (2005) points out, strategic performance measurement systems have essential differences: some are only combinations of financial and non-financial measures, whereas others can establish the relationship between operation and strategy. Therefore, it is of great significance to investigate the effects of the specific characteristics of strategic performance measurement systems on the organization.

2.2. Procedural fairness in budgeting

Studies on procedural fairness in budgeting mainly focus on the effect of budget participation. Lindquist (1995) uses procedural justice theory to explain the uncertainty in the relationship between budget participation satisfaction and performance. The study finds that if budget participants are allowed to express their opinions in the process of budget setting, their job satisfaction and performance are significantly higher than those of employees who are not allowed to participate in budget setting. On the basis of Lindquist (1995), Libby (1999) proposes that as enterprises have limited resources and not all budget requirements can be met, fairness is particularly important in the budget allocation process. Lau and Lim (2002) argue that when subordinates think that the budget process is unfair, budget participation plays a more positive role in improving firm performance. Wentzel (2002) finds that participation in the budget process can improve managers' understanding of how to determine budget allocation. This understanding promotes information justice, which is an aspect of procedural justice. Thus, budget participation and procedural justice in budgeting are positively related. The characteristics of the enterprise information system can also affect procedural fairness in budgeting. For example, Sun et al. (2017) find that the integration level of the information system can positively affect procedural fairness in budgeting, thus improving firm performance.

Numerous researchers examine the economic consequences of procedural fairness in budgeting, including the effects of procedural fairness on employees' work pressure, budget slack and budget goal commitment. Lau and Tan (2006) study the relationships between employees' budget participation, procedural justice, trust and job stress and find that employees' budget participation improves their sense of fairness, thus reducing their job stress. Maiga and Jacobs (2007) find that procedural fairness and trust have significant positive effects on budget goal commitment, thus reducing managers' motivation to have budget slack. Sholihin et al. (2011) find that procedural fairness positively affects the relationship between budget participation and goal commitment by promoting interpersonal trust. However, Groen (2018) finds that budget participation can positively affect budget goal commitment through distributive fairness and informative fairness, however, no mediation effects were found on interpersonal fairness, procedural fairness and budget goal commitment.

This analysis of the literature indicates that procedural justice plays an important role in budgeting, which reduces employees' work pressure, weakens budget slack motivation and enhances budget goal commitment,

and that these effects mainly come from the mediation effect exerted through budget participation. Budget participation and information system integration are the main factors affecting procedural justice in budgeting. No studies consider how the strategic performance measurement system affects procedural justice in budgeting.

3. Hypothesis development and conceptual model

3.1. The strategy translation process and firm performance

The standard strategy translation process can improve the fit between the manager and the organization, thus improving firm performance. The theory of person–organization fit holds that individuals and organizations need to align in terms of culture, values, atmosphere, goals and established habits (Kristof, 1996). In the standard strategy translation process, managers' budget objectives are related to firm strategy, and they recognize the relationship between their own interests and the firm's objectives, which increases the fit between individual and organizational objectives. In addition, the establishment of strategic objectives, performance measures and targets is related to managers' performance evaluations and compensation, which motivates them to establish long-term relationships with the enterprise and cultivate a culture, habits and values that fit with the organization. In addition, the degree of an individual's acceptance of organizational goals indicates his or her agreement with the organization (Vancouver and Schmitt, 1991). When managers do not understand the organization's priorities, misunderstandings may lead them to engage in low-priority activities and negatively affect their commitment to work, thus hurting the firm's performance. Without understanding the organization's values and priorities, it is difficult for managers to assess whether these values and priorities are suitable, and they will experience more pressure in their work.

In the strategy translation process proposed by Kaplan and Norton (2008), each step provides the basis for the next: for example, the setting of strategic objectives provides the basis for the selection of performance measures, and the target-setting process provides the basis for budget preparation. Superior managers can develop a clear business plan through the above strategic goal-setting process, and subordinate managers can more clearly understand the business goals set by their superiors and confirm them through the budget, which will contribute to the achievement of strategic consensus between superiors and subordinates. In this process, in-depth integration of and fit between the organization's and managers' goals play important roles in the strategic performance measurement system and exert a positive effect on the organization (Ho et al., 2014). Firm managers' consensus on strategic goals can improve the firm's performance by improving the success rate of strategy implementation (West and Schwenk, 1996; Dooley et al., 2000). Based on the above analysis, this paper proposes the following hypothesis:

H1: The standardization of the strategy translation process is positively related to firm performance.

3.2. The strategy translation process and procedural fairness in budgeting

Procedural fairness means that the process of producing results is fair (Lind and Tyler, 1988). Leventhal (1980) defined procedural fairness as involving six principles: consistency, bias suppression, accuracy, correctability, representativeness and ethics. The impact of the strategy translation process on procedural fairness in budgeting is first reflected in the inhibition of managers' bias. When enterprises carry out strategic implementation according to the standard strategy translation process, they need to fully discuss the strategic objectives, performance measures, targets and action plans to form a budget plan. This process helps to strengthen communication between the superior and the subordinate and requires subordinate managers to be more involved in the process of budget preparation and formulation. Budget participation can improve interpersonal relationships at all levels of the organization (Sholihin et al., 2011) and reduce the possibility of decision-making mistakes resulting from the subjective bias of the superior. In addition, when individuals encounter unfavorable decisions, decision makers give reasonable explanations for their decisions, which helps

to eliminate the individual's "worst" interpretation of decision makers' motives and intentions (Bies, 1987), thus enhancing the ethicality of the budget process.

In addition, under the standard strategy translation process, budget objectives and their corresponding performance measures are consensus indicators reached by superiors and their subordinates based on extensive communication, thus enhancing consistency and representativeness in the budget process. Finally, the transparency of performance measures determines how effectively they can guide managers to explore the problems in strategy making and adjust their strategy in a timely manner (Choi et al., 2012). The standard process of strategy translation can help enterprises make clear strategic focus and set up relevant assessment measures. By the improvement of the transparency of performance measures, the accuracy and correctability of the budget process will also be guaranteed. Based on the above analysis, this paper proposes the following hypothesis:

H2: The standardization of the strategy translation process is positively related to the procedural fairness of budgeting.

3.3. Strategy translation process and budget participation

Shields and Shields (1998) point out that researchers should focus not only on the effects of budget participation but also on the antecedents of budget participation. Information asymmetry (Shields and Young, 1993), work interdependence (Shields and Shields, 1998) and environment and work uncertainty (Shields and Shields, 1998) affect budget participation. In the strategy translation process, target setting is an important step before budget planning (Kaplan and Norton, 2008). If subordinates participate in setting performance targets, they will know how to align the performance measures with firm's strategy, make business plans according to the firm's strategy and make detailed budget for these business plans. In the standard strategy translation process, the firm determines the performance evaluation measures and their target values (including their budget objectives) based on their strategic objectives (Kaplan and Norton, 2008).

Under this mechanism, the demand for strategic managers and operators to share information will increase. When managers at the operation level propose budget objectives, they must obtain information from managers at the strategic level to understand the strategy, while to set reasonable and achievable strategic goals, managers at the strategic level must obtain information from management at the operation level. Budget participation is an important way for superior managers to obtain work-related information from their subordinates. The need for information sharing will promote budget participation (Shields and Shields, 1998; Shields and Shields, 1998). Therefore, when a firm's strategy translation process is in line with the standard process, the budget participation of managers at all levels will be higher than in other situations. Based on the above analysis, the following hypothesis is proposed:

H3: The standardization of the strategy translation process is positively related to the level of budget participation

Because studies find that budget participation affects procedural fairness in budgeting (Lindquist, 1995; v) and that procedural fairness in budgeting can affect corporate performance (e.g. Lau and Tan, 2006; Sun et al., 2017), this paper does not propose these two paths as hypotheses; however, we test these paths in the structural equation model, which is shown in Fig. 1.

4. Research design

4.1. Sample selection

This paper uses a survey questionnaire to collect data to test the research hypotheses. Before sending out the questionnaire, the research team interviewed the financial director of an enterprise about the strategy translation process and revised the questionnaire according to the interview. Then, the researchers sent the pilot version of the survey to three corporate finance directors and two accounting professors for their sugges-

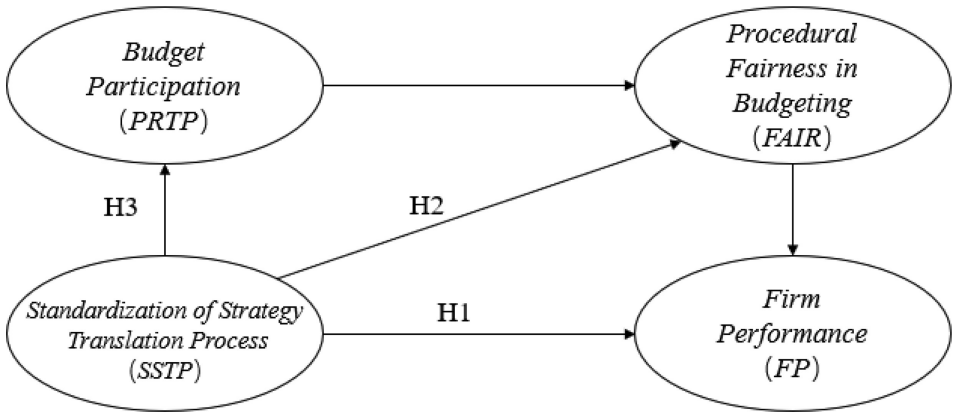

Fig. 1. Structural Equation Model.

tions, and further revisions were made. Finally, the questionnaire was distributed to the managers of Chinese enterprises in June 2017. Through alumni relationships with the Research Institute and cooperation with practitioners, we obtained a list of managers from various industries and levels. Then, the researchers contacted the respondents, who agreed to complete the questionnaire. The questionnaire was distributed in five batches. Before each distribution, one research assistant added the batch of respondents to a WeChat group with their consent, and then the questionnaire was distributed to the group via the Survey Star applet. All of the respondents had to complete all of the scales before they could submit the questionnaire. In total, 554 questionnaires were distributed and 274 questionnaires were returned, of which 250 were valid. The total response rate was 49.46% and the effective questionnaire response rate was 45.13%. Of the 24 invalid responses, one was provided by the chairman of the board of directors, who said that he did not participate in budgeting; 9 respondents stated that enterprises' strategy translation process has nothing to do with the budget, which indicated that the questionnaire was not applicable to their work or that they had not fully understood the questions; and the other 14 questionnaires had response times of less than 7 min.

Table 1 shows the respondents' basic information. Of the respondents who returned valid questionnaires, 84.40% were a chief financial officer (CFO), head of the financial department or other financial personnel, 64.40% worked at state-owned enterprises and 28.00% worked at private enterprises. The average age of the respondents was about 40 years old; on average, they had more than 10 years of working experience and more than 5 years in their current position. This information indicates that the respondents had rich working experience and knowledge of enterprise management practice. In addition, the respondents' industries cover all 19 of the industries listed in the 2012 revised industry classification guidelines issued by the CSRC.

4.2. Measurement instrument

The main explanatory variable is the standardization of the strategy translation process (SSTP). This paper refers to the method of Gimbert et al. (2010) to capture the characteristics of individual enterprises' strategy translation process. The questionnaire developed by Gimbert et al. (2010) asks respondents whether the performance evaluation system clearly includes (1) strategic objectives, (2) performance measures, (3) target setting and (4) action plans. However, studies do not fully discuss the effects of the order of these four factors on enterprises (Gimbert et al., 2010; Bisbe and Malagueño, 2012). Referring to Kaplan and Norton's five-step strategy translation process (2008), this paper adds budgeting to the strategy translation process. The questionnaire asked the participants whether the following five steps are included in the enterprise management process and, if so, in what order: (1) determine the strategic objectives; (2) design the performance measures; (3) determine the target of each measure; (4) formulate the action plan; and (5) prepare the budget. On the basis of these questions, this paper defines 10 variables *(SSTP)*, *sstp_12*, *sstp_13*, *sstp_14*, *sstp_15*, *sstp_23*, *sstp_24*, *sstp_25*, *sstp_34*, *sstp_35* and *sstp_45*, to capture whether the sequence of each two of the five steps

Table 1
Respondents' basic information.

Basic information	N/Mean	Ratio
1. Job Title		
CFO	63	25.20%
Other top management	6	2.40%
Head of finance department	99	39.60%
Staff from finance department	48	19.60%
Head of business department	8	3.20%
Other staff	25	10.00%
2. Gender		
Male	111	44.40%
Female	139	55.60%
3. Size of the firm*		
Over 1000 billion	7	2.80%
100–1000 billion	22	8.80%
10–100 billion	41	16.40%
1–10 billion	82	32.80%
0.1–1 billion	64	25.60%
Less than 0.1 billion	34	13.60%
4. Ownership		
SOE	161	64.40%
Private	70	28.00%
Foreign	14	5.60%
Other	5	2.00%
5. Working experience in the current position	5.27	
6. Working experience	10.18	
7. Age	39.55	

* Firm size is measured by the total revenue of the group, if a respondent comes from a subsidiary, the size is evaluated based on the parent company's scale indicated in the survey.

is consistent with the standard process proposed by Kaplan and Norton (2008). For example, when a firm's management process clearly includes the two steps of "determine strategic objectives" and "design performance measures" and the firm first determines strategic objectives and then designs performance measures, *sstp_12* is equal to 1, and 0 otherwise. Likewise, when the management process of a firm clearly includes the two steps of "making an action plan" and "preparing a budget" and the firm first makes an action plan and then prepares a budget, *sstp_45* is equal to 1, and 0 otherwise. If the sum of the above 10 variables is equal to 10, the firm's strategy translation process is completely consistent with the standard process of Kaplan and Norton (2008).

China's state-owned enterprises have soft budget constraints (Lin et al., 2020), and the hierarchy in state-owned enterprises is significantly more solid than that in private enterprises (Deshpande and Farley, 2000). The power distance between the superior and subordinate has a substantial effect on the fairness of the budgeting process. Therefore, we take state-owned enterprises as a dummy variable in the model. The degree of firm diversification affects the comprehensiveness of performance measures (Abernethy et al., 2004) and thus the strategy translation process. We also control the degree of firm diversification as a dummy variable.[3] Asset size and industry background also affect firm performance, and we include them as dummy variables.

The other main explanatory variables are latent variables, which can be divided into reflective and formative (Bisbe et al., 2007). For the reflective latent variables, the measurement items change together and can replace each other. Eliminating one measurement item does not affect the meaning of the reflective latent variables. The formative latent variables are a series of observed variablesand eliminating one of the measurement

[3] Diversification is measured according to the respondents' judgments on a scale where the variable takes a value of 1 if the firm is not a diversified enterprise, 2 if there are 2–5 business sectors, 3 if there are 6–10 business sectors and 4 if there are more than 10 business sectors.

items will change the meaning of these latent variables. We explain the construction method of each latent variable below.

1. Budget participation (*PRTP*). This paper uses Milani's (1975) method to measure budget participation. It comprises six items scored on a 7-point Likert scale ranging from 1 (the lowest degree) to and 7 (the highest degree): (1) the degree of subordinate managers' participation in budget setting (*prtp_1*); (2) when the budget is adjusted, the superior explains the reasons to the subordinate (*prtp_2*); (3) the frequency of budget discussions initiated by subordinate managers (*prtp_ 3*); (4) the degree of subordinate managers' influence on the final budget (*prtp_4*); (5) the importance of subordinate managers' contribution to budgeting (*prtp_5*); and (6) when setting the target, the frequency with which the superior solicits opinions from the subordinate (*prtp_6*). We use the reflective approach to construct the latent variables of budget participation.
2. Procedural fairness in budgeting (*Fair*). Sun et al. (2017) propose six standards of procedural fairness based on Leventhal (1980): consistency, bias suppression, accuracy, correctability, representativeness and ethics. We also measure procedural justice based on these standards. The questionnaire asks respondents to score 21 statements related to their recognition of the 21 items in the appendix on a 7-point Likert scale ranging from 1 (the lowest degree) to 7 (the highest degree). We use the formative method to construct the latent variable of procedural fairness in budgeting.
3. Firm performance (*FP*). Referring to the method of Sun et al. (2017), this paper divides firm performance into financial and non-financial performance and uses the formative method to construct this variable. The questionnaire asks respondents to evaluate the performance of their enterprises in the past three years compared with the industry average level in terms of (1) return on total assets, (2) ratio of cash flow from operating activities to sales revenue, (2) ratio of sales cost to sales revenue, (4) ratio of the sum of sales expenses and management expenses to sales revenue, (5) growth rate of sales revenue, (6) market share, (7) R&D intensity, (8) customer satisfaction, (9) on-time delivery and (10) employee satisfaction.

4.3. Structural equation model

A structural equation model (SEM) is used to test the hypotheses. Two methods are commonly used to estimate structural equation models: the covariance-based and component-based SEM approaches. The latter uses partial least squares (PLS) estimation and is considered to be most suitable for small samples and formative models (Chin, 1998). The PLS model includes a measurement model and a structural model. In general, the conceptual model of the relationships between latent variables is defined according to the measurement model, and then the relationships between latent variables are estimated through the structural model. This procedure is used to estimate the reliability and validity of the measurement model and then to estimate the structural model. This paper uses SmartPLS 2.0 to estimate the structural model.

5. Empirical results

5.1. Measurement model

The descriptive statistics of the main variables are shown in Table 2. Panel A of Table 3 shows the loadings and cross-loadings of the observation items. Following Chin (1998), items with loadings less than 0.7 are excluded from the structural equation model. The cross-loadings of the observation items listed in panel A of Table 3 and other potential variables are less than their loadings, which conforms to the standard proposed by Chin (1998). Panel B of Table 3 shows the composite reliability (CR) value and average variance extracted (AVE) value of each latent variable. The CR values of all of the latent variables are greater than 0.7 and the AVE values are greater than 0.5. Furthermore, according to the standard proposed by Fornell and Larcker (1981), the variance shared by each latent variable and its observation item should be higher than that shared by the other latent variables. AVE represents the variance shared by the latent variable and its observation items, which reflects the convergent validity of the latent variable (Chin, 1998). The square root of AVE

Table 2
Summary statistics of the main variables.

Variable	N	Mean	SD	Min	Median	Max
SSTP						
sstp_12	250	0.788	0.410	0	1	1
sstp_13	250	0.792	0.407	0	1	1
sstp_14	250	0.780	0.415	0	1	1
sstp_15	250	0.800	0.401	0	1	1
sstp_23	250	0.368	0.483	0	0	1
sstp_24	250	0.596	0.492	0	1	1
sstp_25	250	0.464	0.500	0	0	1
sstp_34	250	0.756	0.430	0	1	1
sstp_35	250	0.696	0.461	0	1	1
sstp_45	250	0.292	0.456	0	0	1
PRTP						
prtp_1	250	3.776	1.613	1	4	7
prtp_2	250	4.104	1.528	1	4	7
prtp_3	250	3.460	1.359	1	3	7
prtp_4	250	3.332	1.393	1	3	7
prtp_5	250	4.016	1.578	1	4	7
prtp_6	250	3.848	1.443	1	4	7
Fair						
fair_b1	250	4.480	1.465	1	5	7
fair_b2	250	4.556	1.486	1	4	7
fair_b3	250	4.464	1.426	1	4	7
fair_a01	250	4.320	1.648	1	4	7
fair_a02	250	4.844	1.468	1	5	7
fair_a03	250	4.268	1.592	1	4	7
fair_a04	250	4.716	1.517	1	5	7
fair_a05	250	4.328	1.587	1	5	7
fair_a06	250	4.808	1.532	1	5	7
fair_a07	250	4.664	1.735	1	5	7
fair_a08	250	4.832	1.685	1	5	7
fair_a09	250	4.920	1.648	1	5	7
fair_a10	250	4.412	1.446	1	5	7
fair_a11	250	4.600	1.557	1	5	7
fair_a12	250	4.712	1.564	1	5	7
fair_a13	250	4.592	1.646	1	5	7
fair_a14	250	4.480	1.621	1	5	7
fair_a15	250	4.584	1.624	1	5	7
fair_a16	250	4.548	1.555	1	5	7
fair_a17	250	4.508	1.492	1	5	7
fair_a18	250	4.516	1.457	1	5	7
fair_a19	250	4.924	1.431	1	5	7
fair_a20	250	4.980	1.398	1	5	7
fair_a21	250	4.880	1.435	1	5	7
FP						
fp 1	250	4.088	1.537	1	4	7
fp 2	250	4.492	1.492	1	5	7
fp 3	250	4.264	1.395	1	4	7
fp 4	250	4.216	1.386	1	4	7
fp 5	250	4.024	1.560	1	4	7
fp 6	250	4.192	1.522	1	4	7
fp 7	250	3.588	1.741	1	4	7
fp 8	250	4.748	1.307	1	5	7
fp 9	250	5.132	1.476	1	5	7
fp 10	250	4.392	1.362	1	4	7

Table 3
Loadings and cross-loadings, construct reliability and convergent validity, Panel A: Observation item loadings and cross-loadings, Panel B: Construct reliability and convergent validity of the variables.

	FAIR	*FP*	*PRTP*	*STP*
fair_a07	**0.712**	0.281	0.391	0.202
fair_a08	**0.760**	0.362	0.467	0.196
fair_a09	**0.759**	0.392	0.463	0.185
fair_a10	**0.765**	0.352	0.478	0.168
fair_a11	**0.837**	0.416	0.479	0.227
fair_a12	**0.851**	0.404	0.537	0.256
fair_a13	**0.786**	0.372	0.493	0.103
fair_a14	**0.742**	0.395	0.470	0.164
fair_a15	**0.793**	0.387	0.514	0.116
fair_a16	**0.842**	0.435	0.552	0.115
fair_a17	**0.845**	0.434	0.571	0.149
fair_a18	**0.778**	0.494	0.508	0.118
fair_a19	**0.808**	0.399	0.499	0.100
fair_a20	**0.827**	0.404	0.504	0.103
fair_a21	**0.821**	0.410	0.491	0.105
fp_1	0.346	**0.775**	0.257	0.174
fp_2	0.365	**0.750**	0.324	0.117
fp_5	0.292	**0.740**	0.267	0.185
fp_6	0.243	**0.703**	0.207	0.113
fp_8	0.429	**0.823**	0.358	0.249
fp_9	0.426	**0.769**	0.318	0.212
fp_10	0.497	**0.819**	0.327	0.204
prtp_1	0.397	0.293	**0.754**	0.049
prtp_2	0.596	0.396	**0.785**	0.148
prtp_3	0.470	0.274	**0.810**	0.121
prtp_4	0.529	0.303	**0.842**	0.181
prtp_5	0.450	0.253	**0.813**	0.071
prtp_6	0.503	0.326	**0.792**	0.0766
sstp_12	0.143	0.196	0.140	**0.911**
sstp_13	0.220	0.255	0.160	**0.914**
sstp_14	0.167	0.206	0.111	**0.853**
sstp_15	0.132	0.185	0.074	**0.887**
	FAIR	*FP*	*PRTP*	*SSTP*
CR	0.963	0.910	0.914	0.939
AVE	0.634	0.592	0.640	0.795

Note: The bold values in Panel A indicate the loadings of the observation items, and the other values are cross-loadings.

should be higher than the correlation coefficients of the latent variables, which is consistent with the results in Table 4. The above results show that the reliability and validity of the latent variables meet the requirements.

There is no obvious sequential relationship between step 2 and the subsequent steps, as the mean values of *sstp_23*, *sstp_24* and *sstp_25* are low (0.368, 0.596 and 0.464, respectively), indicating that most enterprises do not set relevant targets after determining their performance measures and do not formulate relevant action plans and budgets based on their performance measures.

According to Spekle (2014), performance measures can be divided into exploratory use and incentive-oriented use. Exploratory performance measures are those that help organizations learn through performance feedback and find strategic growth opportunities, while incentive-oriented performance measures are those used as incentive benchmarks. The standard strategy translation process can help managers establish internal information and technology networks, consider the future development of the organization and improve enterprise performance through communication and coordination on strategic issues. Therefore, enterprises adopting the standard strategy translation process will use more exploratory performance measures.

Chinese enterprises prefer to adopt incentive-oriented rather than exploratory performance measures. For example, when Chinese state-owned enterprises set business performance targets, they mainly assess

Table 4
Coefficients of the latent variables and square roots of the AVE.

	FAIR	*FP*	*PRTP*	*SSTP*
FAIR	**0.7962**	0	0	0
FP	0.5001	**0.7693**	0	0
PRTP	0.6236	0.3900	**0.7997**	0
SPP	0.1916	0.2404	0.1411	**0.8916**

Note: The bold values in the table indicate the square root of each latent variable's AVE.

two financial indicators, earnings before tax and extraordinary items and return on equity (Du et al., 2012). The proportion of the equity incentive using the net profit growth rate as the exercise standard[4] is as high as 96.4% (Dai and Song, 2018). Few enterprises set exploratory business measures to monitor business growth and correlate the budget with the completion of non-financial performance. In the budgeting process, most Chinese enterprises directly predict their financial targets based on their historical revenue and profit status and then decompose the budget target from the strategy, which results in the low factor loadings for *sstp_23*, *sstp_24* and *sstp_25*.

To eliminate the influence of the existence of the items with factor loadings less than 0.7 on the research conclusion, we add the unsaturated factor to the structural equation model for analysis, and the results remain unchanged. For the fourth and fifth steps of the strategic transformation process, *sstp_45*, the main value is only 0.292. We therefore infer that in most Chinese enterprises, the high power of superiors over subordinates means that the budget formulation process does not follow the action plan developed based on the strategy. A budget is set first, and then an action plan is formulated according to the budget. This is fully proved by the relevant literatures (Wang, 2008; Yang, 2020) and our research.

5.2. Results for the structural equation model

The path analysis results for the structural equation are shown in Table 5 and Fig. 2. The estimated coefficient of the path $SSTP \rightarrow FP$ is 0.150, which is significantly positive at the 1% level, indicating that the strategy translation process has a direct effect on procedural fairness in budgeting. Hypothesis 1 is thus supported. The estimated coefficient of the path $SSTP \rightarrow FAIR$ is 0.106, which is significantly positive at the 1% level, indicating that the strategy translation process has a direct effect on procedural fairness. Hypothesis 2 is thus supported. The estimated coefficient of the path $SSTP \rightarrow PRTP$ is 0.141, which is significantly positive at the 1% level, indicating that the strategy translation process can enhance fairness in the budget process. Hypothesis 3 is thus supported. The estimated coefficient of the path $PRTP \rightarrow FAIR$ is 0.610, which is significantly positive at the 1% level, indicating that the strategy translation process promotes procedural fairness in budgeting by exerting a positive effect on budget participation (*PRTP*), an intermediary variable between the strategy translation process and procedural justice in budgeting. Consistent with previous studies (e.g., Wentzel, 2002; Maiga and Jacobs, 2007), the estimated coefficient of the path $FAIR \rightarrow FP$ is 0.471, which is significantly positive at 1% level, indicating that procedural fairness in budgeting can positively affect firm performance.

5.3. Robustness check

To ensure the robustness of the research results, we changed the measurement method and used the method of Gimbert et al. (2010). In the resulting questionnaire, we asked the respondents whether the performance evaluation system of their units clearly contain five elements: strategic objectives, performance measures, target values, action plans, and a budget. The number of elements (1–5) reported is defined as *SEQ*, which reflects

[4] Refer to the relevant performance target that one needs to achieve to obtain the equity incentive. For example, the Qifan Cable (605222) clearly stated in the draft of equity incentive in that the performance assessment objective of restricted shares at the end of the first restricted sale period is " The net profit of the company in 2021 shall not be less than 120% of the base period in 2020. ".

Table 5
Path model results.

	Estimated coefficient	Mean value of estimated coefficient	SD	T	Hypothesis
SSTP → FP	0.150***	0.154	0.056	2.687	H1
FAIR → FP	0.471***	0.478	0.051	9.202	
PRTP → FAIR	0.610***	0.614	0.040	15.090	
SSTP → FAIR	0.106***	0.107	0.050	2.099	H2
SSTP → PRTP	0.141***	0.146	0.061	2.313	H3

Note: The bootstrap sample size is 1000.
*** Indicate significance at the 1% level.

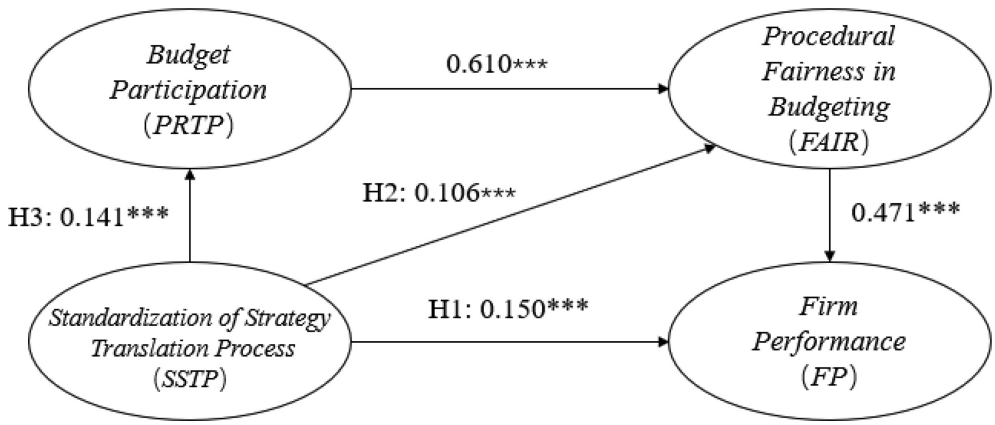

Fig. 2. Results for the Structural Equation Model.

whether the five steps of the strategic transformation process of Kaplan and Norton (2008) are explicitly included in the firm performance evaluation system. However, *SEQ* cannot reflect the sequence of these steps. After replacing *SSTP* with *SEQ*, the main results for the structural equation model remain significant, as shown in Table 6.

5.4. Additional analysis

In certain situations, improving financial performance may come at the expense of non-financial performance (for example, R&D and employee satisfaction might be negatively related to ROA). To mitigate the tradeoff between financial and non-financial performance, we separate these types of performance and run the SEM model again. The results in Table 7 show that *SSTP* and *Fair* are no longer significantly related to financial performance (the t-values are 0.338 and 0.313, respectively), but they are still significantly related to non-financial performance (with t-values of 2.404 and 8.165, respectively). Non-financial performance has a significant positive effect on financial performance (t = 18.278). The results show that the standardized strat-

Table 6
Robustness check.

	Estimated coefficient	Mean value of estimated coefficient	SD	T	Hypothesis
FAIR → FP	0.4523***	0.4578	0.049	9.2245	H1
PRTP → FAIR	0.5978***	0.6016	0.0424	14.106	
SEQ → FAIR	0.0955*	0.0902	0.0555	1.7214	H2
SEQ → FP	0.1854***	0.1847	0.0557	3.3277	
SEQ → PRTP	0.2679***	0.2668	0.0625	4.2886	H3

Note: The bootstrap sample size is 1000.
*** Indicate significance at the 1% level.

Table 7
Additional analysis separating financial and non-financial performance.

	Estimated coefficient	Mean value of estimated coefficient	SD	T
FAIR → FFP	0.017	0.012	0.050	0.338
FAIR → FNFP	0.447***	0.445	0.055	8.165
FNFP → FFP	0.748***	0.752	0.041	18.278
PRTP → FAIR	0.601***	0.602	0.043	14.136
SSTP → FAIR	0.125***	0.131	0.052	2.395
SSTP → FFP	−0.014	−0.010	0.044	0.313
SSTP → FNFP	0.141***	0.148	0.059	2.404
SSTP → PRTP	0.180***	0.197	0.062	2.885

egy translation process has positive effects on non-financial performance and, ultimately, on financial performance. The results indicate that non-financial performance mediates the relationship between the strategy translation process and the firm's financial performance.

6. Conclusion and discussion

6.1. Conclusion

This paper uses the sequence of strategic objectives, performance measures, target values, action plans and budgeting to capture the differences in the strategy translation process and uses a structural equation model to analyze the questionnaire data to investigate the effects of the strategy translation process on firms' performance and procedural fairness in budgeting. The results show that consistency in the strategy translation process with strategic objectives, performance measures, target setting, action plans and budgeting directly and positively affects firm performance and that consistency in the standard strategy translation process positively affects procedural fairness in budgeting directly or indirectly through the mediating effect of budget participation. This result holds when the degree of standardization of the strategy translation process is replaced with the strategic decision-making sequence proposed by Gimbert et al. (2010). The findings of this paper suggest that in management practice, when the formulation of performance measures, setting of target values, formulation of action plans and budgeting are based on the enterprises' strategic objectives, superior managers can provide clearer explanations for the budget value, enabling subordinate managers to better understand how to set the target and thus increasing their perception of the fairness of the budget process. In addition, enterprises can integrate the strategy translation process into the budgeting process to form an effective management mechanism to improve firm performance.

6.2. Discussion

We observe that when conducting strategy translation, most Chinese firms have concrete strategy plans, but in the following steps proposed by Kaplan and Norton (2008), the strategy translation process is less structured. More specifically, most Chinese firms do not have strategic performance metrics to link the firm's strategy with the performance target, action plan and financial budget, leading to low mean values of *sstp_23*, *sstp_24* and *sstp_25*. Therefore, the second step proposed by Kaplan and Norton (2008), to formulate and use performance measures that are strategically aligned, seems to be the most important step for Chinese enterprises to implement strategy.

Another notable finding concerns the sequence between the action plan and the budget. The mean value of *sstp_45* is fairly low, indicating that most Chinese enterprises use a less effective sequence in their strategy translation process, in which they do not formulate their budget according to their action plan, but create the budget first and then decide the action plan. We infer that this phenomenon is caused by the high power distance between subordinates and superiors in Chinese culture, where more powerful superiors formulate the budget before listening to subordinates' action plan.

This process is problematic because the budget may lose its role of adjusting the resource plan according to the changes in the firm's business environment and become a controlling device that guides the business based

on preset numbers. We therefore suggest that more Chinese enterprises adjust their action plans more frequently according to their strategy changes and use rolling forecasts so that their budgets can be formed based on the moving action plan to incorporate more changing variables in a more dynamic environment and to improve strategy translation processes.

The findings of this paper can provide practitioners with a better understanding of the relationship between budget and strategy and provide inspiration for improving the budgeting process. The practical implication of the results is that setting a reasonable strategy translation process can help enterprises to prepare their budgets fairly and thus help managers achieve higher performance. These findings have reference value for policymakers who determine the application guidelines of management accounting. The findings also clarify the relationship between the Application Guidelines of Management Accounting No. 100 – Strategic Management, No. 101 – Strategic Map and Application Guidelines of Management Accounting and No. 200 – Budget. The findings of this study also show that the strategy translation process has a positive effect on budgeting behavior. Strategic mapping can play a valuable role in the strategy translation process and strengthen the relationship between strategy and budgeting. Enterprises should therefore use the above three application guidelines in combination.

Declaration of Competing Interest

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

Appendix. Measurement items

Variable	Definition
Standardization of Strategy Translation Process (SSTP)	
sstp_12	When a firm's management process clearly includes the two steps of "determine strategic objectives" and "design performance measures" and the firm first determines its strategic objectives and then designs performance measures, it takes a value of 1, and 0 otherwise.
sstp_13	When a firm's management process clearly includes the two steps of "determine the strategic objectives" and "set target value" and the firm first determines its strategic objectives and then sets the target value, it takes a value of 1, and 0 otherwise.
sstp_14	When a firm's management process clearly includes the two steps of "determine strategic objectives" and "formulate action plan" and the firm first determines its strategic objectives and then formulates its action plan, it takes a value of 1, and 0 otherwise.
sstp_15	When a firm's management process clearly includes the two steps of "determine strategic objectives" and "prepare a budget" and the firm first determines its strategic objectives and then prepares its budget, it takes a value of 1, and 0 otherwise.
sstp_23	When a firm's management process clearly includes the two steps of "design performance measures" and "set target value" and the firm first designs performance measures and then set the target value, it takes a value of 1, and 0 otherwise.
sstp_24	When a firm's management process clearly includes the two steps of "design performance measures" and "formulate action plan" and the firm first designs performance measures and then formulates an action plan, it takes a value of 1, and 0 otherwise.
sstp_25	When a firm's management process clearly includes the two steps of "design performance measures" and "prepare a budget" and the firm first designs performance measures and then prepares its budget, it takes a value of 1, and 0 otherwise.
sstp_34	When a firm's management process clearly includes the two steps of "set target value" and "formulate action plan" and the firm first sets its target value and then formulates its action plan, it takes a value of 1, and 0 otherwise.

sstp_35 When a firm's management process clearly includes the two steps of "set target value" and "prepare a budget" and the firm first sets a target value and then prepares a budget, it takes a value of 1, and 0 otherwise.

sstp_45 When a firm's management process clearly includes two steps of "formulate action plan" and "prepare a budget" and the firm first formulates an action plan and then prepares a budget, it takes a value of 1, and 0 otherwise.

SEQ "How many of the following procedures do your enterprise's performance measurement system clearly include: (1) strategic objectives, (2) performance measures, (3) target value, (4) action plan, (5) budgeting?"

Budget Participation (PRTP)

prtp_1 "The extent to which subordinate managers participate in budget-setting."

prtp_2 "The sufficiency of the superior's explanation to the subordinate of the reasons for budget adjustments."

prtp_3 "The frequency of budget discussions initiated by subordinate managers."

prtp_4 "The influence of subordinates on the final budget."

prtp_5 "The importance of subordinate managers' contribution to budgeting."

prtp_6 "The frequency with which superiors seek advice from subordinates when setting targets."

Procedural fairness in budgeting (Fair)

fair_01 "Budget planning procedures are applied consistently across all business units."

fair_02 "Budget planning procedures are applied with clear timeline."

fair_03 "Budget decision maker don't favor one business unit over another when the budget is decided."

fair_04 "We prepare the budget based on accurate information."

fair_05 "The current budget process contains provisions that allow us to appeal the budget set for our business units."

fair_06 "The current budget planning procedures adequately represent the concerns of all business units."

fair_07 "The current budget planning procedures conform to my own standards of ethics and morality."

fair_08 "Budget control procedures are applied consistently across all business units."

fair_09 "Budget control procedures are applied with clear timeline."

fair_10 "The budget decision maker doesn't favor one business unit over another when the budget is controlled."

fair_11 "We set the budget based on accurate information."

fair_12 "The current budget process contains provisions that allow us to appeal the budget decision maker's budget control behavior."

fair_13 "The current budget control procedures adequately represent the concerns of all business units."

fair_14 "The current budget control procedures conform to my own standards of ethics and morality."

fair_15 "Budget evaluation procedures are applied consistently across all business units."

fair_16 "Budget evaluation procedures are applied with clear timeline."

fair_17 "The budget decision maker doesn't favor one business unit over another when performance is evaluated."

fair_18 "We evaluate performance based on accurate information."

fair_19 "The current budget process contains provisions that allow us to appeal the performance evaluation behavior of the budget decision maker"

fair_20 "The current budget evaluation procedures adequately represent the concerns of all business units."

fair_21 "The current budget evaluation procedures conform to my own standards of ethics and morality."

Firm Performance (FP)

fp _1 Total return of investment on assets (ROA)

fp_2 Cash flow from operating activities/sales revenue

fp_3 Cost of sales/revenue from sales

fp_4 (Sales expenses + management expenses)/sales revenue

fp_5 Growth rate of sales revenue

fp_6	Market share
fp_7	R & D intensity (R & D investment/sales revenue)
fp_8	Customer satisfaction
fp_9	On-time delivery
fp_10	Employee satisfaction

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Does an abnormal change in deferred tax assets interfere with analysts' earnings forecasts?

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ABSTRACT

In 2007, China adopted the single balance sheet liability method for tax accounting, but its shortcomings have emerged. I sample A-share listed companies from 2007 to 2018 to study whether an abnormal change in deferred tax assets interferes with analysts' earnings forecasts and find that an abnormal change in deferred tax assets increases the error and divergence of these forecasts. Compared with a negative abnormal change in deferred tax assets, a positive abnormal change has a greater impact on earnings forecasts. Additionally, the level of corporate governance, audit quality and analysts' professional ability have moderating effects on the correlation between an abnormal change in deferred tax assets and earnings forecasts. However, an abnormal change in deferred tax liabilities does not have a significant impact on that correlation.

1. Introduction

Accounting standard-setting bodies such as the Financial Accounting Standards Board (FASB) and the International Accounting Standards Board (IASB) believe that the balance sheet liability method based on the asset–liability view is more useful for valuation than other income tax accounting treatment methods such as the tax payable method, which is helpful for achieving the financial reporting goal of "decision usefulness" and better serves the users of financial reports. As accounting standards converge internationally, Chinese accounting standards for business enterprises are aligning with international accounting standards. CAS-18 (*Income Taxes*) indicates that Chinese enterprises should adopt the single balance sheet liability method for income tax accounting, a requirement that has had a significant impact on the financial statements of Chinese listed companies. One of the most obvious effects of CAS-18 is that following their adoption of the balance

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sheet liability method, the deferred tax assets of Chinese listed companies are rapidly increasing year by year (Dai et al., 2013a). Studies show that when using the balance sheet liability method, deferred tax information is of incremental "relevance" (Guenther and Sansing, 2004; Chen et al., 2009; Chludek, 2011; Dai et al., 2013a; Laux, 2013).

However, many studies point out that the balance sheet liability method is overly complex (Chen and Schoderbek, 2000; Zhou et al., 2017) and subjective (Dai et al., 2013b). Zhou (2011) questions the method's rationality and proposes that the deferred tax assets and deferred tax liabilities it generates are inconsistent with traditional concepts of assets and liabilities, rendering the method highly misleading. In addition, many studies find that enterprises may use deferred tax information for profit manipulation purposes (Phillips et al., 2003; Graham et al., 2012; Wang et al., 2016). Chinese scholars find that Chinese listed companies generally manipulate profits by adjusting their deferred tax assets (Qu et al., 2009; Dai et al., 2013b; Gai and Lu, 2014; Li et al., 2020). This issue has also attracted the attention of regulatory authorities. In 2019, the China Securities Regulatory Commission (CSRC) reviewed the annual reports of 924 listed companies, identified important problems affecting these companies and published the *2019 Annual Report Supervision of Listed Companies*. The report notes that one common problem experienced by Chinese listed companies is that deferred tax assets are not properly recognized. Specifically, many listed companies do not fully consider whether they are likely to obtain sufficient taxable income in the future. Such companies may recognize large amounts of deferred tax assets and include them in current profits even when they have experienced serious operational uncertainty and consecutive years of losses.

The unreasonable recognition of deferred tax assets by enterprise management has a significant impact on the financial reports of listed companies. For example, from 2014 to 2016, LeTV recognized a large amount of deferred tax assets through the losses of non-wholly owned subsidiaries. Compared with previous years, the company's deferred tax assets changed significantly and as a result, LeTV encountered a strange phenomenon in that its income tax expense was negative while its net profit was much higher than its total profit. Li et al. (2020) propose that enterprise management can manipulate profits by recognizing a large amount of deferred tax assets, which will lead to an abnormal change in deferred tax assets compared with previous years. The index of this abnormal change can be obtained by calculating the degree of change in deferred tax assets in the current period compared with previous years. The larger the abnormal change in deferred tax assets, the greater the possibility of default. In this case, can deferred tax information help report users make accounting decisions, as expected by the accounting standard-setting bodies? Will report users be disturbed by an abnormal change in deferred tax assets?

There are a wide range of users of financial reports. Analysts are a professional group of users (Qu et al., 2016). In theory, they should pay more attention to the information contained in financial reports than other users, and their decisions should be more frequently correct. In practice, analysts' earnings forecasts may deviate from enterprises' real earnings. For example, from 2015 to 2017, analyst reports on LeTV focused on items such as prime operating revenue and net profit, but none mentioned the company's deferred tax assets or analyzed an income change caused by the company's abnormal change in deferred tax assets; furthermore, almost all analysts issued optimistic earnings forecasts. The case of LeTV demonstrates that analysts do not necessarily understand and pay attention to deferred tax assets. Indeed, analysts' earnings forecast ability may be disturbed by deferred tax assets. As shown in Fig. 1, before 2007, the error and divergence of analysts' earnings forecasts were relatively small. After 2007, earnings forecast error and divergence increased significantly, a difference that may be directly related to the 2007 implementation of the new accounting standards. Accounting treatments with high complexity and maneuverability increase the difficulty of analysts' earnings forecasts. The application of deferred tax is a typical example of the complexity of accounting standards. If analysts do not have a good understanding of deferred tax information, they are likely to make forecasts that deviate greatly from the actual earnings of enterprises when forecasting future earnings based on data from past financial reports.

In this case, it may be more difficult for ordinary stakeholders to correctly interpret and use deferred tax information when making decisions. We cannot conclude that the balance sheet liability method is more useful in valuation and report users' decision-making. Therefore, the usefulness of deferred tax information from the perspective of analysts' earnings forecasts is an important research topic. However, few studies consider the impact of deferred tax information on the decisions of analysts and stakeholders other than ordinary stock

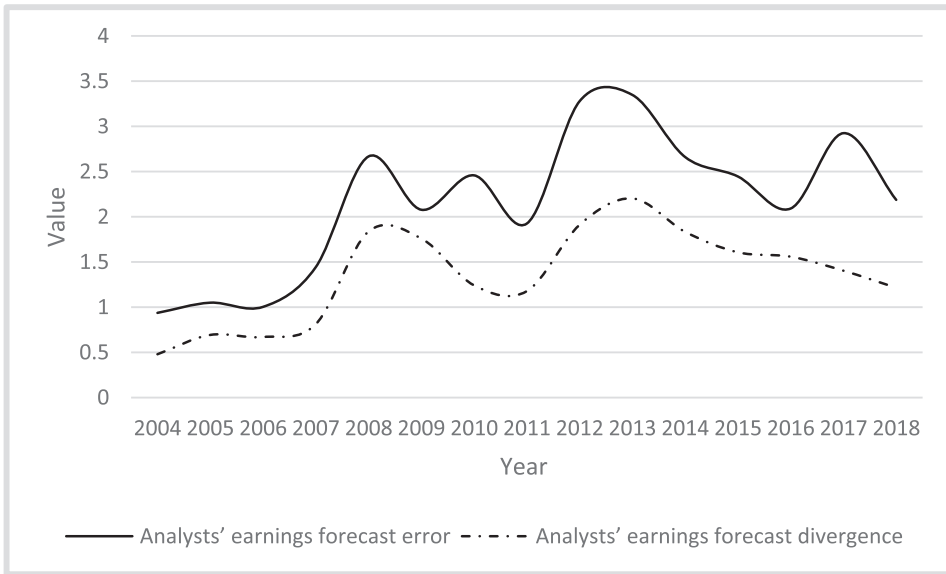

Fig. 1. Analysts' earnings forecast error/divergence trend change.

investors (Wang and Dai, 2012). Taking Chinese A-share listed companies from 2007 to 2018 as a sample, I find that an abnormal change in deferred tax assets increases the error and divergence of analysts' earnings forecasts, but an abnormal change in different directions has different effects. Compared with a negative abnormal change in deferred tax assets, a positive abnormal change has a greater negative impact on analysts' earnings forecasts. Further analysis finds that the higher the level of corporate governance, the higher the audit quality and the stronger the analysts' professional ability, the lower the negative impact of an abnormal change in deferred tax assets on analysts' earnings forecasts. Furthermore, an abnormal change in deferred tax liabilities does not have a significant impact on analysts' earnings forecasts.

This paper makes two important contributions to the literature. First, whereas studies focus on the value relevance of deferred tax information (Chludek, 2011; Laux, 2013) and whether listed companies use deferred tax information for earnings manipulation (Phillips et al., 2003; Graham et al., 2012), few consider whether deferred tax information affects analysts' earnings forecasts. Although a few studies focus on the impact of deferred tax on analysts (Amir and Sougiannis, 1999; Chen and Schoderbek, 2000; Chen et al., 2003), these studies concentrate on whether analysts apply deferred tax information to their earnings forecasts, not the impact of deferred tax information on the error and divergence of analysts' earnings forecasts. However, because the Chinese capital market is different from the capital markets of other countries, especially the United States, results based on foreign capital markets may be different from those obtained for Chinese enterprises. Unlike previous studies, I find that abnormal changes in the deferred tax assets of Chinese listed companies significantly increase the error and divergence of analysts' earnings forecasts. This research enriches the literature on deferred tax information and analysts' earnings forecasts. Second, most studies adopt the view that because of the correlation between deferred tax and stock price, the balance sheet liability method is useful for valuation, and the international convergence of accounting standards should be vigorously promoted. Unlike previous studies, I focus on the negative impact of the balance sheet liability method, which shows that against the background of the international convergence of accounting standards, the artificial complexity of accounting standards may interfere with stakeholders' decision-making, and the balance sheet liability method may be unable to achieve its financial reporting purpose of decision usefulness.

2. Literature review

2.1. Deferred tax information

Some studies question the rationality of deferred tax accounting standards. Zhou (2011) remarks that the cost of the balance sheet liability method is high, but its profit is low; moreover, this method lacks a theoretical basis. He proposes that the tax payable method has more advantages than the balance sheet liability method and that book–tax differences should be disclosed in the notes to financial reports. Dai et al. (2013b) propose that the balance sheet liability method is highly subjective, which gives management more room for earnings manipulation. Zhou (2011) proposes that the concept of tax base has logical problems and that the tax base of assets and the tax base of liabilities are divergent. By calculating the minimum value of the deferred tax assets and deferred tax liabilities that should be recognized by enterprises, Zhou et al. (2017) find that the actual recognition amount of enterprises is lower than the minimum value that should be recognized. They argue that because Chinese listed companies continue to experience difficulty in adapting to complex income tax accounting standards, standard-setting bodies should simplify these standards.

Some studies find that listed companies use deferred tax to manipulate earnings. Phillips et al. (2003) propose that deferred tax indicators can signal a company's earnings management behavior. Specifically, deferred tax expenses have incremental usefulness in identifying the earnings management behavior that helps companies avoid income decline and loss. Burgstahler and Eames (2003) propose that when companies are at a critical point of profit and loss, companies with small profits will make less provision for the valuation of deferred tax assets than will companies with small losses. Graham et al. (2012) find that management uses deferred tax to manipulate earnings so that the company meets or exceeds the goal of analysts' earnings forecasts. Wang et al. (2016) find that enterprises achieve their profit objectives by manipulating deferred tax items and that deferred tax can be used to detect enterprise earnings management.

Since China's implementation of the balance sheet liability method, Chinese scholars have been considering the method's earnings management problem. Qu et al. (2009) compare listed companies in the EU and China and find that such companies can engage in earnings management through deferred tax assets. Gai and Lu (2014) find that some enterprises adjust their profits by adjusting expenses through deferred tax assets, and the reliability of deferred tax information is in doubt.

2.2. Deferred tax information and analysts' earnings forecast

Some foreign studies focus on whether deferred tax information has an impact on analysts. Chen and Schoderbek (2000) use the August 1993 increase in the United States corporate income tax rate from 34% to 35% as their research background and find that mispricing is more obvious for companies that adjust their deferred tax and increase profits in response to a tax rate change. They also hold the view that analysts usually do not include deferred tax adjustments in their earnings forecasts. To some extent, their research results show that both the stock market and analysts have an insufficient understanding of deferred tax. Using quarterly data from 1993 and 1994 from the United States, Chen et al. (2003) find a significant positive correlation between the adjustment of deferred tax related to declining profits and analysts' earnings forecast revision after a change in the corporate tax rate, but there is no similarly significant correlation in an environment of increasing profits. However, they do not consider whether an abnormal change in deferred tax will affect the error and divergence of analysts' earnings forecasts, nor do they further analyze the reasons for this effect.

3. Hypotheses

Chinese listed companies adopted the balance sheet liability method in 2007. The balance sheet liability method is a typical application of the asset–liability view. According to the asset–liability view, enterprises should consider the impact of each transaction or event on their assets and liabilities and recognize either deferred tax assets or deferred tax liabilities through the differences between the carrying amount and the tax base of their assets and liabilities. The balance sheet liability method covers a wider range of circumstances than previous methods and includes transactions and events that are not directly related to the income state-

ment, better meeting the concerns of the IASB and the FASB about the usefulness of financial reports. However, the balance sheet liability method also has well-known problems, such as high complexity, poor comprehensibility and high subjectivity (Zhou et al., 2017; Li et al., 2020), which may interfere with report users' ability to read and understand financial statements.

Studies show that specific accounting information may interfere with analysts' earnings forecasts. Huang (2016) finds that because of the uncertainty and low sustainability of other comprehensive income, the higher the proportion of other comprehensive income, the greater the error in analysts' earnings forecasts. Chen et al. (2014) and Qu et al. (2016) find that because listed companies may use goodwill impairment for downward profit adjustment, the higher the goodwill impairment of enterprises, the lower the accuracy and the higher the divergence of analysts' earnings forecasts. So how does deferred tax information affect analysts' earnings forecasts? Referring to Li et al. (2020), I focus on deferred tax assets and propose that through the following three aspects, an abnormal change in deferred tax assets will interfere with analysts' earnings forecasts:

First, the balance sheet liability method is highly complex and difficult to understand (Zhou et al., 2017). Under the balance sheet liability method, enterprise management must first recognize a temporary difference by comparing the tax base of its assets and liabilities to the carrying amount of its assets and liabilities, and then it must recognize deferred tax assets or deferred tax liabilities according to the nature of that temporary difference. The calculation methods used to determine deferred tax assets and deferred tax liabilities are complex and difficult to understand, and current accounting standards do not uniformly define the tax base of assets and liabilities (Zhou et al., 2017). In addition, the concepts of deferred tax assets and deferred tax liabilities are misleading. The concept of deferred tax assets is not consistent with the traditional definition of assets, and the concept of deferred tax liabilities is not consistent with the traditional definition of liabilities (Zhou, 2011). These problems are likely to make it difficult for analysts to read and understand deferred tax information in enterprise financial statements. When reading the current financial statements of listed companies, analysts may either be unable to interpret or pay little attention to the deferred tax assets item, and they may make earnings forecasts based only on indicators such as the company's operating profit. In this case, the greater the abnormal change in the deferred tax assets of listed companies, the greater the potential error and divergence of analysts' earnings forecasts.

Second, the recognition and reversal of deferred tax assets are usually the result of the subjective estimation and judgment of enterprise managers who lack original documents (Dai et al., 2013b), and thus their judgment is unreliable. Under the balance sheet liability method, the earnings recognized by enterprise management based on a change in assets and liabilities belong to unrealized earnings that are unsupported by original documents. On the one hand, this decreases both the credibility of the deferred tax information and the possibility that analysts will use deferred tax information to make earnings forecasts. On the other hand, even if analysts apply deferred tax information to their earnings forecasts, analysis of this report item depends on various analysts' professional ability because the item is unsupported by original documents, increasing the divergence of earnings forecasts made by different analysts.

Third, the balance sheet liability method is highly subjective and creates an opportunity for enterprise management to manipulate profits. Enterprise management often uses deferred tax assets to manipulate earnings (Burgstahler and Eames, 2003; Gai and Lu, 2014). Gai and Lu (2014) find that Chinese listed companies use deferred tax assets to increase profits, gradually increasing the deferred tax assets of Chinese listed companies. In practice, decisions about the recognition time and amount of deferred tax assets are within the enterprise management's authority. Differences between the carrying amount and the tax base of assets provides companies with space to deliberately manipulate financial data through deferred tax assets (Li et al., 2020). For example, LeTV used deferred tax assets to manipulate profits so that the losses of non-wholly owned subsidiaries became the income of LeTV. Whether an enterprise can recognize deferred tax assets based on its tax losses depends on its management's estimation of whether it will have enough future taxable income to deduct. Without the support of original documents, enterprise management has the opportunity to manipulate profits. The manipulation of profits by enterprise management will reduce earnings quality, affecting analysts' ability to forecast earnings (Chen et al., 2014). An abnormal change in deferred tax assets is likely to reflect the motivation of enterprise management to manipulate profits and beautify the enterprise's financial statements. On the one hand, if analysts do not correctly interpret an abnormal change in deferred tax assets, they are likely to be misled by beautified financial statement items, resulting in large earnings forecast errors and diver-

gence. On the other hand, even if analysts identify earnings manipulation behavior by enterprise management either in previous or current financial statements or based on previous experience, it can be reasonably expected that enterprise management may use deferred tax assets for earnings management, analysts may find it difficult to predict the direction and size of future earnings manipulation by management. In this case, different analysts may have different expectations based on their knowledge, experience and analysis models, resulting in greater divergence in earnings forecasts. Therefore, my first hypothesis is as follows:

H1: *Ceteris paribus*, an abnormal change in deferred tax assets is positively associated with analysts' earnings forecast error and divergence.

In practice, it is easy for enterprise management to use deferred tax assets to adjust profits upward. As pointed out in the *2019 Annual Report Supervision of Listed Companies*, Chinese listed companies commonly experience the problem that deferred tax assets are not properly recognized. Many listed companies do not fully consider whether they can obtain sufficient taxable income in the future, and they even recognize large deferred tax assets under conditions of continuous losses and significant uncertainty about whether they can sustain their operations. Studies find that due to tax losses and other factors, the cost of manipulating profits by increasing deferred tax assets is low and enterprise management's earnings manipulation is difficult to detect. It is common for Chinese listed companies to use deferred tax assets for upward profit adjustment rather than downward profit adjustment (Gai et al., 2014; Li et al., 2020). Therefore, a positive abnormal change in deferred tax assets is more likely than a negative abnormal change to be derived from the motivation of enterprise management to manipulate profits and beautify financial statements. The greater the positive abnormal change in deferred tax assets, the greater the possibility that current financial statement profits deviate from actual earnings, the lower the overall earnings quality, and the easier it is to disturb analysts' ability to forecast earnings. Therefore, my second hypothesis is as follows:

H2: *Ceteris paribus*, compared with a negative abnormal change in deferred tax assets, a positive abnormal change in deferred tax assets has a greater impact on analysts' earnings forecast error and divergence.

4. Research design

4.1. Sample selection and data sources

This paper selects all A-share listed companies from 2007 to 2018 as a sample. The sample period begins in 2007 because China adopted the single balance sheet liability method in 2007. The sample selection process is as follows: (1) I exclude all observations of special treatment firms in imminent danger of delisting during the sample period; (2) I exclude all observations from financial companies; and (3) I exclude all observations with missing data for the variables of interest. The data for the main variables are from the China Stock Market & Accounting Research (CSMAR) database. To mitigate the influence of outliers, all continuous variables are winsorized at the 1st and 99th percentiles.

4.2. Variable selection

4.2.1. Analysts' earnings forecasts

Referring to the measurement methods of analysts' earnings forecasts by Wang and Wang (2012) and Zhou et al. (2014), I measure analysts' ability to make earnings forecasts based on two aspects: analysts' earnings forecast error and analysts' earnings forecast divergence.

$FERR_{it}$ is analysts' earnings forecasts error for company i in year t, $FERR_{it} = |FEPS_{it} - AEPS_{it}|/|AEPS_{it}|$, where $AEPS_{it}$ is the company's actual earnings per share, and $FEPS_{it}$ is the average value of analysts' earnings per share forecast before the company's actual earnings announcement. The larger the $FERR_{it}$ value, the greater the analyst earnings forecast error.

$FDISP_{it}$ is analysts' earnings forecast divergence for company i in year t, $FDISP_{it} = \text{Std}\ (FEPS_{it})/|AEPS_{it}|$, where $AEPS_{it}$ is the company's actual earnings per share and Std ($FEPS_{it}$) is the standard deviation of analysts' earnings per share forecast before the company's actual earnings announcement. The larger the $FDISP_{it}$ value, the greater the analyst earnings forecast divergence.

4.2.2. Abnormal change in deferred tax assets

Referring to the method of Li et al. (2020), I use the abnormal change in deferred tax assets to measure the fluctuations in deferred tax assets of listed companies. $abDTA_{it} = (DTA_{it} - DTAm_{it})/DTAm_{it}$, where DTA_{it} is the deferred tax assets of company i in year t, and $DTAm_{it}$ is the average value of deferred tax assets of company i in the previous 3 years. The larger the $abDTA_{it}$ value, the greater the abnormal change in deferred tax assets of listed companies.

In addition, I set up two variables to further test H2. (1) *abDTA_pos*, which is the positive abnormal change in deferred tax assets. When *abDTA* is greater than 0, $abDTA\_pos = abDTA$, otherwise $abDTA\_pos = 0$. (2) *abDTA_neg*, which is the negative abnormal change in deferred tax assets. When *abDTA* is less than or equal to 0, $abDTA\_neg = abDTA$, otherwise $abDTA\_neg = 0$.

4.2.3. Other control variables

Following prior studies (Su and Wei, 2013; Tan et al., 2015), I include the following control variables: company size (*SIZE*), asset–liability ratio (*LEV*), return on assets (*ROA*), earnings volatility (*EV*), company loss (*LOSS*), ownership concentration (*SHARE*), analyst following (*FOLLOW*), company age (*AGE*) and nature of property rights (*STATE*). In addition, year and industry fixed effects are controlled, and standard errors clustered at the company level are used for the models. The definition of each variable is shown in Table 1.

4.3. Research model

I use Models (1) and (2) to test H1. Because analysts often forecast next year's earnings based on the previous year's financial information, the explained variables are the error and divergence of analysts' earnings forecasts in year $t + 1$. The main explanatory variables are the abnormal change in deferred tax assets in year t. I expect β_1 to be significantly positive, that is, the abnormal change in deferred tax assets increases the error and divergence of analysts' earnings forecasts.

$$FERR_{i,t+1} = \beta_0 + \beta_1 abDTA_{i,t} + Control + YEAR\ \ FE + INDUSTRY\ \ FE + \varepsilon_{i,t} \quad (1)$$

Table 1
Definitions of the variables.

Variable	Definition
Panel A: Explained variables	
FERR	Analysts' earnings forecast error, average error of analysts' earnings forecast/absolute value of the company's actual earnings
FDISP	Analysts' earnings forecast divergence, standard deviation of analysts' earnings forecast/absolute value of the company's actual earnings
Panel B: Explanatory variables	
abDTA	The abnormal change in deferred tax assets, (deferred tax assets in year t – average value of deferred tax assets in the previous 3 years)/average value of deferred tax assets in the previous 3 years
abDTA_pos	The positive abnormal change in deferred tax assets, when *abDTA* is greater than 0, $abDTA\_pos = abDTA$, otherwise $abDTA\_pos = 0$
abDTA_neg	The negative abnormal change in deferred tax assets, when *abDTA* is less than or equal to 0, $abDTA\_neg = abDTA$, otherwise $abDTA\_neg = 0$
Panel C: Control variables	
SIZE	Company size, natural logarithm of total assets
LEV	Asset–liability ratio, total liabilities divided by total assets
ROA	Return on assets, net profit divided by total assets
EV	Earnings volatility, deviation of *ROA* in the past 3 years
LOSS	Company loss, equals 1 if the company has a loss in year t, and 0 otherwise
SHARE	Ownership concentration, shareholding ratio of the top 10 shareholders
FOLLOW	Analyst following, natural logarithm of the number of analysts following the company plus 1
AGE	Company age, natural logarithm of the company's listing years plus 1
STATE	Nature of property rights, equals 1 if the company is a state-owned enterprise, and 0 otherwise

$$FDISP_{i,t+1} = \beta_0 + \beta_1 abDTA_{i,t} + Control + YEAR\ \ FE + INDUSTRY\ \ FE + \varepsilon_{i,t} \quad (2)$$

This paper uses Models (3) and (4) to test H2. The explained variables are the error and divergence of analysts' earnings forecasts in year $t + 1$. The main explanatory variables are the positive abnormal change in deferred tax assets and the negative abnormal change in deferred tax assets in year t. I expect β_1 to be significantly positive and β_2 to be not significant, that is, compared with the negative abnormal change in deferred tax assets, the positive abnormal change in deferred tax assets interferes more strongly with analysts' earnings forecasts.

To further test H2, I test Models (1) and (2) using subsamples. All observations with *abDTA* greater than 0 are defined as the subsample with a positive abnormal change in deferred tax assets, otherwise they are defined as the subsample with a negative abnormal change in deferred tax assets. It is expected that in the positive abnormal change subsample, β_1 is significantly positive, and in the negative abnormal change subsample, β_1 is not significant.

$$FERR_{i,t+1} = \beta_0 + \beta_1 abDTA\_pos_{i,t} + \beta_2 abDTA\_neg_{i,t} + Control + YEAR\ \ FE + INDUSTRY\ \ FE + \varepsilon_{i,t} \quad (3)$$

$$FDISP_{i,t+1} = \beta_0 + \beta_1 abDTA\_pos_{i,t} + \beta_2 abDTA\_neg_{i,t} + Control + YEAR\ \ FE + INDUSTRY\ \ FE + \varepsilon_{i,t} \quad (4)$$

5. Empirical results

5.1. Descriptive statistics

Table 2 shows the descriptive statistics of main variables. The minimum value of *FERR* is 0.006, the maximum value is 34.000 and the standard deviation is 5.202, indicating that there are large differences in analysts' earnings forecast errors in the sample. The minimum value of *FDISP* is 0.000, the maximum value is 21.115 and the standard deviation is 3.147, indicating that there are large differences in analysts' earnings forecast divergence in the sample.

The mean value of *abDTA* is 0.273, the median value is 0.202 and the standard deviation is 0.415. The mean value of *abDTA_pos* is 0.315, the median value is 0.202 and the standard deviation is 0.359. The mean value of *abDTA_neg* is –0.415, the median value is 0.000 and the standard deviation is 0.132. There are certain differences in the abnormal change in deferred tax assets in the sample. More companies have a positive abnormal change than a negative abnormal change in deferred tax assets. The descriptive statistics of the other variables are similar to those in previous studies (Huang, 2016; Qu et al., 2016; Cheng and Pan, 2017).

Table 2
Summary statistics.

VarName	Obs	Mean	SD	Min	Median	Max
FERR	18,493	2.519	5.202	0.006	0.820	34.000
FDISP	18,493	1.553	3.147	0.000	0.561	21.115
abDTA	18,493	0.273	0.415	–0.991	0.202	1.875
abDTA_pos	18,493	0.315	0.359	0.000	0.202	1.875
abDTA_neg	18,493	–0.415	0.132	–0.991	0.000	0.000
SIZE	18,493	22.030	1.203	19.084	21.871	25.912
LEV	18,493	0.423	0.204	0.050	0.418	1.037
ROA	18,493	0.047	0.044	–0.183	0.043	0.203
EV	18,493	0.176	0.192	0.000	0.113	1.352
LOSS	18,493	0.052	0.222	0.000	0.000	1.000
SHARE	18,493	0.600	0.147	0.223	0.613	0.953
FOLLOW	18,493	1.795	0.999	0.000	1.946	3.714
AGE	18,493	2.525	0.581	0.693	2.565	3.296
STATE	18,493	0.384	0.486	0.000	0.000	1.000

Note: Variable definitions are presented in Table 1.

5.2. Correlation coefficients

The correlation coefficients are shown in Table 3. There is a significant positive correlation between *abDTA* and *FERR* and *FDISP* at the 1% level, that is, the greater the abnormal change in deferred tax assets, the lesser the accuracy of analysts' earnings forecasts and the greater the divergence of analysts' earnings forecasts, which is consistent with H1. There is a significant positive correlation between *abDTA_pos* and *FERR* and *FDISP* at the 1% level, but there is no significant correlation between *abDTA_neg* and *FERR* and *FDISP*, which is consistent with H2. Table 3 shows the univariate test; specific relationships must be tested using multiple regression analysis. In addition, a variance inflation factor (VIF) < 10 indicates that there is no serious multicollinearity problem.

5.3. Main regression results

The multiple regression results between the abnormal change in deferred tax assets and analysts' earnings forecasts are shown in Table 4. Columns (1) and (2) are the regression results of H1. The coefficients of *abDTA* are significantly positive at the 1% level, indicating that there is a significant positive correlation between the abnormal change in deferred tax assets and the error and divergence of analysts' earnings forecasts, which is consistent with H1. Columns (3)–(8) are the regression results of H2, of which columns (3) and (4) are the test

Table 3
Correlation coefficients.

	FERR	*FDISP*	*abDTA*	*abDTA_pos*	*abDTA_neg*	*SIZE*	*LEV*
FERR	1	0.707***	0.020***	0.023***	0.009	–0.126***	–0.025***
FDISP	0.831***	1	0.078***	0.085***	0.035	–0.028***	–0.012
abDTA	0.017**	0.029***	1	0.991***	0.678***	0.045***	0.076***
abDTA_pos	0.020***	0.036***	0.952***	1	0.612***	0.069***	0.101***
abDTA_neg	–0.000	–0.007	0.556***	0.275***	1	–0.057***	–0.061***
SIZE	–0.047***	0.002	0.023***	0.039***	–0.032***	1	0.559***
LEV	0.012*	0.025***	0.068***	0.103***	–0.064***	0.555***	1
ROA	–0.196***	–0.203***	0.026***	–0.007	0.102***	–0.146***	–0.416***
EV	0.051***	0.075***	–0.087***	–0.093***	–0.022***	0.007	–0.053***
LOSS	0.115***	0.141***	–0.006	0.035***	–0.114***	0.034***	0.145***
SHARE	–0.052***	–0.041***	0.012	–0.013*	0.073***	0.030***	–0.151***
FOLLOW	–0.096***	–0.022***	0.041***	0.016**	0.084***	0.267***	–0.049***
AGE	–0.011	0.001	0.068***	0.128***	–0.134***	0.377***	0.421***
STATE	–0.031***	–0.018**	0.005	0.033***	–0.075***	0.338***	0.317***

	ROA	*EV*	*LOSS*	*SHARE*	*FOLLOW*	*AGE*	*STATE*
FERR	–0.291***	0.105***	0.125***	–0.074***	–0.121***	–0.127***	–0.117***
FDISP	–0.194***	0.151***	0.080***	–0.032***	0.104***	–0.123***	–0.116***
abDTA	0.019***	–0.117***	–0.001	–0.020***	0.056***	0.032***	–0.017**
abDTA_pos	–0.005	–0.135***	0.014*	–0.050***	0.045***	0.072***	0.002
abDTA_neg	0.103***	0.013*	–0.077***	0.089***	0.092***	–0.165***	–0.113***
SIZE	–0.189***	–0.017**	0.032***	–0.028***	0.257***	0.397***	0.336***
LEV	–0.451***	–0.084***	0.138***	–0.166***	–0.048***	0.443***	0.317***
ROA	1	0.131***	–0.383***	0.258***	0.388***	–0.213***	–0.184***
EV	0.073***	1	0.155***	0.231***	0.185***	–0.251***	–0.154***
LOSS	–0.501***	0.138***	1	–0.083***	–0.141***	0.064***	0.065***
SHARE	0.227***	0.194***	–0.082***	1	0.152***	–0.355***	–0.106***
FOLLOW	0.362***	0.128***	–0.142***	0.164***	1	–0.086***	–0.060***
AGE	–0.193***	–0.211***	0.071***	–0.360***	–0.047***	1	0.490***
STATE	–0.155***	–0.101***	0.065***	–0.094***	–0.059***	0.463***	1

Note: This table presents the Pearson correlation coefficients in the lower left part and the Spearman's rank correlation coefficients in the upper right part. All tests are two-tailed. Variable definitions are presented in Table 1.

* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$

Table 4
Abnormal change in deferred tax assets and analysts' earnings forecasts.

	(1) *FERR* Full sample	(2) *FDISP* Full sample	(3) *FERR* Full sample	(4) *FDISP* Full sample	(5) *FERR* Positive abnormal change	(6) *FERR* Negative abnormal change	(7) *FDISP* Positive abnormal change	(8) *FDISP* Negative abnormal change
abDTA	0.328***	0.237***			0.437***	0.408	0.376***	–0.092
	(3.38)	(4.06)			(3.45)	(1.03)	(4.97)	(–0.37)
abDTA_pos			0.359***	0.334***				
			(3.01)	(4.65)				
abDTA_neg			0.200	–0.160				
			(0.67)	(–0.88)				
SIZE	–0.070	0.078***	–0.070	0.078***	–0.056	–0.121	0.069**	0.086
	(–1.45)	(2.67)	(–1.44)	(2.69)	(–1.04)	(–1.11)	(2.14)	(1.27)
LEV	–1.093***	–0.959***	–1.098***	–0.973***	–1.251***	–0.465	–1.041***	–0.599
	(–4.16)	(–6.05)	(–4.17)	(–6.14)	(–4.26)	(–0.77)	(–5.93)	(–1.59)
ROA	–26.390***	–17.510***	–26.393***	–17.519***	–27.103***	–23.675***	–17.691***	–16.850***
	(–22.44)	(–24.68)	(–22.44)	(–24.70)	(–20.68)	(–8.80)	(–22.58)	(–10.06)
EV	1.656***	1.201***	1.655***	1.198***	1.685***	1.659***	1.286***	0.941***
	(7.95)	(9.56)	(7.94)	(9.53)	(7.41)	(3.11)	(9.46)	(2.83)
LOSS	–0.010	0.296**	–0.019	0.267**	0.299	–0.741*	0.511***	–0.299
	(–0.05)	(2.47)	(–0.10)	(2.22)	(1.29)	(–1.83)	(3.69)	(–1.19)
SHARE	–1.028***	–0.652***	–1.028***	–0.653***	–1.224***	0.052	–0.764***	–0.053
	(–3.52)	(–3.71)	(–3.52)	(–3.71)	(–3.78)	(0.08)	(–3.95)	(–0.12)
FOLLOW	–0.130***	0.137***	–0.129***	0.138***	–0.146***	–0.033	0.120***	0.236***
	(–2.86)	(4.99)	(–2.85)	(5.06)	(–2.91)	(–0.30)	(4.00)	(3.49)
AGE	–0.146	–0.149**	–0.152	–0.166***	–0.162	–0.226	–0.116*	–0.466***
	(–1.50)	(–2.55)	(–1.55)	(–2.81)	(–1.50)	(–0.93)	(–1.80)	(–3.06)
STATE	–0.288***	–0.165***	–0.286***	–0.160***	–0.244**	–0.451**	–0.143**	–0.229*
	(–3.15)	(–2.99)	(–3.13)	(–2.90)	(–2.38)	(–2.21)	(–2.33)	(–1.80)
_cons	5.389	0.624	5.391	0.631	4.990	7.251**	0.736	1.430
	(1.46)	(0.28)	(1.46)	(0.28)	(1.34)	(2.56)	(0.33)	(0.81)
YEAR	YES	YES	YES	YES	YES	YES	YES	YES
INDUSTRY	YES	YES	YES	YES	YES	YES	YES	YES
N	18,493	18,493	18,493	18,493	15,062	3,431	15,062	3,431
adj. R^2	0.0680	0.0735	0.0679	0.0737	0.0728	0.0537	0.0804	0.0587

Notes: This table reports the regression results for Eqs. (1)–(4) to examine the association between the abnormal change in deferred tax assets and analysts' earnings forecasts for H1 and H2. The first row represents the estimated coefficients; the second row represents the t-values. All continuous variables are winsorized at the 1st and 99th percentiles to moderate the effects of outliers. All tests are two-tailed. Variable definitions are presented in Table 1.

* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$

results for the full sample; the regression results show that the coefficients of *abDTA_pos* are significantly positive at the 1% level, and the coefficients of *abDTA_neg* are not significant. Columns (5)–(8) are the test results for the subsamples. The regression results show that in the positive abnormal change subsample, the coefficients of *abDTA* are significantly positive, but in the negative abnormal change subsample, the coefficients of *abDTA* are not significant. These regression results are consistent with H2. In general, the regression results show that an abnormal change in deferred tax assets can interfere with analysts' reading and understanding ability of an enterprise's financial reports and increase the error and divergence of their earnings forecasts. Furthermore, a positive abnormal change in deferred tax assets interferes more strongly with analysts' earnings forecast ability than a negative abnormal change. To some extent, the regression results show that the usefulness of the balance sheet liability method may not meet the expectations of accounting standard-setting bodies.

5.4. Further analysis

5.4.1. The moderating effect of corporate governance level

The level of corporate governance may have an impact on the relationship between an abnormal change in deferred tax assets and analysts' earnings forecasts. A higher level of corporate governance can effectively supervise enterprise management and restrict profit manipulation. It can also create a more transparent environment for analysts' earnings forecasts, improve the quality of accounting information and reduce interference in the provision of certain financial information to analysts (Xu and Zhu, 2016). Therefore, I expect that improved corporate governance can weaken the interference of an abnormal change in deferred tax assets with analysts' earnings forecasts.

To test the moderating effect of the corporate governance level, I refer to Wu et al. (2020) and construct a corporate governance level index (*CGI*) using 14 variables[1] related to corporate governance, such as audit committee size and compensation committee size. Specifically, taking the median value of each of the 14 variables as the boundary, this paper constructs 14 dummy variables. All observations above the median take a value of 1 and 0 otherwise; next, the 14 dummy variables are added to obtain the *CGI* measure. The minimum value of *CGI* is 0 and the maximum value is 14. The higher the *CGI*, the higher the level of corporate governance. This paper divides the full sample into two subsamples of low corporate governance level and high corporate governance level and carries out subsample regression. It is expected that in the low corporate governance level subsample, the abnormal change in deferred tax assets will have a greater impact on analysts' earnings forecasts than in the high corporate governance level subsample. The regression results are shown in Table 5. In the low corporate governance level subsample, the coefficients of *abDTA* are significantly positive at the 1% level, whereas in the high corporate governance level subsample, the coefficients of *abDTA* are not significant. These regression results show that the level of corporate governance has a moderating effect on the correlation between an abnormal change in deferred tax assets and analysts' earnings forecasts and can weaken the negative impact of an abnormal change in deferred tax assets on analysts' earnings forecast ability, at least to some extent.

5.4.2. The moderating effect of audit quality

Audit quality may moderate the relationship between an abnormal change in deferred tax assets and analysts' earnings forecasts. An effective external supervision mechanism helps inhibit the opportunistic behavior of enterprise management and provide a better information environment for users of financial reports. Studies show that an audit has an external governance function (Fan and Wong, 2005) and can become an alternative mechanism of internal governance (Zheng and Yan, 2016). Improved audit quality helps reduce both agency costs and information asymmetry (Lei et al., 2015), and it improves the quality of both accounting information and external financial reporting. In listed companies with higher audit quality, management may be subject to stricter external supervision and be less likely to use deferred tax assets to manipulate profits than in companies with lower audit quality, and the overall earnings quality of these companies is likewise higher.

[1] The specific definitions of the 14 variables related to the corporate governance level are provided in Appendix A.

Table 5
The moderating effect of the corporate governance level.

	(1) *FERR* Low corporate governance level	(2) *FERR* High corporate governance level	(3) *FDISP* Low corporate governance level	(4) *FDISP* High corporate governance level
abDTA	0.364***	0.171	0.264***	0.059
	(2.58)	(1.02)	(3.15)	(0.57)
SIZE	–0.207***	–0.021	0.010	0.080
	(–2.70)	(–0.27)	(0.22)	(1.60)
LEV	–1.197***	–0.845*	–1.241***	–0.728***
	(–3.11)	(–1.87)	(–5.42)	(–2.59)
ROA	–25.705***	–26.469***	–17.222***	–18.081***
	(–15.26)	(–12.55)	(–17.18)	(–13.29)
EV	2.016***	1.952***	1.465***	1.491***
	(6.03)	(4.76)	(7.36)	(5.85)
LOSS	0.202	–0.259	0.439***	0.026
	(0.71)	(–0.67)	(2.60)	(0.09)
SHARE	–1.285***	–0.504	–0.766***	–0.244
	(–2.99)	(–1.11)	(–3.00)	(–0.85)
FOLLOW	–0.153**	–0.139*	0.139***	0.150***
	(–2.35)	(–1.72)	(3.58)	(3.17)
AGE	0.004	–0.471***	–0.161*	–0.261***
	(0.03)	(–2.89)	(–1.89)	(–2.58)
STATE	–0.287**	–0.193	–0.169*	–0.125
	(–1.97)	(–1.39)	(–1.95)	(–1.46)
_cons	9.413***	7.937***	3.267***	2.591**
	(6.17)	(5.02)	(3.60)	(2.40)
YEAR	YES	YES	YES	YES
INDUSTRY	YES	YES	YES	YES
N	8,963	9,530	8,963	9,530
adj. R^2	0.0702	0.0706	0.0767	0.0759

Notes: This table presents the moderating effect of the corporate governance level on the association between an abnormal change in deferred tax assets and analysts' earnings forecasts. The first row represents the estimated coefficients; the second row represents the t-values. All continuous variables are winsorized at the 1st and 99th percentiles to moderate the effects of outliers. All tests are two-tailed. Variable definitions are presented in Table 1.

* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$

Therefore, in listed companies with higher audit quality, an abnormal change in deferred tax assets is more likely to arise from routine business activities, which can truly reflect the earnings status of the company and will not have an overly negative impact on analysts' earnings forecasting ability.

Zhang and Wen (2016) find that the audit quality of a Chinese enterprise is best reflected by whether it is audited by a "big ten" firm. Therefore, this paper chooses "big ten" to measure audit quality. If enterprises are audited by one of the "big ten" auditors, they are defined as having high audit quality; if not, they are defined as having low audit quality. As shown in Table 6, in the high audit quality subsample, *abDTA* is not significant, whereas in the low audit quality subsample, *abDTA* is significantly positive. These regression results show that audit quality moderates the relationship between an abnormal change in deferred tax assets and analysts' earnings forecast error and divergence. Improved audit quality can reduce the negative impact of an abnormal change in deferred tax assets on analysts' earnings forecasts.

Table 6
The moderating effect of audit quality.

	(1) *FERR* Low audit quality	(2) *FERR* High audit quality	(3) *FDISP* Low audit quality	(4) *FDISP* High audit quality
abDTA	0.388***	0.139	0.300***	0.063
	(2.74)	(0.91)	(3.63)	(0.62)
SIZE	–0.102	–0.044	0.110**	0.038
	(–1.36)	(–0.57)	(2.51)	(0.78)
LEV	–0.589	–1.689***	–0.528**	–1.473***
	(–1.54)	(–3.59)	(–2.37)	(–4.90)
ROA	–25.958***	–27.059***	–16.204***	–19.312***
	(–14.95)	(–14.51)	(–16.05)	(–14.32)
EV	1.573***	2.128***	1.057***	1.678***
	(5.14)	(5.26)	(5.92)	(6.32)
LOSS	–0.020	0.046	0.296*	0.223
	(–0.07)	(0.13)	(1.67)	(0.83)
SHARE	–1.050**	–0.780*	–0.719***	–0.358
	(–2.41)	(–1.66)	(–2.84)	(–1.23)
FOLLOW	–0.095	–0.187***	0.152***	0.125***
	(–1.43)	(–2.72)	(3.89)	(3.10)
AGE	–0.164	–0.267*	–0.273***	–0.172*
	(–1.06)	(–1.67)	(–3.03)	(–1.67)
STATE	–0.290**	–0.275*	–0.105	–0.196**
	(–2.22)	(–1.72)	(–1.39)	(–2.02)
_cons	8.729***	6.921***	1.627*	2.710***
	(5.80)	(4.44)	(1.85)	(2.60)
YEAR	YES	YES	YES	YES
INDUSTRY	YES	YES	YES	YES
N	9,287	9,206	9,287	9,206
adj. R^2	0.0586	0.0820	0.0622	0.0903

Notes: This table presents the moderating effect of audit quality on the association between an abnormal change in deferred tax assets and analysts' earnings forecasts. The first row represents the estimated coefficients; the second row represents the t-values. All continuous variables are winsorized at the 1st and 99th percentiles to moderate the effects of outliers. All tests are two-tailed. Variable definitions are presented in Table 1.

* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$

5.4.3. The moderating effect of analysts' professional ability

Some studies show that analysts' professional ability affects their forecast error and divergence (Clement and Tse, 2005; Bonner et al., 2007). If improving analysts' professional ability helps weaken the negative impact of an abnormal change in deferred tax assets on analysts' earnings forecasts and reduces the error and divergence of analysts' earnings forecasts, it is possible to compensate for the defects of the balance sheet liability method by improving analysts' professional ability, at least to some extent.

To test the moderating effect of analysts' professional ability, referring to the literature, I take star analyst as a measurement of analysts' professional ability and perform the subsample test. Referring to Zhou et al. (2016), I take the best analyst selected by *New Fortune* as the representative of analysts' professional ability. If an analyst is rated best analyst in the year prior to the publication of an analyst report, he or she is recorded as a star analyst. The regression results are shown in Table 7. In the non-star analyst subsample, the coefficients of *abDTA* are significantly positive at the 1% level; however, in the star analyst subsample, the coefficients of *abDTA* are not significant. These regression results show that analysts' professional ability can moderate the relationship between an abnormal change in deferred tax assets and analysts' earnings forecast

Table 7
The moderating effect of analysts' professional ability.

	(1) *FERR* Non-star analyst	(2) *FERR* Star analyst	(3) *FDISP* Non-star analyst	(4) *FDISP* Star analyst
abDTA	0.403***	0.180	0.305***	0.123
	(2.61)	(1.16)	(3.33)	(1.17)
SIZE	–0.085	–0.056	0.079	0.041
	(–0.88)	(–0.72)	(1.56)	(0.79)
LEV	–0.611	–1.799***	–0.618**	–1.525***
	(–1.41)	(–3.84)	(–2.54)	(–4.86)
ROA	–24.983***	–27.403***	–15.314***	–19.972***
	(–12.83)	(–14.31)	(–12.40)	(–15.11)
EV	1.377***	1.895***	0.790***	1.770***
	(3.89)	(5.32)	(3.86)	(7.38)
LOSS	–0.026	0.300	0.339	0.403
	(–0.08)	(0.58)	(1.45)	(1.19)
SHARE	–0.542	–1.808***	–0.587**	–0.839***
	(–1.18)	(–3.92)	(–2.18)	(–2.86)
FOLLOW	–0.121*	–0.415***	0.200***	–0.183***
	(–1.70)	(–4.26)	(4.94)	(–3.04)
AGE	–0.176	–0.217	–0.207***	–0.121
	(–1.05)	(–1.41)	(–2.60)	(–1.12)
STATE	–0.307*	–0.271**	–0.172**	–0.150
	(–1.95)	(–1.97)	(–2.05)	(–1.63)
_cons	7.062***	10.065***	1.639	4.247***
	(4.02)	(5.77)	(1.57)	(3.71)
YEAR	YES	YES	YES	YES
INDUSTRY	YES	YES	YES	YES
N	10,367	8,126	10,367	8,126
adj. R^2	0.0582	0.0900	0.0615	0.1095

Notes: This table presents the moderating effect of analysts' professional ability on the association between an abnormal change in deferred tax assets and analysts' earnings forecasts. The first row represents the estimated coefficients; the second row represents the t-values. All continuous variables are winsorized at the 1st and 99th percentiles to moderate the effects of outliers. All tests are two-tailed. Variable definitions are presented in Table 1.

* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$

error and divergence. Star analysts with stronger professional ability are less disturbed by an abnormal change in deferred tax assets. Improvement in analysts' professional ability can inhibit the negative impact of an abnormal change in deferred tax assets, at least to some extent.

5.4.4. The effect of an abnormal change in deferred tax liabilities

Like deferred tax assets, deferred tax liabilities are an important part of deferred tax information. Will an abnormal change in deferred tax liabilities interfere with analysts' earnings forecasts? Although deferred tax liabilities are highly complex and easily ignored by analysts, according to both the literature (Gai and Lu, 2014; Li et al., 2020) and the practice of Chinese listed companies, there is little possibility of manipulating deferred tax liabilities, which have a small fluctuation range overall. Enterprise management can manipulate deferred tax assets more easily than deferred tax liabilities. Therefore, an abnormal change in deferred tax liabilities is more likely than an abnormal change in deferred tax assets to arise out of routine business activities, and it may not have a significant impact on analysts' earnings forecast error and divergence.

The method for calculating an abnormal change in deferred tax liabilities is similar to that for an abnormal change in deferred tax assets. $abDTL_{it} = (DTL_{it} - DTLm_{it})/DTLm_{it}$, where DTL_{it} is the deferred tax liabilities of company i in year t, and $DTLm_{it}$ is the average value of deferred tax liabilities of company i in the previous

3 years. The larger the $abDTL_{it}$ value, the greater the abnormal change in the deferred tax liabilities of listed companies. The regression models are shown in Models (5) and (6). The explained variables are still the error and divergence of analysts' earnings forecasts in year $t+1$. The main explanatory variable is an abnormal change in deferred tax liabilities in year t. It is expected that α_1 in Models (5) and (6) is not significant, that is, an abnormal change in deferred tax liabilities will not have a significant impact on the error and divergence of analysts' earnings forecasts.

$$FERR_{i,t+1} = \alpha_0 + \alpha_1 abDTL_{i,t} + Control + YEAR\ \ FE + INDUSTRY\ \ FE + \varepsilon_{i,t} \quad (5)$$

$$FDISP_{i,t+1} = \alpha_0 + \alpha_1 abDTL_{i,t} + Control + YEAR\ \ FE + INDUSTRY\ \ FE + \varepsilon_{i,t} \quad (6)$$

The impact of an abnormal change in deferred tax liabilities on analysts' earnings forecasts is shown in Table 8. The coefficients of *abDTL* are not significant, indicating that the abnormal change in deferred tax liabilities has a small impact on analysts' earnings forecasts. In practice, deferred tax assets are more easily manipulated by management, which primarily manipulates profits by adjusting deferred tax assets rather than deferred tax liabilities. As a result, an abnormal change in deferred tax liabilities will not substantially interfere with analysts' ability to forecast earnings. From the full sample, the range of the abnormal change in deferred tax assets is greater than that of the abnormal change in deferred tax liabilities, which confirms my conclusion, at least to some extent.

Table 8
Abnormal change in deferred tax liabilities and analysts' earnings forecasts.

	(1) *FERR*	(2) *FDISP*
abDTL	–0.010	0.007
	(–0.16)	(0.18)
SIZE	–0.115	0.014
	(–1.59)	(0.32)
LEV	–1.411***	–1.200***
	(–3.45)	(–4.65)
ROA	–26.071***	–18.969***
	(–14.99)	(–15.91)
EV	2.073***	1.657***
	(5.51)	(6.93)
LOSS	0.274	0.313
	(0.76)	(1.24)
SHARE	–1.418***	–0.798***
	(–3.51)	(–3.18)
FOLLOW	–0.027	0.173***
	(–0.40)	(4.24)
AGE	–0.261*	–0.195**
	(–1.86)	(–2.24)
STATE	–0.208	–0.142*
	(–1.50)	(–1.76)
_cons	7.753***	3.440***
	(4.91)	(3.10)
YEAR	YES	YES
INDUSTRY	YES	YES
N	16,978	16,978
adj. R^2	0.0515	0.0617

Notes: This table reports the regression results of Equations (5) and (6) to examine the association between an abnormal change in deferred tax liabilities and analysts' earnings forecasts. The first row represents the estimated coefficients; the second row represents the t-values. All continuous variables are winsorized at the 1st and 99th percentiles to moderate the effects of outliers. All tests are two-tailed. Variable definitions are presented in Table 1.

* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$

Table 9
Change the measurement method of the explained variable.

	(1) *FERR_before*	(2) *FDISP_before*	(3) *FERR_before*	(4) *FDISP_before*
abDTA	0.307***	0.189***		
	(3.94)	(4.07)		
abDTA_pos			0.414***	0.283***
			(4.32)	(5.00)
abDTA_neg			–0.132	–0.216
			(–0.55)	(–1.47)
SIZE	–0.057	–0.014	–0.056	–0.014
	(–1.45)	(–0.61)	(–1.44)	(–0.58)
LEV	–1.294***	–0.856***	–1.311***	–0.871***
	(–6.11)	(–6.71)	(–6.18)	(–6.83)
ROA	–23.082***	–15.355***	–23.093***	–15.371***
	(–24.35)	(–27.10)	(–24.37)	(–27.13)
EV	1.338***	1.085***	1.333***	1.083***
	(7.98)	(10.91)	(7.95)	(10.89)
LOSS	–0.237	0.177*	–0.269*	0.151
	(–1.47)	(1.78)	(–1.65)	(1.52)
SHARE	–1.177***	–0.631***	–1.176***	–0.632***
	(–5.02)	(–4.51)	(–5.01)	(–4.52)
FOLLOW	–0.028	0.060***	–0.026	0.062***
	(–0.76)	(2.67)	(–0.70)	(2.77)
AGE	–0.205***	–0.083*	–0.223***	–0.099**
	(–2.63)	(–1.77)	(–2.84)	(–2.10)
STATE	–0.304***	–0.179***	–0.299***	–0.175***
	(–4.14)	(–4.06)	(–4.06)	(–3.96)
_cons	4.693	2.234	4.701	2.241
	(1.60)	(1.31)	(1.60)	(1.32)
YEAR	YES	YES	YES	YES
INDUSTRY	YES	YES	YES	YES
N	10,898	10,898	10,898	10,898
adj. R^2	0.0430	0.0545	0.0428	0.0544

Notes: This table reports the regression results of Eqs. (1)–(4) to examine the association between an abnormal change in deferred tax assets and analysts' earnings forecasts for H1 and H2. *FERR_before* and *FDISP_before* are used instead of *FERR* and *FDISP* in Eqs. (1)–(4). The first row represents the estimated coefficients; the second row represents the t-values. All continuous variables are winsorized at the 1st and 99th percentiles to moderate the effects of outliers. All tests are two-tailed. Variable definitions are presented in Table 1.
* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$

5.5. Robustness tests

5.5.1. Change the measurement method of the explained variable

In the previous tests, I measure the error and divergence of analysts' earnings forecasts based on the after-tax index of earnings per share. In the robustness test part, I use the pretax earnings forecast index to measure the error and divergence of analysts' earnings forecasts. I use *FERR_before* to measure analysts' pretax earnings forecast error. $FERR\_before_{it} = |FEPS\_before_{it} - AEPS\_before_{it}|/|AEPS\_before_{it}|$, where $AEPS\_before_{it}$ is the company's actual earnings per share before interest and taxes, $FEPS\_before_{it}$ is the average value of earnings per share before interest and taxes[2] forecasted by analysts before the company's actual earnings announcement. The greater the $FERR\_before_{it}$ value, the greater the error of analysts' pretax earnings

[2] I use earnings per share before interest and taxes forecasted by analyst when estimating analysts' pretax earnings forecast error and divergence because the CSMAR database only discloses earnings before interest and taxes forecasted by analysts, but not earnings before taxes forecasted by analysts.

forecasts. I use *FDISP_before* to measure analysts' pretax earnings forecast divergence. $FDISP\_before_{it}$ = Std ($FEPS\_before_{it}$)/|$AEPS\_before_{it}$|, where $AEPS\_before_{it}$ is the company's actual earnings per share before interest and taxes and Std ($FEPS\_before_{it}$) is the standard deviation of earnings per share before interest and taxes forecasted by analysts before the company's actual earnings announcement. The greater the $FDISP\_before_{it}$ value, the higher the divergence of analysts' pretax earnings forecasts. The regression results are shown in Table 9. In columns (1) and (2), the coefficients of *abDTA* are significantly positive at the 1% level. In columns (3) and (4), the coefficients of *abDTA_pos* are significantly positive at the 1% level, whereas the coefficients of *abDTA_neg* are not significant, so the robustness test results are consistent with the main regression results.

5.5.2. Change the measurement method of the explanatory variable

Considering that an abnormal change in deferred tax assets of enterprises may be affected by other enterprises in the same industry and have certain industry characteristics, in the robustness test, I also use the abnormal change in deferred tax assets adjusted by the industry average value (*adjDTA*) to measure the

Table 10
Change the measurement method of the explanatory variable.

	(1) *FERR*	(2) *FDISP*	(3) *FERR*	(4) *FDISP*
adjDTA	0.302***	0.222***		
	(2.68)	(3.11)		
adjDTA_pos			0.345**	0.309***
			(2.00)	(2.95)
adjDTA_neg			0.240	0.099
			(1.08)	(0.68)
SIZE	–0.069	0.078**	–0.069	0.080**
	(–1.10)	(2.11)	(–1.09)	(2.15)
LEV	–1.090***	–0.957***	–1.094***	–0.964***
	(–3.38)	(–4.88)	(–3.38)	(–4.91)
ROA	–26.374***	–17.499***	–26.376***	–17.502***
	(–18.62)	(–19.07)	(–18.63)	(–19.09)
EV	1.651***	1.198***	1.646***	1.187***
	(6.40)	(7.62)	(6.37)	(7.53)
LOSS	–0.009	0.297	–0.015	0.285
	(–0.03)	(1.52)	(–0.05)	(1.46)
SHARE	–1.031***	–0.655***	–1.036***	–0.665***
	(–3.04)	(–3.12)	(–3.04)	(–3.16)
FOLLOW	–0.129**	0.137***	–0.129**	0.138***
	(–2.47)	(4.50)	(–2.46)	(4.52)
AGE	–0.148	–0.150**	–0.151	–0.156**
	(–1.28)	(–2.28)	(–1.30)	(–2.36)
STATE	–0.289***	–0.165**	–0.288***	–0.164**
	(–2.62)	(–2.52)	(–2.62)	(–2.50)
_cons	5.377***	0.617	5.368***	0.599
	(4.15)	(0.75)	(4.13)	(0.73)
YEAR	YES	YES	YES	YES
INDUSTRY	YES	YES	YES	YES
N	18,493	18,493	18,493	18,493
adj. R^2	0.0679	0.0734	0.0678	0.0734

Notes: This table reports the regression results of Eqs. (1)–(4) to examine the association between an abnormal change in deferred tax assets and analysts' earnings forecasts for H1 and H2. *adjDTA*, *adjDTA_pos* and *adjDTA_neg* are used instead of *abDTA*, *abDTA_pos* and *abDTA_neg* in Eqs. (1)–(4). The first row represents the estimated coefficients; the second row represents the t-values. All continuous variables are winsorized at the 1st and 99th percentiles to moderate the effects of outliers. All tests are two-tailed. Variable definitions are presented in Table 1.

*$p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$

explanatory variable. At the same time, I set *adjDTA_pos* and *adjDTA_neg* to distinguish the positive and negative abnormal changes in deferred tax assets. The regression results are shown in Table 10. In columns (1) and (2), the coefficients of *adjDTA* are significantly positive at the 1% level. In columns (3) and (4), the coefficients of *adjDTA_pos* are significantly positive at the 5% and 1% levels, respectively, whereas the coefficients of *adjDTA_neg* are not significant. The results of the robustness test are consistent with the main regression results.

5.5.3. Other robustness tests

Considering that Chinese enterprises began to adopt the balance sheet liability method in 2007, the total amount of deferred tax assets in 2007 compared with other years was relatively small, but the growth rate was relatively large. Furthermore, the Chinese enterprise income tax rate changed in 2007, and the new tax rate was adopted in 2008. Therefore, I exclude the 2007 observations and retest all of the regression models. The regression results remain unchanged. In addition, to further control for individual differences, fixed effects models are used for all of the regressions, and the results remain unchanged.

6. Conclusions and policy implications

6.1. Conclusions

In 2007, Chinese listed companies implemented CAS-18 (*Income Taxes*) and adopted the single balance sheet liability method for income tax accounting treatment. However, the deferred tax information generated by this method has well-known deficiencies, including a high level of complexity, a low level of understandability and the ease with which it can be manipulated by enterprise management. From an analyst's perspective, I select data from Chinese A-share listed companies from 2007 to 2018 to test the effect of an abnormal change in deferred tax assets on analysts' earnings forecasts. The results show that an abnormal change in deferred tax assets significantly increases the error and divergence of analysts' earnings forecasts, but an abnormal change in different directions has different effects on analysts' earnings forecasts. Specifically, a positive abnormal change in deferred tax assets has a negative impact on analysts' earnings forecasts, but a negative abnormal change does not have a significant impact. Further tests find that the level of corporate governance, audit quality and analysts' professional ability can moderate the relationship between an abnormal change in deferred tax assets and analysts' earnings forecasts. The impact of an abnormal change in deferred tax assets on analysts' earnings forecasts is more significant in the low corporate governance level, low audit quality and non-star analyst subsamples than in the high corporate governance level, high audit quality and star analyst subsamples. In addition, an abnormal change in deferred tax liabilities does not have a significant impact on analysts' earnings forecasts.

6.2. Policy implications

First, the international convergence of accounting standards in China was implemented after 2007, when listed companies in China began to use the single balance sheet liability method for income tax accounting treatment. However, I find that an abnormal change in deferred tax assets under the balance sheet liability method has a negative impact on analysts' earnings forecasts. Indeed, after 2007, the overall earnings forecast errors and divergence of Chinese analysts increased significantly. Given the international convergence of accounting standards, accounting standard-setting bodies should consider the reality of Chinese enterprises and establish accounting standards that are suitable for the sustainable development of these enterprises. The formulation of accounting standards should serve the users of financial reports, consider the reliability and comprehensibility of accounting information and attempt to reduce the manipulation space for enterprise management, not blindly pursue international convergence. Second, I find that improved corporate governance and audit quality can weaken the negative impact of an abnormal change in deferred tax assets on analysts' earnings forecasts. Therefore, enterprises should improve the level of internal governance; in addition, external auditors should improve audit quality and strengthen the audit of enterprise accounting information, which would improve both the supervision of enterprise management and the quality of accounting informa-

tion. Third, analysts should improve their professional skills, correctly understand and analyze the deferred tax information of enterprises, identify the profit manipulation motivations of enterprises by adjusting their deferred tax assets and provide more accurate information to investors. Financial report users should improve their ability to read financial reports and judge an enterprise's profitability by integrating all aspects of its information.

Declaration of Competing Interest

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

Appendix A.

Variable	Definition
CGI	Corporate governance index (CGI) is the sum of 14 internal governance factors.
(1) Audit Committee Size	An indicator variable equal to 1 if the size of a company's audit committee is greater than the median of the sample, and 0 otherwise.
(2) Compensation Committee Size	An indicator variable equal to 1 if the size of a company's compensation committee is greater than the median of the sample, and 0 otherwise.
(3) Nomination Committee Size	An indicator variable equal to 1 if the size of a company's nomination committee is greater than the median of the sample, and 0 otherwise.
(4) Strategy Committee Size	An indicator variable equal to 1 if the size of a company's strategy committee is greater than the median of the sample, and 0 otherwise.
(5) Independence of Audit Committee	An indicator variable equal to 1 if the percentage of a company's independent directors on the audit committee is greater than the median of the sample, and 0 otherwise.
(6) Independence of Compensation Committee	An indicator variable equal to 1 if the percentage of a company's independent directors on the compensation committee is greater than the median of the sample, and 0 otherwise.
(7) Independence of Nomination Committee	An indicator variable equal to 1 if the percentage of a company's independent directors on the nomination committee is greater than the median of the sample, and 0 otherwise.
(8) Independence of Strategy Committee	An indicator variable equal to 1 if the percentage of a company's independent directors on the strategy committee is greater than the median of the sample, and 0 otherwise.
(9) Expertise of Supervisory Board	An indicator variable equal to 1 if the number of a company's committee members with accounting and financial expertise is greater than the median of the sample, and 0 otherwise.
(10) Number of Supervisory Board Members	An indicator variable equal to 1 if the number of a company's supervisory board members is greater than the median of the sample, and 0 otherwise.
(11) Number of Supervisory Board Meetings	An indicator variable equal to 1 if the number of a company's supervisory board meetings is greater than the median of the sample, and 0 otherwise.

Appendix A (*continued*)

Variable	Definition
(12) Share Ownership of Supervisory Board Members	An indicator variable equal to 1 if the share ownership of a company's supervisory board members is greater than the median of the sample, and 0 otherwise.
(13) Share Ownership of the Largest Shareholder	An indicator variable equal to 1 is the share ownership of a company's largest shareholder is greater than the median of the sample, and 0 otherwise.
(14) Share Ownership of the Largest and Second-largest Shareholders	An indicator variable equal to 1 is the share ownership of a company's largest shareholder and second-largest shareholder is greater than the median of the sample, and 0 otherwise.

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