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Tracing back to the source: Understanding the corporate governance of boards of directors in Chinese SOEs

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ABSTRACT

Based on the relevant theories of corporate governance and the special institutional background of Chinese state-owned enterprises (SOEs), this paper systematically reviews the literature on the independence and governance effect of SOE boards. We find that the governance effect of SOE boards is driven by the dual characteristics of SOEs: state involvement in ownership and market incentives. With the state involved in ownership, SOEs adhere to the leadership of the Communist Party of China (CPC), which results in an enhanced governance effect. Under market incentives, SOEs tend to have an optimal board structure that helps mitigate both the shareholder–management agency problem (Type I agency problem) and the controlling shareholder–minority shareholder agency problem (Type II agency problem). In terms of the governance effect of boards, directors appointed by non-controlling shareholders are effective in alleviating Type I and Type II agency problems, and this highlights the importance of mixed-ownership reforms in SOEs. Independent directors, especially those with a professional background, also play a role in improving corporate governance. However, independent directors in SOEs have relatively weak incentives to monitor, which limits their governance effect. This paper shows positive implications for promoting mixed-ownership reforms and improving board governance in SOEs.

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1. Introduction

According to the literature, business operations have two types of agency problems. Type I agency problems are caused by potential conflicts of interest between shareholders and management when the company's ownership and management rights are separated (Jensen and Meckling, 1976; Shleifer and Vishny, 1997). In the United States, the Type I agency problem is more common due to numerous institutional investors, a mature securities market, and dispersed equity shareholdings. When a company's shareholders are relatively concentrated and minority investor protection is weak, controlling shareholders may expropriate the interests of minority shareholders through "tunneling," resulting in a Type II agency problem (La Porta et al., 1999; Claessens et al., 2000). The Type II agency problem is more common in China and other transition economies (Jiang et al., 2010; Zhu et al., 2015).

Bebchuk and Weisbach (2010) point out that the most common way that shareholders protect their interests is by appointing company directors. Therefore, directors and boards have become core issues in corporate governance research (Fama and Jensen, 1983). From a legal perspective, a board is established to meet regulatory requirements, but from an economic perspective, a board's role is to solve the principal–agent problems between shareholders and management that are inherent in a company's development. Corporate governance principles issued by the Organization for Economic Cooperation and Development (OECD) emphasize the board's role in both strategic guidance and effective supervision. In recent years, boards have played an increasingly important role in corporate governance driven by shareholder activism.

In U.S. companies, a board usually consists of inside and outside directors. Inside directors are full-time employees of the company, whereas outside directors are not. Generally, outside directors are considered to be independent directors, but some, such as bankers or lawyers, also have business connections with the company; these are called "affiliated directors" or "gray directors" (Adams et al., 2010). Independent directors, nonexecutive directors with monitoring incentives to protect shareholders' interests, have become increasingly important (Gordon, 2006). Researchers use the proportion of independent directors on a board to measure board independence. The higher the proportion of independent directors, the stronger the independence of the board (see for example, Tan, 2003; Li and Xu, 2014).

Studies of the U.S. market provide evidence emphasizing the contribution of outside directors, especially independent directors, to board independence. For example, focusing on Forbes 500 companies from 1985 to 1995, Fich and Shivdasani (2006) find that on a typical board, 55% of directors were outside directors (outside directors are independent directors in their sample), 30% were inside directors, and 15% were gray directors. Linck et al. (2008a) find that the proportion of outside directors is relatively high in large-scale companies and is gradually increasing in all companies, based on the data of 6,931 listed companies in the U.S. from 1990 to 2004. Since the enactment of the Sarbanes-Oxley Act, the proportion of outside directors for listed companies in the U.S. has continued to increase (Linck et al., 2008b).

Chinese companies' corporate governance practices and academic research concerning them have developed in accordance with the reform of Chinese enterprises, especially SOE reforms (Li et al., 2019). The reform of SOEs is key to China's overall economic reforms, and improving SOEs' corporate governance is an important step in establishing a modern corporate system. Therefore, scholars have focused on corporate governance issues in SOEs, and there is a long stream of research (see, e.g., Wu,1993; Qian,1995; Li et al.,2001). Moreover, the establishment and development of China's stock market is closely related to the reform of SOEs. Transforming SOEs through listing has been the main driving force for the development of China's securities market (Lin, 1999, 2006; Zhu and Lu, 2012). To better protect the interests of minority investors, China's securities regulatory authorities proactively promote the reform of corporate governance in Chinese listed companies. On January 7, 2002, the China Securities Regulatory Commission (CSRC) issued guidelines for the governance of listed companies (ZJF [2002] No. 1), which standardize the basic principles of corporate governance, ways to protect investors, and the basic code of practice standards and professional ethics that must be followed by directors, supervisors, managers, and other senior executives of Chinese listed companies. To effectively supervise controlling shareholders and managers and to safeguard the interests of minority shareholders, the guidelines for establishing an independent director system in Chinese listed companies (ZJF [2001] No. 102) explicitly state that independent directors should constitute more than one-third of

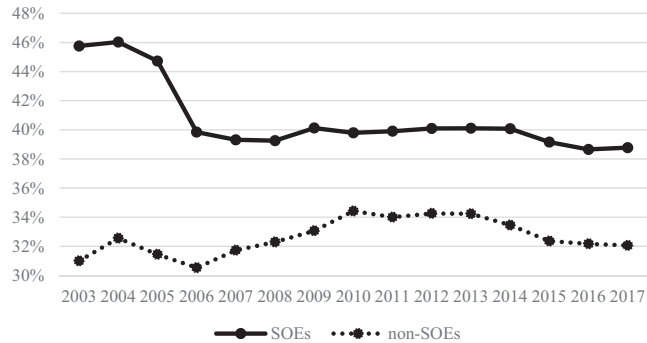

Fig. 1. The ratio of ownership by the largest shareholder in A-share listed companies.

the board of Chinese listed companies, which means that regulatory authorities are paying attention to board independence in Chinese listed companies.

However, in China, the history of board policies is relatively short, and the concept of supervision is still being explored. Moreover, compared with ownership in the United States and other developed countries, ownership is more concentrated in Chinese listed companies, especially state-owned listed companies, which leads to more severe Type II agency problems. According to Azar et al. (2018), in U.S. listed companies, the largest shareholder usually owns less than 10% of the firm. However, in Chinese A-share listed companies, the largest shareholder owns more than 30% of the firm, on average. Moreover, the proportion of shares held by the largest shareholder is significantly higher in state-owned listed companies than in non-state-owned listed companies (Fig. 1).

Given China's current corporate governance structure, can independent directors effectively monitor controlling shareholders and management to enhance firm value, and has the goal of improving board independence been achieved? Previous studies have not reached consistent conclusions on these questions for several reasons. On the one hand, independent directors can gain recognition from investors due to the independent director's aim of representing the interests of all investors and providing more objective opinions and suggestions from a third-party perspective (Rosenstein and Wyatt, 1990). On the other hand, compared with other types of directors who are more closely connected with listed companies, independent directors may have some weaknesses, such as insufficient information (Duchin et al., 2010), lack of knowledge in related fields, weak motivation to perform their duties (Zhu et al., 2015), and vulnerability to controlling shareholders and management (Hwang and Kim, 2009; Coles et al., 2014), which weaken the supervisory role of independent directors (Mehran, 1995; Ferris et al., 2003; Wang, 2007). However, with the continuous improvement of China's independent director system, more studies have found that board independence can alleviate Type II agency problems (Ye et al., 2007) and improve companies' financial performance (Wang et al., 2006; Zhao et al., 2008) and earnings quality (Wang et al., 2008; Zhao et al., 2008).

Compared to the focus on the role of outside (independent) directors on the boards of U.S. companies, Chinese researchers have gradually begun to direct their attention to directors appointed to the boards of Chinese listed companies by non-controlling shareholders. Xin et al. (2013) find that Chinese CEO turnover–performance sensitivity is higher when the proportion of directors appointed by non-controlling shareholders increases. Hu and Lu (2015) find that both directors appointed by controlling shareholders and those appointed by non-controlling shareholders can reduce a firm's overinvestment. However, the effect of directors appointed by a controlling shareholder on reducing overinvestment is limited in the presence of duality and separation of ownership. Zhu et al. (2015) find that in situations with concentrated ownership and weak investor protection, directors appointed by non-controlling shareholders better supervise controlling shareholders and management. Cheng et al. (2017) point out that directors appointed by non-controlling shareholders can bring information advantages to noncontrolling shareholders, curbing controlling shareholders' earnings management and stock price manipulation. These studies raise several questions. How efficient is the governance of directors appointed by non-controlling shareholders? Can directors appointed by non-

controlling shareholders make up for the lack of board independence in Chinese listed companies, especially in SOEs?[1]

In this context, this paper systematically reviews the academic literature on board structure and independence as well as the institutional background and regulatory practices of boards of directors in China. Theoretical guidance is required to understand the governance mechanism of boards and how they function, which is the foundation of the research on board structure and board independence. As there are significant differences in board structure and board member roles between domestic and foreign companies, we start with the special institutional background and ownership characteristics of Chinese SOEs and then analyze the corporate governance roles played by different types of directors as we explore board governance in Chinese SOEs. In this way, we can provide a theoretical reference and practical enlightenment regarding current SOE reform, especially mixed-ownership reform.

2. Peculiarities of board governance in Chinese SOEs

With its reform of SOEs, the Chinese government has promoted SOEs' corporate governance, especially board governance. In 1993, the third plenary session of the 14th CPC Central Committee proposed that SOEs should establish a modern corporate system. In the same year, the Company Law of the People's Republic of China was promulgated, providing legal norms and guidelines for corporate governance reform and rules for SOE board construction. In 1999, the fourth plenary session of the 15th CPC Central Committee decided several major issues concerning the reform and development of SOEs. It was proposed that because corporate governance structure is at the core of the corporate system, shareholders, boards of directors and supervisors, and management must divide their responsibilities, coordinate operations, and effectively provide checks and balances. In 2003, the State-Owned Assets Supervision and Administration Commission of the State Council (SASAC) was established and authorized by the State Council to perform its responsibilities as investors in accordance with the Company Law of the People's Republic of China and other laws and administrative regulations. In the same year, the SASAC launched a pilot project for boards of directors in central government controlled SOEs (hereinafter referred to as "central SOEs"). At present, SOEs have established a relatively complete framework for boards of directors, and the role of board governance is becoming increasingly prominent. In central SOEs, boards include both inside and outside directors. In 2009, the SASAC also started to recruit full-time outside directors in central SOEs. In 2014, the SASAC launched a pilot program concerning board authority and granted strategic decision-making, selection, and appraisal authority to the boards of the pilot enterprises, such as the China Energy Conservation and Environmental Protection Group, the China National Building Materials Group, the Sinopharm Group, and the Xinxing Cathay International Group. In 2016, the SASAC further authorized the boards of some pilot enterprises to determine their gross payroll and its distribution.

In sum, the boards of Chinese SOEs have significant dual characteristics: state involvement in ownership and market incentives. Next, we summarize and explore the dual characteristics of board governance based on the "Guidance on Deepening the Reform of SOEs" (ZF [2015] No. 22; hereinafter referred to as "Guidance (2015)") issued by the CPC Central Committee and the State Council on August 24, 2015, and the "Guidance on Further Improving the Corporate Governance Structure of SOEs" issued by the General Office of the State Council on April 24, 2017 (GBF [2017]No. 36; hereinafter referred to as "Guidance (2017)").

2.1. Adhering to CPC's leadership over SOEs

Guidance (2015) points out that "adhering to the CPC's leadership over SOEs is the political direction and principle when deepening the reform of SOEs. It is necessary to implement the principle about overall strict governance of the Party, to give full play to the political core role of the Party organization in companies, to strengthen the construction of the leading group in companies, to innovate the work of the Party building at the primary level, to deepen the construction of a clean and honest Party, to wholeheartedly rely on the work-

[1] We mainly consider state-owned listed companies in our analysis.

ing class, to safeguard the legitimate rights and interests of employees, and to provide a strong political and organizational guarantee and human resource support for the reform and development in SOEs." Guidance (2017) states that "it is the unique advantage of SOEs to insist on the CPC's leadership and to strengthen the Party building. It is necessary to clarify the legal status of the Party organization in the corporate governance structure of SOEs, to incorporate the general requirements of the Party building in the regulations of SOEs, and to clarify the rights, responsibilities and working methods of the Party organization in the decision-making, implementation and supervision processes, so as to make the Party organization an integral part of the corporate governance structure. In addition, it is essential to give a full play to the leading and political core role of the Party, to lead the ideological and political work of the companies, to support board of directors, board of supervisors and management to perform their duties in accordance with the law, and to ensure the implementation of the Party's and national policies.…To give a full play to the supervisory role of inspection, supervision and audit. Besides, the Party members among directors, supervisors, and management team of SOEs shall regularly report to the Party group (Party committee) about the performance of their duties, integrity and self-discipline every year.…The leader of the Discipline Inspection Team (secretary of the Discipline Inspection Commission) may attend the meetings of the board of directors and the special committee of the board as nonvoting delegates." Guidance (2017) also states that SOEs should "actively explore the ways and methods of the organic combination between the principle of the Party's managing cadres and board's selection and appointment of management personnel. By insist on and improving the leadership system of two-way entry and cross appointment, qualified members of the Party group (Party committee) in SOEs can be a member of the board of directors, board of supervisors and management through legal procedures. Qualified members of board of directors, board of supervisors and management are able to enter the Party group (Party committee) according to relevant regulations and procedures; the position of secretary of the Party group (Party committee) and chairman of board of directors should be taken by the same person generally and promote the project about appointing the Deputy Secretary of the Party group (Party committee) as a member of board of directors in centrally-administered SOEs."

Studies find that strengthening the CPC's leadership in SOEs can improve the efficiency of corporate governance. For example, using the data of A-share state-owned listed companies from 2008 to 2010, Ma et al. (2012) study the effect on corporate governance of "two-way entry and cross appointment" between the Party committee and boards of directors, boards of supervisors, and senior management and find that this leadership system is positively related to board efficiency. Ma et al. (2013) find that executives can be discouraged from seizing excessive remuneration when the Party committee participates in SOEs' corporate governance (especially when members of the Party committee are directors, supervisors, and senior executives at listed companies). Chen and Lu (2014) find that SOEs that incorporate Party organizations in corporate governance obtain higher merger and acquisition (M&A) premiums when selling assets or equity.

2.2. Optimizing the board structure of SOEs

The appointment of directors by government regulators and state-owned controlling shareholders is an important way to strengthen boards of directors and implement their functions, which perfectly embody market incentives in SOEs' board construction. Guidance (2015) points out that the key to improve the corporate governance structure of a company is to promote the construction of boards of directors to establish and improve decision-making, implementation, and supervision mechanisms with equal rights and responsibilities, coordinated operations, and effective checks and balances. In addition, it is essential to standardize the conduct of the chairman and CEO, and to give full play to the decision-making role of the board of directors, the supervisory role of the board of supervisors, the managerial role of management, and the core political role of the Party. To strengthen the internal checks and balances of a board, for a wholly state-owned enterprise or a company with the state being the sole investor, its board of directors and board of supervisors shall include employee representatives. Outside directors shall make up a majority of the board, a one person–one vote system shall be implemented, and directors shall be responsible for the decisions of the board. SOEs shall make further improvement by building an outside director team and welcome outside directors with various backgrounds. Guidance (2017) points out that the directors of a wholly state-owned company are responsible to investors and receive instructions from the administrative institution of state-owned properties (a wholly

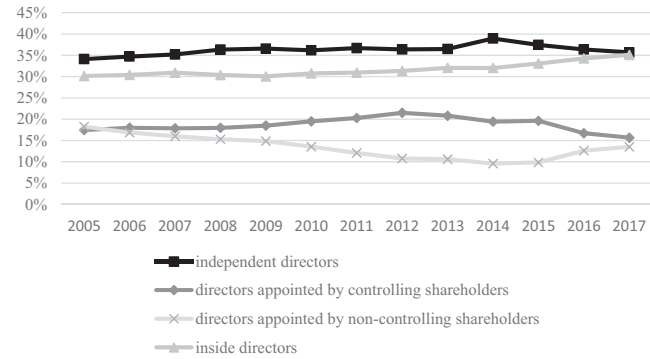

Fig. 2. Changes in the proportion of all types of directors in SOEs.

state-owned company does not have a shareholder meeting, and the administrative institution of state-owned properties performs the duties of a shareholder meeting in accordance with the law). Candidates for outside directors shall be nominated by the administrative institution of state-owned properties and other relevant government agencies, and appointed in accordance with legal procedures. The directors of wholly state-owned or state-controlled companies are nominated by the relevant shareholders based on ownership percentage and elected or replaced by a general meeting of shareholders, and the directors appointed by the state-owned shareholders should actively safeguard the rights and interests of state-owned capital. Outside directors of wholly state-owned companies are supposed to be nominated by the controlling and other shareholders and elected or replaced by a general meeting of shareholders. Furthermore, state-owned holding companies should have a certain proportion of outside directors that are elected or replaced by a shareholder meeting.[2]

The peculiarities of board governance in Chinese SOEs conform to the SOE reform trend and China's institutional environment. The research summarized in this paper regarding SOEs' board characteristics of state involvement in ownership provides great theoretical significance for meeting the goals of fully adhering to the CPC's leadership and strengthening the construction of the Party in SOEs' boards of directors and for promoting the theory of corporate governance. In fact, there are SOEs in many developed countries (such as Électricité De France and Temasek in Singapore), and the board construction of SOEs in each country has its own characteristics. Therefore, this paper also provides guidance from the Chinese experience that other countries can use to strengthen the construction of boards of directors in their SOEs.

3. General characteristics of board structure in Chinese SOEs

Zhu et al. (2015) classify board directors in Chinese listed companies as inside directors, independent directors, directors appointed by controlling shareholders, and directors appointed by non-controlling shareholders. Inside directors are those who hold a position only in the listed company, independent directors do not hold any other positions in the listed company or its shareholder companies, directors appointed by controlling shareholders are those who hold positions in controlling shareholder companies and the listed company, and directors appointed by non-controlling shareholders hold positions in non-controlling shareholder companies and the listed company. To better appreciate the characteristics of board structure in SOEs, we provide the statistics on the composition of various types of directors in A-share state-owned listed companies from 2005 to 2017. Fig. 2 shows that independent directors made up the largest proportion of boards, and that proportion remained above 35% from 2005 to 2017, which shows that SOEs are adequately complying with the requirement in Guidance on Establishing Independent Director System in Listed Companies (ZJF [2001] No. 102): "more than one-third of the board members in listed companies should be independent directors." From 2005 to 2017, the proportion of inside directors on boards also exceeded 30%, reaching 35% in 2017. Senior

[2] As there are no other shareholders in a wholly state-owned company, only the Type I agency problem exists. Outside directors with strong independence can fully express their supervision of the company, effectively supervise management, and play an advisory role.

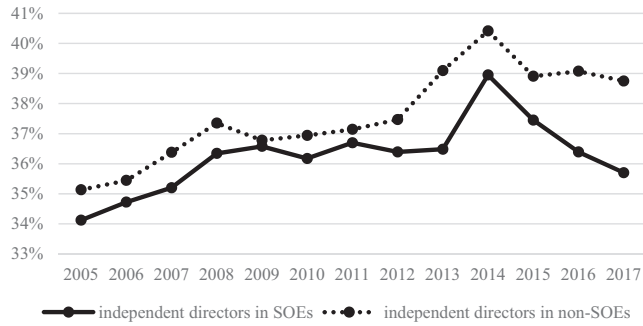

Fig. 3. Changes in the proportion of independent directors in SOEs and non-SOEs.

managers and staff directors inside a company are the main inside directors. From 2005 to 2017, the proportion of directors appointed by controlling shareholders was between 15% and 22%, while that of directors appointed by non-controlling shareholders was between 9% and 18%. At present, the average number of directors in A-share listed companies is about nine. According to the proportions mentioned above, on a typical board, there should be three independent directors, three inside directors, two directors appointed by the controlling shareholder, and one director appointed by non-controlling shareholders. This design is intended to guarantee the independence of the board.

To further compare and analyze the structural differences of boards between SOEs and non-SOEs, we provide a comparison of each type of director in SOEs and non-SOEs.

3.1. Comparative analysis of the proportion of independent directors in SOEs and Non-SOEs

Fig. 3 shows that the proportion of independent directors on the boards of SOEs has reached more than one-third, which is still lower than that of non-SOEs. After 2014, the proportion of independent directors in both SOEs and non-SOEs declined to some extent. However, the decline is more obvious in SOEs, mainly because many officers who were independent directors resigned after the release of the guiding opinion on regulating the Party and government's leading cadres' concurrent posting (post-holding)in companies (see ZZF [2013] No. 18, hereinafter referred to as "Reg. 18"). Analyzing 1,760 resignations by independent directors from 2012 to the first quarter of 2015, Ye et al. (2016) find that 1,017 were resignations of official independent directors after the issuance of Reg. 18. The resignations peaked in 2014 and the first quarter of 2015.

3.2. Comparative analysis of the proportion of inside directors in SOEs and Non-SOEs

Fig. 4 compares the trends of the proportion of inside directors in SOEs and Non-SOEs. Generally, the proportion of inside directors on a board has gradually increased in both SOEs and Non-SOEs. Compared with non-SOEs, inside directors account for a lower proportion of SOEs' boards. The Guiding Opinions on Deepening the Reform of SOEs issued by the CPC Central Committee and the State Council on August 24, 2015 clearly states that "outside directors on the board should be[the] majority," which will affect the structure and independence of SOEs' boards.

3.3. Comparative analysis of the proportion of directors appointed by controlling shareholders in SOEs and Non-SOEs

The appointment of directors (outside directors) to listed companies by state-owned controlling shareholders is an important way to strengthen board construction and improve the governance efficiency of SOEs' boards. Fig. 5 shows the changes in the proportion of directors appointed by controlling shareholders in SOEs and non-SOEs. After 2012, the proportion of directors appointed by controlling shareholders in both SOEs and non-SOEs declined, but the proportion of directors appointed by controlling shareholders was higher

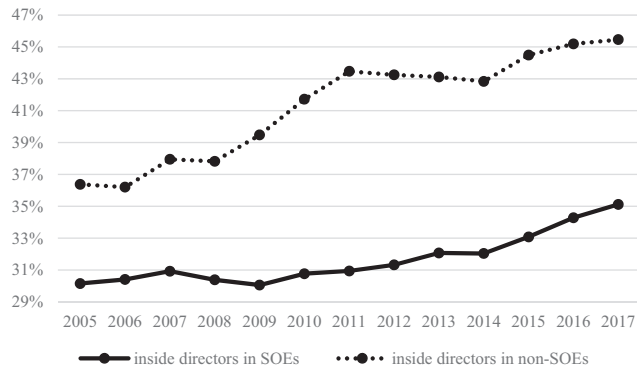

Fig. 4. Changes in the proportion of inside directors in SOEs and non-SOEs.

Fig. 5. Changes in the proportion of directors appointed by controlling shareholders in SOEs and non-SOEs.

in SOEs. Fig. 1 shows that on average, the largest shareholders of SOEs owned about 39% of the company in 2017, which is much higher than the percentage of ownership of the largest shareholders in non-SOEs (32%). Therefore, the proportion of directors appointed by controlling shareholders is higher in SOEs.

3.4. Comparative analysis of the proportion of directors appointed by Non-Controlling shareholders in SOEs and Non-SOEs

Fig. 6 shows that the proportion of directors appointed by non-controlling shareholders in both SOEs and non-SOEs decreased from 2005 to 2014, from about 18% to about 10% in SOEs and from about 14% to about 6% in non-SOEs. After 2015, the proportion of directors appointed by non-controlling shareholders in both

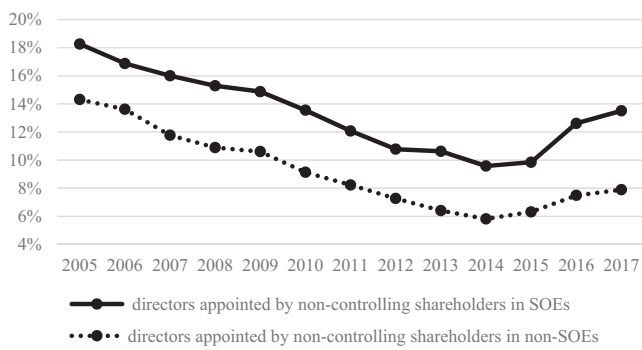

Fig. 6. Changes in the proportion of directors appointed by noncontrolling shareholders in SOEs and non-SOEs.

SOEs and non-SOEs increased. Generally, the proportion of directors appointed by non-controlling shareholders in SOEs is higher. Zhu et al. (2015) and Cheng et al. (2017) point out that due to serious Type II agency problems in SOEs, noncontrolling shareholders have a strong incentive to monitor controlling shareholders to prevent expropriation by controlling shareholders and to improve corporate governance. Appointing directors is an important tool for non-controlling shareholders to safeguard their interests.

4. Independence and the governance effect of boards of directors in Chinese SOEs from the perspective of the Type I agency problem

4.1. The governance effect of directors appointed by controlling and noncontrolling shareholders on the Type I agency problem

The academic research shows that SOEs are prone to problems such as the absence of owners, which reduces the effectiveness of monitoring by shareholders and leads to insider control (Lv et al., 2008). Therefore, it is essential to understand whether the board governance of SOEs in China can effectively solve the agency problem between shareholders and management (Type I agency problem).

4.1.1. The governance effect of directors appointed by controlling shareholders

To monitor and incentivize management, controlling shareholders appoint directors to boards (Gillan and Starks, 2000; Sun and Sun, 2018). Duan et al. (2011) find that the proportion of directors appointed to a board by controlling shareholders increases with controlling shareholders' ownership, and this effect is more pronounced in SOEs. Research shows that directors appointed by controlling shareholders can improve corporate governance to a certain extent. For example, Hu and Lu (2015) find that directors appointed by controlling shareholders have a supervisory and inhibitory effect on overinvestment. Sun and Sun, 2018 find that executive directors appointed by controlling shareholders can curb earnings management and increase companies' pay-performance sensitivity.[3] However, Wang et al. (2015) find that SOE boards with more nonexecutive directors appointed by controlling shareholders have higher agency costs between shareholders and managers, lower pay–performance sensitivity, and less efficient board governance.[4] Wang et al. (2015) argue that this occurs because controlling shareholders control the general meeting of shareholders and are highly involved in the operation of the board through director nominations, which damages the independence of the board, weakens the board's supervision of management, and adversely affects the governance efficiency of the board. Hu and Lu (2015) find that nonexecutive directors (including directors appointed by both controlling and non-controlling shareholders) in non-SOEs significantly inhibit earnings smoothing, but such inhibition is not significant in SOEs. Based on this analysis, we cannot reach a consistent conclusion on the corporate governance effect of directors appointed by controlling shareholders on the Type I agency problem.

4.1.2. The governance effect of directors appointed by Non-Controlling shareholders

What is the governance effect of directors appointed by non-controlling shareholders? Zhu et al. (2015) find that to protect the interests of the non-controlling shareholders they represent, directors appointed by non-controlling shareholders have strong incentives to monitor management and alleviate the Type I agency problem. Xin et al. (2013) find that the higher the proportion of directors appointed by non-controlling shareholders, the higher the CEO turnover–performance sensitivity. Proposal voting is an important way for directors to participate in a company's decision-making and effectively monitor management. Zhu et al. (2015) study the voting behavior of various types of directors and find that compared with other types of directors, directors appointed by non-controlling shareholders are more likely to dissent on board proposals, and such dissension can significantly improve a company's performance. Cai et al. (2018a) use a sample of SOEs from 2008 to 2015 and point out that the appointment of directors, supervisors, and executives from non-SOEs to SOEs is effective in improving pay–performance sensitivity and inhibiting excess executive compensation and

[3] Lu and Hu (2015) and Sun and Sun (2018) include both SOEs and non-SOEs in their studies.

[4] Wang et al. (2015) define nonexecutive directors from controlling shareholders as directors appointed (or nominated) by controlling shareholders who hold working positions in the controlling shareholder and are not paid by the listed companies.

perks in SOEs. Based on a sample of SOEs from 2007 to 2015, Lu et al. (2019) find that non-controlling shareholders with voting rights on a board (through appointed directors) guarantee the efficiency of M&As for SOEs by reducing ineffective M&As (source control) and improving the ability to integrate (process control).

4.2. The governance effect of independent directors on the Type I agency problem

4.2.1. General governance effect of independent directors on the Type I agency problem

According to the Guidance on the Establishment of an Independent Director System in Listed Companies (ZJF[2001] No. 102), independent directors shall perform their duties independently and shall not be affected by large shareholders, controllers, or other units and individuals having an interest in the listed company, and the proportion of independent directors shall be more than one-third of the board. Current academic research and regulatory practice regard the proportion of independent directors as an important indicator of a board's independence. Research finds that improving board independence can reduce financial risks (Yu et al., 2008) and improve firm performance (Wang et al., 2006; Zhao et al., 2008), earnings quality (Wang et al., 2008), and accounting conservatism (Zhao et al., 2008). Using unique board voting data in China, Ye et al. (2011) find that independent directors are more likely to publicly vote against management's proposal when a company's performance is poor. Zhu et al. (2016) find that the higher the ranking of an independent director's position on a board, the more likely they are to dissent from management's decisions. Independent directors' dissension has a positive effect on corporate governance and performance (Ye et al., 2011; Tang et al., 2013; Zhu et al., 2015; Zhu et al., 2016).

Although research documents that the independent director system is effective in monitoring management and improving corporate governance, some studies show that the monitoring effectiveness of independent directors may be restricted by factors such as property rights. Chen and Xie (2011) find that the higher the network centrality of independent directors, the higher the investment efficiency of their companies; however, compared with non-SOEs, the network centrality of independent directors has a weaker influence on the governance effect of investment efficiency in SOEs. Chen and Xie (2012) examine the effect of independent directors' network centrality on pay–performance sensitivity and find that the higher the network centrality of independent directors, the higher the pay–performance sensitivity. However, compared with non-SOEs, the positive effect of independent directors' network centrality on pay–performance sensitivity in SOEs is relatively weak. Zhu et al. (2015) point out that due to the lower risk inherent in SOEs, independent directors have insufficient incentives to supervise, which shows that independent directors are more likely to dissent in non-SOEs. Cai et al. (2017) find that compared with non-SOEs, independent directors with accounting expertise are less likely to inhibit real earnings management behavior in SOEs. Luo et al. (2018) further examine the effect of the location of independent directors on pay–performance sensitivity and find that in SOEs, the proportion of local independent directors is negatively associated with pay–performance sensitivity. Based on this analysis, we find that the governance effect of independent directors on the Type I agency problem in SOEs is weakened due to the property rights issues of SOEs.

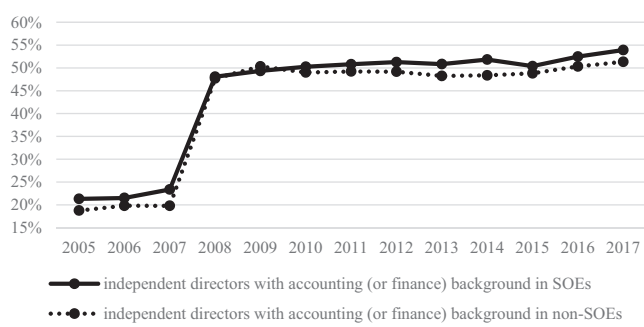

Fig. 7. Changes in the proportion of independent directors with an accounting or finance background in SOEs and non-SOEs.

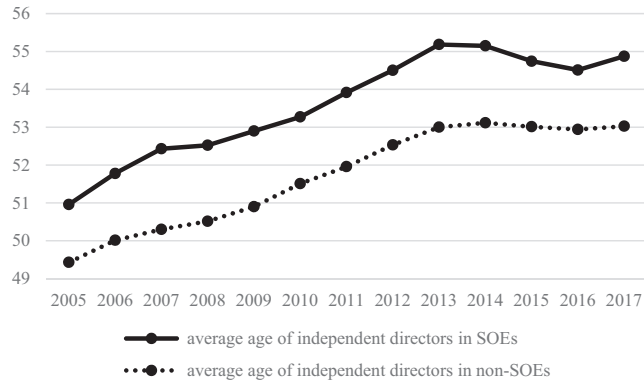

Fig. 8. Changes in the average age of independent directors in SOEs and non-SOEs.

4.2.2. Characteristics of independent directors and the governance effect of independent directors on the Type I agency problem

(1) **Professional Background of Independent Directors**

Recently, scholars have paid more attention to the influence of directors' personal heterogeneity on board independence and its governance effect. According to ZJF(2001) No.102, the independent directors of A-share listed companies must include at least one with accounting expertise (accounting expertise refers to a person with a senior professional title or certified public accountant qualification). Fig. 7 shows the proportion of independent directors with accounting or finance backgrounds for both SOEs and non-SOEs, and it illustrates that since the financial crisis in 2008, the proportion of independent directors with an accounting or finance background has increased significantly in SOEs and non-SOEs. Moreover, in 2017, independent directors with an accounting (finance) background in both SOEs and non-SOEs accounted for more than 50% of all independent directors, which is consistent with the regulatory provisions. Ye et al. (2011) use a sample of Chinese A-share listed companies and find that independent directors with an accounting (finance) background are more likely to dissent from management's proposals. Wu et al. (2015) find that when a company hires a person who worked in the company's current auditing firm as an independent director, the independence between the independent director and the auditor is stronger and the audit is stricter. Zhou et al. (2016) find that expertise can significantly improve the monitoring potential of independent directors.

(2) **Independent Director Age**

The age of an independent director usually represents his or her qualifications and status. Fig. 8 shows the average age of independent directors in SOEs and non-SOEs. In general, independent directors in SOEs are two years older than those in non-SOEs. Using the data of A-share listed companies from 2004 to 2012, Jiang et al. (2015) find that younger independent directors, who are more concerned about their career development, are more inclined to dissent and that independent directors who dissent are more likely to obtain board seats in the future.

(3) **Relative Independence of Independent Directors**

In addition to background and age, the independent director's governance effect is also affected by a director's relative independence. For example, Ye et al. (2011) find that independent directors who have held their position longer than the current chair are more likely to vote against management's proposals. Zhu et al. (2016) find that independent directors who are ranked higher on a board are more likely to vote against management.

5. Independence and the governance effect of boards of directors in Chinese SOEs from the perspective of the Type II agency problem

In China, the ownership of listed companies is relatively concentrated, and controlling shareholders may expropriate the interests of non-controlling shareholders through tunneling when minority investor protection is weak, which leads to the Type II agency problem (Jiang et al., 2010). The next question is whether directors appointed by non-controlling shareholders and independent directors on the boards of SOEs play a governance role in alleviating the Type II agency problem.

5.1. The governance effect of directors appointed by Non-Controlling shareholders on the Type II agency problem Based on the evidence of Mixed-Ownership reform

The integration of different ownership types is called mixed ownership (Shen and Yang, 2019). Since the reforms and opening up in China, a large number of mixed-ownership companies have arisen, and an IPO is an important way for SOEs to attract non-state-owned capital and realize mixed-ownership. After the 18th CPC National Congress in 2012, the mixed-ownership reform of SOEs entered an accelerated stage. The report to the 19th CPC National Congress in 2017 emphasized the intent to "deepen the reform of SOEs, develop the mixed-ownership economy, and cultivate world-class companies with global competitiveness."

Non-state-owned capital (usually in the form of non-controlling shareholders) can play a governance role in SOEs to alleviate the Type II agency problem in two ways. First, non-controlling shareholders can be heard at the general meeting of shareholders. For example, the CSRC has issued various policies to protect minority shareholders and supervise and restrict controlling shareholders, including requiring equity offering proposals to obtain separate approval from voting minority shareholders (Chen et al., 2013) and providing online systems for minority shareholders to vote (Li et al., 2012; Li and Kong, 2013).

Second, non-controlling shareholders can have a voice by holding seats on the board, which can help non-state-owned shareholders improve the governance and operating efficiency of SOEs (Cai et al., 2018b). According to Article 103 of the Company Law of the People's Republic of China, "shareholders who individually or jointly hold more than 3% of the company's shares have the right to nominate candidates as directors." Cai et al. (2018a) finds that from 2008 to 2015, 15.4% of SOEs had at least one director appointed by non-state-owned shareholders. Fig. 2 shows that from 2005 to 2017, the average proportion of directors appointed by non-controlling shareholders in SOEs was 13.4%. Although the proportion of directors appointed by non-controlling shareholders is relatively small, academic papers find that such directors have a positive governance effect on the Type II agency problem. Zhu et al. (2015) find that compared with other directors, directors appointed by non-controlling shareholders are more likely to dissent on board proposals. Moreover, previous studies suggest that agency problems are more severe in SOEs (Shleifer, 1998), which may exacerbate controlling shareholders' tunneling (Gul et al., 2010), and that directors appointed by non-controlling shareholders are more likely to dissent in SOEs (Zhu et al., 2015). Cheng et al. (2017) find that when ownership is more concentrated, non-controlling shareholders can effectively supervise controlling shareholders and protect their own interests by nominating directors to the company. Zhang and Liu (2018) study the mixed-ownership reform of China Unicom and find that non-state-owned companies such as Baidu, Ali, Tencent, and Jingdong play a checks and balances role in the board's decision-making by excessively appointing directors. Using centrally administered SOEs with mixed ownership as a research sample, Liu et al. (2018) study the economic consequences of the balance between state-owned and non-state-owned equity and find that moderately increasing the number of directors appointed by non-state shareholders can increase firm value.

Of course, the effect of mixed-ownership reform is also affected by the external environment. Cai et al. (2018b) find that greater government willingness to delegate power is associated with a higher level of ownership by non-state-owned shareholders in SOEs and a higher proportion of appointed directors, supervisors, and executives by such non-state-owned shareholders. This indicates the importance of the government's willingness to delegate power during the mixed-ownership reform of SOEs.

5.2. The governance effect of independent directors on the Type II agency problem

ZJF(2001) No. 102 clearly states that significant related-party transactions (referring to related-party transactions engaged in by a listed company and a related party that amount to more than RMB3 million or 5% of the latest audited net asset value) must be approved by the independent directors and submitted to the board of directors for discussion. ZJF(2001) No. 102 also stipulates that independent directors must give independent opinions to the board of directors or the general meeting of shareholders related to "listed companies' existing or newly incurred loans or other capital transactions with shareholders, actual controllers and their affiliated companies, exceeding the total amount 3 million RMB or 5% of the latest audited net asset value of listed companies, as well as give opinions about whether listed companies take effective measures to recover the arrears." The literature provides supporting evidence that independent directors have a better governance effect on the Type II agency problem, such as controlling shareholders' tunneling, significant related-party transactions, and so on. Ye et al. (2007) examine controlling shareholders' use of listed companies' funds and find that the introduction of independent directors can effectively inhibit controlling shareholders' tunneling. Using SOEs as the sample, Liu et al. (2012) find that independent directors can reduce underinvestment caused by controlling shareholders' tunneling. Chen (2012) examines the effect of independent directors on agency costs from the perspective of network centrality and finds that when overall network centrality of independent directors is high, the Type II agency problem (controlling shareholders' fund occupation) between controlling shareholders and minority shareholders is effectively restrained. However, in SOEs, in which controlling shareholders are more powerful and the board has less power, the restraining effect of the network centrality of independent directors on the Type II agency problem is weaker.

We should note that although ZJF(2001) No. 102 requires independent directors to be independent, it also stipulates that "the board of directors, supervisors in the listed company, and shareholders individually or jointly holding more than 1% of the issued shares of a listed company may nominate candidates for independent directors, which shall be elected and decided by the general meeting of shareholders." This means that controlling shareholders have an important effect on the nomination of independent directors, so the independence of independent directors may be negatively affected when reducing agency problems between controlling shareholders and minority shareholders (Peng et al., 2018).

6. Conclusions and implications

6.1. Conclusions

Due to the ownership concentration in Chinese SOEs, agency problems between shareholders and management (Type I agency problem) and between controlling shareholders and minority shareholders (Type II agency problem) coexist. SOEs have established a governance structure for boards of directors with certain independence and dual characteristics. From the perspective of state involvement in ownership, it is important for SOEs to adhere to the CPC's leadership to improve the efficiency of their corporate governance and performance. From the perspective of market incentives, the system and structure of SOEs' boards of directors have been established and are under constant reform and improvement. The boards of directors in Chinese listed companies mainly consist of independent directors, directors appointed by controlling shareholders, directors appointed by non-controlling shareholders, and inside directors, and there are significant differences in the monitoring roles of each type of director for Type I and Type II agency problems. Directors appointed by non-controlling shareholders have the most pronounced governance effect in solving Type I and II agency problems. Independent directors, especially those with professional backgrounds, can effectively play a monitoring role in alleviating both types of agency problems. However, in SOEs, because controlling shareholders are strong and independent directors face less risk, independent directors may have weaker monitoring incentives. Due to the close relationship between controlling shareholders and the directors they appoint, there is not a consensus on the governance effect of directors appointed by controlling shareholders. Taken together, this paper shows that in SOEs, the leadership of the CPC provides the leading political and core role in board governance. In addition, China should actively promote mixed-ownership reforms, introduce non-controlling

shareholders to SOEs, make full use of the governance role of non-controlling shareholders, make up for the lack of independence of independent directors, and enhance board independence.

6.2. Implications

This paper's conclusions are important to understanding the structure and independence of boards of directors in Chinese SOEs, to improving the efficiency of board governance, to promoting the mixed-ownership reform in SOEs, and to enhancing the vitality of SOEs. Specifically, this paper has the following implications for enhancing boards of directors in China.

6.2.1. Soes must adhere to the CPC's leadership and embrace the core political role of the Party in companies

SOEs must fully embrace the CPC's leading role, which embodies state involvement in the ownership of SOEs and is also the inevitable result of the exploration of corporate governance practices in SOEs. The functions and responsibility boundaries of the Party committee and boards of directors should be clear under the law. The decision-making procedures and mechanisms of the Party committee and boards of directors should be standardized. It is necessary to adhere to and improve the company leadership system of two-way entry and cross appointment. A comprehensive, objective, and scientific evaluation system should be established for members of the CPC and a company's senior executives concerning two-way entry and cross appointment, which should reflect both the cadre evaluation of the Party committee and the economic evaluation of the board of directors (Wang and Ma, 2014).

In the future, academic research can focus on the role of Party organizations in corporate governance, especially the interaction between Party organizations and boards of directors, supervisors, and management under the two-way entry and cross appointment company leadership system. Research areas could include considering how the Party organization affects the structure and decision-making efficiency of boards of directors and how agency costs between shareholders and management can be reduced. By taking the positive roles of the Party organization in corporate governance and its economic consequences as the objects of case study and empirical research, we can better provide theoretical support and policy suggestions for strengthening the CPC's leadership over SOEs.

6.2.2. Mixed-ownership reform should be accelerated and the governance effect of directors appointed by noncontrolling shareholders should be fully acknowledged

China should accelerate reforms regarding mixed ownership and further realize the potential of SOEs. Mixed-ownership reforms can not only introduce capital from non-controlling shareholders but also give more rights to non-controlling shareholders, especially rights on boards of directors. To effectively reduce agency costs caused by Type I and II agency problems, China should fully recognize the governance role of directors appointed by non-controlling shareholders, gradually increase the proportion of such directors on boards, and enable these directors to exercise more active supervision over controlling shareholders and management.

Promoting mixed-ownership reforms will provide voluminous case study materials and empirical data that researchers can use to study corporate governance in Chinese SOEs. Future research can further focus on the governance modes of boards in mixed-ownership SOEs and reforms' economic consequences. The reforms regarding mixed ownership of SOEs introduce different types of shareholders with different effects onboards. With the increase in non-state-owned shareholders' ownership, directors appointed by non-controlling shareholders to represent the interests of non-controlling shareholders on boards are becoming more important. Studying the role of directors appointed by non-controlling shareholders in board governance can highlight the achievements of mixed-ownership reforms and the market incentives of SOEs with Chinese characteristics.

6.2.3. The professional expertise of independent (Outside) directors should be improved and the independence of boards of directors should be enhanced

China should further improve the professional expertise of independent directors and fully recognize the influence of independent directors from other professional fields to better supervise the decision-making of controlling shareholders and management. To enhance the independence of boards, it is necessary to further

increase the proportion of outside directors. The Guiding Opinions of the General Office of the State Council on Further Improving the Corporate Governance Structure in SOEs (GBF [2017] No. 36) points out that "China should expand the team of full-time outside directors, [and] select and employ a group of incumbent management of SOEs to transfer to full-time outside directors." China should fully recognize the role of full-time outside directors in SOEs, make good use of their technical and managerial knowledge, and take advantage of their independence. China should further explore the selection and employment mechanisms and compensation incentives of full-time outside directors to ensure that they can actively participate in SOEs' board governance and enhance their value.

The implementation of the outside director system in SOEs also raises a new possibility for academic research, especially for studying the incentive policies and economic consequences of outside directors. Based on foreign studies, domestic studies on corporate boards mainly focus on independent directors. However, in addition to the employment of independent directors, the proportion of outside directors can be further increased on the boards of Chinese SOEs, as outside directors from different sources have different incentives. The research on the selection and employment mechanisms of full-time outside directors and the effectiveness of compensation incentives will motivate full-time outside directors to monitor, and thus further improve the independence and governance effect of boards of directors in SOEs from the perspective of market incentives.

Declaration of Competing Interest

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

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Does environmental labeling exacerbate heavily polluting firms' financial constraints? Evidence from China

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ABSTRACT

The Chinese Ministry of Environmental Protection has enacted an environmental policy that restricts the investment activities of heavily polluting firms by increasing their financial constraints. In this paper, we examine the impact of environmental labeling on firms' financial constraints. We document that the financial constraints of heavily polluting firms increase more than those of other firms after the issuance of environmental labeling. The debt and equity financing channels of heavily polluting firms are restricted, with smaller bank loans and less equity issuance in the future. The effect is stronger in firms that make a smaller contribution to the local government's gross domestic product, receive greater media coverage, and are located in heavily polluted provinces. The environmental regulation is effective in increasing the environmentally friendly practices and decreasing the performance growth of heavily polluting firms. Our findings not only contribute to the growing literature on the factors influencing financial constraints, identifying the effects of non-monetary factors on financial constraints, but also provide more evidence for the underlying mechanism of efficient environmental policy. Our results also provide practical suggestions for investors and institutions on evaluating firms and for regulatory authorities on further implementing environmental policy.

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1. Introduction

China has achieved rapid economic development since the beginning of the 21st century; its gross domestic product (GDP) growth soared from 8.5% in 2000 to 14.2% in 2007. However, the consumption of resources and energy and emissions of pollutants have also increased. Industrial waste water discharge, for example, rose from 19.4 billion tons in 2000 to 24.7 billion tons in 2007.[1] Average emissions of sulfur dioxide (SO_2) and atmospheric particulate matter with a diameter of less than 2.5 μm ($PM_{2.5}$) have also been increasing since 2000 (Fig. 1). The degree and scale of environmental pollution continue to expand, and there have been serious incidents of pollution every year. In 2002, for instance, the collapse of a dam of a lead-zinc mine tailings pond contaminated Qingshui River, making the water in Guizhou province undrinkable. In recent years, water pollution events, toxic leaks, and many other incidents have occurred in several provinces. These events have threatened rare animals with extinction and damaged the health of millions of people. This has all resulted in huge economic losses and harm to human life and the environment. The purpose of promoting economic development is to improve people's lives, yet it can often make them worse off. It is thus urgently necessary to intensify environmental protection efforts in China.

To transform its pattern of economic development to promote social and economic sustainability, China must increase its environmental protection efforts. The Chinese government has enacted a series of environmental protection regulations to encourage firms to be environmentally conscious. These include laws, such as the Law on the Prevention and Control of Environmental Pollution by Solid Waste (2004) and Law on Energy Conservation (2007); market-based policies, such as Administrative Regulations on Levy and Use of Pollutant Discharge Fee (2003); and voluntary policies, such as Measures on Open Environmental Information (Trial) (2007) (detailed information on these regulations is provided in Appendix Table A.1). Although many environmental regulations have been implemented, little improvement in environmental protection was evident at the beginning of the 21st century; the effect of governance only began to appear in around 2008.

The initial lack of efficiency of China's environmental laws was due to a lack of definite direction. The regulations neither defined the list of heavily polluting firms clearly nor implemented direct control of heavily polluting firms' production and operations. However, in 2008, the Chinese Ministry of Environmental Protection issued Administrative Measures on Use of China Environmental Labeling (Administrative Measures), which provided a classification of heavily polluting industries and outlined requirements for environmental protection verification. Administrative Measures provided a list of heavily polluting firms, making it clear for both the relevant departments and the firms themselves that they would be strictly monitored and regulated by previous environmental laws. Administrative Measures also specified that classified heavily polluting firms must pass the environmental protection verification process before trying to raise funds in the capital market through initial public offerings or secondary equity offerings. Thus firms labeled as heavily polluting firms now face fiercer financial constraints and have less funding to invest in polluting projects. Our study examines the change in firms' financial constraints after the issuance of environmental labeling.

Many studies focus on the effectiveness of environmental policy. Researchers examine capital markets' reaction to the disclosure of environmental information in other countries, such as the U.S. (Badrinath and Bolster, 1996; Hamilton, 1995; Konar and Cohen, 1997) and Canada (Foulon et al., 2002; Lanoie et al., 1998). In China, only a few recent studies demonstrate the impact of environmental events on the stock market, with mixed results. Xu et al. (2012) find a weak impact, while Ren et al. (2018); Viard and Fu (2015); Xu et al. (2016), and Zhang et al. (2018) find a stronger market reaction for related firms. However, there is little empirical evidence of the underlying mechanism by which environmental policy affects financing decisions. We examine the impact of environmental regulation on the financial constraints of Chinese listed firms. We focus on three topics: how environmental regulation influences firms' financial constraints; the mechanism by which the relationship between financial constraints and regulation differs between firms; and whether the regulation is an effective method of pollution control.

To examine whether financial constraints are affected by environmental labeling, we follow the methodology in Kaplan and Zingales (1997) and Lamont et al. (2001) to construct a Kaplan-Zingales (KZ) index to

[1] Data from the China Environmental Statistics Bulletin.

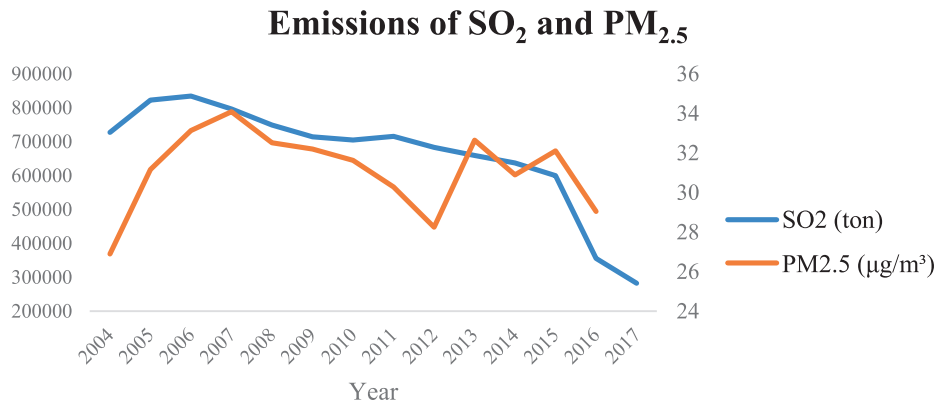

Fig. 1. Emissions of SO_2 and $PM_{2.5}$(Data from the National Bureau of Statistics of China.) in China from 2004 to 2017.

measure financial constraints. As omitted trends may be correlated with financial constraints, and may be the result of unobserved differences between heavily polluting firms and other firms, we use a difference in differences (DiD) approach to determine the influence of environmental labeling on the KZ index, and reach our main conclusion that environmental policy has a significant negative impact on the financial constraints of heavily polluting firms. To determine in detail how environmental labeling affects firms' financing channels, we use several kinds of bank loans and equity issuance as the dependent variables to test how the debt and equity financing channels of heavily polluting firms change. We verify that both the bank loans provided for heavily polluting firms and their future equity issuance decrease more than those of non-polluting firms. The heavily polluting firms are punished by receiving reduced capital due to the environmental policy. In addition, in light of the differential effect of environmental labeling on financial constraints, we regress the baseline DiD model partitioned by three adjustment variables and find that the impact is mainly concentrated in heavily polluting firms that make a smaller contribution to the local government's GDP, receive greater media coverage, and are located in heavily polluted provinces. Moreover, to assess the effectiveness of the environmental policy, we focus on both direct and indirect effects. The $PM_{2.5}$ emissions of heavily polluting firms decrease more than those of non-polluting firms, and revenue growth also decreases after the policy. We conclude that the environmental policy is effective, resulting in higher financial constraints, lower revenue growth, and more environmentally responsible behavior for heavily polluting firms. As a robustness check, we use alternative measurements for financial constraints, conduct a placebo test and a more standard DiD test, and check that the parallel trend assumption is satisfied.

Our study contributes in several ways to the growing literature on financial constraints and on environmental policy. First, most studies examine the internal factors influencing financial constraints, such as firm size (Almeida et al., 2004; Hadlock and Pierce, 2010) and political connection (Cull et al., 2015; Li et al., 2008); only a few take a theoretical perspective on the relationship between financial constraints and external factors (Beaudry et al., 2001). Our study complements this stream of the literature by providing empirical evidence of the relationship between national policy and financial constraints. Second, researchers generally focus on the external economic factors that influence financial constraints. Our paper identifies how non-monetary factors affect financial constraints. Previous studies explain the mechanism by which monetary policy and industrial policy affect financial constraints. Compared with Murphy et al. (1989), who present industrialization as a big push that drives coordinated investment, and Beaudry et al. (2001), who show that monetary instability adversely affects the allocation of investment, our study explains the mechanism through the non-monetary policy side and provides the first evidence for the link between environmental regulation and changes in firms' financial constraints. Third, we add to existing studies on the efficiency of environmental policy in view of firm-level behavior. Fowlie et al. (2012) and Konar and Cohen (1997) directly investigate the consequences of the environmental program, documenting that heavily polluting firms reduce their emissions after the disclosure of pollution information. We provide possible reasons for the environmental policy's success by examining the mechanism by which the heavily polluting firms are affected and why they choose to reduce polluting

activities by showing that heavily polluting firms are more likely to be financially constrained and find it harder to invest further in polluting projects. Lastly, our study provides guidance for individual and institutional investors on evaluating environmental policy and regulation for heavily polluting firms. Our results also provide evidence that will assist regulatory authorities in implementing environmental policy.

The remainder of this paper proceeds as follows. Section 2 presents the literature review. Section 3 develops the hypotheses. Section 4 discusses the research design. Section 5 presents the empirical results, and Section 6 contains the robustness tests. Section 7 concludes the paper.

2. Literature review

2.1. Research on the factors affecting financial constraints

Financial constraints are a type of financial friction caused by information asymmetry between issuers and investors (Tirole, 2006). Financial constraints make it difficult for firms to raise adequate funding, and are an important factor in firms' investment and financing decisions. The factors influencing financial constraints can be classified into two categories: firm characteristics (internal factors) and external financing environment characteristics (external factors).

In terms of internal factors, firm size and age, political connection, and reputation are important factors affecting financing constraints. Firm size and age are particularly useful predictors of financial constraint levels. As small firms have less collateral and lower information transparency, they have higher frictional costs and thus are more likely to encounter financing constraints (Almeida et al., 2004). Financial constraints drop sharply as young and small firms mature and grow (Hadlock and Pierce, 2010). In developing countries, especially in regions with weaker market institutions and weaker legal protection, political connections help firms to obtain loans from banks or other state institutions and to gain more financial resources in the capital mmarket (Cull et al., 2015; Li et al., 2008). Firms with political connections enjoy a lower cost of equity capital (Boubakri et al., 2012), have preferential access to bank credit (Charumilind et al., 2006; Claessens et al., 2008), borrow more and have a higher default rate (Khwaja and Mian, 2005), and gain more subsidies (Johnson and Mitton, 2003), thus facing lower financial constraints. In addition, there are effective alternative financing channels based on reputation and relationships (Allen et al., 2005).

From the perspective of the external financing environment, financial constraints are affected mainly by financial development. Countries with more developed financial markets generally have a better external financing environment. Financial development lowers the cost of external financing for firms. In less financially developed countries with weaker investor protection, companies often face severe financing constraints that distort the efficient allocation of investment, thereby increasing the gap between firms' internal and external funding costs (Khurana et al., 2006; LaPorta et al., 1997; Love, 2003; Rajan and Zingales, 1998). Firms' financing choice also depends on competition within their industry, such as the number of firms in the industry, elasticity of demand, and convexity of production costs (Adam et al., 2007).

2.2. Research on the effect of national policy on firms' financing behavior

Government and national policies have important external impacts on firms' financing and investment behavior. Political and economic factors affect firms' behavior in seeking financing. The offer price, share allocation, and other terms are affected when governments privatize state-owned enterprises via a public share offering (Jones et al., 1999). Some researchers find that public policy can complement the capital market. Industrialization is a big push that drives coordinated investment across sectors under an imperfectly competitive economy (Murphy et al., 1989). However, national policy may also have the opposite effect on firms' investment and financing. Monetary instability adversely affects the allocation of investment (Beaudry et al., 2001). In Finland, government funding of small to medium-sized enterprises disproportionately helps firms from industries that are dependent on external financing (Hyytinen and Toivanen, 2005). An increase in policy instability will in the short run lead firms to reduce their R&D efforts (Greenwald and Stiglitz, 1990). In emerging markets, especially in China, the influence of government intervention on the national

economy is huge. Government regulation plays an active role as an alternative mechanism in an incomplete legal environment (Pistor and Chenggang, 2002).

Aside from macroeconomic policies, environmental regulations have an indirect influence on firms' financial constraints. As more environmental policies are implemented and more efforts are made to monitor the environmental performance of companies, studies are increasingly examining the economic consequences of these regulations in various countries. In the U.S., many environmental programs, such as the Regional Clean Air Incentives Market and the Toxics Release Inventory, have been shown to be effective (Fowlie et al., 2012; Konar and Cohen, 1997). Researchers show that capital markets react to the disclosure of environmental information and penalize environmentally unfriendly firms by decreasing their firm value, thus creating additional strong incentives for pollution control in developed countries, such as the U.S. (Badrinath and Bolster, 1996; Hamilton, 1995; Konar and Cohen, 1997), Canada (Foulon et al., 2002; Lanoie et al., 1998), and European countries (Lundgren and Olsson, 2010), in addition to developing countries (Gupta and Goldar, 2005). In China, environmental events had a weak impact on the stock market in the first few years of the 21st century (Xu et al., 2012). More recently, Chinese environmental regulations and information have become more effective and have caused market reactions affecting the related firms (Ren et al., 2018; Viard and Fu, 2015; Xu et al., 2016; Zhang et al., 2018).

3. Hypothesis development

National policy has a major impact on firms' financing and investment activities. In China, this effect is particularly significant because of the government's strong intervention. Firms often face incomplete external information when making investment decisions. As the government specifically defines in its policies which kinds of firms are likely to receive major support and which kinds of firms will be strictly monitored or punished, the issuance of policies and regulations substantially changes firms' investment environment. Increasing attention has been paid to environmental protection in recent years; consequently, the issuance of environmental policy acts as a signal for financial institutions and investors, altering their decisions following the regulation and thus changing firms' financing channels. First, the issuance of classification reduces financial institutions' and investors' market expectations and valuation of firms in heavily polluting industries; thus the affected firms are less able to raise funds in the capital market. Second, due to government pressure and the low valuation of firms, the policy reduces banks' willingness to provide loans for heavily polluting firms. Therefore, in our first hypothesis, we propose that the financial constraints of heavily polluting firms increase more after the issuance of environmental policy.

H1. The financial constraints of heavily polluting firms increase more than those of non-polluting firms after the issuance of environmental policy.

Because the environmental policy stipulates that all firms classified as heavily polluting have to pass environmental protection verification before applying for listing or refinancing, the policy directly regulates the financing channels of heavily polluting firms, acting as a negative signal for these firms. We wish to identify the underlying mechanism by which firms' financing channels are constrained by environmental policy. Firms finance projects using internal funds, debt, and new equity (Fazzari et al., 1988). However, firms that have received bad news are less likely to seek external debt and equity financing (Autore et al., 2014). Bank loans and equity issuance reflect firms' debt and equity financing channels, respectively. Therefore, we examine how firms' bank loan and equity issuance behaviors are affected by the environmental policy.

While the behavior of government-owned banks is affected by the central government (Dinc, 2005; Sapienza, 2004), banks must follow local governments' directives. To comply with national environmental policy, local governments limit the financing channel of heavily polluting firms by urging banks to provide less loans to them. Moreover, on top of mandatory directives from local governments, banks themselves are less willing to lend to heavily polluting firms, because they are less viable after the environmental policy. Firms negatively affected by the environmental policy tend to have worse development prospects, leading to lower credit guarantees, so banks are less willing to lend to them because of the increased default rate. This leads to the next hypothesis.

H2a. Banks provide smaller loans for heavily polluting firms than non-polluting firms after the issuance of environmental policy.

Concerning the equity financing channel, we focus on firms' equity issuance in the capital market. The issuance of classification indicates that firms in heavily polluting industries are less capable of sustainable development. As a result, not only will investors' market expectations and financial institutions' valuation of heavily polluting firms drop, but credit rating agencies and analysts will downgrade their ratings and recommendations. Considering the possible lower returns of heavily polluting firms in the future, both individual and institutional investors are less likely to invest in the affected firms. It is thus more difficult for the affected firms to raise funds through the capital market. The equity issuance of heavily polluting firms will decrease. This leads to the next hypothesis.

H2b. The frequency and amount of the equity issuance of heavily polluting firms are lower than those of non-polluting firms after the issuance of environmental policy.

Although the release of environmental labeling by the Ministry of Environmental Protection (MEP) and the government's requirement that firms become more environmentally friendly afford heavily polluting firms equal treatment, the effect of the policy still varies among related firms, even in the same industry. Due to the different considerations of different stakeholders, the effect of the environmental policy varies with firm characteristics and other external factors. There are thus variations in the association of environmental policy with financial constraints across firms partitioned by various adjustment variables.

Given the importance of GDP as a comprehensive indicator of economic performance, local governments in China always seek to increase GDP to show their greater competitiveness. Local governments will always give stronger support to firms that contribute more to local GDP, and will seldom decrease support for them. Even if the MEP attempts to enforce environmental protection and some firms that make a large contribution to GDP are classified as heavily polluting firms, local governments will continue to support these firms to sustain their high performance and high growth and thus guarantee their GDP contribution, either through local bank loans or through government subsidies. However, to demonstrate that they are abiding by the national environmental policy, local governments still need to decrease their support for heavily polluting firms. As a result, they will reduce their support of heavily polluting firms that contribute less to GDP. Therefore, we expect that such firms will be more financially constrained. Based on the above analysis, we propose research hypothesis H3a:

H3a. The financial constraints of heavily polluting firms increase more for firms that make a smaller GDP contribution than for firms with a larger GDP contribution.

Environmental protection in China is typically regarded as more urgent in more heavily polluted provinces. For example, in 2006 the provincial Environmental Protection bureau in Shanxi province declared that Shanxi could not increase its GDP at the expense of the environment; its air quality and discharge of solid waste ranked last in China, and its surface water quality (inferior category V) ranked second to last. Previously, for economic reasons, the local governments of polluted provinces had allowed enterprises to violate environmental laws and regulations, resulting in severe ecological damage. The State Environmental Protection Administration (SEPA) has frequently urged heavily polluted provinces to alleviate or eliminate this practice. Thus, more attention is paid to heavily polluting firms located in heavily polluted provinces, and heavily polluted provinces are subject to greater environmental protection pressure and stricter monitoring. Due to the frequent SEPA announcements to improve the environment, the local governments of heavily polluted provinces have tried to reduce the production and investment of heavily polluting firms by constraining their financial channels. However, heavily polluting firms in less polluted provinces receive less attention and are under less pressure, meaning that restrictions on these firms are more moderate. Based on this analysis, we propose research hypothesis H3b:

H3b. The financial constraints of heavily polluting firms increase more for firms located in heavily polluted provinces than for firms located in less polluted provinces.

The effect of the financial constraints of heavily polluting firms also varies with public pressure. Previous studies demonstrate that public pressure can have different economic consequences. Media coverage in Russia increases the probability of a corporate governance violation being reversed (Dyck et al., 2008). The press performs a monitoring role for accounting fraud by rebroadcasting information from other information intermediaries (analysts, auditors, and the courts) and by undertaking original investigation and analysis (Dyck et al., 2010; Miller, 2006). Heavily polluting firms with greater media coverage receive more investor attention. As the phrase has it, "evil news rides post, while good news baits"; once bad news is reported about a firm, such as being classified as heavily polluting, greater media coverage offers faster dissemination, and investor expectation will drop much more dramatically. Firms with greater media coverage will thus be affected by bad news more seriously and will experience a greater increase in financial constraints. Based on the above analysis, we propose research hypothesis H3c:

H3c. The financial constraints of heavily polluting firms increase more for firms with greater media coverage than for firms with less media coverage.

4. Research and design

4.1. Institutional background, sample selection, and data collection

This study focuses on the effect of environmental labeling on firms' financial constraints. We choose the issuance of *Administrative Measures on Use of China Environmental Labeling (2008)*[2] by the Chinese Ministry of Environmental Protection on June 24th, 2008, as a quasi-natural experiment.

To encourage listed companies in heavily polluting industries to conscientiously implement national environmental protection laws, regulations, and policies, to avoid investment risks due to environmental pollution, and to regulate firms' investment in social fundraising, SEPA issued the Notice of Environmental Protection Verification for Enterprises Applying for Listing and Refinancing[3] in 2003 and Notice on Further Standardizing Environmental Protection Verification for Enterprises in Heavily Polluting Industries Applying for Listing or Refinancing[4] in 2007, according to the relevant provisions of the China Securities Regulatory Commission. These two environmental policies required heavily polluting firms to pass environmental protection verification before applying for listing or refinancing, and clearly illustrated the content of, requirements for, and procedure of verification: for instance, the main pollutants discharged must meet national discharge standards, and the firm must have a pollutant discharge permit and a safe disposal rate (nearly 100%) for industrial solid waste and hazardous waste. However, the two policies only briefly defined heavily polluting firms and did not clearly state the relevant firms. For this reason, to better define heavily polluting firms, Administrative Measures on Use of China Environmental Labeling further specified the classification of heavily polluting industries for environmental protection verification. These measures defined heavily polluting firms and listed all heavily polluting industries in detail, making it clear for related departments and firms what kind of firms must pass environmental protection verification before submitting applications for listing or refinancing. We regard all of the firms in the heavily polluting industries listed in the Administrative Measures as heavily polluting firms. The affected firms are under stricter monitoring and regulation by the above environmental laws. Thus firms labeled as heavily polluting firms face fiercer financial constraints and lack funds to invest in polluting projects.

We take 2009 as the event year of the financial outcome of the environmental protection verification policy, select the companies listed on the Shanghai and Shenzhen Stock Exchanges as the research objects, and collect

[2] http://www.gov.cn/gzdt/2008–07/07/content_1038083.htm
[3] http://www.csrc.gov.cn/pub/shenzhen/xxfw/tzzsyd/ssgs/scgkfx/scxx/201410/t20141010_261520.htm
[4] http://www.csrc.gov.cn/pub/shenzhen/xxfw/tzzsyd/ssgs/scgkfx/scxx/201410/t20141008_261334.htm

Table 1
Sample selection. The sample is taken from companies listed on the Shanghai and Shenzhen Stock Exchanges from 2004 to 2013 (five years before and after the event year 2009) for empirical analysis. The financial data are from the CSMAR database and the bank loan data from the WIND database. The initial firm-year sample has 18,480 observations and the final full sample includes 15,838 complete observations, and represents 2426 non-financial firms.

	Observations
A-share listed companies from 2004 to 2013	18,480
Minus: firms in financial industries	494
Minus: observations with non-positive assets, liabilities, or equity	438
Minus: incomplete observations missing main control variables	1710
Final observations	15,838

the financial data of A-share listed companies in non-financial industries from 2004 to 2013 (five years before and after the event year) for empirical analysis. The financial data used in this paper are from the CSMAR database, and the bank loan data are from the WIND database. The initial firm-year sample has 18,480 observations and the final full sample includes 15,838 observations with non-missing main control variables, and represents 2,426 firms. Table 1 shows the sample selection procedure.

4.2. Variable definitions

1. Heavily polluting firms

We classify the heavily polluting industries stipulated in the Administrative Measures into eight categories based on the Guidelines for the Industry Classification of Listed Companies (2001) published by the Securities Supervision Commission: the mining, textile, garment and fur, metal and non-metal, petrochemical and plastic, food and beverage, hydropower and gas, biomedical, and paper printing industries (details in Appendix Table A.2). Firms in these eight industries are heavily polluting firms.

2. Kaplan and Zingales (KZ) index

Theoretically, the degree of financing constraints is indirectly reflected by many key corporate financial variables. Kaplan and Zingales (1997) classify their sample of U.S. firms into five groups on the basis of their degree of financial constraint, based on qualitative information in their annual reports from management's discussion of liquidity and capital resources, together with quantitative information in the companies' financial statements and notes. As the model in Kaplan and Zingales (1997) contains three variables that they collect by hand and that are not available through the COMPUSTAT database, later literature (Almeida et al., 2004; Baker et al., 2003; Lamont et al., 2001) uses the regression coefficients to construct the KZ index, consisting of a linear combination of five accounting ratios (cash flow to total capital, Tobin's Q, debt to total capital, dividends to total capital, and cash holdings to capital), resulting from a restricted version of the central regression of Kaplan and Zingales (1997), the ordered logit model without hand-collecting variables and without year dummies.[5]

China differs from most countries in that its legal and financial systems and institutions are underdeveloped, but its economy is growing rapidly. La Porta et al. (2002) and La Porta et al. (2000) find that firms in countries with poorer protection of outside shareholders tend to have lower dividend ratios and a lower Tobin's Q due to more severe agency problems. Allen et al. (2005) examine Chinese firms and verify that listed Chinese firms tend to underpay dividends to their shareholders, have a lower Tobin's Q on average, and rely more heavily on debt than firms in LLSV-sample countries (La Porta et al., 2002; La Porta et al., 2000;

[5] The regression model is $KZ = -1.002\ CF_{it}/A_{it-1} + 0.283\ TobinQ_{it} + 3.319\ LEV_{it} - 39.368\ DIV_{it}/A_{it-1} - 1.315\ C_{it}/A_{it-1}$

LaPorta et al., 1997). There are thus fundamental differences between Chinese and U.S. firms, especially in dividends, Tobin's Q, and debt, which are used to construct the KZ index.

Kaplan and Zingales (1997) generate their regression model using U.S. firms from 1970 to 1984. We follow the methodology in Kaplan and Zingales (1997) to construct the regression model using Chinese firms in our sample. First, we use the five financial ratios in the KZ model to classify the firm-year level sample into six categories to roughly define the level of firms' financial constraints. Following the signs of coefficients in the KZ model, we find that the higher the firm's Tobin's Q and debt, the more financially constrained it is; the lower the firm's cash flow, dividend, and cash holdings, the more financially constrained it is. We then construct KZ_{sum} as the sum of KZ_1 to KZ_5, where KZ_1 equals 1 if CF_{it}/A_{it-1} is lower than the median; KZ_2 equals 1 if DIV_{it}/A_{it-1} is lower than the median; KZ_3 equals 1 if C_{it}/A_{it-1} is lower than the median; KZ_4 equals 1 if LEV_{it} is higher than the median; and KZ_5 equals 1 if Q_{it} is higher than the median. KZ_{sum} is the rough classification. Second, we use an ordered logit model to regress KZ_{sum} on CF_{it}/A_{it-1}, DIV_{it}/A_{it-1}, C_{it}/A_{it-1}, LEV_{it} and Q_{it} and estimate the coefficients to obtain a more accurate estimation. Finally, we use the estimated ologit model[6] to re-estimate the KZ index for each firm to obtain a more accurate financial constraint status. Listed companies in China with low cash flow, low cash holdings, low dividends, high leverage, and more investment opportunities usually face severe financing constraints. The higher the KZ index, the more financially constrained the firm (see Table 2).

4.3. Test model

To further assess whether there is a difference between the influence of the environmental labeling on the financial constraints of heavily polluting firms and non-polluting firms in China, we first use the DiD approach as the baseline model to determine the influence of environmental labeling on the KZ index. This methodology compares the financial constraints of a sample of treatment firms classified as heavily polluting firms with those of control firms classified as non-polluting firms, before and after policy changes that cause an exogenous shock to financial constraints.

The DiD methodology has several key advantages. First, it rules out omitted trends that are correlated with financial constraints in both the treatment and control groups. Second, it helps establish causality, as tests are conducted surrounding the issuance of environmental labeling, which causes exogenous variation in the change in financial constraints (the main independent variable). Lastly, the DiD approach controls for constant unobserved differences between the treatment and control groups.

We follow the literature and control for various firm characteristics that affect financial constraints. First, we use the firm size, ROA, growth, and property, plant, and equipment (PPE) to control for firm characteristics. Second, within China's system, a firm's ownership type greatly influences its financial decision-making and the economic consequences. "Soft budget constraints" (i.e. State-owned enterprises can survive even if they lose money, because the state always provides assistance to them.) (Kornai, 1986) of state-owned enterprises and their innate advantages in obtaining resources mean that the financing constraints they face are weaker than those of non-state-owned enterprises. We thus use SOE to control for the correlation between type of ownership and local governments' financing. Third, we use *Risk* to control for market risk and to eliminate the influence of market risk on financial constraints. Lastly, we control for year, industry, and province fixed effects. This methodology fully controls for fixed differences between treated and nontreated firms via industry and province fixed effects. The year dummies control for aggregate fluctuations. Our estimate of the effect of environmental labeling is β_1.

The model is as follows:

$$KZ_{i,t} = \beta_0 + \beta_1 Pollute_i \times Post_t + \beta_2 Size_{i,t} + \beta_3 ROA_{i,t} + \beta_4 Growth_{i,t} + \beta_5 PPE_{i,t} + \beta_6 SOE_{i,t} + \beta_7 Risk_{i,t} + \beta_8 Year_t + \beta_9 Industry_{i,t} + \beta_{10} Province_{i,t} + \varepsilon \quad (1)$$

[6] Our ologit regression model is estimated as $KZ = -9.2947\ CF_{it}/A_{it-1} - 37.2426\ DIV_{it}/A_{it-1} - 4.0485\ C_{it}/A_{it-1} + 3.9520\ LEV_{it} + 0.5092$ Tobin $Q_{it} + \varepsilon$ (Appendix 3). The sign of each coefficient is the same as that of the KZ model provided in Lamont, O., C. Polk, and J. Saa-Requejo, 2001, Financial constraints and stock returns, *Review of Financial Studies* 14, 529–554.

Table 2
Variable definitions and calculations.

Panel A: dependent variables	
KZ	Measurement of financial constraint, based on cash flow, dividend, cash, leverage, and Tobin's Q
Panel B: key testing variables (KeyProxy)	
Pollute	Dummy variable, equal to 1 if the firm is classified as a heavily polluting firm, and 0 otherwise
Post	Dummy variable, equal to 1 if the observation happens after 2009, and 0 otherwise
Panel C: additional test variables	
TotalLoan	Total loans (long-term loans + short-term loans)/revenue
ShortLoan	Short-term loans, short-term loans/revenue
LongLoan	Long-term loans, long-term loans/revenue
EquityIssuanceFrequency	The number of equity issuances by the firm in year t (Gustafson and Iliev, 2017)
EquityIssuanceAmount	Natural logarithm of 1 plus the annual amount of equity issuance, in millions of RMB (Gustafson and Iliev, 2017)
ΔCash	(Cash - lagged cash)/lagged total assets
Investment	(PPE - lagged PPE + depreciation)/lagged total assets (Erel et al., 2015)
Panel D: control variables	
Size	Firm size, ln (total assets)
ROA	Profitability, net profit/total assets
Growth	Firm growth, (revenue - lagged revenue)/lagged revenue
PPE	Tangibility of assets, (inventory + fixed assets)/lagged total assets
SOE	Nature of ownership, equal to 1 if the firm is a state-owned enterprise, and 0 otherwise
Risk	Market risk, standard deviation of the firm's daily market return per year
HHI	Herfindahl-Hirschman Index
GDP	Natural logarithm of total GDP of a city, in billions of RMB
Population	Natural logarithm of total city population, in ten thousands
Coastal	Dummy variable, equal to 1 if the city is coastal, and 0 otherwise
Num of Industrial Firms	The total number of listed industrial firms in a city
Year	Annual dummy variable
Province	Province dummy variable
Industry	Industry dummy variable, based on Guidelines for the Industry Classification of Listed Companies (2001)

To verify hypothesis H2a, we change the dependent variable to the firms' bank loans, and test total loans, short-term loans, and long-term loans respectively. The model is as follows:

$$Loan_{i,t} = \beta_0 + \beta_1 Pollute_i \times Post_t + \beta_2 Size_{i,t} + \beta_3 ROA_{i,t} + \beta_4 Growth_{i,t} + \beta_5 PPE_{i,t} + \beta_6 SOE_{i,t} + \beta_7 Risk_{i,t} + \beta_8 Year_t + \beta_9 Industry_{i,t} + \beta_{10} Province_{i,t} + \varepsilon \quad (2)$$

To verify hypothesis H2b, we use a similar model. The dependent variables change to the equity issuance variables, including both the frequency and the amount of equity issuance. The model is as follows:

$$EquityIssuance_{i,t} = \beta_0 + \beta_1 Pollute_i \times Post_t + \beta_2 Size_{i,t} + \beta_3 ROA_{i,t} + \beta_4 Growth_{i,t} + \beta_5 PPE_{i,t} + \beta_6 SOE_{i,t} + \beta_7 Risk_{i,t} + \beta_8 Year_t + \beta_9 Industry_{i,t} + \beta_{10} Province_{i,t} + \varepsilon \quad (3)$$

5. Empirical results and analysis

5.1. Sample description and descriptive statistics

Table 3 describes the sample distribution by fiscal year and by province. The percentage of heavily polluting firms begins to decrease in 2009, meaning that the issuance of administrative measures is effective, and the

Table 3
Sample distribution. This table presents the sample distribution by fiscal year and by province. Panel A reports the number of heavily polluting firms and non-polluting firms per year, showing a decreasing trend in the percentage of heavily polluting firms by year. Panel B reports the number of observations of heavily polluting firms and non-polluting firms in every province.

Panel A: Sample distribution by fiscal year

Year	Observations	Polluting Observations	Polluting/Total	Non-polluting Observations	Non-polluting/Total
2004	1181	497	42.08%	684	57.92%
2005	1235	526	42.59%	709	57.41%
2006	1225	514	41.96%	711	58.04%
2007	1267	538	42.46%	729	57.54%
2008	1413	586	41.47%	827	58.53%
2009	1461	602	41.20%	859	58.80%
2010	1600	640	40.00%	960	60.00%
2011	1944	755	38.84%	1189	61.16%
2012	2200	852	38.73%	1348	61.27%
2013	2312	887	38.37%	1425	61.63%
Total	15,838	6397	40.39%	9441	59.61%

Panel B: Sample distribution by province

Province	Observations	Polluting Observations	Polluting/Total	Non-polluting Observations	Non-polluting/Total
Anhui	536	242	45.15%	294	54.85%
Beijing	1106	349	31.56%	757	68.44%
Chongqing	281	125	44.48%	156	55.52%
Fujian	580	173	29.83%	407	70.17%
Gansu	199	134	67.34%	65	32.66%
Guangdong	2008	612	30.48%	1396	69.52%
Guangxi	229	126	55.02%	103	44.98%
Guizhou	182	102	56.04%	80	43.96%
Hainan	215	68	31.63%	147	68.37%
Hebei	345	211	61.16%	134	38.84%
Heilongjiang	264	74	28.03%	190	71.97%
Henan	411	266	64.72%	145	35.28%
Hubei	605	205	33.88%	400	66.12%
Hunan	456	201	44.08%	255	55.92%
Jiangsu	1286	441	34.29%	845	65.71%
Jiangxi	253	133	52.57%	120	47.43%
Jilin	326	171	52.45%	155	47.55%
Liaoning	509	187	36.74%	322	63.26%
Inner Mongolia	206	156	75.73%	50	24.27%
Ningxia	99	79	79.80%	20	20.20%
Qinghai	81	52	64.20%	29	35.80%
Shandong	936	485	51.82%	451	48.18%
Shanxi	243	198	81.48%	45	18.52%
Shaanxi	265	68	25.66%	197	74.34%
Shanghai	1368	348	25.44%	1020	74.56%
Sichuan	667	335	50.22%	332	49.78%
Sinkiang	303	168	55.45%	135	44.55%
Tianjin	272	85	31.25%	187	68.75%
Tibet	76	48	63.16%	28	36.84%
Yunnan	243	136	55.97%	107	44.03%
Zhejiang	1288	419	32.53%	869	67.47%
Total	15,838	6397	40.39%	9441	59.61%

Table 4
Summary statistics. This table presents the descriptive characteristics at the firm-year level of the total firms (Panel A), polluted firms (Panel B), and non-polluted firms (Panel C). All of the continuous variables are 1–99% tailed (winsorized).

Panel A: Full Sample

	Obs	Mean	Std. Dev.	Min	P25	P50	P75	Max
KZ	15,838	2.438	0.967	0	2	2	3	5
TotalLoan	11,500	0.56	0.699	0.002	0.138	0.335	0.69	4.247
ShortLoan	10,982	0.308	0.32	0.002	0.09	0.214	0.413	1.794
LongLoan	8288	0.367	0.635	0	0.038	0.13	0.394	4.033
EquityIssuanceFrequency	15,838	0.084	0.289	0	0	0	0	3
EquityIssuanceAmount	15,838	0.056	0.221	0	0	0	0	1.419
Size	15,838	21.69	1.2	19.29	20.84	21.54	22.36	25.39
ROA	15,838	0.035	0.058	−0.213	0.012	0.034	0.062	0.197
Growth	15,838	0.226	0.55	−0.627	−0.005	0.14	0.313	3.963
PPE	15,838	0.279	0.18	0.008	0.137	0.249	0.398	0.762
SOE	15,838	0.56	0.496	0	0	1	1	1
Pollute	15,838	0.404	0.491	0	0	0	1	1
Risk	15,838	0.03	0.008	0.015	0.024	0.029	0.035	0.056
HHI	15,838	0.067	0.091	0.015	0.03	0.043	0.07	0.798
GDP	15,015	5.782	1.139	3.13	4.964	5.839	6.685	7.678
Population	15,275	6.327	0.701	4.456	5.872	6.414	6.822	8.094
Coastal	15,569	0.336	0.472	0	0	0	1	1
Num of Industrial Firms	15,472	4421	4484	19	921	2750	6344	18,792

Panel B: Treatment group

	Obs	Mean	Std. Dev.	Min	P25	P50	P75	Max
KZ	6397	2.407	0.956	0	2	2	3	5
TotalLoan	4766	0.575	0.654	0.002	0.174	0.388	0.715	4.247
ShortLoan	4617	0.326	0.304	0.002	0.113	0.249	0.433	1.794
LongLoan	3656	0.337	0.566	0	0.049	0.144	0.362	4.033
EquityIssuanceFrequency	6397	0.082	0.283	0	0	0	0	3
EquityIssuanceAmount	6397	0.053	0.214	0	0	0	0	1.419
Size	6397	21.8	1.211	19.29	20.93	21.64	22.5	25.39
ROA	6397	0.037	0.062	−0.213	0.01	0.034	0.067	0.197
Growth	6397	0.217	0.486	−0.627	0.008	0.144	0.309	3.963
PPE	6397	0.356	0.169	0.008	0.224	0.341	0.477	0.762
SOE	6397	0.596	0.491	0	0	1	1	1
Risk	6397	0.03	0.009	0.015	0.023	0.028	0.034	0.056
HHI	6397	0.076	0.129	0.019	0.029	0.035	0.057	0.798
GDP	5967	5.447	1.161	3.13	4.546	5.411	6.33	7.678
Population	6083	6.237	0.7	4.456	5.795	6.298	6.667	8.094
Coastal	6222	0.24	0.427	0	0	0	0	1
Num of Industrial Firms	6177	3380	3968	22	579	1695	5247	18,792

Panel C: Control Group

	Obs	Mean	Std. Dev.	Min	P25	P50	P75	Max
KZ	9441	2.459	0.974	0	2	2	3	5
TotalLoan	6734	0.55	0.729	0.002	0.118	0.302	0.667	4.247
ShortLoan	6365	0.296	0.33	0.002	0.077	0.189	0.391	1.794
LongLoan	4632	0.39	0.684	0	0.032	0.117	0.421	4.033
EquityIssuanceFrequency	9441	0.087	0.297	0	0	0	0	2
EquityIssuanceAmount	9441	0.059	0.231	0	0	0	0	1.419
Size	9441	21.62	1.188	19.29	20.77	21.47	22.27	25.39
ROA	9441	0.034	0.055	−0.213	0.013	0.033	0.059	0.197
Growth	9441	0.232	0.589	−0.627	−0.018	0.137	0.318	3.963
PPE	9441	0.228	0.169	0.008	0.098	0.193	0.319	0.762

(*continued on next page*)

Table 4 (*continued*)

Panel C: Control Group								
	Obs	Mean	Std. Dev.	Min	P25	P50	P75	Max
SOE	9441	0.535	0.499	0	0	1	1	1
Risk	9441	0.03	0.008	0.015	0.024	0.029	0.035	0.056
HHI	9441	0.061	0.051	0.015	0.033	0.047	0.073	0.424
GDP	9048	6.002	1.068	3.13	5.286	6.091	6.828	7.678
Population	9192	6.387	0.695	4.456	5.934	6.469	6.901	8.094
Coastal	9347	0.4	0.49	0	0	0	1	1
Num of Industrial Firms	9295	5113	4671	19	1365	4032	6637	18,792

firms engage in more environmentally friendly behavior after the issuance. Shanxi, Ningxia, and Inner Mongolia are the provinces with the most heavily polluting firms, accounting for more than 70% of them.

Table 4 reports the descriptive characteristics at the firm-year level of the total firms (Panel A), heavily polluting firms (Panel B), and non-polluting firms (Panel C). All of the continuous variables are 1–99% tailed (winsorized). Fig. 2 shows the KZ index of the heavily polluting firms and non-polluting firms. The financial constraints of heavily polluting firms were low before 2009 but surpassed those of non-polluting firms after 2009.

5.2. Impact of environmental labeling on financial constraints

Table 5 presents the results of estimating Eq. (1). To evaluate whether the heavily polluting firms were constrained after being labeled, we focus on the coefficients on the interaction term (*Pollute*Post*). These coefficients are both positive and statistically significantly different from 0. In Column 1, where we only include industry, year, and province fixed effects, the coefficient on the interaction term is 0.10. This coefficient equals 0.06 when we include other firm-level control variables in Column 2. For the control variables, there is a significant positive correlation between a company's financial constraints (*KZ*) and both state-owned-enterprise status (*SOE*) and market risk (*Risk*), and significant negative correlations between profitability (*ROA*) and firm growth (*Growth*). The results show that after the issuance of environmental labeling, the financial constraints (KZ index) of the heavily polluting firms increase 0.06 more than those of non-polluting firms. Heavily polluting firms' investment decisions are discouraged, so their financing channels are restricted and they are

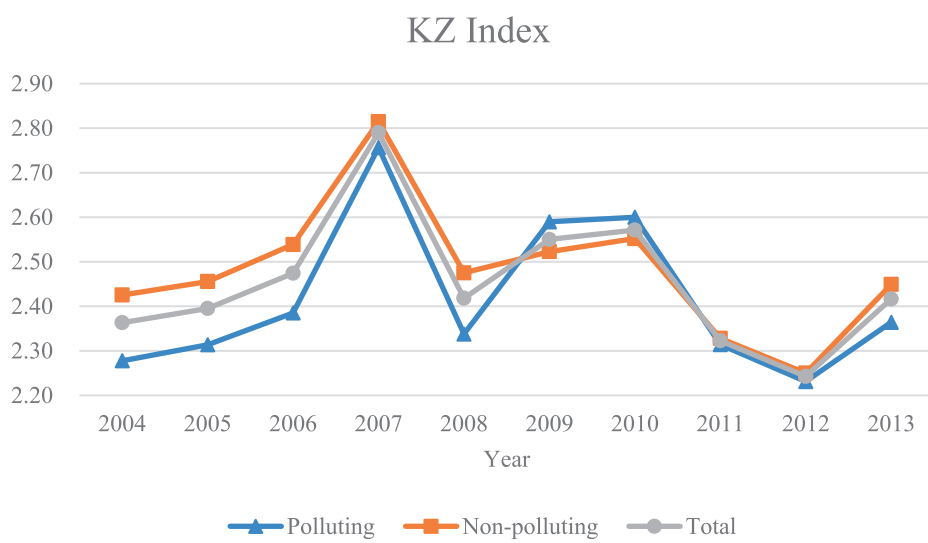

Fig. 2. Trend of the KZ index for the treatment group and control group.

Table 5
Impact of environmental labeling on financial constraints. Columns 1 and 2 report the results of DiD tests examining how the issuance of environmental labeling, the exogenous change, affects firms' financial constraints. The regression model is $KZ = Pollute * Post + Controls$. Columns 3 and 4 report changes in financial constraints after the environmental labeling of both heavily polluting firms and non-polluting firms. t-values are given in parentheses below the coefficients. *** (**) (*) indicate significance at the 1% (5%) (10%) two-tailed level.

	KZ			
	(1)	(2)	(3)	(4)
Pollute*Post	0.10***	0.06**		
	(2.58)	(2.09)		
Post			0.25***	0.11***
			(9.16)	(4.54)
Size		0.00	−0.03*	0.02
		(0.23)	(−1.75)	(1.24)
ROA		−7.78***	−8.00***	−7.09***
		(−45.57)	(−33.13)	(−30.11)
Growth		−0.06***	−0.02	−0.06**
		(−3.10)	(−0.46)	(−2.52)
PPE		0.05	0.26**	−0.00
		(0.70)	(2.53)	(−0.04)
SOE		0.07***	0.08**	0.09***
		(3.03)	(2.08)	(2.84)
Risk		13.14***	17.13***	14.51***
		(7.90)	(12.81)	(11.33)
HHI		0.11	0.10	−0.21
		(0.59)	(0.45)	(−0.47)
Constant	2.22***	1.95***	2.39***	1.61***
	(19.64)	(7.20)	(6.48)	(4.85)
Year	Yes	Yes	No	No
Industry	Yes	Yes	Yes	Yes
Province	Yes	Yes	Yes	Yes
Cluster	Firm	Firm	Firm	Firm
Observations	15,838	15,838	6397	9441
R-squared	0.09	0.32	0.36	0.27

forced to stop polluting. Firms with higher profitability, higher growth rates, and lower market risk have lower financial constraints, which is consistent with common sense. The results verify hypothesis H1.

To examine the main cause of the difference in the change of financial constraints between heavily polluting firms and non-polluting firms, we separate the whole sample into two subsamples. In Column 3 (Column 4), we test how the financial constraints of heavily polluting firms (non-polluting firms) change after the issuance of environmental labeling. We hope to identify whether the difference between two groups is caused by the increasing financial constraints of heavily polluting firms or by the decreasing financial constraints of non-polluting firms. The coefficients of the term *Post* are significantly positive in both Column 3 and Column 4, showing that the financial constraints of both groups increased after environmental labeling. The coefficient is 0.25 in Column 3 but 0.11 in Column 4, indicating a higher increase in the financial constraints of polluting versus non-polluting firms. The government tends to limit financial support for heavily polluting firms after the issuance of environmental labeling rather than providing more support for non-polluting firms. In general, local governments decrease their financial support for heavily polluting firms to show that they are abiding by the environmental policy and urge heavily polluting firms to improve the environment.

5.3. Impact of environmental labeling on bank loans and annual return

To further assess how environmental labeling affects firms' debt and equity financing channel, we test how the bank loans and equity issuance of heavily polluting firms change. We first replace the dependent variable in the baseline model with total loans, short-term loans and long-term loans and estimate Eq. (2) separately to test for the debt financing channel. The results reported in Table 6 show that there are significant negative

Table 6
Impact of environmental labeling on bank loan and equity issuance. This table reports DiD tests examining how the issuance of environmental labeling affects firms' bank loans and equity issuance in the stock market. The regression model is *Loan* (*EquityIssuance*) = *Pollute* + *Post* + *Pollute* * *Post* + *Controls*. The dependent variable *Loan* indicates total bank loans (*TotalLoan*), short-term loans (ShortLoan) and long-term loans (*LongLoan*). The dependent variable *EquityIssuance* indicates the frequency (*EquityIssuanceFrequency*) and amount (*EquityIssuanceAmount*) of equity issuance. t-values are given in parentheses below the coefficients. *** (**) (*) indicate significance at the 1% (5%) (10%) two-tailed level.

	(1) Total Loan	(2) Short Loan	(3) Long Loan	(4) Equity Issuance Frequency	(5) Equity Issuance Amount
Pollute*Post	−0.05**	−0.01	−0.04*	−0.02**	−0.02***
	(−2.05)	(−0.92)	(−1.76)	(−2.52)	(−3.03)
Size	0.09***	0.00	0.06***	0.04***	0.04***
	(13.95)	(0.11)	(9.99)	(16.50)	(18.49)
ROA	−3.06***	−1.79***	−1.66***	−0.04	−0.07***
	(−22.36)	(−25.30)	(−12.05)	(−1.07)	(−2.78)
Growth	−0.04**	−0.03***	−0.02	0.11***	0.10***
	(−2.29)	(−4.79)	(−1.07)	(15.12)	(14.34)
PPE	0.02	−0.02	−0.01	−0.02	0.00
	(0.34)	(−0.92)	(−0.24)	(−1.29)	(0.11)
SOE	−0.10***	−0.06***	−0.07***	−0.01	−0.00
	(−7.62)	(−8.46)	(−4.64)	(−1.62)	(−1.32)
Risk	2.44**	1.41**	0.49	1.00**	1.35***
	(2.15)	(2.45)	(0.42)	(2.17)	(3.58)
HHI	0.58**	0.15	0.28*	0.03	−0.00
	(2.15)	(1.10)	(1.66)	(0.58)	(−0.09)
Constant	−1.35***	0.41***	−1.29***	−0.80***	−0.98***
	(−8.90)	(5.42)	(−8.02)	(−14.33)	(−17.85)
Year	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes	Yes
Province	Yes	Yes	Yes	Yes	Yes
Observations	11,500	10,982	8,288	15,838	15,838
R-squared	0.29	0.18	0.29	0.08	0.13

correlations between the interaction term (Pollute*Post) and a company's total bank loans (Column 1) and long-term loans (Column 3), while there is no significant correlation between the interaction term (Pollute*Post) and a company's short-term loans (Column 2), indicating that after the issuance of environmental labeling, the total bank loans of the heavily polluting firms decrease by 0.05 more than those of non-polluting firms, and the long-term loans decrease by 0.04 more than those of non-polluting firms. Changes in the short-term loans make little difference for either type of firm. Local governments reduce the total loans of heavily polluting firms more by reducing their long-term loans more. The results confirm hypothesis H2a. If a firm's cash holdings are insufficient for an investment project, long-term loans are a major funding source for it. Banks make short-term loans to firms only to maintain their daily production and operation. Thus, local governments still provide heavily polluting firms with short-term loans to help them operate smoothly, but local governments make smaller long-term loans to heavily polluting firms to discourage their investment in polluting projects.

We then use Eq. (3), where the dependent variable changes to firms' equity issuance variables, to test for the equity financing channel. Listed firms can raise new funds through public offerings, private placements, and rights issues. We therefore include three types of equity issuance when calculating the frequency and amount. The results reported in Table 6, Columns 4 and 5 show that there are significant negative correlations between the interaction term (Pollute*Post) and firms' equity issuance, indicating that both the frequency and amount of the equity issuance behavior of heavily polluting firms decrease by 0.02 more than those of non-polluting firms after the issuance of environmental labeling. Heavily polluting firms are less likely than non-polluting firms to raise funds from the capital market. The results confirm hypothesis H2b.

Table 7
Cross-sectional variation in the association of environmental labeling and financial constraints. This table reports DiD tests partitioned by firms' contribution to GDP, firm's media coverage, and the province where firms are headquartered, conducted to examine the differences in the effect of environmental labeling on financial constraints. The regression model is $KZ = Pollute + Post + Pollute * Post + Controls$. t-values are given in parentheses below the coefficients. *** (**) (*) indicate significance at the 1% (5%) (10%) two-tailed level.

Dependent variable = KZ	Contribution to GDP		Forest Coverage		Media Coverage	
	Small	Large	Small	Large	Small	Large
Pollute*Post	0.09**	0.02	0.08**	0.04	0.05	0.11***
	(2.46)	(0.44)	(2.07)	(0.99)	(1.27)	(2.80)
Size	0.01	−0.01	−0.01	0.01	−0.03**	0.03***
	(1.01)	(−0.81)	(−1.35)	(1.24)	(−2.34)	(2.68)
ROA	−7.06***	−8.44***	−7.86***	−7.61***	−7.05***	−7.80***
	(−36.85)	(−43.19)	(−39.05)	(−41.55)	(−33.53)	(−39.37)
Growth	0.06**	−0.15***	−0.07**	−0.06**	−0.05*	−0.11***
	(2.05)	(−6.30)	(−2.30)	(−2.33)	(−1.88)	(−3.84)
PPE	0.36***	−0.16***	0.11	0.02	0.11	0.09
	(5.44)	(−2.65)	(1.62)	(0.40)	(1.62)	(1.39)
SOE	0.13***	−0.00	0.09***	0.06***	0.09***	0.02
	(6.30)	(−0.02)	(4.24)	(2.77)	(3.94)	(0.95)
Risk	9.88***	16.19***	17.41***	9.07***	11.23***	17.34***
	(4.65)	(8.00)	(8.00)	(4.57)	(4.41)	(8.02)
HHI	0.43	−0.11	−0.16	0.57**	0.04	0.31
	(1.28)	(−0.54)	(−0.77)	(1.98)	(0.16)	(1.16)
Constant	1.63***	2.50***	2.11***	2.12***	2.58***	1.36***
	(6.56)	(9.88)	(8.18)	(9.20)	(8.81)	(5.20)
Year	Yes	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes	Yes	Yes
Province	Yes	Yes	Yes	Yes	Yes	Yes
Observations	7,921	7,917	7,148	8,690	6,797	6,729
R-squared	0.29	0.37	0.32	0.32	0.29	0.35
F test	F = 6.47, p = 0.000***		F = 1.56, p = 0.002***		F = 34.03, p = 0.000***	

5.4. Cross-sectional variation in the effect of environmental labeling on financial constraints

We hope to identify the varying effects of environmental labeling on financial constraints partitioned by different adjustment variables. We regress Eq. (1) in subsamples partitioned by firms' contribution to GDP, firms' media coverage, and the province where firms are headquartered.

Local governments tend to support firms that make a greater contribution to GDP, so they will seldom restrain the financial channels of heavily polluting firms that contribute greatly to local GDP. However, to demonstrate their abidance by national environmental policy, local governments will increase the financial constraints of heavily polluting firms that contribute less to local GDP. Based on the income formula approach to GDP,[7] the higher the sales taxes a firm pays, the more the firm contributes to GDP. We thus classify firms with above median taxes payable as firms making a greater contribution to GDP, and the firms with below median taxes payable as firms making a smaller contribution to GDP. In Columns 1 and 2 of Table 7 we estimate Eq. (1) separately for the groups making a small versus a large contribution to GDP. The coefficient of the interaction term (Pollute*Post) for firms making a greater contribution to GDP is insignificant, while the coefficient for firms making a smaller contribution to GDP is significantly positive, indicating that heavily polluting firms in this group suffer 0.09 more financial constraints after the issuance of environmental labeling. The difference between the two coefficients is significant, consistent with our hypothesis H3a.

As heavily polluted provinces are under higher environmental protection pressure, their local governments will increase the financial constraints of heavily polluting firms more prominently than the governments of less polluted provinces, to follow the newly announced environmental policy and improve the environment. We

[7] The income approach formula to GDP is: Total national income = Sales Taxes + Depreciation + Net foreign factor income

predict that the more heavily polluted province a heavily polluting firm is located in, the higher the financial constraints the firm will have compared with other firms. Forests are important to a healthy environment. They protect soil, provide habitat for wildlife and purify the air by absorbing noxious fumes and generating oxygen. The higher the forest coverage a province has, the more the province is environmentally friendly. To measure the degree of pollution in a province, we use forest coverage as a measurement of the level of provincial environmental protection. The data on forest coverage are collected from the main results of China's Seventh National Forest Resources Inventory. The higher the forest coverage, the less polluted the province. We classify the firms into two groups: firms located in provinces with forest coverage below the median (heavily polluted provinces, small group) and firms located in provinces with forest coverage above the median (weakly polluted provinces, large group). In Columns 3 and 4 of Table 7, we estimate Equation (1) separately for the small and large groups. The coefficient of the interaction term (Pollute*Post) for firms in the small group is significantly positive, showing that heavily polluting firms in heavily polluted provinces suffer 0.08 more financial constraints after the issuance of environmental labeling. The coefficient for firms in less polluted provinces is insignificant and the difference between the coefficients of the two subsamples is significant. The results are consistent with our hypothesis H3b.

Firms with greater media coverage receive more investor attention. Investors will be reluctant to finance heavily polluting firms with greater media coverage and will turn to investing in more sustainable firms. We thus expect that heavily polluting firms with greater media coverage will experience an increase in financial constraints. To measure the media coverage of each firm, we use the number of news reports on a firm per year. The news data are from the Financial News Database of Chinese Listed Companies (CFND) from China Research Data Services. We divide the firms into a small group of firms whose media coverage is below the median and a large group of firms whose media coverage is above the median. In Columns 5 and 6 of Table 7 we estimate Eq. (1) separately for the two groups. The coefficient of the interaction term (Pollute*Post) for firms with more media coverage is significantly positive, showing that heavily polluting firms with more media coverage suffer 0.11 more financial constraints after the issuance of environmental labeling. The coefficient for firms with less media coverage is insignificant and the comparison between two coefficients is significant. The results are consistent with hypothesis H3c.

5.5. Effect of environmental labeling

We aim to evaluate the issuance of environmental labeling in China and to determine whether the policy has achieved its goals. The environmental policy is designed to encourage firms to be environmentally friendly. First we focus on the direct effect. We attempt to determine whether heavily polluting firms will take action to improve their environmental record. In the spirit of Ebenstein et al. (2017), we use the $PM_{2.5}$[8] in the city where a firm is located as a firm-level environmental indicator and test the changes in $PM_{2.5}$ concentration between different firms. In Table 8, Panel A, we test how environmental labeling affects firms' $PM_{2.5}$ emissions. We also include city-level control variables, such as GDP, population, whether the city is a coastal city, and the number of industrial firms in the city.[9] Only the coefficient of the interaction term (Pollute*Post) in the concentrated sample (firms that contribute less to GDP, are located in heavily polluted provinces, and receive greater media coverage) is significantly negative, indicating that the $PM_{2.5}$ emissions of heavily polluting firms decrease 1.31 more than those of non-polluting firms after environmental labeling. However, the other interaction term coefficients are insignificant, suggesting that the direct effect of environmental policy only exists in the firms that receive the most attention.

In Panel B, we then examine the indirect effect of environmental labeling. Because the issuance of environmental labeling defined heavily polluting firms in detail and required that classified heavily polluting firms pass environmental protection verification if they wish to raise funds or refinance in the capital market, heavily polluting firms may face fiercer financial constraints and lack funds to invest in projects, resulting in a decline in

[8] Data from Global Annual PM2.5 Grids from MODIS, MISR, and SeaWiFS Aerosol Optical Depth (AOD), with GWR provided by the Socioeconomic Data and Applications Center (https://sedac.ciesin.columbia.edu/data/set/sdei-global-annual-gwr-pm2-5-modis-misr-seawifs-aod/data-download)

[9] Data from the China City Statistical Yearbook

Table 8
Effect of environmental labeling. This table reports the results of DiD tests of the full sample and also tests partitioned by firms' contribution to GDP, firms' media coverage, and the province where firms are headquartered, to examine differences in the effect of environmental labeling on financial constraints. The regression model is $PM_{2.5}$ (*Growth*) = *Pollute* + *Post* + *Pollute* * *Post* + *Controls*. t-values are given in parentheses below the coefficients. *** (**) (*) indicate significance at the 1% (5%) (10%) two-tailed level.

Panel A: Effect of environmental labeling on $PM_{2.5}$

Dependent variable = $PM_{2.5}$	Full Sample	Contribution to GDP		Forest Coverage		Media Coverage		Concentrated Sample
		Small	Large	Small	Large	Small	Large	
*Pollute*Post*	0.17	0.44	−0.21	0.24	0.10	0.08	0.05	−1.31*
	(0.80)	(1.42)	(−0.68)	(0.73)	(0.39)	(0.24)	(0.17)	(−1.81)
Size	−0.06	−0.10	−0.04	0.07	−0.09*	−0.06	−0.01	0.26
	(−1.30)	(−1.54)	(−0.55)	(0.89)	(−1.72)	(−0.89)	(−0.18)	(1.36)
ROA	−2.68***	−3.67***	−0.88	−0.14	−3.68***	−3.66***	−2.07	−2.30
	(−3.00)	(−2.82)	(−0.69)	(−0.10)	(−3.57)	(−2.66)	(−1.58)	(−0.72)
Growth	0.00	0.11	−0.06	−0.06	−0.00	0.06	−0.10	−0.43
	(0.05)	(0.82)	(−0.59)	(−0.45)	(−0.03)	(0.55)	(−0.72)	(−0.72)
PPE	0.53	0.62	0.34	0.62	0.52	0.76	−0.21	−1.18
	(1.57)	(1.31)	(0.72)	(1.11)	(1.38)	(1.54)	(−0.42)	(−0.88)
SOE	−0.02	0.00	−0.02	−0.29*	−0.17	0.14	−0.26	−0.40
	(−0.22)	(0.01)	(−0.13)	(−1.67)	(−1.29)	(0.80)	(−1.53)	(−1.10)
HHI	0.55	4.96**	−1.68	1.71	0.77	−0.08	1.25	−1.29
	(0.34)	(2.26)	(−0.80)	(0.69)	(0.45)	(−0.03)	(0.58)	(−0.24)
GDP	3.97***	3.65***	4.18***	1.15***	5.33***	4.29***	3.76***	0.46
	(34.04)	(22.64)	(24.96)	(5.24)	(39.39)	(24.27)	(20.52)	(0.94)
Population	−0.06	−0.39*	0.14	2.12***	−0.60***	−0.43*	0.45*	2.63***
	(−0.38)	(−1.78)	(0.60)	(6.97)	(−3.45)	(−1.91)	(1.77)	(3.86)
Coastal	−4.74***	−5.08***	−4.31***	−9.27***	−1.84***	−4.05***	−5.08***	−9.48***
	(−19.00)	(−15.44)	(−11.06)	(−21.60)	(−5.97)	(−10.76)	(−13.16)	(−10.66)
Num of Industrial Firms	−0.00***	−0.00***	−0.00***	−0.00***	−0.00***	−0.00***	−0.00***	−0.00
	(−11.38)	(−6.97)	(−8.51)	(−5.54)	(−13.72)	(−7.73)	(−7.12)	(−1.14)
Constant	31.90***	34.37***	32.89***	22.06***	8.75***	33.17***	28.85***	18.37***
	(22.27)	(17.44)	(15.64)	(8.69)	(5.17)	(15.28)	(12.98)	(3.52)
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	14,754	7,347	7,407	6,629	8,125	6,291	6,261	1,200
R-squared	0.84	0.84	0.84	0.84	0.72	0.84	0.84	0.85

Panel B: Effect of environmental labeling on growth

Dependent variable = *Growth*	Full Sample	Contribution to GDP		Forest Coverage		Media Coverage		Concentrated Sample
		Small	Large	Small	Large	Small	Large	
*Pollute*Post*	−0.03*	−0.01	−0.04	−0.05*	−0.02	−0.01	−0.06**	−0.09**
	(−1.87)	(−0.55)	(−1.34)	(−1.90)	(−0.74)	(−0.52)	(−2.34)	(−2.14)
Size	0.03***	0.02***	0.04***	0.03***	0.03***	0.03***	0.04***	0.02*
	(6.38)	(2.98)	(4.56)	(3.98)	(4.86)	(3.43)	(4.84)	(1.87)
ROA	1.97***	1.94***	1.90***	1.83***	2.11***	2.08***	2.11***	1.63***
	(24.10)	(17.87)	(14.96)	(15.63)	(18.37)	(15.03)	(18.47)	(8.24)
PPE	−0.05*	−0.03	−0.06	−0.07	−0.04	−0.11**	0.00	0.06
	(−1.66)	(−0.59)	(−1.33)	(−1.38)	(−0.84)	(−2.14)	(0.03)	(0.63)
SOE	−0.04***	−0.04***	−0.05***	−0.05***	−0.03**	−0.03*	−0.05***	−0.01
	(−4.16)	(−3.03)	(−2.93)	(−3.37)	(−2.35)	(−1.80)	(−3.20)	(−0.65)
Risk	9.28***	4.34***	14.06***	7.32***	10.81***	7.64***	10.69***	3.11
	(7.78)	(3.08)	(7.38)	(4.19)	(6.60)	(3.83)	(5.93)	(1.05)
HHI	−0.10	−0.10	−0.10	−0.15	−0.04	−0.25	0.03	0.35
	(−0.79)	(−0.57)	(−0.62)	(−0.95)	(−0.17)	(−1.23)	(0.18)	(0.97)

(*continued on next page*)

Table 8 (*continued*)

Panel B: Effect of environmental labeling on growth

Dependent variable = *Growth*	Full Sample	Contribution to GDP		Forest Coverage		Media Coverage		Concentrated Sample
		Small	Large	Small	Large	Small	Large	
Constant	−0.60***	−0.24	−0.82***	−0.51***	−0.64***	−0.44**	−0.82***	−0.25
	(−4.66)	(−1.36)	(−3.99)	(−2.62)	(−3.61)	(−2.02)	(−3.99)	(−0.92)
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	15,838	7,921	7,917	7,148	8,690	6,797	6,729	1,303
R-squared	0.08	0.09	0.08	0.08	0.08	0.08	0.10	0.16

their future growth. If the heavily polluting firms foresee less sustainable development, they will try to improve their pollution control to obtain more financial support, and thus the environmental policy can achieve its goals. We test the change in firms' revenue growth after environmental labeling. The coefficient of the interaction term in the full sample is significantly negative, indicating that heavily polluting firms experience a decrease in growth after environmental labeling. The coefficients are also significantly negative in the subsamples located in heavily polluted provinces (Column 4) or with greater media coverage (Column 7). Moreover, firms that satisfy all three characteristics (Column 8) have a much lower growth. The coefficient is −0.09, much lower than other coefficients. The environmental policy is effective, resulting in higher financial constraints, lower revenue growth, and more environmentally conscious behavior among heavily polluting firms.

6. Robustness check

6.1. Alternative measurements for financial constraints

Starting with Fazzari et al. (1988), a large number of studies estimate the sensitivity of investment to cash flow, and use the estimated sensitivity as a measure of financial constraints. They suggested that firms that do not have sufficient access to external capital markets cannot respond to investment incentives. If firms are constrained in their ability to raise funds externally, investment spending may be sensitive to the availability of internal finance. Investment may display "excess sensitivity" to movements in cash flow.

Almeida et al. (2004) suggest that one can measure financial constraints from how firms save cash from incremental cash flow. In their model, the effect of financial constraints is captured by the firm's propensity to save cash out of cash flows. Constrained firms should tend to save cash from cash flow, while unconstrained firms can invest at the first-best level and do not need to adjust their savings behavior.

To avoid our results being driven by our measurement of financial constraints, we use both cash–cash flow sensitivity and investment–cash flow sensitivity as alternative measures of financial constraints to examine the effect of environmental labeling on firms' financial constraints. The results are consistent with the previous finding. In Columns 1 and 2 of Table 9, both three-way interaction terms (*Pollute*Post*CF*) are significantly positive, showing that the financial constraints increase after the issuance of environmental labeling.

6.2. Parallel trends assumption

DiD estimation requires a parallel trends assumption; that is, there must be similar trends in the outcome variables (the KZ index in our setting) during the pre-event period for both the treatment and the control groups. Only when they are similar before the policy can the DiD method extract the causal effect of the policy. Fig. 3 shows the evolution of the differences in financial constraints between the treatment and control groups before and after the issuance of environmental labeling. The difference between the two groups fluctuates around 0 before the policy and is significantly greater than 0 in the year of adoption and one year after,

Table 9
Cash flow sensitivities. This table reports the effect of environmental labeling on the cash–cash flow and investment–cash flow sensitivities. The regression model is $\Delta Cash\ (Investment) = Pollute * Post + CF + Pollute * CF + Post * CF + Pollute * Post * CF + Controls$. $\Delta Cash$ is measured as (Cash − lagged cash)/lagged total assets. *Investment* is measured as (PPE − lagged PPE + depreciation)/lagged total assets, based on (Erel et al., 2015). t-values are given in parentheses below the coefficients. *** (**) (*) indicate significance at the 1% (5%) (10%) two-tailed level.

	ΔCash	Investment
*Pollute*Post*	−0.07***	−0.14*
	(−2.77)	(−1.66)
CF	−0.24	0.06
	(−0.86)	(1.19)
*Pollute*CF*	0.75**	0.73***
	(2.31)	(3.81)
*Post*CF*	0.09	−0.07
	(0.31)	(−1.26)
*Pollute*Post*CF*	0.70**	2.38*
	(2.03)	(1.65)
Size	0.02***	0.02***
	(3.01)	(3.41)
ROA	−0.42**	−1.01**
	(−2.35)	(−1.98)
Growth	0.27***	0.29***
	(3.46)	(4.60)
PPE	−0.14***	0.29***
	(−4.06)	(4.36)
SOE	−0.01	−0.00
	(−0.74)	(−0.20)
Risk	2.86	−1.30
	(1.37)	(−0.40)
HHI	0.04	0.37*
	(0.66)	(1.66)
Constant	−0.48***	−0.61***
	(−2.95)	(−4.40)
Year	Yes	Yes
Industry	Yes	Yes
Province	Yes	Yes
Observations	15,838	15,794
R-squared	0.65	0.35

indicating that the two groups follow parallel trends in the pre-treatment period and that the KZ index increases after a firm is labeled a heavily polluting firm.

We also show the dynamics in a regression framework (reported in Table 5). In the spirit of Bertrand and Mullainathan (2003) and Fang et al. (2014), we test the significance of the difference between the treatment and control groups before and after the event. We add the interaction term between the year dummy variables and treatment dummy variables to the regression. The comparison is made five years before and two years after the policy. Before(n) is a dummy that equals 1 if a firm-year observation is from the nth year before the issuance of environmental labeling and 0 otherwise; Current is a dummy that equals 1 if a firm-year observation is from the event year and 0 otherwise; After(n) is a dummy that equals 1 if a firm-year observation is from the nth year after the issuance of environmental labeling and 0 otherwise. The interaction terms can capture the differences between the two groups in each year to see whether there is a parallel trend between the two groups.

$$KZ_{i,t} = \beta_0 + \beta_1 Before5_t \times Pollute_i + \beta_2 Before4_t \times Pollute_i + \beta_3 Before3_t \times Pollute_i + \beta_4 Before2_t \times Pollute_i + \beta_5 Before1_t \times Pollute_i + \beta_6 Current_t \times Pollute_i + \beta_7 After1_t \times Pollute_i + \beta_8 After2_t \times Pollute_i + \beta_9 Control\ \ Variables_{i,t} + \beta_{10} Year_t + \beta_{11} Industry_{i,t} + \beta_{12} Province_{i,t} + \varepsilon$$

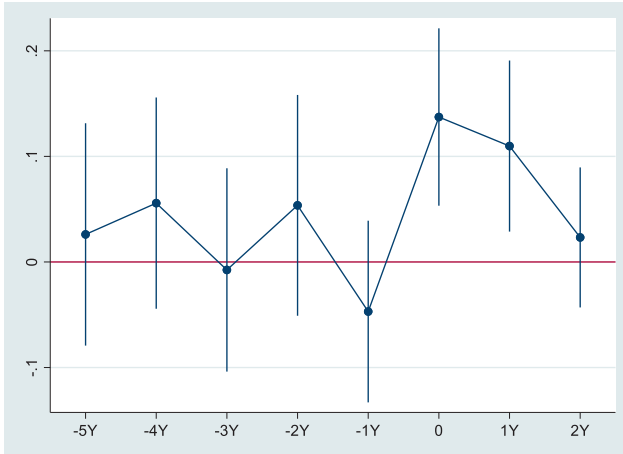

Fig. 3. Trend of the difference between the treatment group and control group(Fig. 3 shows the point estimates and 90% confidence interval of the differences in financial constraints (KZ) between the treatment firms and control firms around the issuance of environmental labeling.)

In Table 10, the interaction term before the adoption of environmental labeling is insignificant but it is significantly positive in the adoption year and one year after, suggesting that the treatment and control group can indeed be compared, and the policy effect may appear one year after the issuance of environmental labeling, and then disappear soon after.

6.3. Placebo test

To verify that the results are not caused by the time trend, we conduct a placebo test. We extend the event year back to 2006 for the placebo test. We set the pre-event period as 2003 to 2005 and the post-event period as 2006 to 2008; the treatment and control groups are still heavily polluting firms and non-polluting firms. This restriction of the sample makes it possible to check that the results are not driven by the time trend. We re-regress the baseline DiD model. The results are reported in Table 11. The coefficients of the interaction term (*Pollute*Post*) are no longer significant, indicating that the hypothesis of parallelism is valid and it is the true event that leads to the final results.

6.4. DiD test with firm fixed effect

To enhance the reliability of the DiD test, following Bertrand and Mullainathan (2003), we further conduct a more standard generalized DiD test, including year and firm fixed effects. In Table 12, the coefficients of the interaction term (*Pollute*Post*) in Columns 1 and 2 are significantly positive and the coefficients of the term *Post* in Columns 3 and 4 are also significantly positive, similar to Table 5. The results of our baseline model are robust.

6.5. Elimination of the influence of industrial policy

Since China launched its industrial policy in the 11th Five Year Plan (2006–2010) and 12th Five Year Plan (2011–2015), firms in the industries mentioned in the policy have been supported by the government. As an important means for the government to intervene in the economy, industrial policy involves not only traditional trade policy but policies that affect other aspects of firms' costs, such as trade taxes, output taxes, policy-based loans, and government subsidies. The launch of an industrial policy potentially affects firms' financial constraints (Eaton and Grossman, 1986; Kollmann and Roeger, 2012; Musacchio et al., 2015).

One concern is that some of the firms labeled as heavily polluting firms are also not supported by industrial policy; thus the results would be driven by the industrial policy rather than the environmental labeling. To verify that our results are not driven by the industrial policy, we first split the treatment sample into supported

Table 10
Parallel trends assumption. This table reports the trend of the KZ index before and after the issuance of environmental labeling. We add the interaction term between the year dummy variables and treatment dummy variables. The comparison is made five years before and two years after the policy. t-values are given in parentheses below the coefficients. *** (**) (*) indicate significance at the 1% (5%) (10%) two-tailed level.

	KZ
*Before5*Pollute*	0.02
	(0.42)
*Before4*Pollute*	0.05
	(1.01)
*Before3*Pollute*	−0.01
	(−0.21)
*Before2*Pollute*	0.05
	(1.00)
*Before1*Pollute*	−0.05
	(−1.06)
*Current*Pollute*	0.14***
	(3.20)
*After1*Pollute*	0.11***
	(2.65)
*After2*Pollute*	0.02
	(0.68)
Size	−0.09***
	(−3.36)
ROA	−4.34***
	(−24.73)
Growth	−0.16***
	(−8.83)
PPE	0.67***
	(6.93)
SOE	−0.05
	(−0.86)
Risk	4.10***
	(2.81)
HHI	0.06
	(0.27)
Constant	3.88***
	(6.90)
Year	Yes
Industry	Yes
Province	Yes
Observations	15,838
Number of firms	2,426
R-squared	0.18

and not-supported groups to test how the financial constraints of the heavily polluting firms are affected by industrial policy. Next, we test whether the effect of environmental labeling still exists in firms supported by industrial policy. We use two classifications from the industrial policy, ''supported firms'' and ''key supported firms,'' according to the industry development plan in the five-year plan.

In Table 13, Columns 1 and 2, we use ''support'' as the criterion, while in Columns 3 and 4, we use ''key support'' as the criterion. The coefficients of *Post* are significantly positive in Columns 1 to 4, showing that regardless of whether the heavily polluting firms are supported by industrial policy, the financial constraints still increase significantly after the issuance of environmental labeling. In Column 5 (Column 6), we select all firms with support (key support) from industrial policy as a sample. The coefficients of the interaction term (*Pollute*Post*) are significantly positive, suggesting that the financial constraints of heavily polluting firms increase more than those of non-polluting firms within firms supported by industrial policy. Even if the firms are supported by the industrial policy, the effects of environmental labeling still exist. The results in Table 13 thus indicate that industrial policy is not the driving force and our previous results are robust.

Table 11
Placebo test. This table reports the results of DiD tests of the baseline model, changing the event year to 2006 and the period to 2003 to 2008. t-values are given in parentheses below the coefficients. *** (**) (*) indicate significance at the 1% (5%) (10%) two-tailed level.

	KZ
	(1)	(2)
*Pollute*Post*	0.05	0.01
	(1.42)	(0.37)
Size		−0.07***
		(−4.35)
ROA		−5.95***
		(−30.60)
Growth		−0.06**
		(−2.54)
PPE		0.22***
		(2.76)
SOE		−0.06**
		(−2.04)
Risk		10.45***
		(5.12)
HHI		0.05
		(0.22)
Constant	1.88***	3.26***
	(13.51)	(8.57)
Year	Yes	Yes
Industry	Yes	Yes
Province	Yes	Yes
Observations	7,450	7,450
R-squared	0.12	0.33

Table 12
DiD test with firm and year fixed effects. This table reports the results of DiD tests of the baseline model (Table 5) with firm and year fixed effects. t-values are given in parentheses below the coefficients. *** (**) (*) indicate significance at the 1% (5%) (10%) two-tailed level.

				KZ
	(1)	(2)	(3)	(4)
*Pollute*Post*	0.10***	0.04*		
	(3.91)	(1.74)		
Post			0.35***	0.26***
			(14.05)	(10.94)
Size		−0.09***	−0.06**	−0.03
		(−4.64)	(−2.30)	(−1.18)
ROA		−4.33***	−4.97***	−3.32***
		(−29.19)	(−22.48)	(−16.30)
Growth		−0.16***	−0.12***	−0.16***
		(−8.99)	(−3.64)	(−7.64)
PPE		0.67***	0.58***	0.66***
		(8.70)	(5.55)	(5.84)
SOE		−0.04	0.05	−0.18***
		(−1.06)	(0.90)	(−2.95)
Risk		4.19***	12.60***	9.86***
		(3.02)	(10.53)	(8.61)
HHI		0.09	−0.14	0.35
		(0.59)	(−0.77)	(0.96)
Constant	2.16***	3.87***	3.13***	2.65***
	(94.23)	(9.61)	(5.41)	(5.49)
Year	Yes	Yes	No	No
Firm	Yes	Yes	Yes	Yes
Observations	15,838	15,838	6,397	9,441
R-squared	0.56	0.62	0.62	0.59

Table 13
Impact of environmental labeling on the financial constraints of firms with industrial policy support. The regression model is $KZ = Post + Controls$, with the sample restricted to heavily polluting firms in Columns 1–4. Column 1 (Column 2) contains heavily polluting firms supported (not supported) by industrial policy after the issuance of environmental labeling. Column 3 (Column 4) contains heavily polluting firms with (without) key support from industrial policy. The regression model is $KZ = Pollute * Post + Controls$, with the sample restricted to all firms with support (key support) from industrial policy in Column 5 (Column 6). t-values are given in parentheses below the coefficients. *** (**) (*) indicate significance at the 1% (5%) (10%) two-tailed level.

	KZ					
	Heavily polluting firms with support	Heavily polluting firms without support	Heavily polluting firms with key support	Heavily polluting firms without key support	All firms with support	All firms with key support
Post	0.29***	0.20***	0.25***	0.24***		
	(10.52)	(3.86)	(2.90)	(9.39)		
*Pollute*Post*					0.13***	0.18***
					(3.79)	(2.87)
Size	−0.04***	−0.00	−0.03	−0.04***	−0.01	0.04***
	(−2.98)	(−0.20)	(−0.75)	(−3.12)	(−1.24)	(2.70)
ROA	−7.93***	−7.88***	−6.78***	−8.05***	−8.01***	−8.13***
	(−35.19)	(−19.89)	(−10.39)	(−39.63)	(−48.55)	(−28.34)
Growth	−0.03	0.02	−0.14	0.00	−0.05**	−0.04
	(−0.84)	(0.25)	(−1.44)	(0.07)	(−2.15)	(−0.95)
PPE	0.34***	0.03	0.11	0.27***	0.22***	0.02
	(4.12)	(0.22)	(0.58)	(3.56)	(3.85)	(0.22)
SOE	0.05	0.19***	−0.04	0.09***	0.05***	0.05
	(1.63)	(4.73)	(−0.57)	(3.64)	(2.75)	(1.35)
Risk	17.18***	17.70***	14.85***	16.71***	10.33***	9.76***
	(10.96)	(7.45)	(3.67)	(11.80)	(5.41)	(2.80)
HHI	0.10	3.58**	11.53**	0.03	0.10	−0.44
	(0.50)	(2.04)	(2.01)	(0.15)	(0.51)	(−0.51)
Constant	2.72***	1.28**	1.89**	2.66***	2.23***	1.18***
	(9.62)	(2.30)	(2.28)	(9.56)	(10.70)	(3.27)
Year	No	No	No	No	Yes	Yes
Industry	Yes	Yes	Yes	Yes	Yes	Yes
Province	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4,516	1,881	723	5,674	9,666	3,015
R-squared	0.35	0.39	0.40	0.36	0.34	0.37

7. Conclusions

In this paper, we examine the effect of China's environmental policy on firms' financial constraints. We use the issuance of Administrative Measures on Use of China Environmental Labeling (2008) as the external shock, and use a DiD approach to test the effect and mechanism. The findings reveal that environmental policy has a significant negative impact on the financial constraints of heavily polluting firms. Both the bank loans and the equity issuance of heavily polluting firms decrease more, suggesting that their debt and equity financing channels are restricted. Further, we find that heavily polluting firms that make a smaller contribution to the local government's GDP, receive greater media coverage, and are located in heavily polluted (versus non-polluted) provinces are more likely to be financially constrained. Lastly, environmental regulation has an effect both directly and indirectly, as the firm-level $PM_{2.5}$ emissions and revenue growth of heavily polluting firms decrease more than those of non-polluting firms. Therefore, the environmental policy is effective, resulting in higher financial constraints, lower revenue growth, and more environmentally conscious behavior in heavily polluting firms.

Our study makes a number of practical contributions. From the perspective of financial constraints, we analyze the impact of environmental policy on microeconomic entities and supplement the research by considering environmental policy as a noneconomic external factor. In addition, we evaluate the efficiency of the environmental policy through different mechanisms and enrich the literature related to environmental policy. Our conclusion is that environmental policy constrains the investment activities of heavily polluting firms. However, the effect does not cover all heavily polluting firms; only selected firms are financially constrained. Our study also provides guidance for individual investors and institutions on evaluating firms, and for regulatory authorities on implementing further environmental policy.

Declaration of Competing Interest

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

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Appendix A. Tables A1–A3.

Table A1
Environmental policies.

Launch Year	Laws and Regulations in English	Laws and Regulations in Chinese
2003	Administrative Regulations on Levy and Use of Pollutant Discharge Fee	排污费征收使用管理条例
2004	Law on the Prevention and Control of Environmental Pollution by Solid Waste	固体废物污染环境防治法
2007	Law on Energy Conservation	中华人民共和国节约能源法
2007	Measures on Open Environmental Information (Trial)	环境信息公开办法(试行)
2008	Circular Economy Promotion Law	循环经济促进法
2008	Administrative Measures for the Use of China Environmental Labeling	上市公司环保核查行业分类管理名录
2010	Measures for Environmental Administrative Punishment	环境行政处罚办法
2011	Notice on the Adjustment of the Subsidies for Energy-efficient Vehicles	关于调整节能汽车推广补贴政策的通知
2014	Guiding Opinions on Further Promoting Compensable Use and Pilot Tests of Emissions Trading	关于进一步推进排污权有偿使用和交易试点工作的指导意见
2015	Atmospheric Pollution Prevention and Control Law	大气污染防治法
2015	Measures for the Public Participation in Environmental Protection	环境保护公众参与办法

Table A2
Heavily polluting industries.

Industry Code	English Name	Chinese Name
B	Mining industry	采掘业
C0	Food and beverage industry	食品饮料业
C1	Textile, garment, and fur industry	纺织服装皮毛业
C3	Paper printing industry	造纸印刷业
C4	Petrochemical and plastic industry	石化塑胶业
C6	Metal and non-metal industry	金属非金属业
C8	Biomedical industry	生物医药业
D	Hydropower and gas industry	水电煤气业

Table A3
Ordered logit model from Kaplan and Zingales. This table reports the results of the ordered logit model in the calculation of the KZ index (Lamont et al., 2001). The number of observations is 15,838. t-values are in parentheses.

CF_{it}/A_{it-1}	−9.2947***
	(−50.70)
DIV_{it}/A_{it-1}	−37.2426***
	(−37.57)
C_{it}/A_{it-1}	−4.0485***
	(−39.54)
LEV_{it}	3.9520***
	(43.34)
$TobinQ_{it}$	0.5092***
	(40.86)
cut1	−4.9371***
	(-49.54)
cut2	−1.0333***
	(−16.08)
cut3	1.0860***
	(17.34)
cut4	3.0201***
	(45.21)
cut5	5.5830***
	(66.12)
Log likelihood	−18766.526
Pseudo-R^2	0.2343

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Independent technical directors and their effect on corporate innovation in China ☆

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ABSTRACT

As outside advisors, independent directors serve as both consultants and monitors. Based on empirical studies of corporate innovation and independent directors, we used data from listed firms in China from 2007 to 2017 to examine the effect of hiring independent technical directors on the board of directors. This study focused on a firm's innovation performance and the extent to which this performance is influenced by the relevance of a director's expertise to the activities of the firm. The results show that when the technical expertise of an independent director is relevant to the operational field of the firm, the firm should perform better in terms of innovation. This result is still significant when applying the two-stage instrumental variable method, showing a higher significance when using the exogenous event of the 2014 Wenfeng.plc case. Moreover, independent technical directors influence innovation primarily by encouraging firms to deepen their current field of research rather than expanding to other fields. Our findings can guide corporations to hire more relevant independent technical directors and can help the government design more accurate policies that promote innovation and entrepreneurship.

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1. Introduction

With China facing an economic slowdown after decades of rapid growth, Premier Keqiang Li stated that the key to further development was to strengthen cooperation between industries and research institutions. This has sparked increased interest in combining theoretical studies with practical applications. Increasingly, independent directors, a natural bridge between universities and businesses, have emerged from universities.

Since 2001, the Securities and Exchange Commission has requested that at least one third of the boards of listed firms in China be independent directors. According to Ferris et al. (2003), independent directors play two roles: supervisors and consultants. As supervisors, they monitor and evaluate the performance of managers and influence their compensation. As consultants, they give professional advice on business operations and strengthen firms' research capabilities.

In their supervisory role, independent directors are less likely to conspire with managers (Fama & Jensen, 1983) because they are put on the board through a nomination process (Cavaco et al., 2017). They also tend to be more sensitive to the opinions of outsiders about the company (Laux, 2008). Thus, independent directors can effectively monitor business operations. Agrawal and Chadha (2005) found that when an audit committee includes independent directors with a CPA or CFA qualification, the firm will have better earnings management. However, their study focused only on independent directors with a financial background and did not examine all independent technical directors. Moreover, if the cost of information is relatively high in a firm, a higher number of independent directors can have a negative effect on corporate performance (Duchin et al., 2010; Cavaco et al., 2017).

In their role as consultants, independent directors can support a corporation by providing external communication channels and reducing information costs (Bazerman & Schoorman, 1983). They can also make valuable suggestions that insiders cannot (Dalton et al., 1999). Fich and White (2005) found that when an external CEO is appointed to the board, the firm's potential can be better realized, especially when the CEO belongs to the same industry and has relevant business knowledge. However, they examined all board members and did not specifically study independent directors.

Specific industry knowledge is crucial for a corporation (Coles et al., 2008; Linck et al., 2008). Audretsch and Lehmann (2010) found that technology companies tend to recruit academics as independent directors to compensate for the board's lack of professional knowledge. Similarly, White et al. (2014) showed that large, rapidly growing corporations tend to appoint academics as independent directors. Masulis and Zhang (2018) provided evidence that if independent directors are distracted, the company's firm-specific knowledge will decrease and board commitment will decrease. In this respect, independent directors mainly fulfill their consulting role through low-cost knowledge transfer (McCabe & Nowak, 2008). This is a natural process for both the firm and independent directors. However, the literature has highlighted the tendency of certain types of corporations to hire academics as independent directors but has not explained it. In this study, we supplement the literature by examining the effect of having more independent academic directors with relevant backgrounds on a firm's innovation performance. Our research also investigated the mechanisms used to influence a corporation.

The literature on the relationship between independent technical directors and corporate innovation performance is still limited. On the one hand, independent technical directors can use their expertise to help companies improve their innovation performance. On the other hand, as a company knows its main activities, employing a specialist can have a lesser effect than hiring a generalist. In addition, as independent directors have no real control over a company, it is difficult to judge the real effect of an independent director on a firm's innovation performance. The relationship between independent technical directors and corporate innovation performance requires further empirical analysis and evaluation.

Using panel data from listed firms on the Shanghai Stock Exchange (SSE) and the Shenzhen Stock Exchange (SZSE) in China from 2007 to 2017, this study explored whether matching the expertise of independent directors and the activities of their companies affects the number of applications and authorizations for innovation patents. In China, there are three types of patents: technical invention patents, utility model patents, and design patents. Design and utility model patents indicate changes in the appearance or functions of existing products. Technical invention patents refer to the creation of a new product. This study used the

number of technical invention patents as a measure of real innovation and considers the other two types of patents as strategic innovations.

The technical invention patent application rate was used to measure the quantity of innovation, and the authorization rate was used to measure the quality of innovation. Using empirical analysis, we found that when the expertise of independent directors is relevant to the firm's activities, the technical invention patent application rate increases and the number of applications for design patents decreases, while the number of utility patents is not statistically significant. Thus, in terms of innovation quantity, corporate innovation performance improves as the company allocates more resources to technical invention patents, which are of higher quality than the other two types.

Similar results are obtained for the authorization rate, also indicating an improvement in innovation performance. Based on these results, we can conclude that independent technical directors can use their expertise and knowledge to help listed companies achieve technological innovation and provide technical guidance. Therefore, if companies hire independent directors with relevant business expertise, the industry should perform better in terms of innovation and have healthier economic growth.

We tested our results using the two-stage instrumental variable (IV) approach, and the results are still significant, which helps us eliminate selection bias. We also introduced an exogenous event, the 2014 Wenfeng.plc shock. Wenfeng.plc did not disclose important information regarding the transfer of shares in its annual report, but the independent directors signed the statements. This case was deemed a major problem by the Chinese Securities and Exchange Commission. We used this case to help solve the endogeneity problem, and the results for all observations after 2014 are much more significant. Furthermore, we studied how independent technical directors fulfill their role as consultants within the firm and found that they prefer to use their knowledge to help companies explore their current research field rather than expanding to other fields. If firms want to introduce cutting-edge breakthroughs and gain a competitive advantage in their industry, this is of great practical importance. Using the mechanism test, we show that independent technical directors improve corporate innovation performance mainly by encouraging firms to spend more on R&D and enabling them to obtain more government subsidies.

This study makes three main contributions. First, previous studies only focused on the academic major of independent directors, and few studies examined their research expertise. In contrast, we examined theories about the characteristics of independent directors. Using manual data collection and processing, this study explored how the correlation between the expertise of a director and the main activities of the firm influences innovation performance.

Second, we contribute to the literature on the advisory function of a board. To date, no study has specifically shown whether the consulting role of independent directors can improve the innovation performance of firms. From the perspective of corporate governance in listed companies, we focused on the consulting role of independent directors in terms of corporate innovation. We showed how a system of independent directors can play a role in corporate governance and decision-making.

Third, compared with most other countries in which corporations prefer to hire technical experts with experience in their fields, the recent guidelines of the government have incentivized Chinese corporations to hire academics from universities. As our study focused on the Chinese context, we were able to analyze whether technical professionals can contribute to corporate innovation and, therefore, to the development of the industry, further stimulating economic growth.

Fourth, our findings provide advice to both corporations and governments to improve innovation capabilities. The idea of combining industry operations and academic research has been promoted for decades, and the Chinese government has adopted relevant policies. However, corporations may mistakenly focus on strategic innovation rather than technical innovation. In addition, if firms hire more independent directors with expertise relevant to their activities, the application and authorization rates for design patents may decrease.

The rest of this paper is organized as follows. Section 2 reviews the literature and develops our research hypotheses. Section 3 presents the descriptive statistics. Sections 4–6 report and analyze the results of our empirical tests. Section 7 summarizes the conclusions and suggests policy implications.

2. Literature review and hypothesis development

This paper is based on two streams of literature. The first explores the relationship between the characteristics of independent directors as outsiders and firm decisions. The second is related to the factors that stimulate innovation in a corporation.

2.1. Characteristics of independent directors and corporate decisions

Numerous studies have concluded that independent directors with little or no connection to a company can significantly influence corporate performance, both positively and negatively. For instance, independent directors can limit managerial discretion because they can punish managers after undesirable outcomes (Fama & Jensen, 1983). Ahmed and Duellman (2007) found that firms with a high proportion of independent directors recognize losses more quickly, suggesting that they have high earnings quality. Ferreira et al. (2011) found a positive relationship between the proportion of independent directors and earnings informativeness. Other studies have shown a positive correlation between the presence of independent directors and firm performance (e.g., Rosenstein & Wyatt, 1990; Ferris et al., 2003; Swan and Honeine, 2010; Armstrong et al., 2014; Al-Dhamari and Ismail, 2013). In contrast, Yermack (1996) showed that a smaller proportion of independent directors on the board results in better corporate performance, consistent with the results of several other studies (e.g., Bhagat & Black, 2002; Anderson et al., 2004; Boone et al., 2007).

Many studies have focused on the different characteristics of independent directors and how they affect the way companies operate. Using a sample of U.S. firms, Adams and Ferreira (2009) found that female directors have a significant effect on board inputs and firm outcomes. Masulis and Mobbs (2014) argued that when firms with independent directors experience an exogenous increase in the relative ranking of directors, their performance will improve. Other characteristics studied include the background of independent directors (Gang et al., 2007), gender (Shukeri et al., 2012; Ferreira et al., 2018), reputation (Brochet & Srinivasan, 2014; Fos et al., 2017), and tenure (Bonini et al., 2017).

Recent studies have examined the mechanisms by which the characteristics of independent directors influence corporate innovation. As mentioned earlier, in general, independent directors play two roles: monitors and consultants (Ferris et al., 2003). Monitoring can be seen as an intrinsic requirement of the board member position, while consulting allows them more freedom. As monitors, outside board members increase the oversight of business operations by the board (Balsmeier et al., 2017). They can terminate managers for poor performance (Weisbach, 1988), incentivizing them to perform better (Sitglitz & Weiss, 1983). Innovation is part of daily operations, so it can be enhanced by increased board control.

As consultants, independent directors can help companies find solutions at a lower cost than hiring outside consulting services. Jiraporn et al. (2017) investigated the effect of independent directors on corporate innovation by using R&D investments to quantify innovation performance. They concluded that board governance has a significant effect on innovation productivity. Similar studies have found a significant correlation between the characteristics of independent board members and innovation, but these studies have mainly focused on the proportion of independent directors on monitoring committees (Faleye et al., 2011) or on the transition to an independent board of directors (Balsmeier et al., 2017).

However, there has been little research on the relevance of the expertise of an outside board member for the main area of innovation of the company. In addition, unlike monitoring, consulting relies mainly on the expertise of independent directors.

2.2. Corporate innovation performance

The second stream of literature explores the factors that contribute to improving corporate innovation performance. Over the past decade, the number of studies on corporate innovation has increased considerably. Innovation is vital for national economic growth and can help a corporation develop its long-term competitive advantage (Porter, 1992). Some studies have argued that firm characteristics can increase corporate innovation. For instance, firms embedded in alliance networks with both high clustering and high reach have more innovative outputs than those without these characteristics (Schilling & Phelps, 2007). In addition, firms with

independent boards are expected to have more innovation activities (Balsmeier et al., 2017). However, Bazrafshan et al. (2016) showed that there is an optimal level of firm disclosure and that once this level is reached, firm performance decreases.

2.3. Hypothesis development

The presence of independent directors can have opposite effects on corporations, depending on their role. As consultants, independent directors can provide the management team with different opinions and expertise (Balsmeier et al., 2017), especially if they are university professors or experts in their field. Their suggestions and experiences can inspire the management team to increase a firm's innovation activities by developing new ideas and putting them into practice. As monitors, independent directors can exercise stronger control over the management team (Sitglitz & Weiss, 1983). Therefore, managers are pressured to produce decent results in a short period. These managers tend to pursue fewer exploratory projects to improve overall performance (Manso, 2011). R&D investments are typically long-term projects that can possibly hurt short-term financial outcomes. Therefore, managers may be incentivized to reduce investment in R&D. A board may also avoid exploring new areas if it finds that the short-term stock market cannot properly reflect the investment made in innovation (Cohen et al., 2013). As a result, corporate investment in real innovation may decrease.

However, these studies may not be relevant to China's unique setting. Independent directors can have different effects on Chinese firms. China's patent law divides patents into three categories–design patents, utility model patents, and technical invention patents–and research in China must recognize these categories. Innovation activities should be divided into high-quality and low-quality innovations. High-quality innovations help improve technology and competitive advantages, while low-quality innovations benefit from government subsidies or are introduced to comply with laws and regulations. Only high-quality innovations contribute to business development. Therefore, we propose Hypothesis 1.

H1. Firms with independent directors whose expertise is relevant to their operational field will have more high-quality innovations.

As mentioned earlier, independent directors can serve as monitors or consultants. Faleye et al. (2011) argued that the quality of monitoring improves when independent directors are given more oversight duties, but intense monitoring can interfere with the process of sharing strategic information between CEOs and directors (Holmstrom, 2005). If the jobs of technical directors are related to the activities of the firm, they will naturally transfer their knowledge to the management team in their role as consultants (McCabe & Nowak, 2008). This helps the corporation develop a firm-specific competitive advantage (Osterloh & Frey, 2006). For the firm, hiring an independent director with expertise relevant to its activities is a way to transfer knowledge at a lower cost. Thus, independent technical directors are more likely to provide expertise to the management team (Rosenstein & Wyatt, 1990) and to impose less control over management (Byrd & Hickman, 1992), allowing them and other types of independent directors to fulfill their own duties.

In addition, Williamson (1975) described an internal market mechanism in a multidivisional firm in which internal groups compete for limited resources. Resources are defined as a firm's physical, human, and organizational assets (Wernerfelt, 1984). As R&D resources involve these three types of assets, they can be subject to a similar competitive mechanism. According to Mathews' (1997) resource leverage view, because R&D resources are limited, innovation projects must compete to obtain resources. We expect firms to offer incentives to focus on high-quality innovations, thereby reducing the physical and human resources allocated to low-quality innovations.

Thus, the reallocation of innovative resources and the redeployment of human capital contribute to refocusing the scope of innovation (Alon et al., 2016). Moreover, when independent directors act as consultants, they can provide resources to conduct important research in the operational field of the company. When a firm has access to appropriate resources, it will choose to conduct high-quality research rather than low-quality research. Therefore, we propose Hypothesis 2.

H2. Firms with independent directors whose expertise is relevant to their operational field will have fewer low-quality innovations.

3. Empirical design

3.1. Sample selection

Data from Chinese firms listed on the SSE and the SZSE from 2007 to 2017 were collected and used in this study. We excluded the following firms: firms receiving special treatment due to poor performance, firms with negative equity or a negative fixed asset ratio, firms without directors, and firms with an abnormal debt to asset ratio, i.e., less than or >1. We winsorized the tails of the distribution at the 1% and 99% levels. In total, 721 corporations and 5123 observations were used in the analyses. All data on patents, independent directors, and operational fields were collected from the China Stock Market & Accounting Research (CSMAR) database. Table 1 presents the raw data and the processed data classified by industry type. The proportion in each industry did not change significantly after removing noise from the raw data.

3.2. Measurement of key variables

As innovation is abstract and subjective for companies, several recent studies have used patent data to quantify it (e.g., Amore et al., 2013; Brav et al., 2018; Donges et al., 2019). Some studies have used R&D investment as a measure of innovation (e.g., Faleye et al., 2011; Manso, 2011; De Simone et al., 2017; Chircop et al., 2018), but this measure cannot distinguish between high-quality and low-quality innovations. Other researchers have used raw patent counts and the number of citations received by a patent to measure the financial and technical value of an innovation (Harhoff et al., 1999; Hall et al., 2005; Cerqueiro et al., 2016). Some research has even looked at technology classes (González-Uribe and Groen-Xu, 2017). When researchers study innovation in China, they generally assume that design patents are more likely to be low-quality innovations because they do not make significant technological changes. In contrast, technical invention patents are more likely to be considered high-quality innovations.

In this study, we measured the innovation capability of companies using the number of patent applications filed and the number of patents authorized. We divided patents into three categories according to the degree of innovation: technical invention patents, utility model patents, and design patents. Given the high degree of skewness in the absolute value of the number of patents, which cannot reflect the relative relationship of the three patent types, we measured the dependent variables by their proportion. The more technical the invention patents filed by a firm, the greater its technological achievements, and the stronger its innovation capability. For the quantity of corporate innovation, we used the proportion of technical invention patent applications (*Invent-apply*), the proportion of utility model patent applications (*Utility-apply*), and the proportion of design patent applications (*Design-apply*) to the total number of innovations. For the quality of corporate innovation, we used the proportion of authorized technical invention patents (*Invent-grant*), the proportion of authorized utility model patents (*Utility-grant*), and the proportion of authorized design patents (*Design-grant*) to the total number of innovations. In other words, we measured the motivation for corporate innovation and the strategies used from two aspects, quantity and quality.

In terms of key independent variables, 867 independent technical directors specializing in law and accounting were eliminated from the 721 corporations. To determine whether the professional background and research fields of independent directors correspond to the operational field of their companies, we used various sources, including their resumes, firms' annual reports, and official company websites. We then created a key independent variable, *Specialist*, which is equal to 1 if the expertise of an independent director corresponds to the operational field of the firm, and 0 otherwise.

Following Balsmeier et al. (2017), we defined control variables as those that can interfere in the relationship between the expertise of an independent director and corporate innovation in terms of patent applications and authorizations. We found that there are significant differences in the proportion of R&D expenditure to total assets (*R&D*) and in company size, measured by total assets (*Size*), among the companies in our sample. These two variables have significant positive correlations with innovation activities. Tobin's Q is often used as an important indicator to measure the performance or growth of a company. Therefore, we used *Tobin's Q* to control the effect of a company's future growth potential on its innovation activities. As replacement costs

Table 1
Variable allocation for the manufacturing industries. This table represents the raw data that we collected from the CSMAR database and the processed data without noise classified by industry. We specifically chose companies in the manufacturing industries, i.e., category C in the database, and calculated the frequency, percentage, and cumulative percentage of each industry.

Industry	Raw Data			Processed Data		
Manufacturing Industry	Frequency	Percentage	Cumulative Percentage	Frequency	Percentage	Cumulative Percentage
Special equipment manufacturer	1311	7.80	7.80	232	8.52	8.52
Instrument manufacturer	269	1.60	9.40	37	1.36	9.88
Other manufacturer	136	0.81	10.21	8	0.29	10.17
Agricultural and sideline food processor	358	2.13	12.34	71	2.61	12.78
Chemical manufacturer	1682	10.00	22.34	246	9.03	21.81
Chemical fiber manufacturer	205	1.22	23.56	20	0.73	22.54
Pharmaceutical manufacturer	1741	10.36	33.91	313	11.49	34.03
Printing and reproduction of recorded media	61	0.36	34.28			
Furniture manufacturer	70	0.42	34.69	12	0.44	34.47
Waste resources recycling	57	0.34	35.03			
Education, recreation, and sports supplies manufacturer	80	0.48	35.51	11	0.40	34.88
Non-ferrous metal smelting and rolling	741	4.41	39.92	132	4.85	39.72
Wood, bamboo, rattan, palm, grass products manufacturer	86	0.51	40.43	3	0.11	39.83
Rubber and plastic products manufacturers	480	2.85	43.28	85	3.12	42.95
Car manufacturer	804	4.78	48.06	103	3.78	46.73
Electrical machinery and equipment manufacturer	1562	9.29	57.35	309	11.34	58.08
Leather, fur, and feather products manufacturer	32	0.19	57.54	1	0.04	58.11
Petroleum processor, coking, and nuclear fuel processor	195	1.16	58.70	27	0.99	59.10
Textile industry	438	2.61	61.31	80	2.94	62.04
Clothing industry	231	1.37	62.68	42	1.54	63.58
Computers, and other electronic equipment manufacturer	2275	13.53	76.21	419	15.38	78.96
General equipment manufacturer	1016	6.04	82.26	167	6.13	85.10
Paper products manufacturer	234	1.39	83.65	33	1.21	86.31
Wine, beverage, and refined tea manufacturer	435	2.59	86.24	69	2.53	88.84
Metal products manufacturer	405	2.41	88.65	53	1.95	90.79
Transporting equipment manufacturer	468	2.78	91.43	71	2.61	93.39
Non-metallic mineral products manufacturer	701	4.17	95.60	97	3.56	96.95
Food industry	249	1.48	97.08	48	1.76	98.72
Ferrous metals industry	491	2.92	100.00	35	1.28	100.0
Total	16,813	100.00		2724	100.00	

are difficult to obtain, we used the ending balance of total assets. In addition, we controlled for the logarithm of age (*Ln_Age*), the liability-to-asset ratio (*Leverage*), the fixed capital ratio (*Tangibility*), the size of the board (*Boardsize*), the proportion of independent directors on the board (*Indepboard*), institutional ownership (*Inst*), the internal control index (*Intercontrol_index*), the logarithm of analyst coverage (*Ln_coverage*), and the revenue growth rate (*Growth_rev*). To reduce the skewness of the numerical values, we used the logarithms of these values. See Appendix A for the definitions of the variables.

Table 2 presents the descriptive statistics of the main variables. The mean of the key independent variable, *Specialist,* is 0.615, indicating that 61.5% of the companies in manufacturing industries employed independent technical directors during the study period. From the perspective of R&D expenditure, the maximum value of R&D expenditure of listed companies in China is 21.9% and the minimum value is 0.0%. The standard deviation of the sample is 0.0112, which indicates that the ratio of R&D expenditure to total assets in Chinese companies is significant.

On average, the proportion of technical invention patent applications is higher than the proportion of other patent applications. The proportions of technical invention patent applications and utility model patent applications to the total number of patent applications are approximately 0.4, while the proportion of design patent applications to the total number of patent applications is only 0.097. On average, the number of authorized technical invention patents is significantly lower than the number of technical invention patent applications. In comparison, the proportion of authorized utility model patents and that of authorized design patents are much higher. In addition, the average number of years of listing of the companies in the sample is 5.36 years. The average number of board members is 8.969. The average number of independent directors is 3.293, and the ratio of R&D expenditure to total assets is 0.33%.

Table 2
Descriptive statistics of the variables. The sample consisted of 721 firms with financial and patent data available from the CSMAR database. Patents are divided into three categories according to the degree of innovation, i.e., technical invention patents, utility model patents, and design patents. We calculated the proportion of each category in the patent data, distinguishing between authorizations and applications and defining them as *Invent-apply, Utility-apply, Design-apply, Invent-grant, Utility-grant*, and *Design-grant*. *Specialist* is the key dummy variable. If the expertise of independent directors hired by the company in a given year corresponds to its operational field, *Specialist* = 1; otherwise, *Specialist* = 0. *Ln_Size* is computed as the logarithm of total assets. *Ln_Age* is computed as the logarithm of the company's trading years since the IPO. *Leverage* is computed as total liabilities divided by total assets. *Tangibility* is computed as the carrying value of fixed assets divided by total assets. *Tobin's Q* is computed as market capitalization divided by asset replacement cost. *R&D* is computed as R&D expenditure divided by total assets. *Boardsize* is computed as the number of directors. *Indepboard* is computed as the number of independent directors. The control variables are winsorized at the 1st and 99th percentiles.

Variable	Sample size	Mean	Std dev	Min	Median	Max
Invent-apply	2043	0.473	0.348	0.000	1.000	1.000
Utility-apply	2043	0.430	0.337	0.000	0.400	1.000
Design-apply	2043	0.097	0.228	0.000	0.500	1.000
Invent-grant	2021	0.351	0.386	0.000	0.000	1.000
Utility-grant	2021	0.537	0.395	0.000	0.167	1.000
Design-grant	2021	0.112	0.252	0.000	0.667	1.000
Specialist	5123	0.615	0.487	0.000	0.000	1.000
Ln_Size	5123	21.970	1.267	19.170	21.719	28.000
Ln_Age	3971	1.551	0.763	0.000	2.944	2.833
Tangibility	5105	0.182	0.143	0.000	0.171	0.852
Tobin's Q	4993	2.584	2.155	0.113	1.775	24.940
R&D	3147	0.003	0.011	0.000	0.000	0.219
Boardsize	5106	8.969	1.811	3.000	9.000	18.000
Indepboard	5107	3.293	0.632	1.000	3.000	8.000
Leverage	2021	0.401	0.198	0.024	0.394	0.946
Inst	2043	0.188	0.201	0.000	0.125	1.487
Intercontrol_index	2043	660.314	133.001	0.000	676.590	999.750
Ln_coverage	2043	1.388	1.135	0.000	1.946	4.174
Growth_rev	2043	1.211	0.515	0.263	1.1024	5.429

3.3. Construction of the empirical model

When creating the model, we first verified the relationship between the relevance of the expertise of an independent director and the firm's technical invention patent application rate, which is illustrated in the line chart in Fig. 1. The horizontal axis indicates the year and the vertical axis indicates the average number of technical invention patent applications. As shown in Fig. 1, when the expertise of the independent director is relevant to the operational field of the company (*Specialist* = 1), the average number of technical invention patent applications is significantly higher than when *Specialist* is equal to 0. This indicates that the relationship between the expertise of independent directors and the operational field of their companies has a positive effect on the number of patent applications.

Fig. 2 shows the relationship between the relevance of the expertise of independent directors and the number of technical invention patent authorizations in companies. The horizontal axis indicates the year and the vertical axis indicates the average number of invention patents granted. As the graph shows, when the expertise of the independent director corresponds to the main activities of the company (*Specialist* = 1), the average number of invention patents granted is significantly higher than when *Specialist* is equal to 0. This indicates that the relationship between the expertise of independent directors and the operational field of their companies has a positive effect on the authorization of technical invention patents.

To explain how the relationship between the relevance of the expertise of independent technical directors and the operational field of their companies influences corporate innovation, we followed Balsmeier et al. (2017) and constructed the following model using the ordinary least squares (OLS) method:

$$Patent_{i,t+1} = \beta_0 + \beta_1 Specialist_{i,t} + \gamma_t + \mu_i + X_{it} + \varepsilon_{it} \quad (1)$$

There are six indicators that measure how patents work in terms of quantity and quality. As innovation activities are delayed to some extent, following Atanassov (2013), we used patent data lagged by one year ($t + 1$) to measure the effect of hiring independent technical directors in year t. The key explanatory variable, $Specialist_{i,t}$, measures whether the expertise of the independent directors hired in year t corresponds to the main operational field of their companies. As fixed effects can eliminate the influence of unobserved variables that are constant over time, we adopted a two-way fixed effects model. The subscripts i and t represent the i^{th} firm and the t^{th} year, respectively ($t = 2007,\ldots, 2017$), γ_t represents time fixed effects, μ_i represents firm fixed effects, X_{it}represents other control variables, and ε_{it} is the residual term. We used heteroskedasticity-robust standard errors.

4. Empirical results of the baseline model

The regression results of Model (1) are presented in Table 3. The dependent variables in Columns 1 to 3 are the three types of patent applications: the proportion of technical invention patent applications, the propor-

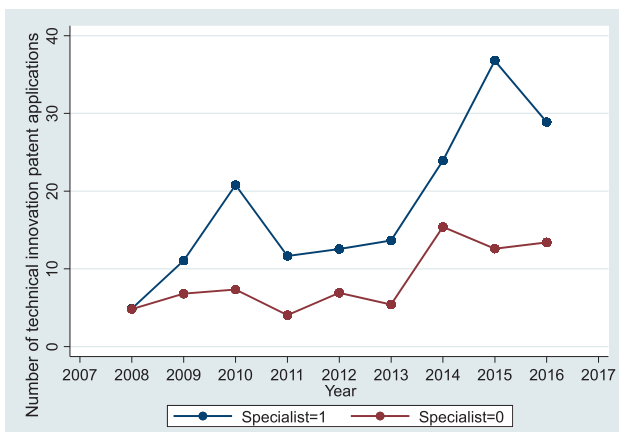

Fig. 1. Relevance of the expertise of independent directors and patent applications.

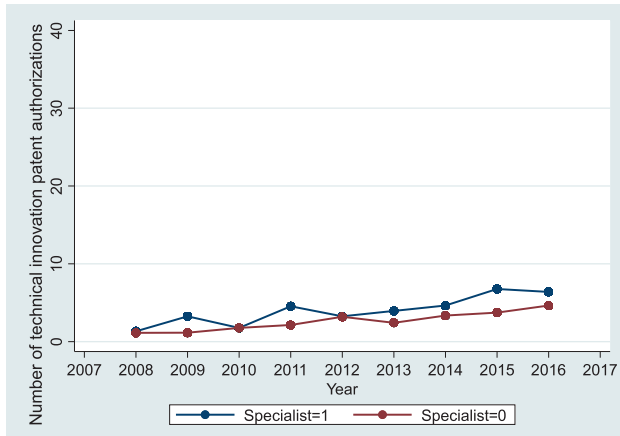

Fig. 2. Relevance of the expertise of independent directors and patent authorizations.

tion of utility model patent applications, and the proportion of design patent applications, respectively. The results show that having independent technical directors with expertise in the operational field of their companies significantly increases the proportion of technical invention patent applications, with a coefficient of 0.07, significant at the 1% level. However, the proportion of utility model patent applications is not significantly affected, and there is a negative effect on the proportion of design patent applications, with a coefficient of −0.05, which is significant at the 1% level. These results indicate that the participation of independent technical directors encourages firms to focus on high-quality technical invention patents rather than blindly increasing the number of patents. Therefore, the involvement of independent technical directors improves firms' innovation capability.

The dependent variables in Columns 4–6 are the proportion of the three types of authorized patents: technical invention patents, utility model patents, and design patents. The coefficient of authorized technical invention patents is 0.05, and that of authorized design patents is −0.05, both of which are significant at the 1% level. These results indicate that independent technical directors with expertise in the operational field of their companies not only motivate companies to increase their innovation activities but also improve the quality of their invention patents.

As independent directors can have a long-term effect on innovation performance, we further studied how hiring relevant independent technical directors affects the number of patent applications over the following three years. The assumption is that the proportion of patent applications is a better indicator of a firm's initiative than the proportion of authorized patents. Table 4 shows that by employing independent technical directors, corporations experience an increase in the proportion of technical invention patent applications and a decrease in the proportion of design patents in subsequent years, and this positive effect increases over time. This implies that independent technical directors contribute more as consultants when they stay on the board for a longer period.

5. The endogeneity problem and robustness tests

We examined the robustness of the causal relationship between independent technical directors and corporate innovation from two aspects. First, we used propensity score matching (PSM) to test the robustness of the benchmark model, and we found that the test results are essentially consistent with Table 3. Second, we used a placebo test to confirm that the significance we found was indeed due to the presence of independent directors.

5.1. PSM test: exclusion of inter-group heterogeneity

To reduce the endogeneity problem caused by sample selection bias and the influence of confounding variables, we used the PSM method and the variable *Specialist* to perform a logit regression on the control

Table 3
Independent technical directors and corporate innovation: Baseline results. This table presents the panel regression estimates of Model (1) for the number of patents classified by degree of innovation from 2007 to 2017 as a function of *Specialist*. We used the patent data in year *t + 1* to measure the effect of hiring independent technical directors in year *t*. *Specialist* measures whether the expertise of the independent directors hired in year *t* corresponds to the operational field of their companies. We adopted the firm and year fixed effects model for analysis. The t-statistics are reported in brackets. ***, **, and * indicate that the parameter estimates are significantly different from 0 at the 1%, 5%, and 10% levels, respectively.

	(1) *Invent-apply*	(2) *Utility-apply*	(3) *Design-apply*	(4) *Invent-grant*	(5) *Utility-grant*	(6) *Design-grant*
Specialist	0.07***	−0.01	−0.05***	0.05**	−0.00	−0.05***
	(2.72)	(−0.65)	(−3.38)	(2.10)	(−0.18)	(−3.00)
Tangibility	−0.03	0.07	−0.04	−0.16*	0.22**	−0.05
	(−0.38)	(0.88)	(−0.78)	(−1.77)	(2.51)	(−0.94)
Ln_Age	0.05	−0.08*	0.03	0.10**	−0.13***	0.03
	(1.03)	(−1.80)	(0.90)	(2.03)	(−2.77)	(1.03)
Ln_Size	−0.00	−0.01	0.01	0.01	0.01	−0.02
	(−0.05)	(−0.38)	(0.61)	(0.44)	(0.59)	(−1.43)
Leverage	0.02	−0.02	0.00	0.03	−0.10	0.06
	(0.28)	(−0.34)	(0.06)	(0.38)	(−1.13)	(1.13)
R&D	0.03	0.28	−0.31	0.47	−0.32	−0.16
	(0.06)	(0.61)	(−0.90)	(1.07)	(−0.67)	(−0.44)
Tobin's Q	0.00	−0.01	0.00	0.01	−0.01	−0.01
	(0.18)	(−0.95)	(0.85)	(1.29)	(−0.64)	(−1.15)
Indepboard	−0.25	0.02	0.23	−0.21	−0.06	0.27
	(−1.14)	(0.10)	(1.38)	(−0.88)	(−0.22)	(1.36)
Boardsize	−0.01	0.01	−0.00	−0.01	0.01	0.00
	(−0.90)	(0.91)	(−0.15)	(−0.76)	(0.59)	(0.11)
Inst	0.07	−0.06	−0.01	−0.04	0.09	−0.05
	(1.01)	(−1.04)	(−0.23)	(−0.61)	(1.38)	(−0.96)
Intercontrol_index	0.00	−0.00	−0.00	0.00	−0.00	−0.00
	(1.60)	(−0.76)	(−0.82)	(1.04)	(−0.31)	(−0.85)
Ln_coverage	0.01	−0.01	−0.01	−0.01	0.01	0.00
	(1.09)	(−0.65)	(−0.83)	(−0.85)	(0.74)	(0.22)
Growth_rev	−0.03	−0.00	0.03	−0.01	−0.01	0.02
	(−1.23)	(−0.22)	(1.45)	(−0.48)	(−0.43)	(1.44)
Constant	0.36	0.80***	−0.16	−0.04	0.70**	0.34
	(1.01)	(2.64)	(−0.70)	(−0.10)	(2.11)	(1.37)
Firm and year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2043	2043	2043	2021	2021	2021
F-value	1.72	0.92	1.83	1.63	1.73	1.74
Adj. R^2	0.23	0.27	0.22	0.23	0.29	0.21

variables to obtain propensity scores. The regression results show that the liability-to-asset ratio, the proportion of R&D expenditure, and the fixed capital ratio all affect the choice of a company to hire an independent director. Therefore, it was necessary to match the companies using the PSM method. We estimated a propensity score model and calculated the propensity score for each listed company. In addition, nearest neighbor matching was applied to the one-to-one matching of each listed company. To ensure the effectiveness of the PSM method, we carried out a balance test of the samples, with satisfactory results. The estimation results are presented in Table 5.

5.2. Falsifiability test: assuming false key explanatory variables

To ensure that the significance of the main results was not simply due to random or accidental factors, we conducted a placebo test. We assumed that the relationship of the expertise of an independent director and the operational field of the company did not occur in the same year as the innovation performance of the company, but one to three years before the change. To this end, we created three false variables, $Specialist\_{t-1}$, $Specialist_{t-2}$, and $Specialist_{t-3}$. We then used these variables in turn to replace the key explanatory variable

Table 4
Independent technical directors and corporate innovation: Long-term effect. This table presents the regression estimates of the number of patents classified by degree of innovation from 2007 to 2017 as a function of *Specialist* in the long term. We used the patent data to measure the effect of hiring independent technical directors in year $t + 2$, $t + 3$, and $t + 4$. *Specialist* measures whether the expertise of the independent directors hired in year t corresponds to the operational field of their companies. We controlled for firm and year fixed effects. Unless otherwise indicated, the figures in brackets are t-statistics, clustered at the firm level. ***, **, and * indicate that the parameter estimates are significantly different from 0 at the 1%, 5%, and 10% levels, respectively.

	(1)Invent-apply $_{t+2}$	*(2)Design-apply* $_{t+2}$	*(1)Invent-apply* $_{t+3}$	*(2)Design-apply* $_{t+3}$	*(1)Invent-apply* $_{t+4}$	*(2)Design-apply* $_{t+4}$
Specialist	0.10**	−0.07***	0.13***	−0.08***	0.14***	−0.08**
	(2.42)	(−3.03)	(3.01)	(−2.83)	(2.65)	(−2.05)
Tangibility	0.05	0.03	−0.09	0.05	0.04	0.11
	(0.50)	(0.78)	(−0.74)	(0.72)	(0.20)	(1.34)
Ln_Age	0.13**	0.03	0.13*	0.03	0.20**	0.02
	(2.30)	(1.19)	(1.79)	(0.91)	(2.16)	(0.44)
Ln_Size	0.04**	−0.01	0.05**	−0.01	0.04	−0.02
	(2.33)	(−1.34)	(2.52)	(−1.48)	(1.48)	(−1.21)
Leverage	0.09	−0.01	0.13	−0.00	−0.11	0.08
	(0.92)	(−0.23)	(1.17)	(−0.04)	(−0.65)	(0.87)
R&D	−0.31	−0.09	−0.86	−0.29	−0.23	−0.18
	(−0.55)	(−0.36)	(−1.21)	(−1.56)	(−0.31)	(−0.59)
Tobin's Q	0.01	−0.01	0.02	−0.01*	−0.02	−0.00
	(0.83)	(−1.30)	(1.12)	(−1.89)	(−0.99)	(−0.60)
Indepboard	−0.26	0.31	0.19	−0.14	0.06	−0.20
	(−0.85)	(1.49)	(0.50)	(−0.48)	(0.10)	(−0.64)
Boardsize	−0.03**	0.00	−0.02	−0.01	−0.02	−0.01
	(−2.41)	(0.44)	(−1.24)	(−1.14)	(−1.28)	(−1.05)
Constant	−0.57	0.15	−1.02**	0.50*	−0.81	0.55
	(−1.34)	(0.67)	(−2.01)	(1.82)	(−1.22)	(1.48)
Firm and year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	885	885	575	575	339	339
F-value	4.05	2.77	3.59	2.33	2.34	1.13
Adj. R^2	0.28	0.18	0.24	0.20	0.31	0.35

Table 5
Independent technical directors and corporate innovation: PSM results. This table presents the PSM regression estimates of the number of patents classified by degree of innovation from 2007 to 2017 as a function of *Specialist*. We used the patent data in year $t + 1$ to measure the effect of hiring independent technical directors in year *t*. *Specialist* was used to conduct a logit regression on the control variables to obtain propensity scores. We estimated the propensity score model and calculated the propensity score for each listed company. Nearest neighbor matching was applied to the one-to-one matching of each listed company, and 990 valid observations were obtained, representing 327 listed companies. We controlled for firm and year fixed effects. The t-statistics are reported in brackets. ***, **, and * indicate that the parameter estimates are significantly different from 0 at the 1%, 5%, and 10% levels, respectively.

	(1) *Invent-Apply*	(2) *Utility-apply*	(3) *Design-apply*	(4) *Invent-grant*	(5) *Utility-grant*	(6) *Design-grant*
Specialist	0.11***	−0.02	−0.09***	0.10**	−0.01	−0.09***
	(3.20)	(−0.54)	(−3.30)	(2.59)	(−0.22)	(−3.08)
Tangibility	−0.02	0.05	−0.02	−0.16	0.24**	−0.08
	(−0.25)	(0.52)	(−0.34)	(−1.42)	(2.25)	(−1.25)
Ln_Age	0.06	−0.07	0.01	0.10*	−0.10*	−0.00
	(1.21)	(−1.56)	(0.27)	(1.83)	(−1.80)	(−0.04)
Ln_Size	0.04**	−0.03**	−0.00	0.01	0.01	−0.03**
	(1.99)	(−2.27)	(−0.26)	(0.69)	(0.94)	(−2.34)
Leverage	−0.01	−0.06	0.07	0.06	−0.08	0.02
	(−0.08)	(−0.80)	(1.17)	(0.51)	(−0.75)	(0.35)
R&D	−0.20	0.62	−0.43	0.86	−0.38	−0.48
	(−0.29)	(1.01)	(−1.15)	(1.55)	(−0.59)	(−1.03)
Tobin's Q	0.01	−0.01*	−0.00	0.01	−0.00	−0.01**
	(1.63)	(−1.80)	(−0.07)	(1.33)	(−0.19)	(−1.99)
Indepboard	−0.61**	0.22	0.40**	−0.08	−0.46	0.54**
	(−2.29)	(0.84)	(2.22)	(−0.26)	(−1.61)	(2.37)
Boardsize	−0.02**	0.02**	−0.00	−0.01	−0.01	0.02**
	(−2.39)	(2.52)	(−0.08)	(−0.54)	(−0.91)	(2.18)
Constant	−0.14	1.12***	0.02	−0.21	0.75**	0.46*
	(−0.36)	(3.34)	(0.09)	(−0.53)	(1.97)	(1.68)
Firm and year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	837	837	837	799	799	799
F-value	3.28	1.79	3.11	2.51	1.24	3.04
Adj. R^2	0.27	0.31	0.15	0.26	0.31	0.19

Specialist and regressed the baseline model again to examine whether the number of patent applications and authorizations of a company still increased. The placebo results are reported in detail in Table 6. The results indicate that there is no significant change in the results after changing the timing, so the main results are robust.

5.3. Placebo test: 500 sampling regressions

To determine whether the two relationships discussed above still exist if the independent directors are of any profession, not just relevant technical fields, we conducted another placebo test to ensure that when the variable *Specialist* is randomly selected, it has no processing effect on the number of technical invention patent applications. To do so, we first disordered the variable *Specialist* and randomly assigned each value of *Specialist* to each observation to generate a simulated explanatory variable *Random_Specialist*. We repeated the process 500 times and recorded the estimated coefficient of $\beta 1$ and its t-value for each sample.

We first regressed the number of technical invention patent applications on *Random_Specialist* and recorded the results. As shown in the upper left panel of Fig. 3, the t-statistic of the *Random_Specialist* coefficient of 500 repeated samples is an inverted U-shape around 0. This result suggests that there is no correlation between the number of technical invention patent applications and *Random_Specialist.* We then regressed the other explanatory variables on *Random_Specialist*, including the number of design patent applications, the number of technical invention patent authorizations, and the number of design patent authorizations. The results are similar.

Table 6
Independent technical directors and corporate innovation: Placebo test. This table presents the regression estimates of the placebo test for the number of patents classified by degree of innovation from 2007 to 2017 as a function of *Specialist* during the previous period. We used the patent data in year *t* to measure the effect of hiring independent technical directors in year *t*. *Specialist t-1* assumes that the expertise of the independent directors hired in year *t-1* corresponds to the operational field of their companies. *Specialist t-2* assumes that the expertise of the independent directors hired in year *t-2* corresponds to the operational field of their companies. *Specialist t-3* assumes that the expertise of the independent directors hired in year *t-3* corresponds to the operational field of their companies. We controlled for firm and year fixed effects. The t-statistics are reported in brackets. * indicates that the parameter estimates are significantly different from 0 at the 10% level.

	(1) *Invent-apply*	(2) *Utility-apply*	(3) *Design-apply*	(4) *Invent-grant*	(5) *Utility-grant*	(6) *Design-grant*
Specialist $_{t-1}$	0.02	−0.00	−0.02	0.04	0.03	−0.07
	(0.46)	(−0.01)	(−0.43)	(0.69)	(0.61)	(−1.26)
Specialist $_{t-2}$	−0.04	−0.03	0.07	−0.13*	0.12*	0.01
	(−0.71)	(−0.30)	(1.16)	(−1.69)	(1.81)	(0.17)
Specialist $_{t-3}$	−0.10	0.11	−0.01	0.02	0.08	−0.10
	(−1.38)	(1.19)	(−0.11)	(0.14)	(0.91)	(−0.87)
Control variables	Controlled	Controlled	Controlled	Controlled	Controlled	Controlled
Firm and year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes

In Table 7, we calculated the average coefficient for each explanatory variable and conducted additional t-tests, rejecting the original hypothesis at the 1% and 5% significance levels. As shown in Table 7, the average coefficients of the explanatory variables are 0.000 for technical invention patent applications, 0.000 for design patent applications, 0.002 for technical invention patent authorizations, and 0.000 for design patent authorizations, respectively. Furthermore, the probabilities of positive and negative β coefficients is similar. In summary, the placebo test shows that the virtual processing effect performed does not exist, which means that the appointment of independent technical directors is the variable that promotes corporate innovation performance.

5.4. Two-stage instrumental variable approach

We adopted the two-stage IV approach. Table 8 presents the results of the following two-stage IV specification:

$$\text{First stage}: \quad \widehat{Specialist}_{i,t} = b_0 + b_1 AveSpecialist_{i,t} + Specialist_{i,t} + controlledvariables + e_{i,t}$$

$$\text{Second stage}: \quad Patent_{i,t+1} = \beta_0 + \beta_1 \widehat{Specialist}_{i,t} + controlled\ \ variables + \varepsilon_{i,t}$$

The $AveSpecialist_{i,t}$ is the first-stage IV for firm i in year t, which refers to the average of the $Specialist_{i,t}$ in the manufacturing industry except for the treatment firm, and $\widehat{Specialist}_{i,t}$is the projected value of *Specialist* obtained from the first-stage regression. Controlled variables stack a list of control variables, as before. The instruments are the degree of proximity between the presence of independent directors and corporate innovation performance. We also controlled for firm and year fixed effects and clustered standard errors at the firm level in all the regressions.

According to the regression results of Stage 2, the coefficients for the numbers of technical invention patents filed and granted are 0.22 and 0.19, respectively. Both coefficients are positive and significant at the 1% level. In addition, the coefficients for the numbers of design patents filed and authorized are −0.19 and −0.20, respectively, both of which are significant at the 1% level, which addresses the problem of selection bias.

5.5. Exogenous shock: the Wenfeng.plc shock

In addition to the 2SLS model above, we introduced an exogenous event. We followed the approach of Black and Kim (2012), who used the Korean law of 1999 as an exogenous shock to evaluate the influence of outside board members, and chose the case of Wenfeng.plc in the context of China. In this case, Wenfeng.-

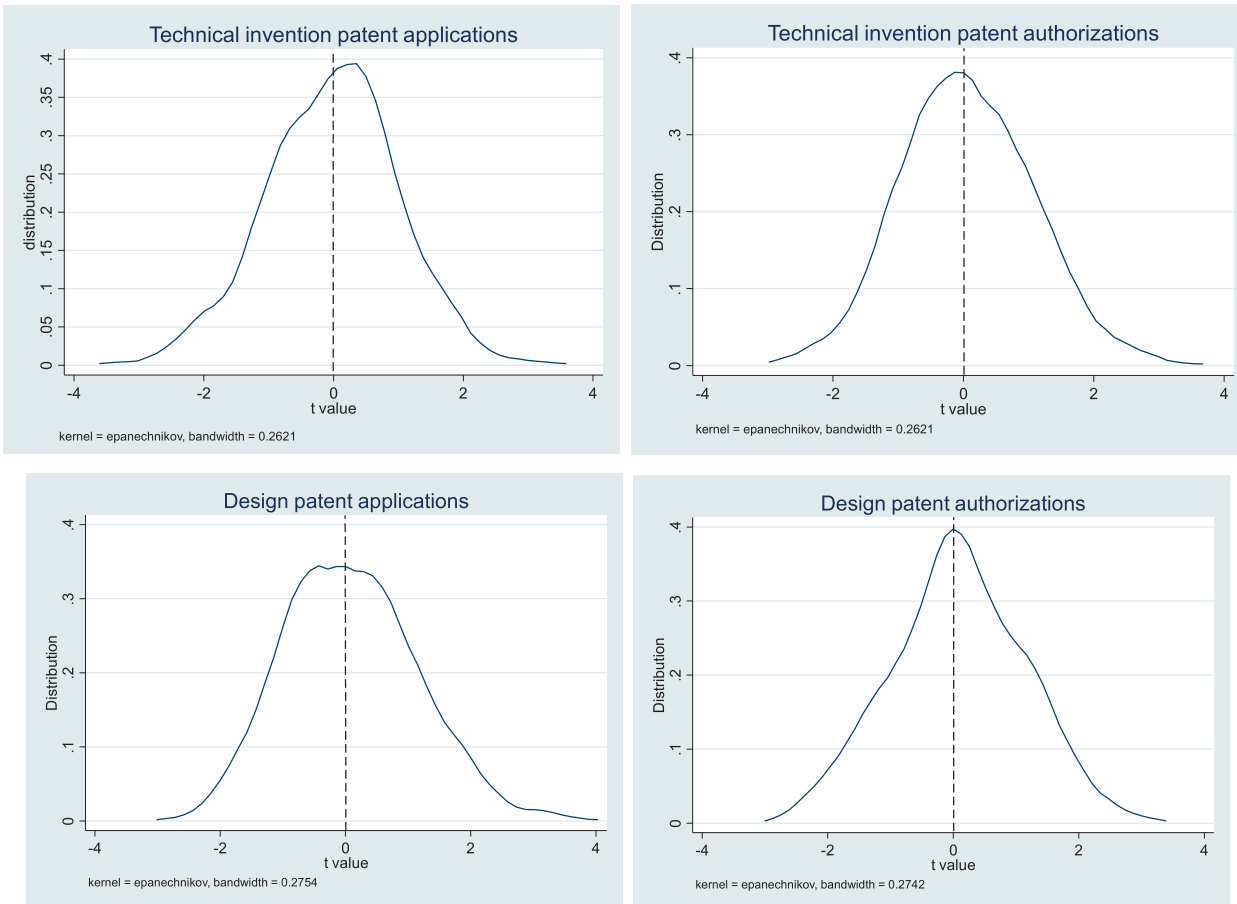

Fig. 3. Kernel density estimate**.** Figure shows the kernel density estimates of the t-statistics. We regressed the explanatory variable *Random_Specialist* on the dependent variables, including the number of technical invention patent applications, the number of technical invention patent authorizations, the number of design patent applications, and the number of design patent authorizations. The process was repeated 500 times, and the t-statistic of the *Random_Specialist* coefficient for the 500 repeated samples is recorded for each sample. In this figure, the horizontal axis represents the t-statistic and the vertical axis represents the distribution.

Table 7
Placebo test (500 repeated samples). This table presents the regression estimates of Model (1) using the 500 repeated samples for the number of patents classified by degree of innovation from 2007 to 2017 as a function of *Specialist*. The key explanatory variable, *Specialist*, in the sample was randomly assigned to each observation based on a retractable (repeatable) sampling method. For each sample, the estimated coefficient of $\boldsymbol{\beta_1}$ and its t-value are recorded. In Table 7, Mean β_1 for *Random_Specialist* reports the descriptive statistics of the estimated coefficient $\boldsymbol{\beta_1}$ for the simulated explanatory variables (the names of the columns are the explanatory variables). In square brackets, the probabilities that the estimated coefficient $\boldsymbol{\beta_1}$ is significantly positive [$\beta > 0$ & $\alpha < 5\%$] or significantly negative [$\beta > 0$ & $\alpha < 5\%$] at the 5% level are reported. In the regression, we clustered the data by firm according to the stock codes and used robust regression to deal with heteroskedasticity. *** indicates that the parameter estimates are significantly different from 0 at the 1% level.

Variable	*Invent-apply*	*Design-apply*	*Invent-grant*	*Design-grant*
$\boldsymbol{\beta_1}$	0.07***	−0.05***	0.05***	−0.05**
t-test	$p = 0.000$***	$p = 0.000$***	$p = 0.000$***	$p = 0.000$***
Mean $\boldsymbol{\beta_1}$ for *Random_Specialist*	0.000	0.000	0.002	0.000
[$\beta > 0$ & $\alpha \leq 5\%$; $\beta < 0$ & $\alpha \leq 5\%$]	[2.2%; 3.2%]	[4.6%; 1.4%]	[3.4%; 2%]	[3.8%; 3%]
[$\beta > 0$ & $\alpha \leq 1\%$; $\beta < 0$ & $\alpha \leq 1\%$]	[0.6%; 0.4%]	[1.6%; 0.2%]	[0.8%; 0.4%]	[0.8%; 0.2%]

Table 8
Two-stage instrumental variable approach. This table presents the two-stage instrumental variable regression estimates for the number of patent applications and authorizations from 2007 to 2017 as a function of *Specialist*. The $AveSpecialist_{i,t}$ is the first-stage IV for firm i in year t, which refers to the average of the $Specialist_{i,t}$ in the manufacturing industry except for the treatment firm, and $\widehat{\text{Specialist}}_{i,t}$ is the projected value of *Specialist* obtained from the first-stage regression. Controlled variables stack a list of control variables. We controlled for firm and year fixed effects. The t-statistics are reported in brackets. ***, **, and * indicate that the parameter estimates are significantly different from 0 at the 1%, 5%, and 10% levels, respectively.

	Stage 1	Stage 2					
	Specialist (1)	*Invent- apply* (2)	*Utility- apply* (3)	*Design- apply* (4)	*Invent- grant* (5)	*Utility- grant* (6)	*Design- grant* (7)
Specialist		0.22***	−0.03	−0.19***	0.19***	0.01	−0.20***
		(5.41)	(−0.68)	(−5.44)	(4.21)	(0.30)	(−4.90)
Tangibility	2.05***	0.09	−0.11*	0.02	−0.05	0.04	0.00
	(5.53)	(1.53)	(−1.90)	(0.54)	(−0.68)	(0.62)	(0.09)
Ln_Age	−0.19	0.08***	−0.14***	0.06***	0.14***	−0.22***	0.08***
	(−0.99)	(2.70)	(−4.85)	(2.85)	(4.07)	(−6.35)	(3.60)
Ln_Size	0.09*	0.01	−0.01	0.00	0.00	0.02**	−0.02***
	(1.75)	(0.97)	(−1.36)	(0.48)	(−0.43)	(2.31)	(−2.78)
Leverage	−0.77**	−0.09*	0.15***	−0.06	−0.07	0.07	0.00
	(−2.50)	(−1.80)	(3.00)	(−1.52)	(−1.24)	(1.25)	(−0.06)
R&D	13.99**	0.59	−0.52	−0.07	1.04	−1.31**	0.27
	(2.28)	(0.79)	(−0.75)	(−0.30)	(1.64)	(−1.98)	(0.85)
Tobin's Q	0.07**	0.01	−0.02***	0.01***	0.01**	−0.02***	0.01
	(2.07)	(1.32)	(−3.51)	(2.67)	(1.98)	(−2.84)	(1.34)
Indepboard	−0.43	−0.33**	−0.09	0.43***	−0.18	−0.24	0.42***
	(−0.43)	(−2.17)	(−0.58)	(3.89)	(−1.08)	(−1.37)	(3.40)
Boardsize	0.03	−0.01	0.00	0.01**	0.00	−0.01	0.01***
	(1.01)	(−1.13)	(−0.49)	(2.19)	(−0.51)	(−1.56)	(2.63)
AveSpecialist	5.11***						
	(16.17)						
Constant	−4.49***	0.1	1.15***	−0.25*	0.03	0.83***	0.14
	(−3.39)	(0.47)	(5.85)	(−1.82)	(0.13)	(3.50)	(0.94)
Observations	2,227	2,064	2,064	2,064	2,043	2,043	2,043
Adj. R^2		0.00	0.03	−0.02	0.01	0.04	−0.01
Weak IV F-statistic		368.5***	368.5***	368.503***	362.14***	362.14***	362.14***

plc transferred 15% of its shares to Lu Yongmin, who held the shares of the Wenfeng Group on behalf of other investors. In fiscal year 2014, Wenfeng.plc did not disclose this information in its annual report. However, independent directors Fan and Jiang signed written confirmation opinions on the report. This case was classified as a significant problem by the China Securities Regulatory Commission in 2014, greatly affecting the conduct of listed companies. Based on this event, we can reasonably infer that other listed companies may act differently before and after 2014.

We divided our sample into two groups: before and after 2014. The first group included all observations before or during 2014, and the second group included all observations after 2014. We ran the baseline regressions again group by group, and the results are presented in Table 9.

In the regression results before 2014, the coefficient for the number of technical invention patents is positive but not significant. However, after 2014, this coefficient is 0.11, which is significant at the 1% level. In addition, the coefficient for the number of authorized technical invention patents is 0.07, which is significant at the 5% level. Regarding the number of design patents, the coefficients of applications and authorizations are negative before 2014 and significant at the 1% and 10% levels, respectively, and the number of authorized design patents decreases more significantly after 2014, significant at the 5% level.

Table 9
Exogenous shock: The Wenfeng.plc shock. The two tables below present the regression results of the baseline model after dividing the sample into two groups, i.e., before and after 2014. Panel A presents the results for all observations before or during 2014, and Panel B presents the results for all observations after 2014. The dependent variables are the proportion of technical invention patents filed, the proportion of utility patents filed, and the proportion of design patents filed to the total number of patents filed in year $t + 1$. *Specialist* measures whether the expertise of the independent directors hired in year t corresponds to the operational field of their companies. We controlled for firm and year fixed effects. The t-statistics are reported in brackets. ***, **, and * indicate that the parameter estimates are significantly different from 0 at the 1%, 5%, and 10% levels, respectively.

Panel A: Subsample before or during 2014

	(1) *Invent-apply*	(2) *Utility- apply*	(3) *Design- apply*	(4) *Invent-grant*	(5) *Utility-grant*	(6) *Design-grant*
Specialist	0.04	0.03	−0.06***	0.03	0.00	−0.03*
	(1.21)	(0.92)	(−3.50)	(0.90)	(0.12)	(−1.93)
Tangibility	−0.03	0.02	0.01	−0.23**	0.19*	0.05
	(−0.35)	(0.24)	(0.25)	(−1.97)	(1.76)	(0.77)
Ln_Age	0.05	−0.07	0.02	0.08	−0.12**	0.05
	(0.98)	(−1.45)	(0.65)	(1.27)	(−2.13)	(1.50)
Ln_Size	0.02	−0.01	−0.01	−0.00	0.02	−0.02*
	(1.42)	(−0.87)	(−1.06)	(−0.01)	(1.11)	(−1.79)
Leverage	−0.05	0.07	−0.02	0.01	−0.05	0.05
	(−0.55)	(0.82)	(−0.45)	(0.06)	(−0.48)	(0.87)
R&D	0.29	0.03	−0.32	0.51	−0.66	0.15
	(0.43)	(0.06)	(−0.90)	(0.90)	(−1.10)	(0.47)
Tobin's Q	0.00	0.01	−0.01	0.01	−0.01	−0.01
	(0.06)	(0.76)	(−1.29)	(1.28)	(−0.65)	(−1.38)
Indepboard	−0.14	−0.37	0.51**	0.13	−0.61*	0.48**
	(−0.41)	(−1.23)	(2.27)	(0.39)	(−1.70)	(2.09)
Boardsize	−0.00	−0.00	0.00	0.00	−0.01	0.01
	(−0.33)	(−0.02)	(0.40)	(0.14)	(−0.79)	(0.99)
Constant	−0.04	0.99***	0.05	0.06	0.80*	0.14
	(−0.12)	(2.87)	(0.24)	(0.14)	(1.85)	(0.60)
Firm and year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1067	1067	1067	1075	1075	1075
F-value	0.68	0.93	2.62	1.36	1.52	1.85
Adj. R^2	0.22	0.24	0.26	0.23	0.29	0.24

Panel B: Subsample after 2014

	(1) *Invent-apply*	(2) *Utility- apply*	(3) *Design- apply*	(4) *Invent-grant*	(5) *Utility-grant*	(6) *Design-grant*
Specialist	0.11***	−0.07**	−0.04	0.07**	−0.01	−0.06**
	(3.20)	(−2.19)	(−1.41)	(2.33)	(−0.36)	(−2.41)
Tangibility	−0.01	0.09	−0.08	−0.16	0.25**	−0.09
	(−0.09)	(0.86)	(−1.11)	(−1.38)	(2.12)	(−1.06)
Ln_Age	0.04	−0.08	0.04	0.06	−0.09	0.03
	(0.57)	(−1.21)	(0.75)	(0.95)	(−1.23)	(0.49)
Ln_Size	0.00	−0.00	0.00	0.01	0.01	−0.02
	(0.15)	(−0.25)	(0.10)	(0.66)	(0.30)	(−1.24)
Leverage	−0.03	−0.03	0.06	−0.04	−0.08	0.12
	(−0.36)	(−0.31)	(0.78)	(−0.38)	(−0.78)	(1.40)
R&D	0.24	0.12	−0.35	0.89	−0.31	−0.58
	(0.26)	(0.15)	(−0.63)	(0.93)	(−0.39)	(−0.92)
Tobin's Q	0.00	−0.01	0.01	−0.00	0.00	0.00
	(0.13)	(−1.07)	(1.23)	(−0.18)	(0.12)	(0.10)
Indepboard	−0.31	0.30	0.01	−0.28	0.25	0.03
	(−1.23)	(1.19)	(0.05)	(−1.04)	(0.78)	(0.13)
Boardsize	−0.01	0.01	−0.00	−0.00	0.01	−0.01
	(−0.67)	(1.17)	(−0.68)	(−0.41)	(1.09)	(−0.80)
Constant	0.40	0.60	−0.01	0.04	0.41	0.55
	(0.89)	(1.52)	(−0.02)	(0.08)	(0.92)	(1.63)

(*continued on next page*)

Table 9 (*continued*)

Panel B: Subsample after 2014						
	(1) *Invent-apply*	(2) *Utility- apply*	(3) *Design- apply*	(4) *Invent-grant*	(5) *Utility-grant*	(6) *Design-grant*
Firm and year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	995	995	995	965	965	965
F-value	1.56	1.27	1.13	1.45	1.00	1.15
Adj. R^2	0.26	0.33	0.19	0.25	0.30	0.22

5.6. Exogenous event: CEO retirement

To address the endogeneity problem, we used the retirement of independent directors as a criterion to create a subsample. Theoretically, independent directors change after the CEO retires, and this period of change is not outside the company's pursuit of independent technical directors, such as for a new technology project.

Table 10
Exogenous event: CEO retirement. This table presents the panel regression estimates of the number of patents classified by degree of innovation from 2007 to 2017 as a function of *Specialist*, using the subsample of years after the CEO's retirement. We used the patent data in year $t + 1$ to measure the effect of hiring independent technical directors in year t. *Specialist* measures whether the expertise of the independent directors hired in year t corresponds to the operational field of their companies. We controlled for firm and year fixed effects. The t-statistics are reported in brackets. ***, **, and * indicate that the parameter estimates are significantly different from 0 at the 1%, 5%, and 10% levels, respectively.

	(1) *Invent-apply*	(2) *Utility-apply*	(3) *Design-apply*	(4) *Invent-grant*	(5) *Utility-grant*	(6) *Design-grant*
Specialist	0.24***	−0.05	−0.19**	0.25***	−0.06	−0.19***
	(3.28)	(−0.87)	(−2.48)	(2.84)	(−0.58)	(−3.23)
Tangibility	−0.00	0.07	−0.07	0.10	0.12	−0.22
	(−0.00)	(0.39)	(−0.70)	(0.35)	(0.38)	(−1.31)
Ln_Age	0.21	−0.40**	0.19	0.30	−0.23	−0.07
	(1.07)	(−2.46)	(1.36)	(1.33)	(−0.75)	(−0.49)
Ln_Size	−0.08	0.06	0.01	−0.09	0.03	0.06
	(−1.54)	(1.64)	(0.31)	(−1.44)	(0.39)	(1.60)
Leverage	0.66***	−0.32	−0.34	0.50	−0.35	−0.15
	(2.73)	(−1.52)	(−1.28)	(1.42)	(−0.87)	(−0.75)
R&D	1.95	−0.86	−1.09	6.28**	−5.76**	−0.52
	(0.82)	(−0.50)	(−0.79)	(2.66)	(−2.48)	(−0.29)
Tobin's Q	0.02	−0.01	−0.01	0.02	−0.02	−0.01
	(0.95)	(−0.58)	(−0.69)	(0.76)	(−0.46)	(−0.34)
Indepboard	−0.11	0.01	0.10	0.25	0.26	−0.51
	(−0.19)	(0.02)	(0.19)	(0.43)	(0.35)	(−1.25)
Boardsize	−0.02	0.00	0.02	−0.02	0.03	−0.01
	(−0.76)	(0.19)	(0.83)	(−0.64)	(0.61)	(−0.30)
Inst	−0.39*	0.23	0.16	−0.72***	0.88***	−0.16
	(−1.76)	(1.53)	(0.94)	(−3.42)	(2.91)	(−1.14)
Intercontrol_index	−0.00	0.00***	−0.00	0.00	0.00	−0.00*
	(−0.78)	(2.83)	(−1.36)	(0.57)	(1.42)	(−1.78)
Ln_coverage	0.09***	−0.12***	0.03	0.06	−0.15***	0.10**
	(2.77)	(−4.71)	(1.04)	(1.02)	(−2.98)	(2.56)
Growth_rev	0.02	−0.09**	0.07**	−0.09	−0.05	0.14***
	(0.50)	(−2.27)	(2.29)	(−1.60)	(−0.76)	(3.67)
Constant	1.44	0.20	−0.64	1.16	0.21	−0.38
	(1.18)	(0.19)	(−0.65)	(0.76)	(0.12)	(−0.50)
Firm and year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	125	125	125	122	122	122
F-value	17.40	6.61	5.51	5.91	4.75	3.84
Adj. R^2	0.77	0.81	0.86	0.58	0.63	0.79

The endogeneity problem can thus be addressed. Specifically, we used data on the age of CEOs and kept an observation if the CEO was over 60, the legal retirement age in China. Then we constructed a new dummy variable, *Post*, equal to 1 if the year is after the CEO's retirement, and 0 otherwise. We only kept observations with $Post = 1$, which means that the company has already gone through the CEO's retirement. We used the new subsample and ran the main regression. The results are reported in Table 10.

Based on the criterion for *Post*, the number of observations is significantly smaller. However, the regression results are essentially the same as those of the baseline model. The coefficients for the numbers of technical patents filed and authorized are 0.24 and 0.25, respectively, both of which are significant at the 1% level. The coefficients for the numbers of design patents filed and granted are −0.19 and −0.19, which are significant at the 5% and 1% levels, respectively. Therefore, after excluding the endogeneity problem, the results are still significant and consistent with the results of the main regression model.

6. Further analysis

6.1. Mechanism test: the role of R&D expenditure

Next, we investigated the mechanism by which independent directors affect corporate innovation. As more R&D expenditure can promote innovation performance, we examined whether the appointment of independent technical directors stimulates R&D expenditure. To this end, we constructed the following model:

Table 11
Independent technical directors and corporate innovation: Mechanism test. This table presents the panel regression estimates of Model (2) for the number of patent applications from 2007 to 2017 as a function of *Specialist* and *R&D*. The dependent variables are the proportion of technical invention patents filed, the proportion of utility patents filed, and the proportion of design patents filed to the total number of patents filed in year $t + 1$. *R&D* refers to the proportion of R&D expenditure to total assets in a company. *Specialist* measures whether the expertise of the independent directors hired in year t corresponds to the operational field of their companies. The key explanatory variable is the interaction term of *R&D* and *Specialist*. We controlled for firm and year fixed effects. The t-statistics are reported in brackets. ***, **, and * indicate that the parameter estimates are significantly different from 0 at the 1%, 5%, and 10% levels, respectively.

	(1) *Invent-apply*	(2) *Utility-apply*	(3) *Design-apply*
*R&D*Specialist*	3.81*	−2.12	−1.69
	(1.79)	(−0.80)	(−0.57)
Specialist	0.08**	−0.00	−0.07***
	(2.21)	(−0.12)	(−2.78)
R&D	−3.79*	2.40	1.38
	(−1.88)	(0.94)	(0.47)
Tangibility	−0.00	0.03	−0.03
	(−0.02)	(0.42)	(−0.61)
Ln_Age	0.06	−0.05	−0.01
	(1.17)	(−1.13)	(−0.24)
Ln_Size	0.03**	−0.03**	−0.01
	(1.97)	(−1.99)	(−0.60)
Leverage	0.00	−0.05	0.05
	(0.01)	(−0.71)	(0.90)
Tobin's Q	0.02**	−0.01	−0.00
	(1.97)	(−1.59)	(−0.83)
Indepboard	−0.58**	0.15	0.43**
	(−2.24)	(0.59)	(2.51)
Boardsize	−0.02*	0.02*	0.00
	(−1.89)	(1.91)	(0.17)
Constant	−0.13	1.00***	0.12
	(−0.34)	(3.16)	(0.53)
Firm and year fixed effects	Yes	Yes	Yes
Observations	939	939	939
F-value	3.63	1.23	2.80
Adj. R^2	0.29	0.34	0.17

$$Patent_{i,t+1} = \beta_0 + \beta_1 Specialist_{i,t} + \beta_2 R\&D + \beta_3 Specialist_{i,t} \times R\&D + \alpha X_{it} + \gamma_t + \mu_i + \varepsilon_{it} \quad (2)$$

The dependent variables are the proportion of technical invention patent applications, the proportion of utility patent applications, and the proportion of design patent applications to the total number of patent applications in firms. The key explanatory variable is the product of *R&D* and *Specialist*. The *R&D* variable is the proportion of R&D expenditure to total assets in a company. A larger *R&D* indicates that the company attaches greater importance to innovation activities. The other control variables remain unchanged. Table 11 shows the regression results of Model (2).

In Table 11, the product of *R&D* and *Specialist* is important. It represents the net effect of the expertise of independent directors and its relevance to corporate innovation performance. The coefficient before *Invent-apply* is 3.81, which is significant at the 10% level. This indicates that independent technical directors encourage corporations to spend more on R&D. However, the coefficients before *Utility-apply* and *Design-apply* are both negative and not statistically significant. This implies that the appointment of independent technical directors steers the R&D and innovation activities of companies, which supports our mechanism test.

6.2. Mechanism test: the role of R&D expenditure and R&D subsidies

We conducted two other tests with different dependent variables. The new dependent variables are *R&D expenditure* and *R&D subsidy*. *R&D expenditure* refers to R&D expenditure for the firm's next fiscal year,

Table 12
Mechanism test: The role of R&D expenditure and R&D subsidies. This table presents the regression estimates of *R&D expenditure* and *R&D subsidy* in year *t + 1* as a function of *Specialist*. *R&D expenditure* refers to R&D expenditure in the next fiscal year of the firm, and *R&D subsidy* refers to R&D subsidies granted by the government in the next period. We controlled for firm and year fixed effects. The t-statistics are reported in brackets. ***, **, and * indicate that the parameter estimates are significantly different from 0 at the 1%, 5%, and 10% levels, respectively.

	(1) *R&D expenditure*	(2) *R&D subsidy*
Specialist	0.01**	0.01**
	(2.58)	(2.44)
Tangibility	−0.01	0.02
	(−1.16)	(1.13)
Ln_Age	−0.02***	−0.00
	(−2.81)	(−0.31)
Ln_Size	−0.00	−0.00
	(−0.98)	(−1.26)
Leverage	−0.02	−0.02
	(−1.43)	(−1.31)
R&D	1.06***	0.04
	(7.29)	(0.19)
Tobin's Q	0.00*	0.00
	(1.66)	(1.14)
Indepboard	0.05*	−0.02
	(1.84)	(−0.54)
Boardsize	−0.00	0.00
	(−0.57)	(0.63)
Constant	0.12***	0.09*
	(2.92)	(1.69)
Firm and year fixed effects	Yes	Yes
Observations	1,282	1,395
F-value	11.82	2.25
Adj. R^2	0.36	0.08

and *R&D subsidy* refers to R&D subsidies granted by the government in the next period. The regression results are presented in Table 12.

The results show that the regression coefficients of *Specialist* on *R&D expenditure* and *R&D subsidy* are 0.01 and 0.01, both of which are significant at the 5% level. This indicates that the appointment of relevant independent technical directors in a given fiscal year encourages companies to spend more on R&D while obtaining more government subsidies for their R&D activities in the next period. In addition, R&D expenditure and R&D subsidies are necessary for further innovation activities. In this sense, independent directors with relevant expertise promote corporate innovation by improving R&D expenditure and government subsidies in their companies.

6.3. R&D quality and the appointment of independent directors

To measure the reliability of our indicators, we further analyzed the relationship between the appointment of independent technical directors and the patent citation rate, which indicates recognition of innovation. We followed Balsmeier et al. (2017) and Lanjouw and Schankerman (2004) and used several patent indicators to describe the quality of innovation, in addition to the number of patent applications and authorizations. We changed the independent variables in Model (1) to *Patent Citation* and *Self-Citation*.

Patent Citation measures the position of a patent in the distribution of citations compared with other patents granted in the same patent category and in the same year. Based on the frequency of patent citations, the degree of innovation recognition can be divided into the top 1% of patents, the top 2–10% of patents, patents that are not in the top 10% but have been cited at least once, and patents that have never been cited. If a patent is in the top 1% or the top 2–10%, it is in the highest percentile of the citation distribution among patents in the same patent category in the same year. To further measure whether independent technical directors can improve the quality of corporate innovation, we selected the top 1% and the top 2–10% of patents as indicators.

Self-Citation measures the number of times a company cites other patents from the same corporation. Following Faleye et al. (2011), more self-citations indicate that a corporation is deepening its current research field, while fewer self-citations suggest that a corporation is expanding its research scope or exploring new fields.

Table 13 presents the number of patents with citations in the top 1%, the top 2–10%, and self-citations. As the results show, the coefficient for patents with citations in the top 1% is 0.05, which is significant at the 10% level. The coefficient for patents with citations in the top 2–10% is 0.11, which is significant at the 5% level. We can therefore conclude that the appointment of independent technical directors promotes high-quality innovations in companies. Moreover, the *Self-Citation* coefficient is 0.24, which is statistically significant, suggesting that corporations mainly delve into their current research field rather than expanding the scope of their research. In short, independent technical directors further promote innovation in the operational field of their companies.

In addition, we introduced the variable *Newpatent* as our new dependent variable, which refers to new patents granted in a new field for firms, as patents in a new field can better represent the innovation capability of a company. Thus, we used this new dependent variable to rerun the regression with the control variables and the fixed effects.

Based on the regression results, the effect of *Specialist* is positive in terms of new patents granted. We can thus infer that the appointment of independent technical directors can improve corporate innovation by improving the number of new patents granted in a new field for companies.

7. Conclusions

We studied all A-share companies listed on the SSE and the SZSE in China from 2007 to 2017 and found that independent technical directors can use their expertise to help public companies with technical innovation, contributing to industrial and economic growth in general. The results are still significant when applying the two-stage IV model, which helps us deal with selection bias. In addition, we used the Wenfeng.plc shock in 2014 as an exogenous event to address the endogeneity problem, and we found that the results for

Table 13
Independent technical directors and corporate innovation: R&D quality. This table presents the regression estimates of the number of patent citations, self-citations, and new patents granted to the company in a new field from 2007 to 2017 as a function of *Specialist*. *Top1* represents the position of the patent in the top 1% of the distribution of citations compared with other granted patents in the same patent category and in the same year. *Top2_10* represents the position of the patent in the top 2–10% in the distribution of citations compared with other granted patents in the same patent category and in the same year. *Self-Citation* represents the number of times a company cites other patents from the same corporation. *Newpatent* represents the number of new patents granted to a firm in a new field. We used the patent data in year $t + 1$ to measure the effect of hiring independent technical directors in year t. *Specialist* measures whether the expertise of the independent directors hired in year t corresponds to the operational field of their companies. We controlled for firm and year fixed effects. The t-statistics are reported in brackets. ***, **, and * indicate that the parameter estimates are significantly different from 0 at the 1%, 5%, and 10% levels, respectively.

	(1) *Top1*	(2) *Top2_10*	(3) *Self-Citation*	(4) *Newpatent*
Specialist	0.05*	0.11**	0.24**	0.82**
	(1.71)	(2.14)	(2.21)	(2.08)
Tangibility	0.08	−0.00	−0.05	−0.37
	(0.62)	(−0.01)	(−0.12)	(−0.30)
Ln_Age	−0.00	0.00	0.00	0.89
	(−0.64)	(0.77)	(0.15)	(1.22)
Ln_Size	0.08**	0.08***	0.22***	1.62**
	(2.33)	(2.72)	(3.36)	(2.34)
Leverage	−0.00	−0.08	0.09	−2.78*
	(−0.02)	(−0.63)	(0.32)	(−1.70)
R&D	3.05	1.84	9.15**	−14.24
	(1.46)	(1.18)	(2.00)	(−1.06)
Tobin's Q	0.02	0.01	0.03	0.17
	(1.57)	(1.14)	(1.34)	(1.06)
Indepboard	0.17	0.85**	1.76	−0.94
	(0.57)	(2.17)	(1.63)	(−0.27)
Boardsize	−0.01	0.00	0.08	0.24
	(−1.40)	(0.13)	(1.64)	(1.59)
Constant	−1.76**	−1.91***	−5.70***	−0.21
	(−2.09)	(−2.93)	(−3.87)	(−0.13)
Firm and year fixed effects	Yes	Yes	Yes	Yes
Observations	831	831	831	−0.00
F-value	1.5666	2.3197	3.5099	(−0.49)
Adj. R^2	0.3022	0.4030	0.3281	0.07

invention patents after 2014 are much more significant. Moreover, specialists can successfully play the role of consultants when their field of expertise is relevant to the operational field of their companies. We also took a closer look at the mechanism by which independent directors increase corporate innovation. We found that independent technical directors increase R&D in the company's current research field rather than expanding to other fields. Furthermore, independent technical directors increase corporate innovation by encouraging firms to spend more on R&D and by enabling them to obtain more government subsidies for R&D.

This study provides empirical evidence to encourage companies to hire academics with relevant backgrounds as independent directors. In addition, we not only enrich and develop the capital market literature but also offer a new perspective for research on the consulting role of independent directors. If corporations adopt a differentiation strategy and want to expand to other fields, they should consider hiring independent technical directors.

This study can guide policymaking and the development of practical applications in the following ways. First, the government is encouraged to conduct research before publishing policy changes that evaluate the difficulty of corporate innovation, based on the relevance of the expertise of technical specialists and the operational field of companies. Second, firms should make full use of independent directors who genuinely participate in corporate governance and innovation and foster industrial transformation. Third, when hiring university professors as independent technical directors, companies should give priority to hiring individuals

whose expertise is consistent with their main activities, which will promote innovation and sustainable and healthy economic development.

Declaration of Competing Interest

The authors declared that there is no conflict of interest.

Appendix A. Variable definitions

This table presents the definitions of the variables used in our models, including the dependent variables, the independent variables, and the control variables.

Variable	Abbreviation	Definition and measurement
Dependent variables	*Invent-apply*	Number of technical invention patent applications out of the total number of patents filed
	Utility-apply	Number of utility model patent applications out of the total number of patents filed
	Design-apply	Number of design patent applications out of the total number of patents filed
	Invent-grant	Number of technical invention patents authorized out of the total number of patents authorized
	Utility-grant	Number of utility model patents authorized out of the total number of patents authorized
	Design-grant	Number of design patents authorized out of the total number of patents authorized
Independent variables	*Specialist*	Dummy variable: if the expertise of an independent director corresponds to the operational field of the company, *Specialist* = 1; otherwise, *Specialist* = 0
Control variables	*Ln_Size*	Logarithm of total assets
	Ln_Age	Logarithm of the company's trading years since the IPO
	Leverage	Total liabilities divided by total assets
	Tangibility	Carrying value of fixed assets divided by total assets
	Tobin's Q	Tobin's Q = market capitalization divided by asset replacement cost
	R&D	R&D expenditure divided by total assets
	Boardsize	Logarithm of the number of directors
	Indepboard	Number of independent directors out of the total number of directors
	Inst	Whether the company is controlled by large institutional investors
	Intercontrol_index	The internal control condition of the company
	Ln_coverage	Analyst monitoring and coverage on the company
	Growth_rev	Revenue growth rate

Appendix B. Expertise of independent directors and corporate innovation

Fig. 1 shows the relationship between the relevance of the expertise of independent directors and the number of technical invention patent applications in companies. The x-axis represents the year and the y-axis represents the number of technical innovation patent applications. The blue line indicates when the expertise of independent directors is relevant to the operational field of their companies. The red line indicates the opposite. Fig. 2 shows the relationship between the relevance of the expertise of independent directors and the number of technical invention patent authorizations in companies. The x-axis represents the year and the y-axis represents the number of technical innovation patents authorized. The blue line indicates when the expertise

of independent directors is relevant to the operational field of their companies. The red line indicates the opposite.

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The impact of the Social Security Fund on auditor litigation risk

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ABSTRACT

In this study, we examine the effect of the Social Security Fund on auditor litigation risk. Using audit fees as a proxy for auditor perceptions of litigation risk, we find that the Social Security Fund significantly reduces auditor litigation risk. Furthermore, we show that the Social Security Fund influences auditor litigation risk through reducing both the audit risk and the business risk of public companies. In addition, the impact of the Social Security Fund for reducing auditor litigation risk is more obvious in the group of firms with low levels of internal governance, which indicates that the Social Security Fund plays an important governance role as a high-quality institutional investor. In summary, we verify that the Social Security Fund, when acting as an institutional investor, plays an important role in corporate governance, and that it helps to reduce auditor litigation risk. Our results provide empirical support for expanding the governance role of the Social Security Fund as an institutional investor in China's A-share market.

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1. Introduction

The National Social Security Fund is involved in many major programs, such as old-age pensions, medical insurance, unemployment benefits, employment injury insurance, and maternity insurance, all of which are important for protecting the national economy, people's livelihoods, and social stability (Li et al., 2018). As of the end of 2018, the Social Security Fund held a total of 1.75 trillion RMB, and 208.37 billion RMB of that sum was invested in China's capital market. The Social Security Fund has gradually become one of the most important institutional investors in the capital market (Li et al., 2018). Unlike institutional investors that gain benefits through short-term trading, the Social Security Fund adheres to the principles of long-term, value-oriented, responsible management of investments. However, up to this point, the role of the Social Security Fund in the capital market has remained unclear. In 2009, the State Council of China issued a statement called the "Implementation Measures for the Transfer of Partial State-owned Shares in the Domestic Securities Market to Enrich the National Social Security Fund." This statement stipulated that although the Social Security Fund holds state-owned shares, it enjoys the right to receive and dispose of those shares, but it should not interfere with the daily operations of the listed companies' management.[1] However, the management teams of the Social Security Fund have a high level of professionalism, and they adhere to a philosophy of long-term value investment. The literature shows that long-term institutional investors prefer to monitor firms internally (e.g., Chen et al., 2007; Pukthuanthong et al., 2017). As is consistent with this view, Huiman Yi, the chairman of the China Securities Regulatory Commission, expresses high expectations that the Social Security Fund will play a helpful role in optimizing investor structure, maintaining stable market development, and improving the market's operational efficiency. He hopes that Social Security Fund managers can continue to apply their professional advantages and contribute to the high-quality development of China's capital market. Therefore, the role of the Social Security Fund in China's capital market is a question worthy of empirical examination.

In the literature, scholars mainly focus on the economic influence of the Social Security Fund, such as its effects on firm value (Fan et al., 2009), the quality of earnings information (Tang, 2011; Li et al., 2018), and dividend policy (Jin et al., 2016). However, few studies discuss the effect of the Social Security Fund on auditors' behavior. In recent years, with the improvement of legal system norms in China's capital market, the litigation risk faced by auditors has increased. In 2006, the new *Securities Law* and the new *Company Law* took effect at the same time. These laws explicitly required auditors to bear joint and several liability for losses caused to investors by false records, misleading statements or major omissions. For example, the Warren accounting firm was first judged to be liable for civil damages because of fraud committed by the Lantian corporation (stock code: 600709). These laws have caused the risk of auditors' litigation to increase over time. According to the first-instance judgment data on accounting firms as defendants in civil cases from 2007 to 2017, as reported on the China judgment document network,[2] the number of cases in which accounting firms (or auditors) have been sued in China has been increasing year by year. For example, there were nearly 250 such lawsuits in 2017. In the case of the securities misrepresentation liability dispute involving Shanghai Da Zhihui Co., Ltd. (in which BDO China Shu Lun Pan's CPAs were accused of violating provision No. 173 of the securities law[3]), the accounting firm and auditors were involved as co-defendants in a total of 112 lawsuits.

Clearly, auditors need to provide reasonable assurance for the fairness of their clients' annual reports, and they must bear the corresponding risks of potential litigation (Simunic and Stein, 1996; Johnstone, 2000; DeFond and Zhang, 2014). Therefore, it is worthwhile to examine the role that the Social Security Fund plays in external governance, and to do so from the perspective of auditors. Institutional investors are likely to become the main plaintiffs in lawsuits, especially when the lawsuits are related to financial information, or when the accounting firm is a co-defendant (Cheng et al., 2010). When institutional investors hold shares of public companies, the litigation risk faced by auditors is increased (Badertscher et al., 2014; Abbott

[1] http://www.csrc.gov.cn/pub/newsite/ssb/ssflfg/xggzjwj/200906/t20090624_108138.html.

[2] http://wenshu.court.gov.cn.

[3] Provision No. 173 of the Securities Law states that "Securities service agencies shall verify the authenticity, accuracy, and completeness of audit reports, asset evaluation reports, financial advisory reports, credit rating reports, or legal opinions and other documents for securities business activities such as issuance, listing, and trading of securities."

et al., 2017; Cassell et al., 2018). The Social Security Fund is the backbone of institutional investors in China's capital market. Therefore, when this fund holds shares in listed companies, the auditor's perception of litigation risk tends to increase. However, the Social Security Fund, as an independent, long-term institution, can play an active role in monitoring listed companies (Brickley et al., 1988; Cornett et al., 2007). Evidence shows that the Social Security Fund holdings improve a company's earnings quality and reduces the likelihood of financial restatements (Tang, 2011; Li et al., 2018), thereby reducing the litigation risk. Therefore, the objective of this study is to explore the governance role of the Social Security Fund from the perspective of auditors.

To pursue this inquiry, we collect data on Chinese A-share listed companies from 2007 to 2017, and we test the impact of the Social Security Fund holdings on auditor litigation risk. The empirical results show that this fund significantly reduces the litigation risk, as the audit risk and the clients' business risk are decreased. Furthermore, we conduct a cross-sectional test based on a listed company's corporate governance index, which is constructed by the principal component analysis method. The results of this test show that the Social Security Fund has a more significant impact on the litigation risk in the group of firms with lower levels of internal governance. This finding supports the suggestion that the Social Security Fund plays a helpful monitoring role. Next, we examine the impact of endogeneity on our results. We perform this analysis because the Social Security Fund prefers to invest in blue chip stocks, and this tendency may affect auditor litigation risk. To address this concern regarding endogeneity, we use the Heckman two-stage regression and the propensity score-based matching (PSM) model. In addition, we lag the Social Security Fund by one period and replace the control variables. After the robustness tests are performed, the results remain unchanged, which indicates the robustness of our conclusions.

Our study makes several contributions. First, it enriches research related to the governance effect of the Social Security Fund and provides a new research perspective. The literature mainly focuses on the effects that stock holding of the Social Security Fund has on firm value (Fan et al., 2009), earnings quality (Tang, 2011; Li et al., 2018), and dividend policy (Jin et al., 2016). Few studies explore the economic impact of the Social Security Fund from the perspectives of the other stakeholders of listed companies. To better understand the role of the Social Security Fund, we examine its impact on auditor litigation risk.

Second, our study extends the research on the impact of institutional investors on auditor litigation risk. The Social Security Fund is an important type of institutional investor, which is significantly different from the other kinds of institutional investors. Therefore, studying the relationship between the Social Security Fund and auditor litigation risk enriches the literature on institutional investors and auditor litigation risk. Badertscher et al. (2014), Abbott et al. (2017), and Cassell et al. (2018) present evidence that institutional investors can significantly increase auditor perceptions of litigation risk. However, the results of our study show that the Social Security Fund reduces the litigation risk.

Finally, our study provides empirical evidence supporting the expanding the role of the Social Security Fund for promoting higher-quality development of the capital market. Fan et al. (2009) believe that the Social Security Fund has a negative effect on corporate value, but Tang (2011) and Li et al. (2018) find that the Social Security Fund improves the earnings quality of listed companies. Thus, the literature fails to reach a consistent conclusion on the governance role of the Social Security Fund in the capital market. Our study investigates the perspectives of auditors and finds evidence that the Social Security Fund reduces auditor litigation risk. Our study also provides empirical evidence that the Social Security Fund plays an active governance role in the capital market.

The next section provides a literature review and develops the study's hypotheses. Section 3 explains our research design. In Section 4, we present a description of the sample and report our main findings. The results of robustness tests are reported in Section 5, and the findings from additional tests are given in Section 6. We offer our conclusions in Section 7.

2. Literature review and hypotheses development

2.1. Literature review

2.1.1. The economic effects of the Social Security Fund

Most of the evidence on the effects of the Social Security Fund holdings centers on its economic consequences. Although the Social Security Fund is a long-term investor, it has the incentive and the capability to monitor listed companies (Chen et al., 2007), but the incentive mechanism of this fund is decoupled from performance and is affected by political and social pressures. Furthermore, the business objectives of the Social Security Fund can be quite different from those of public companies. Thus, the Social Security Fund holdings can have negative effects on the market values of public companies (Fan et al., 2009). However, in the longer term, the Social Security Fund tends to significantly decrease earnings management behavior by public companies (Tang, 2011). Following Tang (2011), Li et al. (2018) use the financial restatements of listed companies as a proxy for earnings quality. They find that the Social Security Fund significantly reduces the likelihood of companies issuing financial restatements. This finding confirms the positive effect that the Social Security Fund has on the earnings quality of public companies. However, the Social Security Fund can play this role only under certain conditions (Tang and Wang, 2018). Although the fund successfully avoids system risks in the course of its investment activities, the absolute numbers of its investment losses are still large. Moreover, the fund's investments show no direct relationship between the period of shareholding and the investment risk, which indicates that this fund has not yet conducted its stock purchase and sale operations on the basis of risk analysis (Tang and Zhai, 2014). A positive correlation is found between Social Security Fund investment and company dividends, which reflects the behavior of both the demand side (from the Social Security Fund) and the supply side (from the listed companies). Public companies formulate their dividend policies based on their holdings of the Social Security Fund, and the Social Security Fund selects stocks by considering the dividend policies of listed companies over their previous years (Jin et al., 2016).

Overall, the literature fails to reach a consistent conclusion on the role of the Social Security Fund in corporate governance.

2.1.2. Previous evidence on institutional investors and auditor litigation risk

Given the potential costs, it is important for auditors to evaluate the factors that drive their litigation exposure in public company audits so that they can plan and price their audits in ways that keep their exposure within reasonable bounds (Cassell et al., 2018). Several studies have discussed two possible countermeasures. One countermeasure is to increase the investment in auditing or to deploy more experienced auditors to prevent the possibility of potentially significant misstatements (Chalmers, 2013; Overend, 2013). The second countermeasure is to charge a risk premium, which can be used as insurance against potential litigation risk in the future (Pratt and Stice, 1994; Simunic and Stein, 1996; DeFond and Zhang, 2014). Both of these measures result in higher audit fees. Consistent with this basic theory, Simunic and Stein (1996), Hay et al. (2006), and Venkataraman et al. (2008) find that companies in industries at high risk of litigation tend to have higher audit fees. Institutional investors are likely to be the main plaintiffs, especially when the lawsuits are related to financial information, or when the accounting firm is a co-defendant (Cheng et al., 2010). When institutional investors hold shares of public companies, the litigation risk faced by auditors tends to increase (Badertscher et al., 2014; Abbott et al., 2017; Cassell et al., 2018). In other words, the client's ownership structure has a significant influence on auditor litigation risk.

In general, the literature suggests that having institutional investors increases auditor perceptions of litigation risk (Simunic and Stein, 1996; Hay et al., 2006; Venkataraman et al., 2008; Badertscher et al., 2014; Cassell et al., 2018). However, the effects that different types of institutional investors have on auditor litigation risk may vary considerably. Unlike short-term institutional investors that buy and sell quickly, institutional investors with long-term investment strategies and no business dealings with the investee companies tend to have more significant monitoring effects on public companies (Chen et al., 2007). As the Social Security Fund is one of the most important institutional investors in the capital market, this fund conducts investment operation management in accordance with the principles of prudent investment, safety first, risk control, and increased returns. These investment principles can play an important role in optimizing investor structures,

maintaining stable market development, and improving the efficiency of market operations. Within the Chinese market environment, can the Social Security Fund play an active governance role? How does this fund affect the litigation risk faced by auditors? Our objective in this study is to answer these questions.

2.2. Hypotheses development

When auditors provide audit services for public companies, they face a multitude of risks related to their engagement, including audit risk and clients' business risk (Johnstone, 2000; Stanley, 2011; Zhai et al., 2017; Cassell et al., 2018). Audit risk mainly concerns the degree to which auditors are diligent and responsible in maintaining their independence while providing audit services, as well as the potential major errors and frauds of the audited financial system are disclosed in the audit report. Business risk mainly concerns the danger that the audited client may face operating losses or bankruptcy (American Institute of Certified Public Accountants [AICPA], 1983; Morgan and Stocken, 1998; Bell et al., 2001). In some audit litigation cases, the auditors perform their examinations in accordance with generally accepted auditing standards and report appropriately on those financial statements, yet they are still exposed to loss or injury to their professional practice due to litigation (AICPA, 1983). Therefore, given the potential hazards, auditors need to fully assess their clients' risks, develop an audit plan that matches those risks, and charge corresponding audit fees (DeFond and Zhang, 2014; Cassell et al., 2018). Badertscher et al. (2014) find that the audit fees charged to firms with public equities are 20–22% higher than fees charged to similar companies that only have public debt. This premium is mainly caused by the differing litigation risk related to different ownership structures. Moreover, institutional investors are more likely to be lead plaintiffs in lawsuits, especially when the lawsuits are related to financial information, or when the accounting firms are named as co-defendants (Cheng et al., 2010). Thus, when a company's stock is held by institutional investors, the auditors perceive higher risks of litigation, and they charge higher audit fees to compensate for that increased risk (Abbott et al., 2017; Cassell et al., 2018).

As an important capital market participant, the Social Security Fund is related to the national economy, to people's livelihoods, and to overall social stability. Throughout the past several decades, the investment and operation activities of the Social Security Fund have successfully avoided systemic risks. However, the absolute numbers of investment losses are still large (Tang and Zhai, 2014). According to "The Social Security Fund Annual Report" released in June 2017, the total assets of the fund were 2.04 billion RMB by the end of 2016, but the investment yield in that year was only 1.73%, which was far lower than the 8.37% average of the fund's annual returns since its establishment (Li et al., 2018). In addition, the report indicated that the Social Security Fund has not operated in accordance with the principles of investment security and profitability, nor has it fully conducted its stock purchase and sale operations on the basis on investment risk analysis (Tang and Zhai, 2014). The effective selection of investment objects is related to how well a fund realizes its investment objectives, and the financial information on listed companies plays an important role in a proper investment decision-making process. Thus, if the Social Security Fund suffers losses due to using low-quality financial information when investing in a particular firm, then the auditor, as the "gatekeeper" for the firm's financial information, faces higher risks of litigation. Thus, we predict that when a client's stock is held by the Social Security Fund, that client's auditors tend to perceive an increased risk of litigation. To test this suggestion, we propose hypothesis H1a, as follows:

H1a: Ceteris paribus, when the Social Security Fund holds shares of public companies, its auditors tend to perceive higher litigation risk.

Another possibility is that the Social Security Fund acts as an independent institution making long-term investments, and therefore it specializes in monitoring and influencing efforts, rather than in trading. In playing this external governance role, the fund may have an important effect in curbing the managers' shortsighted behavior (Harford et al., 2018). The Social Security Fund may have this effect by participating in corporate governance through shareholder proposals and other channels (Gillan and Starks, 2000). First, we consider that the Social Security Fund operates as a long-term investment vehicle, and that it has no direct business dealings with listed companies. In that case, the fund consciously seeks to reduce speculation and

short-term investment, and this is the essential difference between the Social Security Fund and other institutional investors (Li et al., 2018). Second, we suggest that the Social Security Fund management teams are more professional than the teams of other institutional investors, and this greater professionalism is conducive to playing an external monitoring role. After all, fund managers for the Social Security Fund need to meet higher requirements regarding their capabilities for overseeing operations and controlling risks. In addition, the Social Security Fund is usually one of the top 10 shareholders in the listed companies. This level of investment provides a favorable condition for the Social Security Fund to play an active role in monitoring and advising on important corporate decisions (Cornett et al., 2007). Studies show that independent long-term investors are motivated and have the capability to play active supervisory roles in companies (e.g., Gillan and Starks, 2000; Chen et al., 2007; Harford et al., 2018). In examining the long periods of time before and after the Social Security Fund invested in numerous listed companies, it can be seen that these companies' earnings management behavior decreased significantly (Tang, 2011), and their earnings quality has improved (Li et al., 2018). Therefore, we expect that the Social Security Fund can reduce the litigation risk faced by auditors through exerting its capacity for external governance. On the basis of the above-described analysis, we propose hypothesis H1b as follows:

H1b: Ceteris paribus, when the Social Security Fund holds shares of public companies, the auditors tend to perceive lower litigation risk.

3. Research design

3.1. Sample selection

We select Chinese A-share listed companies from 2007 to 2017 as the research sample. The institutional investor data and the financial data used in this study are derived from the China Stock Market and Accounting Research (CSMAR) database. CSMAR is widely used in the literature (e.g., Piotroski et al., 2015; Li et al., 2017; He et al., 2018; Lennox et al., 2018). We exclude firms from financial industries and firms with missing control variables. Our final sample has 17,830 observations for our main test. In addition, all continuous variables are winsorized at the top 1% and bottom 99% levels to reduce the possible impact of outliers on the estimation results.

3.2. Empirical model and variable definition

We use multiple regression analysis to test the research hypotheses proposed in the previous section. With reference to the literature (Stanley, 2011; Badertscher et al., 2014; Cassell et al., 2018), we use model (1), shown below, to empirically test the effect of the Social Security Fund holdings on auditor litigation risk.

$$\begin{aligned}\text{LitigationRisk} = {} & \beta_0 + \beta_1 SSH + \beta_2 OI + \beta_3 Cur + \beta_4 Lev + \beta_5 Liq + \beta_6 Rev + \beta_7 Inv + \beta_8 Size + \beta_9 MB \\ & + \beta_{10} ROA + \beta_{11} Big4 + \beta_{12} Loss + \beta_{13} Dual + \beta_{14} Indexp + \beta_{15} SOE + \beta_{16} Growth \\ & + \beta_{17} CFO + \beta_{18} Abs\_DA + Year + Industry + \varepsilon \end{aligned} \quad (1)$$

Prior theoretical and empirical research finds that the auditor's assessment of the client's business risk plays an important role in audit pricing (e.g., Simunic, 1980; Pratt and Stice, 1994). Therefore, following the literature (Badertscher et al., 2014; Cassell et al., 2018), we use audit fees to proxy for auditor litigation risk. Our first variable of interest, SSH, is a dummy that indicates whether the company's stock is held by the Social Security Fund in the current year. Consistent with the findings of Li et al. (2018), we reason that if a listed company's stock is held by the Social Security Fund in a given year, SSH equals 1, and otherwise it is set to 0. In addition, the role of institutional investors in monitoring depends on the shares they hold (Chen et al., 2007). Therefore, we apply another two proxies (SSF and SSFH). Specifically, if the Social Security Fund ranks in the top 10 of a company's shareholders, SSF takes a value of 1, and 0 otherwise. SSFH equals the natural logarithm of 1 plus the number of social security fund shareholders among the top ten sharehold-

ers at the end of the fiscal year. In accordance with H1a, we predict that β1 will be positive and significant, as we expect that the Social Security Fund holdings increase the litigation risk. In accordance with H1b, we predict that β1 will be negative and significant, as we expect that the Social Security Fund plays a monitoring role.

Following the literature (DeFond and Zhang, 2014; Badertscher et al., 2014; Cassell et al., 2018; Reid et al., 2019), we control the following variables in the model: the percentage of shares held by other institutional investors (OI), current ratio (Cur), leverage (Lev), current assets ratio (Liq), receivable and inventory intensity (Rec and Inv), natural logarithm of total assets (Size), market-to-book ratio (MB), accounting performance (ROA), auditor type (Big4), earnings below zero (Loss), chairman and general manager dual rights (Dual), proportion of independent directors (Indexp), state-owned enterprises (SOE), firm growth (Growth), cash flow from operations (CFO), and accounting information quality (Abs_DA). We also control the year and industry fixed effects. Furthermore, we use the "cluster" method at the company-annual level to adjust the standard error of the coefficient estimates (Petersen, 2005). Detailed definitions of the variables are presented in Table 1.

4. Empirical results

4.1. Descriptive statistics

Table 2 shows that our sample is distributed unevenly across industries. As we can see in the table, the Social Security Fund has its largest investments in Manufacturing, followed by Accommodation and Catering, Transportation, Storage and Postal Services, Electric, Gas, and Water, and in Real Estate.

Table 3 shows the descriptive statistics. Our final sample consists of 17,830 firm-year observations from 2007 to 2017. We can see that the average of audit fees (Ln_Fee) is 13.557. On average, 24.3% of each firm's shares are held by the Social Security Fund (SSH), and 21.0% of our sample firms have the Social Security Fund as one of their top 10 shareholders (SSF). This finding indicates that the Social Security Fund has become more extensively involved in China's capital market over time, and that it holds important positions

Table 1
Variable definitions.

Variable	Definition
Abs_DA	A measure of earnings management, which is computed as the absolute value of discretionary accruals, as estimated by using the modified Jones model.
Big4	Indicator variable that equals 1 if the company is audited by a Big 4 firm in year *t*, and 0 otherwise.
CFO	Cash flow from operations divided by total assets at the end of the year.
Cur	The percentage of current assets over current liabilities.
Dual	Indicator variable that equals 1 if the chairman and the CEO are the same person, and 0 otherwise.
Effort	The natural logarithm of calendar days between the fiscal year-end and the audit report date.
Growth	The percentage change in sales (scaled by total assets) over the previous year.
Indexp	The ratio of the number of independent directors to the total number of directors.
Inv	Total inventory divided by total assets at the end of the year.
Lev	Total debt divided by total assets at the end of the year.
Liq	The percentage of current assets over total assets.
Ln_Fee	The natural logarithm of total audit fees.
Loss	Indicator variable that equals 1 if the company's net income is less than 0, and 0 otherwise.
MB	Market value divided by book value at the end of the year.
OI	The percentage of shares held by other institutional investors (%).
Rec	Total accounts receivable divided by total assets at the end of the year.
ROA	Net income divided by total assets.
Size	The natural logarithm of total assets at the end of the year.
SSF	Indicator variable that equals 1 if the Social Security Fund ranks among the firm's top 10 shareholders in the current year, and 0 otherwise.
SSFH	The natural logarithm of 1 plus the number of social security fund shareholders among the top ten shareholders at the end of the fiscal year.
SSH	Indicator variable that equals 1 if the company's stock is held by the Social Security Fund in the current year, and 0 otherwise.
SOE	A dummy variable that equals 1 if the firm is a state-owned enterprise, and 0 otherwise.

Table 2
Industry distribution.

Industry	SSH = 0	SSH = 1	Total
Agriculture, Forestry, and Fishing	204	85	289
Mining	365	138	503
Manufacturing	8,585	2670	11,255
Electric, Gas, and Water	458	179	637
Construction	319	130	449
Transportation, Storage, and Postal Services	825	261	1086
Information Technology	525	135	660
Wholesale and Retail Trades	69	17	86
Accommodation and Catering	647	267	914
Real Estate	803	170	973
Leasing and Business Services	134	56	190
Scientific Research, Technical Services, and Geological Survey	57	32	89
Water Conservancy, Environment, and Public Facilities Management	111	60	171
Residents Service and Other Services	24	0	24
Education	2	1	3
Health, Social Security, and Social Welfare	6	22	28
Culture, Sport, and Entertainment	111	89	200
Public Administration	249	24	273
Total	13,494	4,336	17,830

Table 3
Descriptive statistics for the full sample.

Variable	Mean	Std.	Min	P50	P75
Abs_DA	0.065	0.073	0.000	0.042	0.082
Big4	0.065	0.247	0.000	0.000	0.000
CFO	0.044	0.075	−0.194	0.044	0.088
Cur	2.269	2.434	0.239	1.532	2.428
Dual	0.225	0.418	0.000	0.000	0.000
Effort	4.488	0.262	3.401	4.500	4.700
Growth	0.226	0.553	−0.556	0.126	0.302
Indexp	0.372	0.055	0.091	0.333	0.400
Inv	0.160	0.152	0.000	0.119	0.202
Lev	0.452	0.211	0.052	0.453	0.616
Liq	0.557	0.213	0.082	0.571	0.719
Ln_Fee	13.557	0.687	12.346	13.459	13.874
Loss	0.083	0.276	0.000	0.000	0.000
MB	2.269	2.066	0.201	1.668	2.867
OI	4.918	5.158	0.000	3.371	6.960
Rec	0.135	0.115	0.000	0.110	0.202
ROA	0.041	0.053	−0.176	0.037	0.067
Size	22.152	1.280	19.639	21.991	22.895
SSF	0.210	0.407	0.000	0.000	0.000
SSFH	0.275	0.602	0.000	0.000	0.000
SSH	0.243	0.429	0.000	0.000	0.000
SOE	0.456	0.498	0.000	0.000	1.000

in the equity structures of numerous companies. Forty-five percent of the firms are controlled by states (or are SOEs). This percentage is very close to the percentage of SOEs as found by CSMAR (42.1%). The mean of Big4 (0.065) indicates that 6.5% of our sample is audited by Big4 accounting firms. In addition, 8.3% of our sample has negative net income.

Fig. 1 shows the trends of the Social Security Fund holdings from 2007 to 2017. We can see that since 2007, the number of companies held by the Social Security Fund has shown an upward trend. Although the number

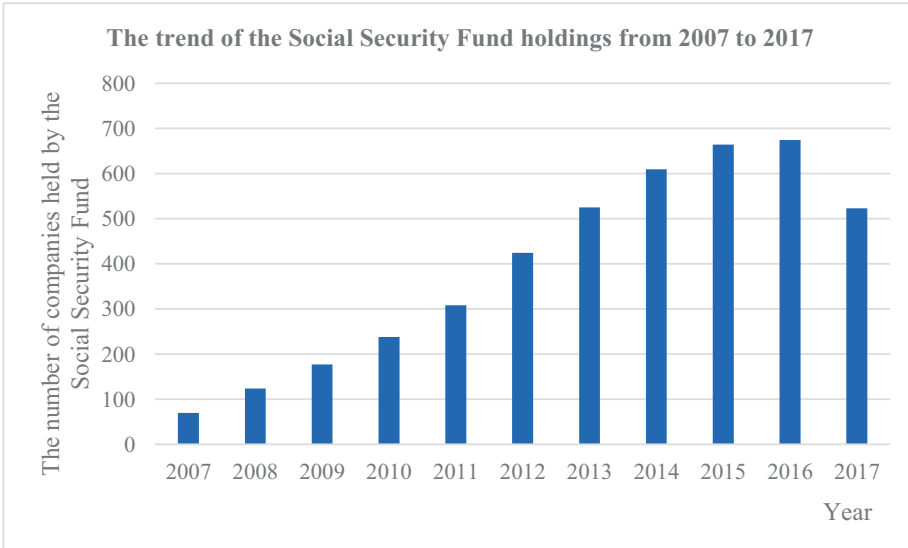

Fig. 1. The trend of the Social Security Fund holdings.

declined slightly in 2017, it has in general increased gradually, which indicates that the Social Security Fund's participation in China's A-share market is expanding.

4.2. Baseline regression

Table 4 shows the regression results of model (1). As shown in this table, the regression coefficients on the Social Security Fund (SSH, SSF, SSFH) are all negative and significant at the p less than 0.05 level. These results provide evidence that the Social Security Fund significantly reduces the risk of litigation perceived by auditors. Thus, our hypothesis H1b is supported.

5. Robustness tests

5.1. The independent variables lagged by one period

To solve the problem of omitted variables and other issues that may exist in our study, we follow Gu et al. (2018) by lagging the independent variables by one period, and substituting them into model (1) for regression. As shown in Table 5, the coefficients of the three proxies (L.SSH, L.SSF, and L.SSFH) are all significantly negative at the 0.01 level, which indicates that our research conclusions remain stable and consistent.

5.2. Heckman selection

As mentioned above, the Social Security Fund may mainly focus on blue chip stocks rather than choosing investment targets in a process of random selection. Therefore, we adopt the Heckman two-stage regression to alleviate the endogeneity problem of sample self-selection bias. In the first stage, we use a probit regression. The dependent variable is whether a listed company's stock is held by the Social Security Fund in a given year (SSH). We include all of the control variables in model (1). In the second stage, we run OLS regressions and include the inverse Mills ratio (Lambda), which is obtained from the first stage. Columns (2) and (3) of Table 6 reflect the results after controlling the Lambda. As shown in columns (2) and (3), the coefficients on the Social Security Fund (SSF and SSFH) are still significantly negative at the 0.01 level, thus proving that our conclusions are robust.

Table 4
The Social Security Fund holdings and auditor litigation risk.

	(1) Ln_Fee	(2) Ln_Fee	(3) Ln_Fee
SSH	−0.017**		
	(−2.30)		
SSF		−0.027***	
		(−3.40)	
SSFH			−0.018***
			(−3.25)
OI	−0.003***	−0.003***	−0.003***
	(−4.65)	(−4.55)	(−4.60)
Cur	−0.017***	−0.017***	−0.017***
	(−10.19)	(−10.19)	(−10.21)
Lev	−0.062**	−0.061**	−0.061**
	(−2.53)	(−2.51)	(−2.50)
Liq	0.094***	0.094***	0.094***
	(3.55)	(3.54)	(3.56)
Rec	0.102***	0.103***	0.103***
	(2.73)	(2.76)	(2.75)
Inv	−0.077**	−0.077**	−0.077**
	(−2.27)	(−2.27)	(−2.27)
Size	0.403***	0.403***	0.403***
	(89.62)	(89.35)	(89.32)
MB	0.038***	0.038***	0.038***
	(17.90)	(17.93)	(17.93)
ROA	−0.753***	−0.744***	−0.743***
	(−8.25)	(−8.14)	(−8.13)
Big4	0.701***	0.700***	0.700***
	(38.10)	(38.10)	(38.11)
Loss	0.014	0.015	0.015
	(1.00)	(1.04)	(1.06)
Dual	0.007	0.007	0.007
	(0.94)	(0.96)	(0.95)
Indexp	−0.004	−0.006	−0.005
	(−0.07)	(−0.11)	(−0.09)
SOE	−0.141***	−0.142***	−0.141***
	(−19.93)	(−20.07)	(−20.03)
Growth	0.005	0.005	0.005
	(0.74)	(0.72)	(0.71)
CFO	0.172***	0.174***	0.174***
	(3.78)	(3.84)	(3.83)
Abs_DA	−0.046	−0.046	−0.046
	(−1.03)	(−1.03)	(−1.04)
Cons	4.540***	4.529***	4.528***
	(45.72)	(45.41)	(45.36)
Year_Industry_FE	Yes	Yes	Yes
Firm_Year_Cluster	Yes	Yes	Yes
N	17,830	17,830	17,830
R^2_a	0.659	0.659	0.659

All regressions are estimated by the ordinary least squares method. All regressions include the industry and year fixed effects. The standard errors are clustered at the stock and year level. The superscripts ***, **, and * indicate two-tailed statistical significance at the 0.01, 0.05, and 0.1 levels, respectively.

Table 5
The Social Security Fund holdings and auditor litigation risk: Lag effects.

	(1) Ln_Fee	(2) Ln_Fee	(3) Ln_Fee
L.SSH	−0.023***		
	(−2.71)		
L.SSF		−0.032***	
		(−3.56)	
L.SSFH			−0.022***
			(−3.54)
OI	−0.003***	−0.002***	−0.003***
	(−3.43)	(−3.35)	(−3.38)
Cur	−0.018***	−0.018***	−0.018***
	(−8.60)	(−8.61)	(−8.63)
Lev	−0.075**	−0.074**	−0.074**
	(−2.53)	(−2.52)	(−2.51)
Liq	0.122***	0.122***	0.124***
	(3.86)	(3.86)	(3.90)
Rec	0.038	0.038	0.037
	(0.85)	(0.86)	(0.84)
Inv	−0.083**	−0.083**	−0.084**
	(−2.07)	(−2.06)	(−2.09)
Size	0.411***	0.411***	0.411***
	(79.93)	(79.68)	(79.63)
MB	0.037***	0.037***	0.037***
	(14.50)	(14.51)	(14.52)
ROA	−0.719***	−0.709***	−0.706***
	(−6.61)	(−6.51)	(−6.48)
Big4	0.692***	0.691***	0.691***
	(34.78)	(34.77)	(34.78)
Loss	0.018	0.018	0.019
	(1.05)	(1.09)	(1.11)
Dual	0.008	0.008	0.008
	(0.88)	(0.91)	(0.89)
Indexp	−0.025	−0.028	−0.027
	(−0.39)	(−0.44)	(−0.42)
SOE	−0.143***	−0.144***	−0.143***
	(−17.48)	(−17.61)	(−17.57)
Growth	0.005	0.005	0.005
	(0.67)	(0.66)	(0.64)
CFO	0.144***	0.146***	0.146***
	(2.60)	(2.64)	(2.64)
Abs_DA	−0.034	−0.033	−0.032
	(−0.62)	(−0.61)	(−0.60)
Cons	4.435***	4.426***	4.424***
	(39.14)	(38.92)	(38.87)
Year_Industry_FE	Yes	Yes	Yes
Firm_Year_Cluster	Yes	Yes	Yes
N	13,334	13,334	13,334
R^2_a	0.659	0.660	0.660

All regressions are estimated by the ordinary least squares method. All regressions include the industry and year fixed effects. The standard errors are clustered at the stock and year level. The superscripts ***, **, and * indicate two-tailed statistical significance at the 0.01, 0.05, and 0.1 levels, respectively.

Table 6
Heckman two-stage regression.

	First stage	Second stage	
	(1) SSH	(2) Ln_Fee	(3) Ln_Fee
SSFH		−0.020***	
		(−3.51)	
SSF			−0.030***
			(−3.88)
OI	0.012***	−0.006***	−0.006***
	(5.78)	(−7.15)	(−7.20)
Cur	−0.009	−0.015***	−0.015***
	(−1.29)	(−8.72)	(−8.83)
Lev	−0.396***	0.025	0.024
	(−4.44)	(0.91)	(0.85)
Liq	0.462***	−0.025	−0.025
	(5.00)	(−0.79)	(−0.78)
Rec	0.129	0.074*	0.075**
	(0.97)	(1.93)	(1.99)
Inv	−0.390***	0.022	0.022
	(−3.12)	(0.58)	(0.56)
Size	0.209***	0.352***	0.352***
	(15.88)	(37.61)	(36.03)
MB	0.014*	0.033***	0.033***
	(1.74)	(14.74)	(14.30)
ROA	3.028***	−1.431***	−1.426***
	(9.06)	(−9.32)	(−9.75)
Big4	0.033	0.686***	0.686***
	(0.74)	(37.25)	(36.16)
Loss	−0.020	0.004	0.003
	(−0.36)	(0.25)	(0.24)
Dual	0.025	0.001	0.001
	(0.93)	(0.08)	(0.11)
Indexp	−0.405**	0.085	0.083
	(−2.06)	(1.42)	(1.37)
SOE	0.134***	−0.173***	−0.173***
	(5.31)	(−20.86)	(−19.77)
Growth	−0.010	0.008	0.008
	(−0.46)	(1.21)	(1.24)
CFO	0.514***	0.034	0.035
	(2.97)	(0.67)	(0.66)
Abs_DA	−0.077	−0.049	−0.048
	(−0.48)	(−1.18)	(−1.05)
Lambda		−1.458***	−1.444***
		(−5.69)	(−5.66)
Cons	−5.719***	6.694***	6.675***
	(−18.97)	(17.94)	(17.54)
Industry_Year_FE	Yes	Yes	Yes
N	17,806	17,806	17,806
R^2_a		0.660	0.660

All regressions include the industry and year fixed effects. The superscripts ***, **, and * indicate two-tailed statistical significance at the 0.01, 0.05, and 0.1 levels, respectively. In the first stage, there are 24 observations not used.

5.3. Propensity score-based matching

We further confirm that our inferences are robust by using the PSM (propensity score-based matching) method as suggested by Armstrong et al. (2010). These researchers argue that using a propensity score design

that achieves maximum variation in the variable of interest, while minimizing variation in the control variables, is a superior econometric approach to matching on an outcome variable. Specifically, the size of the enterprise (Size), asset-liability ratio (Lev), operating cash flow (CFO), return on total assets (ROA), audit

Table 7
Propensity-score matching regression.

	(1) Ln_Fee	(2) Ln_Fee	(3) Ln_Fee
SSH	−0.018*		
	(−1.92)		
SSF		−0.028***	
		(−3.05)	
SSFH			−0.019***
			(−3.11)
OI	−0.004***	−0.004***	−0.004***
	(−3.93)	(−3.78)	(−3.83)
Cur	−0.020***	−0.020***	−0.020***
	(−7.88)	(−7.87)	(−7.90)
Lev	−0.104**	−0.101**	−0.102**
	(−2.53)	(−2.48)	(−2.49)
Liq	0.170***	0.169***	0.171***
	(4.19)	(4.18)	(4.21)
Rec	−0.077	−0.075	−0.076
	(−1.37)	(−1.34)	(−1.35)
Inv	−0.057	−0.056	−0.057
	(−1.04)	(−1.02)	(−1.04)
Size	0.424***	0.424***	0.424***
	(65.65)	(65.66)	(65.61)
MB	0.031***	0.031***	0.031***
	(9.38)	(9.39)	(9.40)
ROA	−0.828***	−0.820***	−0.809***
	(−5.86)	(−5.81)	(−5.73)
Big4	0.681***	0.681***	0.681***
	(29.47)	(29.45)	(29.46)
Loss	−0.000	0.000	0.001
	(−0.00)	(0.01)	(0.03)
Dual	0.005	0.005	0.005
	(0.42)	(0.46)	(0.44)
Indexp	−0.053	−0.057	−0.055
	(−0.63)	(−0.68)	(−0.65)
SOE	−0.154***	−0.157***	−0.156***
	(−14.49)	(−14.66)	(−14.61)
Growth	0.020*	0.020*	0.020*
	(1.95)	(1.92)	(1.90)
CFO	0.196***	0.200***	0.200***
	(2.67)	(2.72)	(2.72)
Abs_DA	−0.127*	−0.127*	−0.129*
	(−1.76)	(−1.76)	(−1.78)
Cons	4.072***	4.065***	4.054***
	(28.13)	(28.12)	(27.98)
Industry_Year_FE	Yes	Yes	Yes
Firm_Year_Cluster	Yes	Yes	Yes
N	8672	8672	8672
R^2_a	0.692	0.692	0.693

All regressions are estimated by the ordinary least squares method. All of the regressions include the industry and year fixed effects. The standard errors are clustered at the stock and year levels. The superscripts ***, **, and * indicate two-tailed statistical significance at the 0.01, 0.05, and 0.1 levels, respectively.

opinions (Opinion), Big Four accounting firms (Big4), state-owned enterprises (SOE), earnings below zero (Loss), market-to-book ratio (MB), earnings quality (Abs_DA), and year and industry fixed effects are all included as our propensity score matching factors. Following Armstrong et al. (2010), we first estimate a

Table 8
Replacing Big4 with Big10.

	(1) Ln_Fee	(2) Ln_Fee	(3) Ln_Fee
SSH	−0.016*		
	(−1.92)		
SSF		−0.029***	
		(−3.41)	
SSFH			−0.019***
			(−3.23)
OI	−0.004***	−0.004***	−0.004***
	(−6.43)	(−6.33)	(−6.37)
Cur	−0.018***	−0.018***	−0.018***
	(−10.35)	(−10.36)	(−10.37)
Lev	−0.134***	−0.133***	−0.133***
	(−5.15)	(−5.14)	(−5.14)
Liq	0.045	0.045*	0.046*
	(1.64)	(1.65)	(1.67)
Rec	0.166***	0.168***	0.167***
	(4.29)	(4.32)	(4.31)
Inv	−0.078**	−0.079**	−0.079**
	(−2.23)	(−2.23)	(−2.24)
Size	0.458***	0.459***	0.459***
	(96.58)	(96.27)	(96.20)
MB	0.047***	0.048***	0.048***
	(21.13)	(21.16)	(21.15)
ROA	−0.855***	−0.842***	−0.841***
	(−8.82)	(−8.69)	(−8.67)
Big10	0.150***	0.150***	0.150***
	(23.12)	(23.11)	(23.11)
Loss	0.010	0.011	0.011
	(0.68)	(0.72)	(0.74)
Dual	0.002	0.003	0.003
	(0.32)	(0.35)	(0.33)
Indexp	0.086	0.083	0.085
	(1.36)	(1.32)	(1.34)
SOE	−0.144***	−0.145***	−0.144***
	(−19.60)	(−19.72)	(−19.69)
Growth	−0.004	−0.004	−0.005
	(−0.64)	(−0.66)	(−0.68)
CFO	0.270***	0.273***	0.272***
	(5.66)	(5.73)	(5.73)
Abs_DA	−0.032	−0.032	−0.032
	(−0.68)	(−0.68)	(−0.69)
Cons	3.346***	3.330***	3.330***
	(31.65)	(31.35)	(31.30)
Industry_Year_FE	Yes	Yes	Yes
Firm_Year_Cluster	Yes	Yes	Yes
N	17,830	17,830	17,830
R^2_a	0.617	0.618	0.617

All regressions are estimated by the ordinary least squares method. All of the regressions include the industry and year fixed effects. The standard errors are clustered at the stock and year levels. The superscripts ***, **, and * indicate two-tailed statistical significance at the 0.01, 0.05, and 0.1 levels, respectively.

propensity score model for the probability that the Social Security Fund holds shares of a public company, conditional on observable features of the contracting environment. Second, we identify the matched pairs with the smallest propensity score differences, and examine the covariate balance between the treatment and the control samples. The number of matched samples is 8672. Finally, we examine the relationship between the

Table 9
The path analysis on the effects of Social Security Fund investment on auditor litigation risk.

Panel A Path 1: Audit risk

	(1) Effort	(2) Effort	(3) Effort
SSH	−0.009**		
	(−2.01)		
SSF		−0.012***	
		(−2.64)	
SSFH			−0.008***
			(−2.76)
OI	−0.001**	−0.001**	−0.001**
	(−2.56)	(−2.49)	(−2.52)
Cur	−0.002	−0.002	−0.002
	(−1.49)	(−1.49)	(−1.50)
Lev	−0.056***	−0.056***	−0.056***
	(−3.36)	(−3.34)	(−3.34)
Liq	0.054***	0.054***	0.054***
	(3.14)	(3.14)	(3.15)
Rec	0.031	0.031	0.031
	(1.28)	(1.29)	(1.29)
Inv	−0.047**	−0.047**	−0.047**
	(−2.08)	(−2.07)	(−2.08)
Size	0.021***	0.021***	0.021***
	(8.76)	(8.84)	(8.84)
MB	−0.004**	−0.004**	−0.004**
	(−2.56)	(−2.55)	(−2.54)
ROA	−0.467***	−0.463***	−0.462***
	(−7.51)	(−7.44)	(−7.42)
Big4	−0.038***	−0.038***	−0.038***
	(−5.81)	(−5.85)	(−5.84)
Loss	0.039***	0.039***	0.039***
	(4.55)	(4.57)	(4.58)
Dual	0.012**	0.012***	0.012**
	(2.56)	(2.58)	(2.57)
Indexp	0.024	0.023	0.024
	(0.70)	(0.68)	(0.69)
SOE	−0.029***	−0.030***	−0.030***
	(−6.44)	(−6.53)	(−6.50)
Growth	−0.016***	−0.016***	−0.017***
	(−3.60)	(−3.60)	(−3.62)
CFO	−0.126***	−0.125***	−0.125***
	(−3.96)	(−3.93)	(−3.93)
Abs_DA	0.000	0.000	0.000
	(0.01)	(0.01)	(0.00)
Cons	4.067***	4.063***	4.062***
	(76.47)	(76.40)	(76.26)
Industry_Year_FE	Yes	Yes	Yes
Firm_Year_Cluster	Yes	Yes	Yes
N	17,830	17,830	17,830
R^2_a	0.080	0.080	0.080

Panel B Path 2: Business risk

	(1) Operate_Factor	(2) Operate_Factor	(3) Operate_Factor	(4) Solvency_Factor	(5) Solvency_Factor	(6) Solvency_Factor
SSH	0.008***			0.023***		
	(3.01)			(6.01)		
SSF		0.010***			0.025***	
		(3.68)			(6.31)	
SSFH			0.006***			0.016***
			(3.83)			(6.71)
OI	−0.001**	−0.001**	−0.001**	−0.000	−0.000	−0.000
	(−2.38)	(−2.44)	(−2.39)	(−0.07)	(−0.14)	(−0.08)
Cur	−0.515***	−0.515***	−0.515***	0.442***	0.442***	0.442***
	(−706.48)	(−706.67)	(−706.24)	(300.74)	(300.99)	(300.91)
Lev	0.212***	0.212***	0.212***	−1.045***	−1.046***	−1.046***
	(19.88)	(19.89)	(19.87)	(−49.41)	(−49.46)	(−49.43)
Liq	−0.014	−0.013	−0.014	−0.036*	−0.035*	−0.036*
	(−0.95)	(−0.94)	(−0.96)	(−1.83)	(−1.79)	(−1.85)
Rec	−0.088***	−0.088***	−0.087***	0.022	0.021	0.022
	(−4.21)	(−4.22)	(−4.19)	(0.80)	(0.79)	(0.82)
Inv	−0.045**	−0.045**	−0.045**	0.062**	0.061**	0.061**
	(−2.26)	(−2.27)	(−2.26)	(2.21)	(2.18)	(2.21)
Size	0.011***	0.011***	0.011***	0.023***	0.023***	0.023***
	(7.03)	(7.01)	(7.04)	(9.34)	(9.34)	(9.32)
MB	0.001	0.001	0.001	0.000	0.000	0.000
	(0.99)	(0.97)	(0.98)	(0.08)	(0.07)	(0.07)
ROA	1.515***	1.512***	1.513***	2.271***	2.267***	2.267***
	(35.36)	(35.15)	(35.25)	(33.48)	(33.33)	(33.38)
Big4	0.034***	0.034***	0.034***	0.024***	0.024***	0.024***
	(3.86)	(3.89)	(3.89)	(2.95)	(3.01)	(3.01)
Indexp	−0.023	−0.022	−0.023	−0.053	−0.050	−0.052
	(−0.96)	(−0.92)	(−0.95)	(−1.52)	(−1.46)	(−1.51)
Dual	0.001	0.001	0.001	0.001	0.001	0.001
	(0.37)	(0.35)	(0.36)	(0.25)	(0.22)	(0.25)
Loss	−0.081***	−0.081***	−0.081***	−0.462***	−0.462***	−0.462***
	(−14.39)	(−14.40)	(−14.40)	(−38.76)	(−38.78)	(−38.81)
SOE	0.004*	0.004*	0.004*	0.000	0.001	0.001
	(1.67)	(1.76)	(1.72)	(0.05)	(0.21)	(0.15)
Growth	0.049***	0.049***	0.049***	0.051***	0.051***	0.051***
	(4.42)	(4.42)	(4.43)	(6.95)	(6.96)	(6.97)
Cons	−0.183***	−0.181***	−0.182***	−0.512***	−0.512***	−0.510***
	(−5.64)	(−5.62)	(−5.62)	(−9.35)	(−9.36)	(−9.31)
Industry_Year_FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm_Year_Cluster	Yes	Yes	Yes	Yes	Yes	Yes
N	11,899	11,899	11,899	11,899	11,899	11,899
R^2_a	0.985	0.985	0.985	0.965	0.965	0.965

All regressions are estimated by the ordinary least squares method. All of the regressions include the industry and year fixed effects. The standard errors are clustered at the stock and year levels. The superscripts ***, **, and * indicate two-tailed statistical significance at the 0.01, 0.05, and 0.1 levels, respectively.

Social Security Fund and the auditor litigation risk by assessing whether the audit fees differ significantly between the treatment and the control groups.

On the basis of the PSM-matched samples, regressions are performed on model (1). The results are shown in Table 7. These empirical results show that the coefficients on the Social Security Fund (SSH, SSF, and SSFH) are all significantly negative, at least at the 0.1 level, and our conclusions remain unchanged.

Table 10
Regulating effects of governance levels in the listed companies.

	Low level of corporate governance			High level of corporate governance		
	(1) Ln_Fee	(2) Ln_Fee	(3) Ln_Fee	(4) Ln_Fee	(5) Ln_Fee	(6) Ln_Fee
SSH	−0.034***			0.005		
	(−3.00)			(0.47)		
SSF		−0.047***			−0.004	
		(−3.92)			(−0.41)	
SSFH			−0.025***			−0.010
			(−3.04)			(−1.32)
OI	−0.003***	−0.003***	−0.003***	−0.003***	−0.003***	−0.003***
	(−3.25)	(−3.14)	(−3.18)	(−3.28)	(−3.23)	(−3.21)
Cur	−0.020***	−0.021***	−0.021***	−0.015***	−0.015***	−0.015***
	(−6.21)	(−6.26)	(−6.28)	(−8.06)	(−8.08)	(−8.10)
Lev	−0.051	−0.049	−0.048	−0.070**	−0.071**	−0.071**
	(−1.28)	(−1.24)	(−1.22)	(−2.26)	(−2.28)	(−2.29)
Liq	0.128***	0.128***	0.128***	0.065**	0.066**	0.067**
	(2.96)	(2.94)	(2.95)	(1.96)	(1.99)	(2.02)
Rec	−0.002	−0.001	−0.002	0.215***	0.215***	0.215***
	(−0.03)	(−0.01)	(−0.04)	(4.63)	(4.63)	(4.64)
Inv	−0.075	−0.073	−0.075	−0.047	−0.049	−0.049
	(−1.37)	(−1.34)	(−1.36)	(−1.12)	(−1.15)	(−1.17)
Size	0.424***	0.425***	0.425***	0.377***	0.377***	0.378***
	(65.07)	(64.90)	(64.78)	(58.92)	(58.72)	(58.78)
MB	0.043***	0.043***	0.043***	0.033***	0.033***	0.033***
	(11.69)	(11.72)	(11.71)	(12.53)	(12.55)	(12.57)
ROA	−0.753***	−0.739***	−0.745***	−0.678***	−0.670***	−0.660***
	(−5.20)	(−5.11)	(−5.13)	(−5.86)	(−5.79)	(−5.71)
Big4	0.694***	0.693***	0.693***	0.697***	0.697***	0.697***
	(30.82)	(30.83)	(30.80)	(21.10)	(21.10)	(21.13)
Loss	0.002	0.002	0.002	0.034*	0.035*	0.035*
	(0.07)	(0.11)	(0.12)	(1.81)	(1.82)	(1.84)
SOE	−0.151***	−0.152***	−0.152***	−0.151***	−0.151***	−0.151***
	(−13.07)	(−13.24)	(−13.21)	(−11.97)	(−11.96)	(−11.95)
Indexp	0.115	0.104	0.104	−0.027	−0.028	−0.028
	(0.90)	(0.81)	(0.82)	(−0.40)	(−0.42)	(−0.42)
Growth	−0.008	−0.008	−0.008	0.012	0.012	0.012
	(−0.70)	(−0.71)	(−0.72)	(1.53)	(1.53)	(1.51)
CFO	0.142**	0.147**	0.143**	0.195***	0.196***	0.198***
	(2.02)	(2.08)	(2.03)	(3.32)	(3.34)	(3.37)
Dual	0.047*	0.047*	0.047*	−0.006	−0.006	−0.006
	(1.81)	(1.80)	(1.82)	(−0.73)	(−0.71)	(−0.70)
Abs_DA	−0.038	−0.037	−0.039	−0.028	−0.028	−0.029
	(−0.55)	(−0.53)	(−0.56)	(−0.49)	(−0.50)	(−0.51)
Cons	4.143***	4.128***	4.138***	5.025***	5.013***	4.999***
	(28.96)	(28.75)	(28.80)	(35.60)	(35.33)	(35.18)
Industry_Year_FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm_Year_Cluster	Yes	Yes	Yes	Yes	Yes	Yes
N	8594	8594	8594	9236	9236	9236
R^2_a	0.680	0.680	0.680	0.618	0.618	0.619

All regressions are estimated by the ordinary least squares method. All of the regressions include the industry and year fixed effects. The standard errors are clustered at the stock and year levels. The superscripts ***, **, and * indicate two-tailed statistical significance at the 0.01, 0.05, and 0.1 levels, respectively.

5.4. Replacing Big4 with Big10

In China, the top 10 accounting firms have high audit quality (Guan et al., 2016), and they charge a fee premium. Following Cai et al. (2019), we replace the top four international accounting firms (Big4) with

the top 10 domestic accounting firms (Big10) to mitigate the problem of potential missing variables. The empirical results are shown in Table 8. The coefficients on Big10 are all significantly positive, and we continue to find that the regression coefficients on the Social Security Fund holdings (SSH, SSF, and SSFH) are still significantly negative, at least at the 0.1 level. These findings support the robustness of this study's conclusions.

6. Further analysis

To analyze the effect path of Social Security Fund holdings on auditor litigation risk, we explore the following two questions. First, what is the effect path of Social Security Fund holdings on reductions of auditor litigation risk? Second, does the impact of Social Security Fund holdings on auditor perceptions of litigation risk vary under differing levels of corporate governance?

6.1. The path of Social Security Fund influence on auditor litigation risk

How does the Social Security Fund affect auditor perceptions of litigation risk? What is the path of that effect? As mentioned earlier, the engagement risks faced by auditors mainly come from audit risk and clients' business risk (Johnstone, 2000; Stanley, 2011; Zhai et al., 2017; Cassell et al., 2018). Auditors adjust their audit plans and audit investments based on their clients' levels of audit risk (Johnstone, 2000; DeFond and Zhang, 2014). Therefore, we use audit input to measure audit risk. Following previous studies (Jha and Chen, 2014; Reid et al., 2019), we consider that the audit input (Effort) is equal to the time interval (in days) between the fiscal year-end and the audit report date. We examine the relation between the Social Security Fund holdings and the audit risk using the following model:

$$\begin{aligned}\text{Audit\_Risk} = {} & \beta_0 + \beta_1 SSH + \beta_2 OI + \beta_3 Cur + \beta_4 Lev + \beta_5 Liq + \beta_6 Rev + \beta_7 Inv + \beta_8 Size + \beta_9 MB \\ & + \beta_{10} ROA + \beta_{11} Big4 + \beta_{12} Loss + \beta_{13} Dual + \beta_{14} Indexp + \beta_{15} SOE + \beta_{16} Growth \\ & + \beta_{17} CFO + \beta_{18} Abs\_DA + Year + Industry + \varepsilon \end{aligned} \quad (2)$$

Panel A of Table 9 reports the results regarding the impact of Social Security Fund holdings on the auditors' audit risk. The dependent variable is auditor input (Effort), and the independent variables are Social Security Fund proxies (SSH, SSF, and SSFH). As shown in the regression results, the coefficients of these Social Security Fund proxies are significantly negative, at least at the 0.05 level, which indicates that the Social Security Fund significantly reduces the auditors' audit risk.

In addition, investments by the Social Security Fund may decrease auditor litigation risk through reducing a company's business risk. Although previous research (Zhai et al., 2017) uses four variables to separately measure the operating risk of an enterprise (such as capital structure (Lev), total return on assets (ROA), loss (Loss), and operating cash flow (CFO)), no one of these variables alone can measure the business risk of an enterprise. Therefore, following Stanley (2011),[4] we use principal component analysis to construct an index of operating risks by selecting five variables, namely operating returns (ROAearnings), operating cash flows (Cashearnings), capital structure (Lev), current ratio (Cur), and interest solvency (InvInterestCov). As is consistent with the approach used by Stanley (2011), the first and second principal components are operating performance (Operate_Factor) and solvency (Solvency_Factor), and our model (3) is established as follows:

$$\begin{aligned}\text{Bus\_Risk} = {} & \beta_0 + \beta_1 SSH + \beta_2 OI + \beta_3 Cur + \beta_4 Lev + \beta_5 Liq + \beta_6 Rec + \beta_7 Inv + \beta_8 Size + \beta_9 MB \\ & + \beta_{10} ROA + \beta_{11} Big4 + \beta_{12} Indexp + \beta_{13} Dual + \beta_{14} Loss + \beta_{15} SOE + \beta_{16} Growth + Year \\ & + Industry + \varepsilon \end{aligned} \quad (3)$$

[4] ROAEarnings = earnings, measured as operating income after depreciation divided by total assets at the beginning of the period; ROACash = operating cash flows divided by total assets at the beginning of the period; CurrentRatio = current ratio, measured as current assets divided by current liabilities; Leverage = leverage, measured as total liabilities divided by total assets; and InvInterestCov = inverse interest coverage, measured as interest expense divided by operating income before depreciation. Following Efendi et al. (2007), the ratio is capped at 2.00 and assigned a value of 2.00, if the operating income before depreciation is negative.

In model (3), the dependent variable, Bus_Risk, is replaced first by Operate_Factor, and then by Solvency_Factor. The independent variables are SSH, SSF, and SSFH. Panel B of Table 9 shows the impact of Social Security Fund holdings on business risk. As the variables of Operate_Factor and Solvency_Factor are both inverse indicators, we expect that the coefficients of SSH, SSF, and SSFH will be significantly positive. The regression results show that the regression coefficients on Operate_Factor and Solvency_Factor are all significantly positive at the 0.01 level, which indicates that the Social Security Fund holdings can significantly reduce an enterprise's business risk. On the basis of the regression results shown in Table 9, we can conclude that the Social Security Fund lowers an auditor's litigation risk by reducing both the audit risk and the business risk.

6.2. Regulatory effect of the level of corporate governance

Companies with lower governance quality provide the environments and the opportunities for management fraud, which results in high auditor litigation risk (Pratt and Stice, 1994). Companies with higher governance quality effectively monitor and restrain their managers' self-interested behavior. As an independent long-term institution, the Social Security Fund specializes in monitoring rather than trading, and it plays an important role in external governance, thereby curbing the managers' short-sighted behavior. Therefore, we expect that the governance role of the Social Security Fund will be more pronounced in the group of companies with lower levels of corporate governance. If the impact of Social Security Fund holdings on auditor litigation risk is found to vary in a theoretically predictable manner, this finding would provide greater confidence in our conclusions. Such a finding would also shed empirical light on the mechanisms through which the Social Security Fund takes a monitoring role in public companies, and it would reduce concerns about reverse causality.

To test our expectation, we divide our sample into two groups by corporate governance level and empirically test whether these groups show different results. We draw on the method applied by Li et al. (2018) and construct a listed company's governance index through principal component analysis. The specific indicators selected are (1) the shareholding ratio of the largest shareholder (FirstH), (2) the sum of squares held by the second to the tenth largest shareholders (Cstr2_10), (3) the proportion of independent directors on the board (Indexp), (4) whether the chairman and CEO are the same person (Dual), (5) the size of the board of directors (Numboard), (6) the proportion of senior executives who hold shares (M_share), (7) whether the company is listed overseas, or if it issues B shares (H/B), and (8) whether the company is state-controlled (SOE). We select the first principal component to measure the governance of the listed companies.

The results are shown in Table 10. The coefficients on the Social Security Fund variables (SSH, SSF, and SSFH) are all significantly negative at the 0.01 level in the group with low corporate governance, but they are not significant in the group with high levels of corporate governance. These results show that the Social Security Fund, as a high-quality, long-term investor, plays an active role in external governance, thereby reducing the litigation risk faced by auditors.

7. Conclusions and implications

As an important institutional investor in China's capital market, the Social Security Fund has attracted increasing attention from scholars and regulators in recent years. However, studies on the governance role played by the Social Security Fund have produced inconsistent conclusions. Unlike previous studies, we examine the governance role of the Social Security Fund from the perspective of auditors. We find that the Social Security Fund significantly reduces the litigation risk faced by auditors, and the main paths to this outcome come through reducing the auditor's audit risk and the enterprise's business risk. Furthermore, we find that the negative correlation between the Social Security Fund and auditor litigation risk is more significant for companies with low levels of corporate governance. Taking these findings together, we verify that the Social Security Fund, as an independent long-term institutional investor, plays an important role in external governance, and that investments by this fund tend to reduce auditor litigation risk.

On the basis of our findings, we offer the following recommendations for reference by policy makers. (1) The Social Security Fund should further enter the capital market as a way to strengthen the team of high-quality institutional investors. The involvement of this fund can steadily improve the investment environment

of China's A-share market, gradually transforming it from a transaction-oriented to a configuration-based market that has long-term value. (2) The Social Security Fund should be encouraged to actively participate in the governance of companies and to play a role in promoting the high-quality management of listed companies. In 2009, the State Council issued its "Implementation Measures for the Transfer of Partial State-owned Shares in the Domestic Securities Market to Enrich the National Social Security Fund." This document states that the Social Security Fund has the right to gain and dispose of transferred shares but should avoid interfering with the daily management of listed companies. Our findings indicate that such restrictions should be lifted, and the Social Security Fund should be encouraged to play an active role in external governance.

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Related party transactions and firm value: The moderating role of corporate social responsibility reporting

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ABSTRACT

This study investigates the influence of related party transactions (RPTs) on firm value. Further, it examines whether a firm's corporate social responsibility (CSR) reporting reflects its corporate values and ethical concerns, therefore mitigating the value-destroying effects of RPTs. Based on 274 observations from publicly listed firms in Indonesia, our results show that RPTs (i.e., related party sales) are negatively related to firm value. Further, we find that in the presence of better CSR reporting, the relationship between RPTs and firm value becomes more positive. This is in line with the view that CSR reporting, which reflects firms' ethical concerns, may serve as a mechanism against managers' opportunism. However, we find that related party payables have a positive relationship with firm value. Further investigation reveals that, although certain RPTs show a short-term, value-enhancing effect, these transactions seem to result in subsequent tunneling activities, suggesting managerial opportunism in the long term.

1. Introduction

Transparency is an important topic in areas such as management, finance and public relations, and it is essential to enhancing stakeholder trust in a firm (Hultman and Axelsson, 2007; Albu and Flyverbom, 2016; Schnackenberg and Tomlinson, 2016). The disclosure of information is particularly important to minimize information asymmetry, to meet the information needs of external stakeholders and to develop trust. Armitage and Marston (2008) find that managers are motivated to provide greater voluntary disclosure transparency because they want to ensure firms' reputation for openness and shareholders' confidence, which may

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result in a higher share price or other commercial benefits. Nevertheless, as firms in many Asian countries are generally characterized by a highly concentrated ownership structure (OECD, 2017) and with concern regarding agency conflict shifting toward the conflict of interest between majority and minority shareholders (Shleifer and Vishny, 1997), insiders of highly concentrated firms (i.e., managers or directors and controlling owners) with better bargaining positions and better access to information have the ability and power to expropriate minority shareholders' interests. One method for such expropriation is related party transactions (hereinafter, "RPTs").

There are two opposing viewpoints regarding RPTs. The first view considers RPTs as potentially opportunistic as they may be used by insiders to maximize self-serving interests at the expense of other shareholders (Gordon et al., 2004; Cheung et al., 2006; Kohlbeck and Mayhew, 2010). However, the second view considers RPTs as potentially efficient as they may provide benefits to firms through a simplified negotiation process, lower transaction costs (Gordon et al., 2004), strategic partnership, risk sharing and the facilitation of contracts (Kohlbeck and Mayhew, 2010).

Some prior studies suggest that firms operating under better ethical concerns, as reflected by their corporate social responsibility (CSR), tend to have less opportunistic behavior (e.g., Garriga and Melé, 2004; Kim et al., 2012; Scholtens and Kang, 2013). Nevertheless, whereas Kim et al. (2012) find that firms that are considered to be socially responsible tend to be more transparent, to have more reliable financial reporting and to be less likely to manipulate reported earnings, another view is that firms may use CSR reporting to conceal corporate misconduct based on opportunistic incentives (Muttakin et al., 2015). Accordingly, using a sample of 274 observations from firms listed in Indonesia, this study investigates whether RPTs enable manager opportunism or efficiency and whether CSR reporting mitigates opportunistic or value-destroying RPTs.

Studies suggest that RPTs in Indonesia are potentially abusive and may lead to the expropriation of wealth by controlling shareholders (Utama and Utama, 2009; Sari and Baridwan, 2014). In addition, Indonesian firms are characterized by high ownership concentration (La Porta et al., 1998; Carney and Child, 2013; Utama et al., 2017). Therefore, conflicts of interest between majority and minority shareholders are more likely to arise. Further, investor protection in Indonesia is still relatively weak compared with other countries (La Porta et al., 2006; Barokah, 2013). Although OJK, then BAPEPAM-LK, has tightened the rules to mitigate opportunistic RPTs, it cannot truly cover all such transactions (Utama et al., 2017).[1] Rule number IX.E. I excludes the obligation to disclose RPTs in relation to a firm's main business activities. However, prior studies argue that such transactions are potentially abusive and thus require more transparency for users of financial statements (Cheung et al., 2006, 2009).

Our findings indicate that concerns about RPTs being both value destroying and value enhancing are warranted. Specifically, this study finds that related party sales are negatively related to firm value. This implies that because the fairness of RPT prices may be doubtful, the market may perceive related party sales as opportunistic and less credible than other sales. However, in the presence of more CSR reporting, the relationship between related party sales and firm value becomes more positive. This finding indicates that ethical concerns may drive firms to be less opportunistic and that CSR reporting reflects firm's incentives to be trustworthy and ethical. Moreover, the relationship between related party payables and firm value is positive, suggesting that the market perceives related party payables as beneficial to listed firms. Interestingly, although these transactions show a short-term, value-enhancing effect, they seem to result in subsequent tunneling activities.

This study makes a number of contributions. First, although CSR has received public attention worldwide, there are relatively few empirical studies on CSR in the context of developing countries, such as Indonesia. This study provides evidence regarding whether RPTs in Indonesia are opportunistic or efficient. Second, this study provides evidence regarding whether ethical concerns drive firms to engage in value-enhancing RPTs instead of opportunistic RPTs. Third, this study sheds light on how CSR reporting affects other corporate behavior besides earnings management and financial performance, namely RPTs. Fourth, this study may be useful to current and potential investors making investment decisions. In particular, as the results confirm the view that firms with more CSR reporting are less likely to behave opportunistically, investors can be assured that resources provided to such firms will be managed efficiently. Lastly, in light of CSR reporting,

[1] BAPEPAM-LK, *Otoritas Jasa Keuangan (OJK),* is the regulator of Indonesia's capital market.

the findings of this study may help regulators and policymakers better understand firms' business practices and the motives for using RPTs and CSR reporting.

The remainder of this paper is organized as follows: Section 2 presents a literature review and the research hypotheses. Section 3 discusses the study's research design. Section 4 presents and discusses the results. Section 5 provides additional analysis on the potential occurrence of subsequent tunneling. Section 6 summarizes the key findings and provides conclusions.

2. Literature review and hypotheses

There are two alternative viewpoints about RPTs: The first considers them to be abusive (opportunistic) transactions, whereas the second view considers them to be efficient (Gordon et al., 2004). Kohlbeck and Mayhew (2017) suggest that RPTs contain potential self-dealing between directors, material owners, officers and investors. Several studies support this view and suggest that as RPTs can be an indicator of agency problems, investors consider them to be opportunistic (e.g., Jian and Wong, 2004; Cheung et al., 2006; Kohlbeck and Mayhew 2010). As insiders of highly concentrated firms, such as managers, directors and controlling owners, have better access to information, they are in a better bargaining position than outsiders, such as non-controlling (minority) shareholders and corporate creditors. Consequently, expropriation by insiders against outsiders' interests are more likely to occur. In such a setting, La Porta et al. (1999, 471) argue that controlling owners tend to have more power to expropriate minority shareholders' interests.

Several other studies, however, argue that RPTs can be beneficial as they may result in saving transaction costs and improving a firm's resource utilization (Chang and Hon, 2000; Chen et al., 2009; Chien and Hsu, 2010). Accordingly, RPTs do not necessarily represent transactions based on fraudulent or deceptive purposes. Instead, RPTs may represent ordinary trade and business activities (Wong et al., 2015). Studies indicate that socially responsible firms tend to be more trustworthy and are more likely to engage in ethical operating decisions. Kim et al. (2012) and Scholtens and Kang (2013) find that socially responsible firms are less likely to engage in earnings management. Similarly, Bénabou and Tirole (2010) argue that CSR can reduce the likelihood of short-term opportunistic behavior by managers. Gao et al. (2014) contend that executives of socially responsible firms are less likely to engage in trading prior to news announcements and profit significantly less from insider trading. Consequently, it is expected that, on the basis of ethics, firms that are perceived as socially responsible are less likely to engage in opportunistic behavior such as value-destroying RPTs; although studies also suggest that firms may be presenting socially responsible behavior to shift stakeholders' focus (Salewski and Zülch, 2014; Muttakin et al., 2015).

Related party sales are undertaken to improve resource allocation efficiency (Wong et al., 2015). However, as the prices charged in related party sales transactions may be unfair compared with industry average prices (Kang, et al., 2014, 277), expropriation may occur. Therefore, RPTs allow shifting earnings between firms, particularly from listed firms to their related parties (Cheung et al., 2006). Several studies have explored the relationship between related party sales and market reactions and contend that the market responds less positively to related party sales transactions (e.g., Jian and Wong, 2004; Cheung et al., 2009). Specifically, in the Chinese context, Aharony et al. (2010) find an association between tunneling in the post-IPO period and upward earnings management through abnormal related party sales in the pre-IPO period. Further, although there may be indications that related party purchases may be conducted at prices higher than independent transactions, studies argue the value-enhancing effect of related party purchases. Chen et al. (2009) argue that RPTs may lower transaction costs, which may in turn improve operational performance and maximize profit. In the same way, Tambunan et al., (2017) provide evidence of the value-enhancing effect of related party purchases, although only in the short term. Accordingly, the following hypotheses are proposed:

H1a. Related party sales negatively influence firm value.

H1b. Related party purchases positively influence firm value.

Prior studies by Jiang et al. (2010) and Tambunan et al. (2017) argue that controlling shareholders may expropriate through related party receivables transactions as they may affect a firm's productive assets and firm value negatively. Stated differently, transactions that involve the payment of cash to related parties (in-

cluding loans and cash assistance) are likely to result in the expropriation of minority shareholders' interests (Cheung et al., 2006). Hence, it is expected that the higher the related party receivables, the worse the firm value. In contrast, cash assistance or loans received from listed firms from related parties are likely to benefit non-controlling shareholders (Cheung et al., 2006, 358). Unsurprisingly, listed firms that are in severe financial difficulty generally receive cash assistance from related parties. Accordingly, we test the following hypotheses:

H1c. Related party receivables negatively influence firm value.

H1d. Related party payables positively influence firm value.

This study further investigates whether CSR reporting, as the reflection of a company's ethical concerns, can explain the negative relationship between a firm's CSR and corporate opportunistic behavior. As pointed out by Kim et al. (2012) and Scholtens and Kang (2013), a firm's CSR generally has an inverse relation to its earnings management. Although this study focuses on the ethical implications of CSR, other motivations might also explain a negative relation between CSR and opportunistic behaviors. Several studies (Verschoor, 2005; Linthicum et al., 2010; Choi and Moon, 2016) argue that as social responsibility may provide positive signals regarding a firm's reputation, firms that value their reputation want to protect it, and therefore, they avoid socially unacceptable activities that may potentially damage their reputation.

In contrast, although ethical and reputational motivations for CSR may explain a negative association between CSR and corporate opportunistic behaviors, other studies argue the opposite. For example, Prior et al. (2008) argue that firms may use CSR to overshadow their value-destroying practices. Similarly, Muttakin et al. (2015) contend that CSR reporting may be used to divert stakeholders' attention and reduce the likelihood of opportunistic practices being scrutinized. Accordingly, if firms engage in CSR reporting in the context of a moral imperative, firms may be less likely to engage in value-destroying (opportunistic) RPTs and more likely to engage in value-enhancing (efficient) RPTs. Nevertheless, if firms engage in CSR reporting to disguise value-destroying practices as a means to pursue self-interest, then firms are likely to engage in value-destroying RPTs. Thus, this study proposes the following hypotheses:

H2a. CSR reporting moderates the relationship between related party sales and firm value.

H2b. CSR reporting moderates the relationship between related party purchases and firm value.

H2c. CSR reporting moderates the relationship between related party receivables and firm value.

H2d. CSR reporting moderates the relationship between related party payables and firm value.

3. Research design

We tested the hypotheses by using multiple regression analysis. The required data are collected from the Indonesia Stock Exchange (IDX) website and BvD Osiris database. Data on RPTs and CSR are hand-collected from annual reports.

3.1. Sample selection

This study includes firms listed on the IDX in 2014 and 2015 because the first phase of the IFRS convergence process in Indonesia was completed in 2012, and the second phase was completed in 2015.[2] This

[2] The first phase of the IFRS convergence process in Indonesia was completed in 2012; in this phase the Financial Accounting Standards Board (i.e., DSAK) endorsed 35 financial accounting standards (PSAKs) adopted from IFRS, including PSAK 7 Related Party Disclosures (Maradona and Chand, 2018; Ikatan Akuntan Indonesia, 2012). PSAK 7 was then adjusted in 2014 and amended in 2016 (effective January 1, 2016). Based on the timeframe of adjustment and amendment to PSAK 7 Related Party Disclosures, we choose 2014–2015 to have a consistent applicable standard on related party disclosures (i.e., the period before the standard was amended) (Ikatan Akuntan Indonesia, 2015).

progress is essential to enhance the quality of Indonesian accounting standards and to convince external stakeholders of the quality of the financial reporting practices of Indonesian firms. The study sampling method includes the following criteria: (1) the firm must issue an annual report; (2) it must not be part of the financial industry; (3) its accounting cycle must end on December 31; (4) it must not have negative book value of equity; (5) it must engage in RPTs; and (6) it must disclose social responsibility activities.

3.2. Variables and research models

The independent variables include four types of RPTs. Following previous studies (Cheung et al., 2006, 2009; Chen et al., 2009), this study uses related party sales (*RP_Sales*), purchases (*RP_Purchases*), receivables (*RP_Rec*) and payables (*RP_Pay*). Each type of RPT is measured by the total of transactions (i.e., sales, purchases, receivables, and payables) scaled by total assets. Firm value is measured by Tobin's q and PBV. Subramanyam (2014, 628) and Ahmad and Jusoh (2014, 480) contend that accounting-based valuation methods are more likely to contain management manipulations and distortions as personal goals and interests may depend on the reported accounting data. Therefore, market-based measures are considered to be superior. CSR reporting indices are gathered from content analysis using the checklist proposed by Gunawan et al., (2009) with eight themes: environment, energy, human resources, community involvement, products, sustainability, external relations and others. Each category is elaborated into a few items with 45 disclosure items in total, which are scored for both quantity and quality of CSR reporting.

Several control variables commonly found in the literature are included in the analysis. This study includes firm age, size, leverage, profitability and RPT disclosure as determinants of firm value and controls for industry and year fixed effects. The regression equations are described as follows:

$$\begin{aligned} FValue_{i,t+1} = {} & \beta_0 + \beta_1 RP\_Sales_{i,t} + \beta_2 RP\_Purchases_{i,t} + \beta_3 RP\_Rec_{i,t} + \beta_4 RP\_Pay_{i,t} + \beta_5 FAge_{i,t} \\ & + \beta_6 FSize_{i,t} + \beta_7 Lev_{i,t} + \beta_8 ROA_{i,t} + \beta_9 RPD_{i,t} + \beta_{10-16} Ind_{i,t} + \beta_{17} Year_{i,t} \\ & + \varepsilon \cdots\cdots\cdots\cdots\cdots\cdots \end{aligned} \quad (1)$$

$$\begin{aligned} FValue_{i,t+1} = {} & \beta_0 + \beta_1 RP\_Sales_{i,t} + \beta_2 RP\_Purchases_{i,t} + +\beta_3 RP\_Rec_{i,t} + \beta_4 RP\_Pay_{i,t} + \beta_5 CSRI_{i,t} \\ & + \beta_6 RP\_Sales * CSRI_{i,t} + \beta_7 RP\_Purchases * CSRI_{i,t} + \beta_8 RP\_Rec * CSRI_{i,t} + \beta_9 RP\_Pay \\ & * CSRI_{i,t} + \beta_{10} FAge_{i,t} + \beta_{11} FSize_{i,t} + \beta_{12} Lev_{i,t} + \beta_{13} ROA_{i,t} + \beta_{14} RPD_{i,t} + \beta_{15-21} Ind_{i,t} \\ & + \beta_{16} Year_{i,t} + \varepsilon \cdots\cdots\cdots\cdots\cdots\cdots .. \end{aligned} \quad (2)$$

where *FValue* = firm value as measured by Tobin's q and PBV; *RP_Sales* = the value of sales of goods and provision of services to related parties divided by total assets; *RP_Purchases* = the value of purchases of goods and receipt of services from related parties divided by total assets; *RP_Rec* = related party receivables divided by total assets; *RP_Pay* = related party payables divided by total assets; *CSRI* = CSR reporting as measured by observing a firm's CSR disclosure quantity (*CSRI_Quan*) and quality (*CSRI_Qual*); *FAge* = natural logarithm of the number of years since listing; *FSize* = natural logarithm of a firm's total market value of equity; *Lev* = total debts scaled by total assets; *ROA* = net income scaled by average total assets; *RPD* = RPT disclosure regarding terms and conditions, pricing policy and arm's length condition of RPTs.

4. Results

This section presents the data analysis, including the descriptive statistics and regression analysis. The final number of observations in the sample is 274 firm-year observations. The sample selection is described in Table 1.

4.1. Descriptive statistics

Table 2 provides a summary of the descriptive statistics of the variables. It shows that although loans provided to and given by related parties are less prevalent, related party sales transactions are common in firms

Table 1
Sample Selection.

Criteria	Number of Firms		Number of Observations
	2014	2015	
Firms listed on Indonesia Stock Exchange (IDX)	514	533	1.047
Less: Firms in the financial industry	(87)	(90)	(177)
Less: Firms with a different fiscal year	(6)	(6)	(12)
Less: Firms with a negative book value of equity	(18)	(20)	(38)
Less: Firms with incomplete data	(272)	(274)	(546)
Total	131	143	274

listed in Indonesia. The results also show that the market value of firms listed on the IDX is generally higher than their book value as indicated by the mean values of 1.7749 and 2.7771 for Tobin's q and PBV, respectively. Moreover, the results indicate that Indonesian firms may put more emphasis on CSR reporting quantity than CSR reporting quality; nevertheless, the disclosure of CSR is still not a common practice among firms, and therefore, CSR reporting by Indonesian firms is still relatively limited.

4.2. Main results

Table 3 presents the analysis of the influence of RPTs on firm value. The results show that the first hypothesis, which states that related party sales negatively influence firm value, is supported ($p < .01$ and $p < .05$, respectively). These findings are consistent with studies suggesting that related party sales are value destroying (e.g., Cheung et al., 2006, 2009). This implies that the market views related party sales figures to be less credible and such transactions to be opportunistic (Jian and Wong, 2004); therefore, the market responds negatively to RPTs.

Contrary to expectation, Hypothesis 1b, which predicts a positive influence of related party purchases on firm value, is not supported because the coefficients of related party purchases are not significant in either model. This implies that related party purchase transactions are not used by related parties to prop up listed firms. A possible explanation for this non-significance may be that as the last-in-first-out (LIFO) method is not allowed, related parties may prefer other methods, which may be more timely and efficient, to prop up listed firms (Jian and Wong, 2010).

In addition, the results show that Hypothesis 1c is not supported, as there is no statistically significant association between related party receivables and firm value, suggesting that the market does not discount firms with high related party receivables. This may be due to the nature of related party receivables, which contain all types of receivables, including loan receivables that may be perceived negatively and sales receivables that may signify an increase in earnings and market confidence in the collection of related party credits (Jiang et al., 2010; Utama and Utama, 2014). According to Wang and Ye (2014), receivables represent the reallocated resources of a firm, namely operational and non-operational reallocated resources. Whereas operational resources are derived from activities such as the sale of goods and services, non-operational receivables may arise from non-operating activities such as loans. Consequently, receivables generated from the sale of goods and services are viewed as part of a firm's normal operating activities; whereas other receivables are non-operational and are often used opportunistically. Therefore, the efficiency and expropriation effects of related party receivables may offset each other, leading to non-significant results.

Regarding H1d, the empirical results show that related party payables positively influence Tobin's q and PBV ($p < .01$); therefore H1d is supported. This is in line with Cheung et al. (2006) who suggest that related party payables are viewed as beneficial by the market. Hence, related party payables tend to have a value-enhancing effect.

The empirical results in Tables 4 and 5 show that the coefficients of the interaction terms between CSR reporting (quantity and quality) and *RP_Sales* on Tobin's q as well as PBV are significant at the 1% and 5% levels, respectively. Hence, Hypothesis 2a, which states that CSR reporting moderates the relationship between related party sales and firm value, is supported. This confirms the view that CSR reporting reflects

Table 2
Descriptive Statistics.

Variable	Data Type	Min.	Max.	Mean	Std. Dev.
RP_Sales	Ratio	0.0000	5.4671	0.1909	0.4436
RP_Purchases	Ratio	0.0000	2.3090	0.1487	0.3432
RP_Rec	Ratio	0.0000	0.4958	0.0434	0.0742
RP_Pay	Ratio	0.0000	0.9515	0.0541	0.1127
$Tobin_{t+1}$	Ratio	0.2268	18.6404	1.7749	2.3531
PBV_{t+1}	Ratio	0.0500	62.9311	2.7771	6.6006
CSRI_Quan	Ratio	0.0844	0.6089	0.2622	0.1032
CSRI_Qual	Ratio	0.0635	0.5556	0.2147	0.0873
FAge	Year	1	45	15	10
FSize	Mil. Rupiah	64,716	437,355,969	18,483,212	53,726,170
Lev	Ratio	0.0401	1.2486	0.5012	0.2070
ROA	Ratio	−0.2253	0.4470	0.0553	0.1011
RPD	Ratio	0	1.0000	0.4197	0.3090

N = 274. *RP_Sales*, *RP_Purchases*, *RP_Rec* and *RP_Pay* = firms' RPTs (sales, purchases, receivables and payables, respectively) scaled by total assets. Tobin = Tobin's Q. PBV = Price-to-book value. *CSRI_Quan* = CSR disclosure quantity. *CSRI_Qual* = CSR disclosure quality. *FAge* = natural logarithm of the number of years since listing. *FSize* = natural logarithm of a firm's total market value of equity. *Lev* = total debts scaled by total assets. *ROA* = net income scaled by total assets. *RPD* = disclosure regarding terms and conditions, pricing policy and arm's length condition of RPTs.

Table 3
RPTs and Firm Value.

Variable	Predicted Sign	Model 1		Model 2	
		Unstd. Coeff. B	*t*-Statistic (*p*-value)	Unstd. Coeff. B	*t*-Statistic (*p*-value)
(Constant)		−1.140	−8.925***	−1.909	−8.088***
RP_Sales	**–**	**−0.023**	**−2.926*** **	**−0.034**	**−2.274** **
RP_Purchases	+	−0.001	−0.196	0.001	0.113
RP_Rec	–	0.006	0.837	0.007	0.504
RP_Pay	**+**	**0.021**	**2.951*** **	**0.040**	**2.999*** **
FAge		**−0.035**	**−2.536*** **	**−0.068**	**−2.718*** **
FSize		**0.075**	**11.156*** **	**0.130**	**10.430*** **
Lev		**0.285**	**4.404*** **	**0.534**	**4.459*** **
ROA		**1.262**	**8.446*** **	**1.431**	**5.184*** **
RPD		−0.003	−0.064	0.001	0.018
Industry Dummy	Included			Included	
Year Dummy	Included			Included	
Adjusted R^2			0.598		0.508
*F*value			24.921		17.564
Sig. (F)			0.000		0.000
Dependent Variable	$Tobin_{t+1}$			PBV_{t+1}	

***, **, * indicate significance at the 0.01, 0.05 and 0.1 levels, respectively.

a firm's corporate values and ethical concerns (Garriga and Melé, 2004; Kim et al., 2012). As a result, firms with strong ethical values as reflected by high quantity and quality CSR reporting tend to have less opportunistic RPTs. However, we do not find support for the moderating effect of CSR reporting on the relationship between other types of RPTs on either firm value measure. Although the coefficients are generally positive, the results are not significant. Nonetheless, this may provide initial but mild support for the negative relationship between CSR reporting and abusive behavior. Overall, our findings suggest that on the basis of ethics, firms with better CSR reporting tend to engage in more responsible operating decisions. Therefore, such firms are less likely to engage in opportunistic and value-destroying transactions that may harm the interests of minority shareholders, but rather they engage in efficient (value-enhancing) transactions.

The empirical results also show that the control variables, namely, firm age (*FAge*), firm size (*FSize*), leverage (*Lev*) and profitability (*ROA*) affect both Tobin's q and PBV with *p*-values less than 1%. More specifically,

Table 4
RPTs, CSR Reporting Quantity and Firm Value.

Variable	Predicted Sign	Tobin		PBV	
		Unstd. Coeff. B	*t*-Statistic (*p*-value)	Unstd. Coeff. B	*t*-Statistic (*p*-value)
(Constant)		−1.071	−6.962***	−1.917	−6.663***
RP_Sales	**–**	**−0.420**	**−3.713*** **	**−0.505**	**−2.387*** **
RP_Purchases	+	0.001	0.112	−0.003	−0.163
RP_Rec	–	0.008	0.939	−0.000	−0.015
RP_Pay	**+**	**0.016**	**1.735****	0.042	**2.454*** **
CSRI_Quan	+/-	−0.230	−1.565	−0.492	**−1.791***
CSRI_Quan*RP_Sales	**+/-**	**0.866**	**3.198*** **	1.048	**2.069****
*CSRI_Quan*RP_Purchases*	+/-	−0.153	−0.602	0.050	0.106
*CSRI_Quan*RP_Rec*	+/-	0.230	0.242	1.017	0.573
*CSRI_Quan*RP_Pay*	+/-	0.697	1.011	0.110	0.086
FAge		**−0.034**	**−2.450*** **	−0.068	**−2.644*** **
FSize		**0.077**	**9.440*** **	0.137	**8.994*** **
Lev		**0.361**	**4.183*** **	0.660	**4.081*** **
ROA		**1.266**	**8.354*** **	1.378	**4.863*** **
RPD		0.003	0.067	0.003	0.034
Industry Dummy	Included			Included	
Year Dummy	Included			Included	
Adjusted R^2			0.600		0.498
F-value			19.637		13.299
Sig. (*F*)			0.000		0.000
Dependent Variable	$Tobin_{t+1}$			PBV_{t+1}	

***, **, * indicate significance at the 0.01, 0.05, and 0.1 levels, respectively.

Table 5
RPTs, CSR Reporting Quality and Firm Value.

Variable	Predicted Sign	Tobin		PBV	
		Unstd. Coeff. B	*t*-statistic (*p*-value)	Unstd. Coeff. B	*t*-statistic (*p*-value)
(Constant)		−0.747	−5.180***	−1.347	−4.966***
RP_Sales	**–**	**−0.436**	**−4.077*** **	**−0.527**	**−2.621*** **
RP_Purchases	+	0.002	0.255	0.000	0.009
RP_Rec	–	0.007	0.856	−0.001	−0.089
RP_Pay	**+**	**0.015**	**1.610***	**0.041**	**2.370*** **
CSRI_Qual	**+/-**	**−0.318**	**−1.804***	**−0.722**	**−2.181****
CSRI_Qual*RP_Sales	**+/-**	**1.054**	**3.468*** **	**1.267**	**2.217****
*CSRI_Qual*RP_Purchases*	+/-	−0.255	−0.828	−0.099	−0.170
*CSRI_Qual*RP_Rec*	+/-	0.815	0.660	2.049	0.882
*CSRI_Qual*RP_Pay*	+/-	1.101	1.290	0.575	0.358
FAge		**−0.032**	**−2.378*** **	**−0.065**	**−2.546*** **
FSize		**0.077**	**9.477*** **	**0.140**	**9.098*** **
Lev		**0.102**	**4.014*** **	**0.172**	**3.611*** **
ROA		**1.248**	**8.296*** **	**1.321**	**4.674*** **
RPD		0.006	0.163	0.013	0.175
Industry Dummy	Included			Included	
Year Dummy	Included			Included	
Adjusted R^2			0.602		0.495
F-value			19.765		13.157
Sig. (*F*)			0.000		0.000
Dependent Variable	$Tobin_{t+1}$			PBV_{t+1}	

***, **, * indicate significance at the 0.01, 0.05, and 0.1 levels, respectively.

firm age affects firm value negatively; whereas firm size, leverage and profitability affect firm value positively. This suggests that firms may become less valuable with age (Chay et al., 2015; Fauver et al., 2017). Moreover,

the market values larger firms more positively (Dang et al., 2017), perceives increased leverage as a signal of stability in future cash flows (Ararat et al., 2017; Kang et al., 2017) and values firms with better performance more highly (Xia, 2008; Chen et al., 2009). In contrast, the coefficients of RPD are insignificant, implying that RPD does not influence firm value.

5. Test of subsequent tunneling

Further testing examines whether RPTs are of a propping nature and indeed add real value to a firm or merely boost performance temporarily and, in turn, enable subsequent tunneling. Ying and Wang (2013) posit that although there is a motivation to support the long-term interests of listed firms, when firms engage in RPTs for short-term purposes, such as to obtain a refinancing qualification, subsequent tunneling may occur in the year after such propping. Moreover, although certain RPTs improve current performance, due to subsequent tunneling, firm performance significantly declines in the following year. This study follows Ying and Wang (2013) and uses a model to test whether RPTs represent temporary propping transactions and enable subsequent tunneling activities.

$$Tunnel_{i,t+1} = r_0 + r_1 Prop_{i,t} + State_{i,t} + \varepsilon \cdots\cdots\cdots\cdots \quad (3)$$

$Prop_{it}$ represents the possible propping (value-enhancing) transactions found in this study. $State_{it}$ is a control variable measured by a dummy variable that takes the value of 1 for state-owned enterprises and 0 otherwise. Following Ying and Wang (2013), who find that state-owned enterprises display significantly more subsequent tunneling behavior than non-state-owned enterprises, this study includes $State_{it}$ as a control variable. Similarly, Cheung et al. (2009) examine RPTs between state-owned Chinese firms and find that minority shareholders seem to be subject to expropriation through tunneling, negatively affecting firm value.

$Tunnel_{i,t+1}$ is a dummy variable derived from the residual term of Eq. (4), which indicates possible abnormal tunneling in the following period. As Eq. (3) considers only possible abnormal tunneling transactions, this study removes the normal components of RPTs that are associated with firm characteristics and industry classifications following Jian and Wong (2010, 84) and using the following regression equation.

$$Tunnel\_rate_{i,t+1} = r_0 + r_1 FSize_{i,t+1} + r_2 Lev_{i,t+1} + r_3 MBRatio_{i,t+1} + + r_j \sum Ind_{i,t+1} + r_j \sum Year_{i,t+1} + \varepsilon \cdots\cdots\cdots. \quad (4)$$

This regression model removes the normal components of RPTs by adding variables associated with firm characteristics and industry classifications, such as size as measured by the natural logarithm of total assets, leverage as measured by total debt over total assets and growth as measured by market-to-book equity. This study also adds industry and year dummy variables. $Tunnel\_rate_{i,t+1}$ represents the ratio of the following period's possible tunneling arising from the purchase of goods or assets, guarantees, mortgages and other projects that generate income for related parties (Ying and Wang, 2013).

The results in Table 6 show that the coefficient of *Prop* is positive and significant, suggesting that transactions that boost current performance may actually be subject to subsequent tunneling as pointed out by Ying and Wang (2013). Further, these results suggest that state-owned enterprises display more subsequent tunneling behavior. This provides an early indication that RPTs may be subject to subsequent tunneling after propping.

6. Sensitivity tests

We also performed sensitivity tests for possible fixed effects. We re-estimated the models controlling for individual firm and year fixed effects in each model. Table 7 reports the results for Model 1 (main effects), and Tables 8 and 9 report the results for Model 2 (moderating effects).

As shown in Table 7, *RP_Sales* is now positive but not significant ($p > .10$). *RP_Purchases* has a positive and marginally significant relation with Tobin's q ($\beta = 0.016$, $p < .1$), consistent with H1b. *RP_Receivables* shows a negative and marginally significant association with Tobin's q ($\beta = -0.015$, $p < .1$), in line with H1c. *RP_Payables* has a positive and significant association ($p < .001$) with both measures of firm value,

Table 6
Additional Analysis Result.

Variable		*B*	Sig.
Step 1[a]	Prop	0.252	0.001
	State	0.647	0.092
	Constant	0.100	0.770
Dependent	$Tunnel_{t+1}$		

***, **, * indicate significance at the 0.01, 0.05 and 0.1 levels, respectively.

Table 7
Regression Results for RPTs and Firm Value.

Variable		Tobin's q	PBV
(Constant)		1.925 (−8.235***)	−2.457 (−6.935***)
RP_Sales	–	0.018 (0.536)	0.047 (0.827)
RP_Purchases	+	0.016 (1.363*)	0.004 (0.179)
RP_Rec	–	−0.015 (−1.592*)	−0.016 (−0.925)
RP_Pay	**+**	**0.023 (2.482***)**	**0.040 (2.494***)**
Fage		−0.010 (−0.385)	0.016 (0.340)
Fsize		**0.136 (10.564***)**	**0.183 (8.111***)**
Lev		0.237 (1.373*)	0.003 (0.030)
ROA		0.254 (1.028)	−0.248 (−0.562)
RPD		−0.010 (−0.191)	−0.050 (−0.569)
Firm Fixed Effects		Included	Included
Year Fixed Effects		Included	Included
Adj. R^2		0.823	0.804
F-value		9.036	8.096
Sig. (*F*)		0.000	0.000

Presents results for RPT and firm value, with unstandardized coefficients B and *t*-statistics. ***, **, * indicate significance at the 0.01, 0.05 and 0.1 levels, respectively.

i.e., Tobin's q ($\beta = 0.023$, $p < .01$) and PBV ($\beta = 0.040$, $p < .01$), consistent with H1d. We re-run the model including each type of related party transaction (i.e., *RP_Sales*, *RP_Purchases*, *RP_Rec*, *RP_Pay*) separately and control for year and firm fixed effects. The results are similar. The result on *RP_Sales* differs from the main effect after controlling for firm fixed effects, indicating that there are other firm-specific factors that affect firm value that are not controlled in this study. For example, previous studies find that Indonesian firms with political connections are associated with higher firm value (Fisman, 2001). Further, Habib et al. (2017) argue that politically connected firms tend to engage more in abusive or opportunistic RPTs, which eventually affects firm value. Specifically, they find that politically connected firms in Indonesia are more likely to use related party loans to tunnel resources and to involve in earnings management. Furthermore, a study in the U.S. context finds that family firms are more likely to engage in RPTs and that their firm value premium tends to decline when they report RPTs, particularly opportunistic RPTs (Kohlbeck et al., 2018).

Hypotheses 2a-2d test the moderating effect of CSR reporting on the association between RPTs and firm value. We re-estimate Model 2 controlling for firm and year fixed effects. Tables 8 and 9 present the results for Eq. (2), considering CSR quantity and quality as moderating variables. The empirical results show that the associations between the interaction terms of CSR reporting (quantity and quality) and *RP_Purchases* with Tobin's q and PBV are significant at the 1% and 5% levels, respectively. The results for the moderating effects of CSR differ from the main effect after controlling for firm fixed effects, indicating that there are other firm-specific factors affecting firm value that are not controlled in this study, for example, political connections (Fisman, 2001; Habib et al., 2017) and family ownership (Kohlbeck et al., 2018).

Table 8
Regression Results for RPT, CSR and Tobin's Q.

Variable	CSR Quantity	CSR Quality
(Constant)	−1.565 (−7.635***)	−1.573 (−7.788***)
RP_Sales	0.018 (1.211)	0.017 (1.148)
RP_Purchases	0.027 (1.986**)	0.027 (2.053**)
RP_Rec	−0.011 (−0.909)	−0.013 (−1.029)
RP_Pay	0.016 (1.448*)	0.011 (0.994)
CSRI_Quan	0.475 (2.324**)	
*CSRI_Quan*RP_Sales*	−0.009 (−0.055)	
CSRI_Quan*RP_Purchases	**−1.449 (−3.428***)**	
*CSRI_Quan*RP_Rec*	0.315 (0.313)	
*CSRI_Quan*RP_Pay*	0.320 (0.346)	
CSRI_Qual		0.521 (2.272**)
*CSRI_Qual*RP_Sales*		0.007 (0.036)
CSRI_Qual*RP_Purchases		**−1.615 (−3.151***)**
*CSRI_Qual*RP_Rec*		0.606 (0.465)
*CSRI_Qual*RP_Pay*		0.847 (0.726)
FAge	−0.002 (−0.709)	−0.003 (−0.929)
FSize	**0.126 (9.586***)**	**0.124 (9.233***)**
Lev	**0.091 (1.835**)**	**0.077 (1.538*)**
ROA	**0.417 (1.518*)**	**0.456 (1.685**)**
RPD	0.033 (0.680)	0.018 (0.371)
Firm Fixed Effects	Included	Included
Year Fixed Effects	Included	Included
Adj. R^2	0.830	0.829
F-value	9.340	9.291
Sig. (*F*)	0.000	0.000

This table presents the results for RPT, CSR reporting quantity, CSR reporting quality and firm value, with unstandardized coefficients B and *t*-statistics. ***, **, * indicate significance at the 0.01, 0.05 and 0.1 levels, respectively.

7. Conclusion, implications and future research

This study provides evidence that concerns regarding RPTs being value destroying and value enhancing are warranted, particularly for certain types of RPTs. The results of all models show that related party sales transactions have a value-destroying effect. Further, we find that related party payables are positively related to both Tobin's q and PBV, suggesting that the market perceives loans or cash assistance provided to listed firms as beneficial. As certain RPTs are found to be abusive (value destroying), it is important that those transactions be reviewed and disclosed properly to ensure that such transactions are conducted in the best interest of stakeholders. Hence, to improve market confidence, regulators should pay more attention to the RPT types that tend to be abusive.

Further, this study provides evidence of moderating effects of both the quantity and quality of CSR reporting on the relationship between RPTs and firm value. Particularly, firms with high CSR reporting quantity and quality tend to have less abusive RPTs. Therefore, investors, policymakers and other stakeholders are encouraged to pay attention to both the quantity and quality of CSR reporting. More importantly, an assurance service and standard could be established to provide guidance for the preparation of CSR reports and to ensure the credibility of a firm's CSR reporting.

This study has several limitations and hence suggestions for future studies are offered. First, the main results differ slightly when individual firm fixed effects are included in the model. As presented in the sensitivity tests section, the statistical results show that firm value is positively influenced by related party purchases and payables, suggesting that these transactions have value-enhancing effects. In addition, firm value is negatively influenced by related party receivables, indicating a value-destroying effect. However, there is no support for

Table 9
Regression Results for RPT, CSR and PBV.

Variable	CSR Quantity	CSR Quality
(Constant)	−2.240 (−6.274***)	−2.256 (−6.441***)
RP_Sales	0.052 (1.978**)	0.049 (1.876**)
RP_Purchases	0.011 (0.477)	0.014 (0.599)
RP_Rec	−0.023 (−1.048)	−0.025 (−1.146)
RP_Pay	0.021 (1.080)	0.014 (0.720)
CSRI_Quan	**0.746 (2.097**)**	
*CSRI_Quan*RP_Sales*	−0.099 (−0.345)	
CSRI_Quan*RP_Purchases	**−1.306 (−1.774**)**	
*CSRI_Quan*RP_Rec*	−0.115 (−0.065)	
*CSRI_Quan*RP_Pay*	1.232 (0.764)	
CSRI_Qual		0.817 (2.055**)
*CSRI_Qual*RP_Sales*		−0.074 (−0.222)
CSRI_Qual*RP_Purchases		**−1.493 (−1.681**)**
*CSRI_Qual*RP_Rec*		0.247 (0.109)
*CSRI_Qual*RP_Pay*		2.257 (1.116)
FAge	−0.005 (−0.891)	−0.005 (−0.994)
Fsize	**0.168 (7.357***)**	**0.165 (7.118***)**
Lev	0.083 (0.951)	0.060 (0.695)
ROA	0.241 (0.504)	0.278 (0.592)
RPD	0.018 (0.219)	0.002 (0.020)
Firm Fixed Effects	Included	Included
Year Fixed Effects	Included	Included
Adj. R^2	0.815	0.816
F-value	8.522	8.557
Sig. (*F*)	0.000	0.000

related party sales. In addition, robustness tests support the negative moderating effect of CSR on the association between related party purchases and firm value. These different results, compared with the main effects, indicate that there are other firm-specific variables that explain the dependent variables. A future study could consider other firm-specific factors such as political connections (Fisman, 2001; Habib et al., 2017) and family control (Kohlbeck et al., 2018) as explanatory variables. Second, this study only considers related party sales, purchases, receivables and payables. Therefore, future studies could consider other types of RPTs or break the RPT categories examined in this study into more detailed components. Further, future studies could explore other possible determinants of opportunistic RPTs, such as the risk of expropriation arising from a firm's ownership structure, corporate governance and financial constraints. Last, this study provides an early indication of the occurrence of tunneling after propping; future studies could further confirm this indication.

Declaration of Competing Interest

The authors declared that there is no conflict of interest.

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