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Stock transferability, the managerial learning effect and corporate innovation

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ABSTRACT

This paper considers stock halts to study the impact of stock liquidity loss on the managerial learning effect based on stock prices. We examine stock halts' impact on corporate innovation and find that discretionary halts hinder innovation. We also find that discretionary halts reduce information quality and increase financial constraints and agent costs. Cross-sectional tests show that this negative impact is more pronounced in samples with high shareholding ratios by large shareholders, institutional investors and private firms. The results indicate that the loss of non-institutional stock trading rights, represented by discretionary stock halts, affects revelatory price efficiency in the secondary market, hinders managers' learning effect and affects enterprises' production and operation decisions. These findings have policy implications for stock circulation-right protection and Chinese capital-market reform.

1. Introduction

Stock price changes absorb a large amount of transaction information in the market, and they thus play an information transmission role. Bond et al. (2012) distinguish traditional stock price efficiency into forecasting price efficiency and revelatory price efficiency. The more effective the secondary market RPE (revelatory price efficiency) is, the more new information managers can learn from it, which affects managers' entity decisions—that is, managers have a learning effect based on the secondary market (Edmans et al., 2017; Goldstein et al., 2023). A large number of studies confirm the important role of managers' stock-price-based learning effect in corporate investment decisions. For example, Chen et al. (2007) find that managers adjust their investment

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decisions based on information learned from changes in the company's own stock price. Ozoguz and Rebello (2013) confirm that corporate decision-making refers to the information conveyed by peer stock prices. Foucault and Fresard (2014) further clarify the substitutionary relationship between the company's own stock price and peer stock prices in managers' decisions, and Feng and Chen (2021) obtain a consistent conclusion using Chinese data. However, secondary market RPE is affected by market liquidity. For example, Ye et al. (2023) find that a reduction in tick size significantly increases RPE and thereby enhances managers' learning effect on stock prices. This paper examines whether stock trading barriers impair the efficiency of secondary market stock prices in absorbing and integrating new information (revelatory price efficiency), thereby impairing managers' substantive decision-making. Different from Ye et al. (2023), who focus on continuous changes in secondary market liquidity, we consider the discontinuous changes in secondary market liquidity caused by trading halts, that is, the possible impact of the suspension and lack of liquidity. Stock trading is a process of continuous absorption and release of information. Investors can obtain the information contained in stock prices by observing stock price changes and then continuously adjust their investment decisions (Grundy and McNichols, 1989; Dow and Gorton, 1993; Zhu et al., 2007; Zuo, 2016). Discretionary halts artificially interrupt stock trading, depriving traders of learning opportunities, thereby damaging the transmission of market information and producing negative consequences—that is, hindering the so-called "learning by doing" mechanism. However, a temporary suspension of trading gives investors a certain amount of time to collect and digest important information, react quickly to new information, reconsider their buying and selling decisions and accelerate the process of forming a new equilibrium price in the market (Corwin and Lipson, 2000). Stock halts may have positive influences by accelerating price discovery and reducing information asymmetry and trading uncertainty, which is the so-called "cooling off" effect. Therefore, it is an empirical question whether the decline in liquidity caused by the suspension of stock trading harms the RPE of the stock price and thereby affects the managers' learning effect. In view of the continued development of China's capital market and the fact that the relevant legal system is still changing and improving, the phenomenon of listed companies' discretionary halts is becoming more frequent, which provides valuable research data for our study. In addition, the China Securities Regulatory Commission has issued policies that provide us with additional opportunities to examine the role of supervision. To this end, we take the relatively common phenomenon of discretionary halts in China's capital market as an entry point to study the impact of stock liquidity damage on RPE and manage's learning effects.

The circulation of stocks in the secondary market is the main way that shareholders transfer control rights and obtain capital gains. It is also the basis for ensuring that stock prices accurately and timely reflect market information. However, because of such reasons as system design and business needs, there are varying degrees of stock circulation rights damage in the capital market, which can be divided into institutional stock circulation rights losses, represented by equity splits, and restricted shares and non-institutional stock circulation rights losses, represented by stock suspensions and stock buybacks. The former, limited to the period during which the policy is implemented, mandatorily restricts part of shareholders' circulation rights. However, the latter may occur at any time and affect all shareholders, and listed companies have certain decision-making rights regarding whether their stocks are tradable. Trading suspension systems are common in capital markets around the world. According to statistics, between 2012 and 2015, Nasdaq and the New York Stock Exchange accounted for 97 % of the days where trading was suspended more than five times. Similar to the U.S. market, in China's capital market, stock halts are mainly stipulated in the Stock Listing Rules of the Shanghai Stock Exchange and Shenzhen Stock Exchange under the guidance of the China Securities Regulatory Commission, and are supplemented by supplementary guidance documents. The Listing Rules mainly regulate the triggering conditions, suspension operations and resumption requirements of exchange-led punitive trading suspensions, where most of the content is aimed at the irregularities of listed companies, and the guidance document mainly regulates the suspension conditions of trading halts applied by listed companies on their own, involving major matters, as well as the main person responsible and the process for implementing the trading halts. However, different from the U.S. capital market, China's exchanges have limited restrictions on listed companies, so companies have great decision-making power regarding stock suspensions. The suspension phenomenon in China's capital market features multiple times, long durations and low compliance with information disclosure during suspension periods (Duan and Huang, 2003; Shi et al., 2019; Luo et al., 2020).

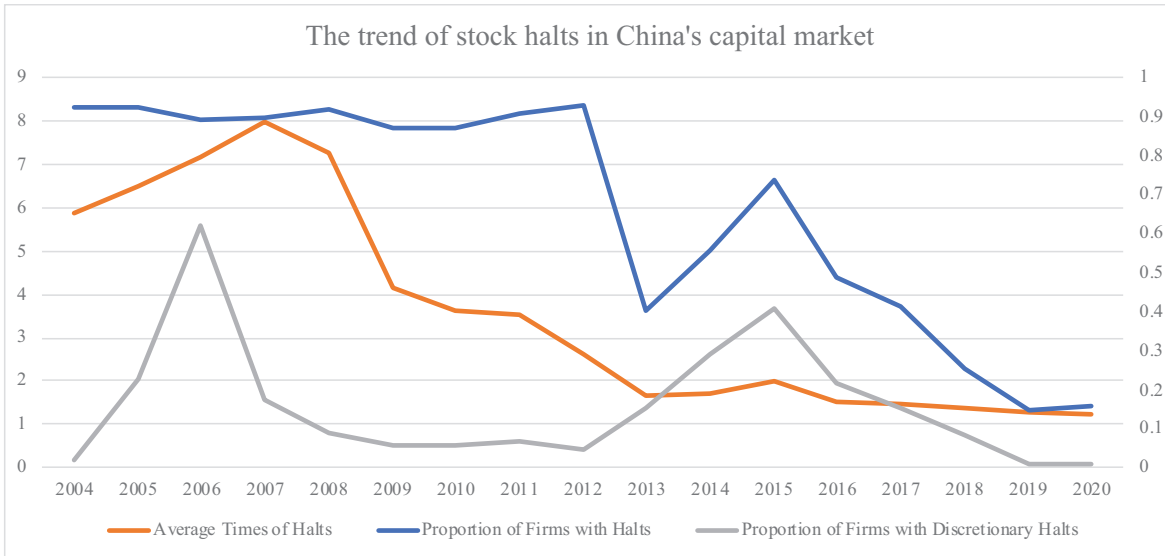

Fig. 1. Annual Trends of Stock Halts in China's Capital Market.

As Fig. 1 shows, since 2007, with the gradual cancelation of routine stock halts for reasons such as the publication of regular reports, the number and proportion of company trading halts have continued to decline. In 2012, the Shanghai and Shenzhen Stock Exchanges further tightened the trading suspension policy on the basis of the original rules, canceling routine stock halts on abnormal fluctuations, temporary reports and shareholders' meetings. Listed companies will only be suspended if they fail to disclose regular reports on time or if there are abnormalities in the shareholders' meeting. Therefore, the proportion of listed companies suspended from trading and the average number of trading halts have both decreased significantly. With the development of China's capital market and the increase in the complexity of the business of listed companies, the use of trading suspension tools has increased. At the same time, different from normal stock halts, numerous suspension anomalies have emerged, such as the abuse of suspension rights, arbitrary applications for suspension, delays of the resumption of trading and insufficient information disclosure during the suspension period. The proportion of companies with discretionary stock halts has increased year by year since 2012, reaching a peak in 2015. In 2016, based on a summary of the experience of existing trading suspension regulations, the Shanghai and Shenzhen Stock Exchanges issued guidance documents on trading suspension and resumption policies, further standardizing listed companies' applications for trading suspension and resumption and subsequent information disclosure. As a result, the times and duration of stock halts by listed companies, especially discretionary stock halts, have been reduced.

The original intent of the trading suspension system is to give investors a certain amount of time to collect and digest important information to protect the interests of information-vulnerable groups. However, because of some unreasonable and inadequate conditions in the design and implementation of the trading suspension system itself, the frequent discretionary stock halts in China's capital market have unreasonably damaged the stock circulation rights of shareholders and caused a temporary lack of stock liquidity. This major event in the secondary stock market has also attracted the attention of the international capital market. Compared with the average suspension ratio of 0.2 % in the MSCI market index, the suspension ratio in China's A-share market has reached 10 %, which has also led companies' liquidity risk and traceability issues triggered by stock halts to become key concerns in the process of China's A-shares entering the MSCI index. MSCI explicitly requires the A-share market to undergo rectification before being included in the emerging market index. Furthermore, after this process, any company that suspends trading for more than 50 days will be removed from the index. Thus, this much-criticized phenomenon of discretionary stock halts has become a major obstacle to the internationalization of China's capital market (MSCI, 2016; 2017). Therefore, it is urgent to accurately and systematically evaluate the economic consequences of the trading suspension system that has been in effect

for decades (Hu et al., 2017). However, most studies use micro-trading data to directly examine the impact of trading suspension events on the structure of stock trading micro markets from a financial perspective, and they find that China's trading suspension system seriously damages the liquidity of stocks and leads to increased stock price volatility (Liao et al., 2009; Hu et al., 2017). This paper considers whether the temporary loss of stock circulation rights caused by discretionary stock halts has a real impact on the daily production and operation of listed companies. Solving this problem helps us comprehensively evaluate the implementation effect of the stock trading suspension system and better understand the important role that stock circulation rights play in the operation of the capital market, especially the impact on the revelatory price efficiency of the secondary market and managers' learning effect based on stock prices.

Innovation is a powerful weapon for enterprises to survive in the complex and ever-changing international market environment, and it is also an important driver of national development and social progress (Porter, 1992; Fan et al., 2008). Innovation has been especially important during the crisis period of the COVID-19 outbreak. For example, the 2020 Government Work Report clearly stated that major breakthroughs must be achieved in core areas in the spirit of "sharpening a sword for ten years". The 20th National Congress of the Communist Party of China again emphasized the need to adhere to the core position of innovation in China's overall modernization drive, enhance the overall effectiveness of the national innovation system and form an open innovation ecosystem that is globally competitive. However, innovation investment is characterized by high investment risk, delayed returns and strong information asymmetry, and it is a discretionary investment with high fluctuations within enterprises. This paper examines how the discretionary stock halts of listed companies affect corporate innovation investment decisions, and it explores the cumulative effect of improper trading suspensions that unreasonably damage stock circulation rights, specifically the impact on the long-term value of enterprises.

This paper selects data from A-share non-financial companies listed on the Shanghai and Shenzhen Stock Exchanges from 2007 to 2020 to examine the impact of discretionary stock halts on corporate innovation investment decisions. We find that the more frequently a listed company discretionarily suspends trading, the lower its R&D investment and innovation output. We also find that, first, discretionary stock halts reduce the quality of corporate information, increase the difficulty of managers' work and make it difficult for decision-makers to identify innovative projects with development prospects. Second, discretionary stock halts worsen the information environment, causing external investors to face a greater degree of information asymmetry. As a result, external investors increase their requirements for returns, leading to greater financial constraints on corporate innovation. Third, discretionary stock halts intensify managers' concerns about future career development, generate higher agency costs and cause insiders to pay less attention to innovation, making innovations difficult to implement effectively. Cross-sectional tests reveal that the impact of discretionary stock halts on corporate innovation is more significant in samples with higher shareholding ratios of major shareholders, non-state-owned enterprises and lower ratios of shareholding by institutional investors, indicating that because of discretionary stock halts, stronger motivations and capabilities for tunneling by major shareholders, weaker protection mechanisms for innovation projects and a weaker supervisory role of external investors contribute to more serious damage to corporate innovation. On this basis, this paper examines the policy effect of the guidance documents issued by the Shanghai and Shenzhen Stock Exchanges in 2016 and finds that with the implementation of the policy to generally restrict discretionary stock halts, the negative effects of discretionary stock halts on corporate innovation become more prominent because the guidance document establishes a public notification system for discretionary stock halts, making it easier for external stakeholders to identify and respond to corporate violations. This research shows that the loss of non-institutional stock circulation rights, specifically the phenomenon of discretionary stock halts, reduces revelatory price efficiency, hinders managers' learning effect based on stock prices, has a real impact on the production and operation decisions of the company's product market and damages opportunities for firms' long-term value growth.

This paper makes the following contributions to the literature. First, we enrich the research on the revelatory price efficiency of the secondary market. Most of the discussions on secondary market RPE and managers' learning effect based on stock prices assume the free circulation of stocks (Chen et al., 2007; Zhu et al., 2007; Ozoguz and Rebello, 2013; Feng and Chen, 2021), ignoring the reality that stock trading may be affected by the loss of institutional and non-institutional stock circulation rights. We start from the frequent

phenomenon of discretionary stock halts in China's capital market and explore whether the suspension and lack of stock liquidity, especially discontinuous changes in liquidity, damage the efficiency of the secondary market's stock price in absorbing and integrating new information, thereby damaging managers' entity decisions. We find that compared with the "cooling off period" effect, stock halts have a dominant impact through "learning by doing" mechanism, especially in the case of discretionary stock halts, which has a real impact on the decision-making of managers, investors and other stakeholders. This also reminds readers that when examining the revelatory price efficiency of the capital market, they should first pay attention to the status of stock circulation rights. It also provides a deeper understanding of the impact of revelatory price efficiency on the decision-making of various market transaction participants.

Second, we supplement the research on the economic consequences of stock circulation rights losses. Prior studies primarily focus on the institutional losses of stock circulation rights, such as share splits, restricted shares of major shareholders and senior executives and their impact on corporate governance and capital market development (Jian and Wong, 2010; Jiang et al., 2010; Zhang and Xu, 2017). However, there are certain differences between institutional and non-institutional stock circulation rights losses. Institutional stock circulation rights losses will disappear with the change to the system. Therefore, studies on such situations have certain limitations in both the time and policy dimensions, but non-institutional stock circulation rights losses, examined in this paper, exist in all markets and at all stages, and their scope of effect is wider, which means that studies and policy recommendations related to non-institutional stock circulation rights losses are more valuable and universal. In addition, institutional stock circulation rights losses only affect some stockholders. For example, in the case of equity splits, non-tradable shareholders bear more systemic risks. However, the loss of non-institutional stock circulation rights affects all stockholders. When transactions are interrupted, no shareholder can perform market operations of buying or selling. In view of the uniqueness of the loss of non-institutional stock circulation rights and the fact that its economic consequences have received less attention in academic research, we start from the phenomenon of discretionary stock halts and explore the real impact of non-institutional losses of stock circulation rights on daily corporate production and operation decisions, thus expanding our understanding of the economic consequences and the important role of stock circulation rights. This paper also expands the research boundaries on the economic consequences of stock halts, especially discretionary stock halts. The literature treats a trading halt as an event and examines the impact of stock halts on investors from the perspective of secondary market transactions. Such studies evaluate the short-term effects of the implementation of the trading suspension policy (Liao et al., 2009; Shi et al., 2019) but give less attention to the economic consequences of discretionary stock halts. We focus on real effects and examine the impact of discretionary stock halts on corporate innovation, which enables us to more comprehensively examine the economic consequences of stock halts and the cumulative effect of improving the suspension policy from a long-term perspective.

Third, this paper expands the research on the determinants of corporate innovation. Most of the literature focuses on internal factors such as the capital and governance structure of enterprises, as well as external factors such as institutional changes and the macro environment, with particular attention to the impact of enterprises' resource acquisition and policy implementation effectiveness on innovation input, output and efficiency. Some studies examine the impact of liquidity on corporate innovation from the perspective of secondary market stock trading (Fang et al., 2014; Wen et al., 2018); however, they mainly focus on the impact of different levels of liquidity on corporate decision-making under the assumption of freely tradable stocks. Moreover, there is currently no consensus on whether increased stock liquidity leads to an increase or decrease in corporate innovation. Increased stock liquidity may enhance corporate innovation by introducing long-term strategic investors and accelerating privatization, or it may stifle innovation by introducing hostile takeovers and inactive institutional investors. We focus on the impact of severe liquidity losses caused by stock trading suspensions on corporate innovation, thus providing a useful contribution to the literature on liquidity based on market micro-data. We find that when the stock price revelation efficiency decreases, discretionary stock halts can serve as a dominant signal to help stakeholders with weak information identify insiders' possible opportunistic behaviors and then make timely decision adjustments to protect their interests. The identification of this explicit signal will also help the government and regulatory agencies to further restrict corporate misconduct and ensure the role of enterprise innovation in supporting national economic development.

The remainder of the paper proceeds as follows. Section 2 reviews the literature and develops the research hypotheses. Section 3 presents the research design and sample selection. Section 4 presents the empirical results, including the main results, robustness tests, endogeneity tests, channel tests, cross-sectional tests and additional tests. Section 5 concludes the paper.

2. Literature review and hypothesis development

2.1. Economic consequences of stock halts

Stock halts, an important transaction stabilization mechanism in the capital market, are the temporary suspension of stock trading by listed companies or exchanges/regulatory authorities before a company is about to release important news or when there is an extreme imbalance in buy and sell orders. The direct results are that stock circulation rights are restricted and shareholders cannot conduct any buying or selling market operations (Hu et al., 2017). Freely trading stock in the secondary market is a process of information exchange and transmission. Therefore, the loss of stock circulation rights hinders the transmission of stock price information, reduces revelatory price efficiency and reduces the information transparency of enterprises. Stock trading is a process of continuous absorption and release of information, as investors can obtain the information contained in stock prices by observing stock price changes and then continuously adjust their investment decisions (Grundy and McNichols, 1989; Dow and Gorton, 1993; Zhu et al., 2007; Zuo, 2016), which is the so-called "learning by doing" mechanism. Artificial interruptions in stock trading deprive traders of learning opportunities, thereby impairing the transmission of market information. Fong (1996) compares the liquidity differences between suspended and unsuspended stocks on the New York Stock Exchange and finds that the trading volatility within two hours after resumption is significantly greater for suspended stocks than for unsuspended stocks. In addition, suspension causes abnormal stock fluctuations, and it can take 20 trading days for abnormal returns to recover (Gerety and Mulherin, 1992). Chen et al. (2016) and Hu et al. (2017) both use the cancelation of abnormal fluctuation suspension as a natural experiment to test the effectiveness of the trading suspension system. They find that stock halts cause an excessive reaction in the prices of minority board stocks. The trading suspension system seriously damages the liquidity of the stock and leads to an increase in stock price volatility. In addition, a temporary suspension of trading gives investors a certain amount of time to collect and digest important information and react quickly to new information, reconsider their buying and selling decisions and accelerate the formation of a new equilibrium price (Corwin and Lipson, 2000). Stock halts may have positive impacts by accelerating price discovery and reducing information asymmetry and trading uncertainty, which is the so-called "cooling off" effect. Liu and Zhang (2012) argue that stock halts shorten the time for stock prices to be affected by rumors and remind investors to pay attention to the content of announcements so that clarifications have better effects. Li et al. (2018) find that abnormal fluctuations and trading suspensions extend the market clearing time interval and improve price discovery efficiency, especially for stocks with a higher degree of information asymmetry, and reduce the liquidity risk of stocks with higher noise trading risks.

Different from the rational use of trading tools in developed capital markets, the suspension mechanism in China provides companies with a significant degree of operational flexibility. It is common for listed companies to use trading suspension tools arbitrarily, which is manifested in more trading suspensions, longer suspension periods and inadequate information disclosure (Duan and Huang, 2003; Luo et al., 2020). Compared with normal trading suspension, discretionary stock halts more severely limit trading rights and cause loss of trading time. Discretionary stock halts also raise concerns regarding information disclosure, as they could serve as a protective shield for managers and major shareholders to pursue personal gains. At a deeper level, discretionary stock halts may signify a fundamental distinction in the motives behind corporate decision-making compared with normal suspensions. Therefore, discretionary stock halts may be more harmful than normal trading suspensions. However, there is still a lack of discussion on the impact of discretionary stock halts on secondary market transactions, corporate decision-making behaviors and stakeholder response methods. Wu et al. (2013) find that controlling shareholders engage in tunneling through stock suspension manipulation before private placements. Shi et al. (2019) are the first to distinguish trading suspension behaviors, and they use an event study approach to discuss the negative impact of discretionary stock halts on investor

wealth. They find that discretionary stock halts create opportunities for insiders to seek personal gain, resulting in a significant reduction in investor wealth. Further research reveals a higher probability of accounting restatements during discretionary stock halts. Yu and Fang (2020b, 2022) examine the impact of discretionary stock halts on the decisions of corporate external stakeholders from the perspectives of auditors and analysts. They find that discretionary stock halts worsen the information environment, reducing the number of analysts following and increasing the error and divergence of analysts' forecasts. Additionally, discretionary stock halts raise the audit risk, prompting auditors to demand higher risk compensation for their services.

2.2. Determinants of corporate innovation

R&D is an important investment channel for companies. The development of new products and technologies helps companies build technical barriers, gain or maintain competitive advantages in fierce market competition and enhance their long-term profitability. Because of characteristics such as high information asymmetry, high investment risk and delayed returns, enterprise innovation exhibits significant volatility in both investment and output. Only when an innovation project is of high quality and accurately identified, the material and financial resources required for R&D are sufficient and the implementation process is effectively supervised can innovation investment achieve positive results.

Financial constraints and agency problems are important factors that affect corporate innovation. From the perspective of financial constraints, research suggests that it is difficult for firms to obtain stable external financing for corporate innovation, and they rely primarily on internal funds (Himmelberg and Petersen, 1994; Brown et al., 2009). The first reason is that R&D investment needs a large scale of financing with a long period of capital occupation. The second reason is that because of the high uncertainty of R&D output, the success of R&D and the market recognition of innovation output cannot be controlled in advance. The third reason is that the information asymmetry of innovation projects may cause adverse selection and moral hazard. To protect proprietary technology, companies disclose little R&D-related information, and as a result, external stakeholders can obtain relatively little information (Liu et al., 2015). Insufficient funding to meet innovation needs can limit a company's R&D capabilities, ultimately harming the development of the national economy (Zhang et al., 2012). Benfratello et al. (2008) and Brown et al. (2009) respectively find that the development of the banking industry and the entry of venture capital in the company's location can prompt companies' R&D investment. Ma et al. (2014) find that stable external financing channels, measured by whether the company obtains bank credit and the size of the credit line, help the company to increase innovation investment. Brown et al. (2012) find that a greater amount of financing stimulates firms' innovation investment and that the development of financial markets can ease corporate financial constraints, which increases corporate innovation. Li and Zheng (2016) and Yu and Fang (2020a) study the impact of government actions on corporate innovation and find that industrial policies, government subsidies and "national team" shareholdings play roles in easing the internal financial pressure of enterprises, which increases their R&D investment.

From the perspective of the principal–agent problem, business owners pay attention to their company's long-term development, so they do not hesitate to increase R&D investment to consolidate or enhance the company's market position through the advent of new technologies and products. When managers face short-term performance pressure, they may try every means to boost short-term gains, which weakens their commitment to the long-term plans set by shareholders. They may reduce investment in innovation to maximize their personal benefits. Therefore, effective incentives and supervision of managers are crucial safeguards for corporate innovation (Balkin et al., 2000). Studies consider the impact of managers' incentives on R&D from the perspectives of executives' monetary compensation (Li and Song, 2010), equity incentives (Bizjak et al., 1993) and incentive structures (Mehran, 2005). They find that increasing salary improves the rationality of managers' R&D decision-making and adopting equity incentives plays a better role of encouraging. Tolerance of managers' short-term failure and affirmation of long-term value can prompt managers to increase innovation investment (Manso, 2011). The board of directors' design of executive compensation contracts also affects innovation expenditures on corporate short-term performance. When managers are about to step down and corporate earnings decrease or become negative, executive compensation and R&D investment are significantly positively correlated. Directly linking salaries to R&D expenditures encourages managers to actively innovate (Cheng, 2004). At the same time, accurate R&D accounting improves the transparency of informa-

tion related to corporate innovation, helps the board of directors assess the true extent of managers' efforts and reduces the likelihood of managers' salary reduction or even dismissal because of short-term substandard performance (Bushman and Smith, 2001); thus, managers will be more motivated to innovate (Zhong, 2018). In terms of supervision, firms with larger institutional investors' shareholdings, more analysts following and higher-level auditors with stronger information acquisition and analysis capabilities are better able to rationally evaluate the decision-making quality of managers, strengthen external supervision, effectively restrain managers' short-sighted behavior and promote corporate innovation (Chung and Kallapur, 2003; Cheng, 2006; Chen et al., 2017). To enhance corporate enthusiasm for innovation, the government also constrains insiders' behavior through administrative regulations to ensure the effective implementation of innovation, and it protects the exclusivity of innovative outputs through legislative procedures such as patent protection (Yu et al., 2016; Bloom et al., 2019).

2.3. Discretionary stock halts and corporate innovation

R&D is an important discretionary investment for enterprises. Whether innovation projects are feasible, innovation resources are sufficient and innovation projects can be approved are important factors that affect corporate investment in innovation. Studies find that higher information quality, lower financing constraints and lower agency costs can increase corporate innovation (Li and Song, 2010; Brown et al., 2012; Foucault and Fresard, 2014). However, discretionary stock halts temporarily suspend the circulation rights of stocks, reduce revelatory price efficiency, hinder information transmission through stock price changes and weaken the supervisory role of external investors and other stakeholders. This leads to more opportunistic motives and behaviors among insiders, significantly harming the interests of minority shareholders. Within this decision framework, investment decisions related to innovation, which are closely tied to a company's competitive position in the product market, are likely to be impacted.

First, discretionary stock halts worsen the corporate information environment, making it difficult for decision-makers such as investors and managers to accurately identify R&D projects. Discretionary stock halts result in a certain degree of information loss. The suspension of stock trading reduces revelatory price efficiency, disrupting the channels through which investors and managers obtain information based on stock price changes. This in turn diminishes the decision-relevant information available to stakeholders (Chen et al., 2007; Zuo, 2016). Discretionary stock halts are also usually accompanied by insufficient information disclosure during the suspension period, which directly affects the amount of information available to stakeholders (Shi et al., 2019). Furthermore, discretionary stock halts increase the service costs for analysts, auditors and other information intermediaries and financial report certifiers. As rational economic agents, they may choose to discontinue following or supervising companies that engage in discretionary stock halts. This exacerbates the lack of information quantity and quality (Yu and Fang, 2020b; 2022). The opaque information environment makes it difficult for investors, especially external investors represented by institutional investors, to accurately assess the true value of a company's innovation projects. This can lead to erroneous influences on the company's decision-making direction. Additionally, discretionary stock halts hinder the transmission of information through stock prices, making it difficult for managers to make timely assessments of the market's recognition of their R&D projects (Chen et al., 2007). Consequently, they may be unable to adjust their innovation investment decisions in a timely manner, potentially leading to the abandonment of high-quality research and development projects. The reduction in stock price information efficiency also affects the effectiveness of management decision-making information sets, making it challenging for managers to accurately identify investment opportunities (Bushman and Smith, 2001). This can result in decreased investment efficiency (Chen et al., 2012) or even lead to overinvestment (McNichols and Stubben, 2008). In addition, to comply with major shareholders' decision to engage in asset stripping, managers need to use appropriate means to evade regulatory scrutiny and potential penalties and to attempt to conceal any violations related to discretionary stock halts. This increases managers' workload and difficulty. With limited resources and attention, managers may find it challenging to address complex innovative research and development issues. As a result, they are unable to fully assess the actual value of innovation projects, which compromises the scientific and rational nature of decision-making (Kaplan, 2008; Chemmanur et al., 2019), leading to a decline in corporate innovation.

Second, discretionary stock halts exacerbate corporate financial constraints and inhibit corporate innovation. From the perspective of internal funds, internal sources of funding are the main contributors to R&D investment because of the high uncertainty associated with innovation (Brown et al., 2012). However, discretionary stock halts lead to more opportunistic self-interested behavior by insiders, resulting in the inevitable diversion of funds that are required for the normal production and operational decisions of the company, which ultimately leads to insufficient investment in innovation. From the perspective of external financing, discretionary stock halts have adverse effects on the information environment of a company, leading to increased information asymmetry for external investors and higher demands for investment returns. This raises the cost and difficulty of equity financing for the company. There are two main reasons for this. The first is that discretionary stock halts cause unjustifiable losses of normal trading time, resulting in temporary liquidity disruptions that hinder the communication and transmission of information contained in stocks. This reduces revelatory price efficiency, directly depriving investors of the opportunity to learn about the true situation of the company through stock prices. Consequently, both the quantity and quality of information obtained by investors are compromised (Grundy and McNichols, 1989; Dow and Gorton, 1993; Zhu et al., 2007; Chen et al., 2007). As a result, investors are unable to make timely adjustments to their investment decisions, and their investment returns are significantly impacted. The second reason is that discretionary stock halts are often accompanied by insufficient information disclosure, leading information intermediaries, such as analysts, to stop following the suspended companies (Yu and Fang, 2022). This exacerbates the information deficiency, making it challenging for investors to reasonably anticipate investment returns and decreasing their investment willingness. Stable investments for corporate innovation become difficult to secure (Hall, 2002). Additionally, investors may demand higher returns in the initial stages of investment, leading to an increase in the cost of equity for the company. Ultimately, this hampers the effective assurance of funds required for corporate innovation. In addition, discretionary stock halts can lead to stricter terms and higher costs for corporate debt financing. As the system for stock trading suspensions continues to improve, the disclosure mechanism for discretionary stock halts makes it easier for external stakeholders to observe a company's violations and impose corresponding penalties. Considering the asymmetry of benefits, creditors pay greater attention to negative information about the company (Ye et al., 2010). To protect their own interests, creditors are more likely to impose higher loan requirements and to demand greater risk compensation from companies that have been discretionarily suspended (Liu and Chen, 2018). As a result, the cost of debt financing increases. Additionally, to avoid triggering default clauses, the fluctuation range of key performance indicators for the company's main operations becomes more limited. This may lead to a reduction in innovation expenses that can affect short-term performance. The increased difficulty and cost of both equity and debt financing impose more severe financing constraints, ultimately leading to decisions to reduce R&D investments (Zhang et al., 2012). Insufficient innovation funding will also have a negative impact on the company's innovation output.

Finally, discretionary stock halts signify a more severe principal–agent problem, leading to a lesser emphasis on innovation by decision-makers and difficulties in effectively implementing innovation projects. Studies focus on the impact of discretionary stock halts on the decision-making of corporate insiders and find that major shareholders conspire with managers to use discretionary stock halts to embezzle the interests of minority shareholders (Yu and Fang, 2021). Therefore, from the perspective of the second type of agency problem, discretionary stock halts cause corporate insiders to prioritize the accumulation of personal wealth, increasing the likelihood of opportunistic manipulations. This may lead to insiders making unscientific decisions and reducing their focus on investment projects related to the long-term value growth of the company, resulting in insufficient investment in corporate innovation and reduced innovation output. From the perspective of the first type of agency problem, discretionary stock halts undermine the interests of external investors. Therefore, when investors become aware of such discretionary halts, the stock market reacts negatively, leading to a decline in the stock prices of the affected listed companies (Shi et al., 2019). Moreover, as suspension regulations improve, the disclosure mechanism for discretionary stock halts further reduces the cost and difficulty for investors to detect such behavior. Because managers' compensation contracts are largely tied to the short-term performance of the company, it is only when those contracts are designed to tolerate the company's short-term poor performance and the level of innovation effort by managers can be accurately assessed that the likelihood of pay cuts or dismissals for managers decreases (Bushman and Smith, 2001; Cheng, 2004) and their motiva-

tion to invest in innovation increases (Manso, 2011; Zhong, 2018). In cases in which discretionary stock halts cause a significant decline in stock prices, out of consideration for their own salary and career development managers find it more difficult to make decisions regarding highly short-term investments with delayed returns in R&D, leading to insufficient innovation investment and a lack of stable innovation output for the company.

Based on the above analysis, our hypothesis is stated formally as follows:

H1. Ceteris paribus, discretionary stock halts decrease corporate innovation.

However, discretionary stock halts may not affect corporate innovation investment. First, when discretionary stock halts attract significant market attention, company's stakeholders become more likely to identify opportunistic behavior by insiders. Reducing funding for innovation projects could trigger even greater negative market reactions. Therefore, rational considerations by insiders would still require them to ensure innovation within the company. Second, stock halts temporarily interrupt stock trading and restrict stock liquidity, which reduces opportunities for hostile takeovers. Additionally, stock halts increase the entry and exit costs for institutional investors and discourage inactive institutional investors from entering the market. This condition is more favorable for institutional investors to play a supervisory role and thus promotes corporate innovation (Fang et al., 2014). Therefore, the relationship between discretionary stock halts and corporate innovation requires empirical testing.

3. Research design and sample selection

3.1. Measurement methods for discretionary stock halts

First, referring to Shi et al. (2019), we divide trading suspensions into private placement, material asset reorganizations, other major events and other matters according to the reasons for stock halts. According to the requirements of the Shanghai and Shenzhen Stock Exchanges in 2016, reasons for discretionary stock halts are categorized as follows: (1) The halt is a private placement without material asset reorganization and the suspension duration exceeds 10 trading days or it involves material asset reorganization and the suspension duration exceeds 1 month; (2) The halt is due to other major matters and the suspension duration exceeds 10 trading days; (3) The reason for the stock halt is material asset reorganization and the suspension duration exceeds 3 months; and (4) The suspension is caused by other matters and exceeds 10 trading days. Then, we add up total number of the firm's discretionary stock halts by year, calculate the natural logarithm of this sum plus 1 and use this variable to measure discretionary stock halts (*NO_ABNORHALT*). We also use the proportion of annual discretionary stock halts relative to the normal trading duration for the year (*PER_ABNORHALT*) in robustness tests.

3.2. Model specification

Following the literature (Li and Zheng, 2016; Chen et al., 2019), we construct the following regression model to test the impact of discretionary stock halts on R&D investment:

$$\begin{aligned} R\&D\ INVESTMENT\ =\ \alpha\ +\ \beta_1 * NO\_ABNORHALT\ +\ \beta_2 * LNTA\ +\ \beta_3 * LEV\ +\ \beta_4 * QUICK\ + \\ \beta_5 * CASH\ +\ \beta_6 * COCF\ +\ \beta_7 * ROA\ +\ \beta_8 * BM\ +\ \beta_9 * BH\ +\ \beta_{10} * PRIVATE\ +\ \beta_{11} *\ OWNERSHIP\ + \\ \beta_{12} * BIG10\ +\ \beta_{13} * MAO\ +\ \beta_{14} * MINDEX\ +\sum INDUSTRY\ +\sum YEAR \end{aligned} \tag{1}$$

The dependent variable *R&D INVESTMENT* is measured from two perspectives: innovation input and output. Innovation input (*RD/TA*) is the ratio of R&D investment to total assets, and innovation output (*PATENT*) is the natural logarithm of the number of annual patent applications plus 1. The independent variable *NO_ABNORHALT* is the number of discretionary stock halts. Referring to the literature, this article also controls other variables that may affect corporate innovation, such as corporate size, profitability, corporate governance, auditor reputation and year and industry fixed effects. See Table 1 for the definitions of the main variables in this paper.

3.3. Data and sample selection

The basic data of stock halts come from CSMAR, and we obtain data for the halt reasons announced by listed companies from the iFinD database. Other data also come from the CSMAR database. Because the implementation of new accounting standards in 2007 resulted in substantial changes in the accounting of report items, the sample range is from 2007 to 2020. Some data are removed according to the following criteria: (1) listed companies classified as belonging to the financial industry by the China Securities Regulatory Commission in 2012, (2) ST companies and (3) samples with missing data. According to the above criteria, 36,651 firm-year observations are obtained. To eliminate the influence of outliers, we winsorize all of the variables at the 1 % level. To control possible cross-sectional effects, all of the standard errors are clustered at the firm level.

Descriptive statistics are shown in Table 2. During the sample period, the average of *RD/TA* of listed companies during the sample period is 0.015 with a standard deviation of 0.018, and the average innovation output is 1.531 with a standard deviation of 1.807, indicating that the R&D investment and innovation output of listed companies are generally low and vary widely among companies. The average number of discretionary stock halts is 0.097 with a standard deviation of 0.254, and the average duration of discretionary stock halts is 0.035 with a standard deviation of 0.110. This suggests that on average, the duration of discretionary stock halts accounts for approximately 3.5 % of the total trading duration, indicating a relatively severe occurrence of discretionary stock halts in Chinese listed companies. Regarding the control variables, the financial indicators show that companies have relatively high liquidity and good debt-paying ability. The average ROA is

Table 1
Main Variable Definitions.

	Symbol	Name	Definition
Dependent Variables	*RD/TA*	R&D Input	The ratio of R&D investment to total assets
	PATENT	R&D Output	The natural logarithm of the number of annual patent applications plus 1
Independent Variables	*NO_ABNORHALT*	Time of Discretionary Stock Halts	The natural logarithm of the total number of discretionary stock halts plus 1
	PER_ABNORHALT	Duration of Discretionary Stock Halts	The ratio of the total duration of discretionary stock halts to the normal trading time
Control Variables	*LNTA*	Firm Size	Log (Total assets)
	LEV	Leverage	Total debt/total assets
	QUICK	Quick Ratio	(Current assets – inventory)/current liabilities
	CASH	Cash Holdings	Monetary funds/total assets
	COCF	Operating Cash Flow	Operating cash flow/total assets
	ROA	Return on Assets	Profit/total assets
	BM	Book to Market Ratio	The ratio of the book value of total assets to the market value
	BH	B/H Share	Binary indicator that equals 1 if the company has B/H shares and 0 otherwise
	PRIVATE	Ultimate Controller	Binary indicator that equals 1 if the ultimate controller is private and 0 otherwise
	OWNERSHIP	Control	Ultimate controller's shareholding/total shares
	BIG10	Big 10 Audit Firm	Binary indicator that equals 1 if the auditor is from the top 10 firms in audit income and 0 otherwise
	MAO	Modified Audit Opinion	Binary indicator that equals 1 if the annual report is issued by an auditor with an unqualified opinion with highlighted matters, a qualified opinion, a negative opinion or an opinion cannot be expressed, and 0 otherwise
	MINDEX	Marketization Index	Marketization index, sorted by decile (Fan et al., 2011)
	INDUSTRY	Industry Dummy Variable	Binary indicator that equals 1 if the firm belongs to a certain industry and 0 otherwise
	YEAR	Year Dummy Variable	Binary indicator that equals 1 if the observation belongs to a certain year and 0 otherwise

0.053, indicating that the net profit accounts for around 5 % of total assets, demonstrating a high profitability level. On average, the largest shareholder holds a stake of 36.6 %, indicating concentrated ownership structure in listed companies. Approximately 40 % of listed companies engage the services of a top 10 auditing firm, and the proportion of non-standard opinions issued is only 4.9 %, indicating high quality of financial reporting by listed companies.

The correlation coefficient matrix in Table 3 shows that the Pearson correlation coefficient between the number of discretionary stock halts (*NO_ABNORHALT*) and innovation input (*RD/TA*) is –0.057, which is significant at the 5 % level. Similarly, the Pearson correlation coefficient between discretionary stock halts duration (*PER_ABNORHALT*) and innovation input (*RD/TA*) is –0.052, which is significant at the 5 % level. This implies that as the number and duration of discretionary stock halts increase, the level of R&D investment decreases, which supports Hypothesis 1. Moreover, it suggests that the measurement methods for discretionary stock halts do not affect the relationship between discretionary stock halts and R&D investment. However, the Pearson correlation coefficients between the number and duration of discretionary stock halts and the innovation output (*PATENT*) are all positive and significant. It should be noted that the above univariate test results may be affected by company characteristics and governance conditions. Therefore, in our regression analysis, we further control variables that may affect the relationship between discretionary stock halts and corporate innovation to obtain results that are closer to the causal relationship between the main variables.

4. Empirical results

4.1. Main results

Table 4 presents the results regarding the effects of discretionary stock halts on corporate innovation. Columns (1) and (2) present the full-sample regression results with innovation input *RD/TA* as the dependent variable. The coefficient of the independent variable *NO_ABNORHALT* is –0.002, which is significant at the 1 % level, indicating that as the number of arbitrary stock halts increases, the information environment of the company deteriorates. As a result, the company's innovation is more likely to be impacted by financial constraints and agency issues, leading to a significant decrease in innovation input. The coefficient of *PER_ABNORHALT* is –0.005, which is significant at the 1 % level. This outcome supports Hypothesis 1, as it indicates that prolonged discretionary stock halts hinder information dissemination, reduce revelatory price efficiency and increase the level of information asymmetry for external investors. Additionally, extended stock halts are

Table 2
Descriptive Statistics.

	N	Mean	STD	Min	Median	Max
RD/TA	36,651	0.015	0.018	0	0.010	0.095
PATENT	36,651	1.531	1.807	0	0.693	9.909
NO_ABNORHALT	36,651	0.097	0.254	0	0	1.099
PER_ABNORHALT	36,651	0.035	0.110	0	0	0.607
LNTA	36,651	22.018	1.316	19.290	21.845	26.049
LEV	36,651	0.440	0.219	0.050	0.431	1.006
QUICK	36,651	1.965	2.527	0.142	1.146	16.35
CASH	36,651	0.188	0.141	0.010	0.148	0.693
COCF	36,651	0.044	0.074	–0.197	0.045	0.251
ROA	36,651	0.053	0.056	–0.111	0.049	0.227
BM	36,651	0.434	0.327	–0.001	0.350	1.782
BH	36,651	0.065	0.246	0	0	1
PRIVATE	36,651	0.620	0.485	0	1	1
OWNERSHIP	36,651	0.366	0.157	0	0.350	0.900
BIG10	36,651	0.409	0.492	0	0	1
MAO	36,651	0.049	0.216	0	0	1
MINDEX	36,651	0.742	0.281	0	0.889	1

Table 3
Correlation Matrix.

	RD/TA	*PATENT*	*NO*	*PER*	*LNTA*	*LEV*	*QUICK*	*CASH*
RD/TA	1							
PATENT	0.130*	1						
NO_ABNORHALT	–0.057*	0.086*	1					
PER_ABNORHALT	–0.052*	0.059*	0.839*	1				
LNTA	–0.147*	0.158*	–0.074*	–0.070*	1			
LEV	–0.254*	–0.010*	0.062*	0.053*	0.394*	1		
QUICK	0.187*	–0.012*	–0.042*	–0.034*	–0.296*	–0.623*	1	
CASH	0.163*	0.033*	–0.066*	–0.055*	–0.221*	–0.397*	0.557*	1
COCF	0.082*	–0.009	–0.070*	–0.065*	0.070*	–0.156*	0.043*	0.130*
ROA	0.258*	–0.004	–0.149*	–0.146*	0.066*	–0.324*	0.166*	0.194*
BM	–0.175*	–0.045*	–0.160*	–0.139*	0.554*	0.130*	–0.148*	–0.170*
BH	–0.093*	0.079*	–0.029*	–0.027*	0.234*	0.119*	–0.096*	–0.070*
PRIVATE	0.234*	–0.042*	0.058*	0.051*	–0.320*	–0.271*	0.225*	0.122*
OWNERSHIP	–0.051*	0.070*	–0.065*	–0.064*	0.161*	–0.034*	0.027*	0.067*
BIG10	0.010*	0.088*	0.005	0.003	0.170*	0.038*	–0.013*	–0.003
MAO	–0.065*	–0.117*	0.102*	0.114*	–0.122*	0.234*	–0.077*	–0.096*
MINDEX	0.230*	0.050*	0.003	0.007	0.036*	–0.140*	0.077*	0.060*

	COCF	*ROA*	*BM*	*BH*	*PRIVATE*	*OWNERSHIP*	*BIG10*	*MAO*
COCF	1							
ROA	0.444*	1						
BM	–0.023*	–0.112*	1					
BH	0.011*	–0.076*	0.260*	1				
PRIVATE	–0.022*	0.154*	–0.253*	–0.209*	1			
OWNERSHIP	0.095*	0.167*	0.067*	0.042*	–0.115*	1		
BIG10	0.027*	0	0.085*	0.175*	–0.121*	0.074*	1	
MAO	–0.114*	–0.265*	–0.097*	0.006	0.049*	–0.130*	–0.042*	1
MINDEX	0.018*	0.108*	0.004	0.050*	0.236*	0.025*	0.015*	–0.058*

*indicates significance at the 5% level or better.

likely to trigger self-interest motives among major shareholders and managers, potentially harming the company's long-term growth opportunities. Columns (3) and (4) list the results with the innovation output *PATENT* as the dependent variable. The coefficients of the independent variables *NO_ABNORHALT* and *PER_ABNORHALT* are both negative and significant at the 1 % level, indicating that discretionary stock halts are detrimental to the acquisition of essential elements for innovation, resulting in a negative impact on innovation output.

Because some companies in the sample disclose zero R&D expenses, while others do not disclose their R&D expenses (treated as zero in this study), we draw on the approach of Koh and Reeb (2015) and rerun the test, excluding samples with zero R&D expenses or undisclosed R&D expenses. The results are listed in columns (5) and (6). The coefficients of the independent variables *NO_ABNORHALT* and *PER_ABNORHALT* are both negative and significant at the 1 % level. This indicates that discretionary stock halts reduce the R&D investment of enterprises. This conclusion remains consistent regardless of the missing values in R&D investment, further supporting Hypothesis 1.

4.2. Robustness tests

In robustness tests, we first consider the possible impact of abnormal stock market fluctuations in 2015 on our main results, so we exclude the sample of 2015 and retest it. The results are shown in Panel A of Table 5. Regardless of whether R&D input or output is used as the dependent variable, the coefficients of the independent variables are negative and significant at the 1 % level, indicating that our conclusions are not due to stock halts caused by abnormal fluctuations in the stock market in 2015. Second, we change the measure of the dependent variable. We first use the ratio of R&D expenses to sales revenue (*RD/SALE*) instead of *RD/TA* to eliminate the impact of the measurement of R&D input on the results. The results are shown in column

Table 4
Main Results.

Variables	Full Sample				RD > 0 Sample	
	(1) *RD/TA*	(2) *RD/TA*	(3) *PATENT*	(4) *PATENT*	(5) *RD/TA*	(6) *RD/TA*
NO_ABNORHALT	–0.002***		–0.165***		–0.003***	
	(–6.261)		(–5.171)		(–6.238)	
PER_ABNORHALT		–0.005***		–0.495***		–0.006***
		(–5.821)		(–7.089)		(–5.336)
LNTA	–0.001***	–0.001***	0.444***	0.443***	–0.002***	–0.002***
	(–3.603)	(–3.623)	(24.973)	(24.940)	(–6.188)	(–6.208)
LEV	–0.003***	–0.003***	–0.497***	–0.496***	–0.001	–0.001
	(–2.920)	(–2.947)	(–5.794)	(–5.788)	(–0.902)	(–0.946)
QUICK	–0.0001	–0.0001	–0.021***	–0.021***	–0.0002**	–0.0002**
	(–1.408)	(–1.412)	(–4.177)	(–4.179)	(–2.364)	(–2.353)
CASH	0.003*	0.003*	0.122	0.124	0.004**	0.004**
	(1.833)	(1.880)	(1.234)	(1.258)	(2.333)	(2.363)
COCF	0.002	0.002	0.103	0.106	0.005**	0.005**
	(1.091)	(1.100)	(0.748)	(0.768)	(2.348)	(2.372)
ROA	0.053***	0.053***	–0.092	–0.114	0.063***	0.063***
	(15.418)	(15.413)	(–0.369)	(–0.458)	(14.642)	(14.620)
BM	–0.005***	–0.005***	–0.178***	–0.179***	–0.005***	–0.005***
	(–8.294)	(–8.244)	(–3.396)	(–3.412)	(–6.470)	(–6.427)
BH	–0.0004	–0.0004	0.102	0.102	0.001	0.001
	(–0.576)	(–0.573)	(1.221)	(1.222)	(0.805)	(0.808)
PRIVATE	0.0001	0.00003	0.013	0.012	–0.001*	–0.001*
	(0.122)	(0.069)	(0.368)	(0.360)	(–1.851)	(–1.921)
OWNERSHIP	–0.002*	–0.002*	–0.047	–0.048	–0.003**	–0.003**
	(–1.943)	(–1.926)	(–0.501)	(–0.512)	(–2.292)	(–2.274)
BIG10	0.001***	0.001***	0.085***	0.085***	0.001**	0.001**
	(2.898)	(2.889)	(3.300)	(3.293)	(2.162)	(2.151)
MAO	–0.002***	–0.002***	–0.186***	–0.179***	–0.0004	–0.0004
	(–2.680)	(–2.645)	(–4.133)	(–3.972)	(–0.515)	(–0.498)
MINDEX	0.005***	0.005***	0.489***	0.488***	0.004***	0.004***
	(7.758)	(7.760)	(9.623)	(9.621)	(5.467)	(5.479)
Constant	0.008**	0.008**	–8.864***	–8.852***	0.033***	0.033***
	(2.054)	(2.042)	(–23.924)	(–23.894)	(6.121)	(6.118)
Year	YES	YES	YES	YES	YES	YES
Industry	YES	YES	YES	YES	YES	YES
Observations	36,651	36,651	36,651	36,651	28,023	28,023
Adj. R^2	0.390	0.390	0.514	0.515	0.309	0.309

The t-values are adjusted according to the individual company clusters (cluster). *, ** and *** represent significance levels of 10%, 5% and 1%, respectively.

(1) of Panel B in Table 5. The coefficient of *NO_ABNORHALT* is –0.002, which is significant at the 1 % level, consistent with our previous results. Second, Li and Zheng (2016) believe that invention patents can better represent substantive innovations with investment value for enterprises, so we further distinguish patent types and test the impact of discretionary stock halts on the number of invention patents and other patent applications. The results are shown in columns (2) and (3) of Panel B in Table 5. The coefficients of *NO_ABNORHALT* are all negative and significant at the 1 % level, indicating that the more times a stock is discretionarily suspended from trading, the less substantive the enterprise's innovation output is. We also conduct a supplementary test from the perspective of innovation efficiency, measuring innovation efficiency by the output of innovation input per unit. Specifically, we take the natural logarithm of the number of patent applications in the year plus 1 and the natural logarithm of the amount of R&D investment in the year plus 1 and then calculate the ratio of these numbers. The results are shown in column (4) of Panel B in Table 5. The coefficient of *NO_ABNORHALT* is still negative and significant at the 1 % level, indicating that discretionary

Table 5
Results of the Robustness Tests.

Panel A: Excluding the Sample of 2015

Variables	(1) *RD/TA*	(2) *PATENT*
NO_ABNORHALT	–0.002***	–0.198***
	(–6.019)	(–5.554)
CONTROLS	YES	YES
Year	YES	YES
Industry	YES	YES
Observations	34,059	YES
Adj. R^2	0.397	YES

Panel B: Changing the Measurement of the Dependent Variables

Variables	(1) *RD/SALE*	(2) *PATENT_EVENT*	(3) *PATENT_OTHER*	(4) *EFFICIENCY*
NO_ABNORHALT	–0.002***	–0.136***	–0.111***	–0.009***
	(–2.786)	(–4.988)	(–3.745)	(–4.134)
CONTROLS	YES	YES	YES	YES
Year	YES	YES	YES	YES
Industry	YES	YES	YES	YES
Observations	36,651	36,651	36,651	28,023
Adj. R^2	0.383	0.447	0.468	0.569

stock halts reduce enterprises' innovation efficiency. The results also show that the measurement methods of the dependent variables do not affect our main conclusions.

4.3. Endogeneity tests

To alleviate endogeneity concerns, we conduct the following endogeneity tests.

1. Adding fixed effects. To address potential omitted-variable concerns and mitigate alternative explanations, we control firm-year fixed effects in the analysis to control for unobserved variables related to company characteristics and macroeconomic conditions. The results, shown in Table 6, Panel A, columns (1) and (2), demonstrate that when we control for company-year fixed effects, the coefficient of the independent variable *NO_ABNORHALT* remains negative and significant at the 5 % level. This consistency with the main test results suggests that when we consider omitted variables, increases in the number and duration of discretionary stock halts contribute to decreases in innovation investment and innovation output.
2. Using a change model. To further characterize the causal relationships between the main variables and alleviate the problems of omitted variables and measurement errors, we test a change model. Specifically, the regression analysis is conducted using the changes in all of the continuous variables between year *t* and year *t*–1. The results are shown in columns (3) and (4) of Panel A in Table 6. The coefficients of *NO_ABNORHALT* are negative and significant at the 1 % level, indicating that as the number of discretionary stock halts increases, companies' R&D input and innovation output decline.
3. Propensity score matching (PSM). To alleviate self-selection basis, referring to Chu and Fang (2016), we use PSM to perform one-to-one matching, and we regress model (1) on the matched sample. Specifically, we first construct a PSM sample, in which the treatment group is a sample with discretionary stock halts and the control group is a sample without discretionary stock halts that year. Second, we calculate the propensity matching score and use a logit model to calculate the probability of discretionary stock halts, where the dependent variable is a binary variable of whether or not a discretionary stock halt occurs and the explanatory variables are the same as in model (1), and we control the industry-year fixed effects. The third step is to match the sample using the one-to-one nearest neighbor matching method, and the matched sample contains 9,208 (4,604 pairs) firm-year observations. Table 6, Panel B shows the differences

Table 6
Results of Endogeneity Tests.

Panel A: Omitted Variable

Variables	Firm Fixed Effects		Change Model	
	(1) *RD/TA*	(2) *PATENT*	(3) *△RD/TA*	(4) *△PATENT*
NO_ABNORHALT	–0.001**	–0.102***		
	(–2.369)	(–4.089)		
△NO_ABNORHALT			–0.0005***	–0.068***
			(–3.136)	(–3.341)
CONTROLS	YES	YES	YES	YES
Year	YES	YES	YES	YES
Industry	NO	NO	YES	YES
Firm	YES	YES	NO	NO
Observations	36,651	36,651	33,788	33,788
Adj. R^2	0.114	0.493	0.056	0.302

Panel B: Between-group T-test

Variables	(1) *DUM = 0*	(2) *DUM = 1*	(3) *DIFF*
RD/TA	0.014	0.013	–0.001***
PATENT	2.028	1.980	–0.048*
NO_ABNORHALT	0	0.736	0.736***
PER_ABNORHALT	0	0.265	0.265***
LNTA	21.820	21.807	–0.003
LEV	0.472	0.468	–0.004
QUICK	1.714	1.697	–0.017
CASH	0.167	0.166	–0.001
COCF	0.031	0.033	0.002
ROA	0.0338	0.0342	0.0004
BM	0.313	0.312	–0.001
BH	0.052	0.048	–0.004
PRIVATE	0.669	0.676	0.007
OWNERSHIP	0.341	0.345	0.004
BIG10	0.420	0.421	–0.001
MAO	0.097	0.089	–0.008
MINDEX	0.722	0.723	0.001
Observations	4604	4604	0

Panel C: Results of the PSM Method

Variables	(1) *RD/TA*	(2) *PATENT*	(3) *RD/TA*	(4) *PATENT*
NO_ABNORHALT	–0.002***	–0.083**		
	(–5.191)	(–2.232)		
PER_ABNORHALT			–0.005***	–0.301***
			(–5.391)	(–3.828)
CONTROLS	YES	YES	YES	YES
Year	YES	YES	YES	YES
Industry	YES	YES	YES	YES
Observations	9208	9208	9208	9208
Adj. R^2	0.313	0.473	0.313	0.473

Table 6 (*continued*)

Panel D: Reverse Causality

Variables	Lag Independent Variables		Lag All Explanatory Variables	
	(1) *RD/TA*	(2) *PATENT*	(3) *RD/TA*	(4) *PATENT*
LAG_NO_ABNORHALT	–0.003***	–0.094***	–0.002***	–0.043
	(–7.907)	(–3.150)	(–6.825)	(–1.423)
CONTROLS	YES	YES	YES	YES
Year	YES	YES	YES	YES
Industry	YES	YES	YES	YES
Observations	34,513	34,513	33,788	33,788
Adj. R^2	0.390	0.515	0.384	0.515

between the treatment and control samples. Fourth, we use the matched sample to perform multiple regressions. As shown in Table 6, Panel C, the coefficients of the independent variables are still negative and significant at the 5 % level. The results of the PSM tests are basically consistent with our main results, indicating that when we control for the influence of other factors, companies with more discretionary stock halts have lower R&D input and innovation output.

4. Reverse causality. Reverse causality is possible because low R&D input or innovation output implies more opportunistic behaviors by insiders who are not concerned with the company's long-term development opportunities. Such companies are more likely to make decisions to suspend trading discretionarily. To overcome the influence of reverse causality and the possible endogeneity problems caused by cross-sectional data, we lag the independent variables by one period and use the number of discretionary stock halts in year t–1 as the independent variable for regression, and we also lag all explanatory variables by one year. The results are shown in Panel D of Table 6. The coefficients of *LAG_NO_ABNORHALT* are all negative and significant at the 1 % level (all explanatory variables are lagged with innovation output as the dependent variable). In both cases, the coefficient of the duration of discretionary stock halts in the previous year is consistent with the results of the main regressions, which means that when we consider the impact of reverse causality, as the number of discretionary stock halts increases, corporate innovation decreases significantly.

4.4. Channel analysis

First, discretionary stock halts are often accompanied by insufficient disclosure of halt-related information, which directly affects stakeholders' ability to obtain information. Moreover, arbitrary stock halts increase the service costs for information intermediaries such as analysts, leading them to cease following and supervising companies that experience such halts. This exacerbates the information loss effect (Shi et al., 2019; Yu and Fang, 2020b, 2022), making it difficult for external investors to accurately assess the true utility of R&D projects. In addition, discretionary stock halts reduce stock price discovery efficiency, hindering managers' learning effect based on stock prices, which makes it challenging for managers to make timely assessments of the market's recognition of their R&D projects and adjust their investment decisions accordingly, potentially leading to the erroneous abandonment of high-quality projects. Furthermore, discretionary stock halts consume managers' decision-making capacity, limiting their time and ability to collect and process useful decision-related information. This results in a decrease in the scientific rigor of management decisions (Chemmanur et al., 2019), ultimately leading to a neglect of long-term interests and reductions in R&D investment and innovation output for the company.

Second, discretionary stock halts signify opportunistic behavior by insiders, leading to greater appropriation of the company's internal funds. Additionally, discretionary stock halts disrupt normal trading hours, resulting in temporary liquidity shortages and reducing revelatory price efficiency, which hinders the informa-

tion transmission function of stock prices (Grundy and McNichols, 1989; Zuo, 2016). The opaque information environment and the emergence of negative news associated with discretionary stock halts increase investment risks for external investors and creditors, leading them to demand higher risk premiums and decreasing their willingness to invest. Consequently, the difficulty and cost of financing for the company increase (Hall, 2002). The heightened financial constraints pose challenges for corporate innovation as R&D investment is reduced. Insufficient R&D funding further hampers the company's ability to generate innovation output.

Finally, discretionary stock halts lead to strong motives for controlling shareholders to engage in expropriation, often in collaboration with managers. Controlling shareholders engage in more opportunistic behaviors that infringe upon the interests of minority shareholders. Excessive self-interest among insiders diminishes the scientific rigor of decision-making, resulting in inadequate attention to long-term value-enhancing investments such as corporate innovation. Moreover, once external investors become aware of the negative event of dis-

Table 7
Channel Analysis.

Panel A: Information Environment

Variables	Path A		Path B	Path C	
	(1) *RD/TA*	(2) *PATENT*	(3) *AQ*	(4) *RD/TA*	(5) *PATENT*
NO_ABNORHALT	–0.002***	–0.171***	0.006***	–0.002***	–0.164***
	(–4.860)	(–5.019)	(4.505)	(–4.795)	(–4.851)
AQ				–0.004*	–1.110***
				(–1.688)	(–5.879)
CONTROLS	YES	YES	YES	YES	YES
Year	YES	YES	YES	YES	YES
Industry	YES	YES	YES	YES	YES
Observations	29,700	29,700	29,700	29,700	29,700
Adj. R^2	0.382	0.521	0.092	0.383	0.521

Panel B: Financial Constraints

Variables	Path A		Path B	Path C	
	(1) *RD/TA*	(2) *PATENT*	(3) *COEC*	(4) *RD/TA*	(5) *PATENT*
NO_ABNORHALT	–0.002***	–0.156***	0.004***	–0.002***	–0.153***
	(–5.277)	(–4.478)	(2.810)	(–5.190)	(–4.420)
COEC				–0.008***	–0.556***
				(–3.885)	(–2.899)
CONTROLS	YES	YES	YES	YES	YES
Year	YES	YES	YES	YES	YES
Industry	YES	YES	YES	YES	YES
Observations	32,594	32,594	32,594	32,594	32,594
Adj. R^2	0.402	0.518	0.316	0.402	0.518

Panel C: Agency Problem

Variables	Path A		Path B	Path C	
	(1) *RD/TA*	(2) *PATENT*	(3) *TURNOVER*	(4) *RD/TA*	(5) *PATENT*
NO_ABNORHALT	–0.002***	–0.165***	–0.016*	–0.002***	–0.161***
	(–6.321)	(–5.171)	(–1.670)	(–6.176)	(–5.061)
TURNOVER				0.004***	0.271***
				(8.727)	(6.429)
CONTROLS	YES	YES	YES	YES	YES
Year	YES	YES	YES	YES	YES
Industry	YES	YES	YES	YES	YES
Observations	36,651	36,651	36,651	36,651	36,651
Adj. R^2	0.390	0.514	0.281	0.397	0.517

cretionary stock halts, managers, out of concern for their compensation and future job prospects, are more likely to reduce investments in long-term and delayed-return innovation projects to boost short-term performance (Manso, 2011; Zhong, 2018). Severe agency problems thus contribute to insufficient R&D investment and a decline in innovation output for the company.

Baron and Kenny (1986) and Quan et al. (2015) provide a useful framework for examining the impact of discretionary stock halts on managers' scientific decision-making, focusing on the perspective of information quality. We use accrual quality (*AQ*) calculated by the DD model (Dechow and Dichev, 2002) to measure decision-makers' information quality. A higher *AQ* indicates poorer information quality, reflecting the deterioration of the information environment caused by discretionary stock halts. The results are shown in Table 7, Panel A. When innovation input is used as the dependent variable in Path A, the coefficient of *NO_ABNORHALT* is –0.002, which is significant at the 1 % level. When innovation output is used as the dependent variable, the coefficient of *NO_ABNORHALT* is –0.171, which is significant at the 1 % level, indicating that discretionary stock halts significantly reduce the company's R&D input and innovation output. The coefficient of *NO_ABNORHALT* in Path B is 0.006, which is significant at the 1 % level, indicating that discretionary stock halts significantly reduce investors' information quality and managers' decision-making. When innovation input is used as the dependent variable in Path C, the coefficients of *NO_ABNORHALT* and *AQ* are –0.002 and –0.004, respectively, both of which are significant at the 1 % level. When we use innovation output as the dependent variable, the coefficients of *NO_ABNORHALT* and *AQ* are –0.164 and –1.110, respectively, both of which are significant at the 1 % level, indicating that the quality of decision-making information plays a partial intermediary role and is one of the channels through which discretionary stock halts reduce corporate innovation. Second, we use the cost of equity capital (*COEC*) to measure the financial constraints faced by the enterprise (Francis et al., 2005). The higher the cost, the greater the financial constraints. The results are shown in Panel B of Table 7. The coefficients of *NO_ABNORHALT* and *COEC* in Path C are both significant at the 1 % level, indicating that greater financial constraints play a partial intermediary role and are one of the channels through which discretionary stock halts reduce corporate innovation. Finally, with reference to Liu and Lu (2007), agency cost is measured by the turnover rate of total assets (*TURNOVER*). The higher the total asset turnover rate, the lower the agency cost. The results are shown in Table 7, Panel C. The coefficients of *NO_ABNORHALT* and *TURNOVER* in Path C are both significant at the 1 % level, indicating that agency costs play a partial intermediary role and are one of the channels through which discretionary stock halts decrease corporate innovation.

4.5. Cross-sectional analysis

The above tests find that discretionary stock halts reduce companies' R&D investment and innovation output. Subsequently, we consider whether the above findings are different under various circumstances. Specifically, we consider ownership structure, the nature of the ultimate controller and the complexity of investors.

In terms of ownership structure, the higher the shareholding ratio of major shareholders, the greater the likelihood and the stronger their ability to engage in tunneling to obtain personal gains. Opportunistic manipulation by insiders affects the company's long-term value. At the same time, managers are more likely to succumb to pressure from major shareholders and to have difficulty implementing innovation investments with delayed returns. When faced with strong control by major shareholders, it is more difficult for other stakeholders to protect their own interests, and they are more likely to choose to terminate the relationship with the company or to demand higher returns in various economic activities, resulting in insufficient resources for enterprise innovation. Therefore, we expect that the real impact of discretionary stock halts on corporate innovation will be more significant when the shareholding ratio of large shareholders is high. Samples are grouped according to the shareholding ratio of the top five shareholders. The results with R&D investment as the dependent variable are shown in columns (1) and (2) of Table 8, Panel A. Compared with the group with lower shareholding percentages for major shareholders, the absolute value of the coefficient for *NO_ABNORHALT* is larger in the group with higher shareholding ratios for major shareholders, and the difference between the groups is significant at the 5 % level. The results with innovation output as the dependent variable are shown in columns (1) and (2) of Table 8, Panel B. The between-group difference in the coefficients is significant at the 10 % level, indicating that when major shareholders hold more shares, insiders have stronger tunneling moti-

Table 8
Cross-sectional Analysis.

Panel A: Innovation Input as the Dependent Variable

Variables	Shareholding ratio of major shareholders		Ultimate controller		Shareholding ratio of institutional investors	
	High	Low	High	Low	High	Low
	(1)	(2)	(3)	(4)	(5)	(6)
	RD/TA	*RD/TA*	*RD/TA*	*RD/TA*	*RD/TA*	*RD/TA*
NO_ABNORHALT	–0.002***	–0.003***	–0.001**	–0.003***	–0.002***	–0.001***
	(–3.595)	(–5.461)	(–2.437)	(–5.875)	(–5.020)	(–3.081)
DIFF	**–0.001****		**–0.002***		**0.001***	
CONTROLS	YES	YES	YES	YES	YES	YES
Year	YES	YES	YES	YES	YES	YES
Industry	YES	YES	YES	YES	YES	YES
Observations	18,333	18,318	13,924	22,727	20,350	16,301
Adj. R^2	0.378	0.408	0.358	0.367	0.395	0.359

Panel B: Innovation Output as the Dependent Variable

Variables	Shareholding ratio of major shareholders		Ultimate controller		Shareholding ratio of institutional investors	
	High	Low	High	Low	High	Low
	(1)	(2)	(3)	(4)	(5)	(6)
	PATENT	*PATENT*	*PATENT*	*PATENT*	*PATENT*	*PATENT*
NO_ABNORHALT	–0.108**	–0.203***	–0.151***	–0.179***	–0.146***	–0.154***
	(–2.027)	(–5.183)	(–3.641)	(–3.726)	(–3.457)	(–3.316)
DIFF	**–0.095***		**–0.028**		**–0.008**	
CONTROLS	YES	YES	YES	YES	YES	YES
Year	YES	YES	YES	YES	YES	YES
Industry	YES	YES	YES	YES	YES	YES
Observations	18,333	18,318	13,924	22,727	20,350	16,301
Adj. R^2	0.378	0.408	0.358	0.367	0.395	0.359

vation and external stakeholders are more likely to avoid risks by reducing the supply of resources required for innovation, ultimately leading to a significant decline in corporate R&D input and output.

In terms of the ultimate controller, state-owned enterprises have the endorsement of the government, which gives them significant advantages in obtaining resources such as land qualifications and funds. This also means that the resources required for innovation in these enterprises are less influenced by the decisions of stakeholders. In addition, major shareholders of state-owned enterprises usually have a government connection. Innovation tasks undertaken by state-owned enterprises are thus more likely to be related to national strategies and to include the will of the government, so this portion of R&D investment is unlikely to decline because of insider opportunism. In contrast, innovation decisions in non-state-owned enterprises are more market-driven. The profitability of innovation projects and the availability of innovation resources are important factors affecting the amount of R&D investment. In non-state-owned enterprises, where discretionary stock halts are more prevalent, both resource acquisition and decision-making rationality are significantly compromised. Therefore, we expect that the real impact of discretionary stock halts on corporate innovation will be more significant among non-state-owned enterprises. The samples are grouped according to whether the ultimate controller is state-owned, and the results with R&D input as the dependent variable are shown in columns (3) and (4) of Panel A in Table 8. Compared with state-owned enterprises, the absolute value of the coefficient of discretionary stock halts is larger for non-state-owned enterprises, and the difference between groups is significant, indicating that state-owned enterprises are subject to smaller resource constraints. In addition, because they undertake policy innovation projects, the decline in innovation investment is smaller. The results with innovation output as the dependent variable are shown in columns (3) and (4) of Table 8, Panel B. Although the absolute value of the coefficient of discretionary stock halts is larger in the non-state-owned enterprise group, the difference between the coefficients for the groups is not significant, which shows that the nature of the ultimate controller does not cause any difference in the impact of discretionary stock halts on innovation output.

In terms of investor complexity, institutional investors usually have stronger information acquisition capabilities and can make more accurate judgments on enterprises' true production and operation status, so their investment decisions are usually more scientific. On this basis, institutional investors play a role in supervising and restricting insiders' decision-making. If institutional investors engage in large-scale selling of stocks, often referred to as "voting with their feet," it will lead to a significant decline in the stock price of the listed company and cause substantial damage to insiders' personal wealth. Therefore, we expect that the real impact of discretionary stock halts on corporate innovation will be more significant when the shareholding ratio of institutional investors is low. The samples are grouped according to whether the ratio of institutional investors' shareholding is above the sample median. The results with R&D investment as the dependent variable are shown in columns (5) and (6) of Panel A in Table 8. Compared with the group with a higher shareholding ratio of institutional investors, the absolute value of discretionary stock halts coefficient is significantly greater in the group with a lower shareholding ratio of institutional investors, indicating that when institutional investors hold more shares, insiders' opportunistic behavior is effectively restricted, corporate decision-making becomes more scientific, the decline in R&D investment is smaller and the damage to the long-term value of the company is less severe. The results with innovation output as the dependent variable are shown in columns (5) and (6) of Table 8, Panel B. The coefficient difference between the groups on discretionary stock halts is not significant, which shows that the shareholding ratio of institutional investors does not change the impact of discretionary stock halts on innovation output.

4.6. The impact of the guidance of the Shanghai and Shenzhen stock Exchanges in 2016

To minimize the occurrence of discretionary stock halts, prevent the abuse of halts and ultimately improve information efficiency, the Shanghai and Shenzhen Stock Exchanges issued the "Guidelines for the Trading Suspension and Resumption of Listed Companies on Major Events" and the "Memorandum of Information Disclosure – Trading Suspension and Resumption of Listed Firms" on 27 May 2016 to tighten suspension standards, shorten halt durations and obligate more implementation efforts. For example, they stipulated that "The Exchange may conduct on-site inspections and take supervisory or disciplinary measures against listed companies and responsible persons when listed companies apply for stock halts randomly, or listed compa-

nies, controlling shareholders, and other related parties abuse trading halts, delay trading resumption time, violate commitments, fail to perform corresponding decision-making procedures, and disclose untrue, inaccurate, or incomplete information."

How does the implementation of these policies affect companies' decisions to invest in innovation? The guidelines further standardized the reasons for suspensions, the duration of suspensions and the disclosure of information during suspensions. They also imposed stricter penalties for violations. These measures decreased the arbitrariness of trading suspensions by listed companies, reduced the negative impact of discretionary suspensions on information disclosure and stock price information transmission and minimized the effects on revelatory price efficiency. As a result, the negative impact of discretionary stock halts on innovation in companies should be mitigated. However, with the widespread standardization of suspension practices and the establishment of a disclosure system for discretionary stock halts, stakeholders of companies are more likely to identify such instances and to have more negative perceptions of companies that engage in such behavior. This may lead to stakeholders exercising greater caution in their investment decisions regarding these companies, exacerbating the scarcity of resources required for innovation. Discretionary stock halts may result in a greater decline in innovation for these companies. Therefore, the impact of these policies is an empirical question.

We use PSM-DID to further test the impact of these two documents. On the basis of the PSM sample, *TREAT* is a binary variable that equals 1 if discretionary halts occur and 0 otherwise. *POST* is a binary variable that equals 1 for the policy announcement year and subsequent years and 0 otherwise. We select the two years before and after the policy as the test window. Because the policy was announced and implemented in the middle of 2016, to eliminate the possible complex situation that year, we also delete the observations for 2016. The results are shown in Table 9. Regardless of whether the 2016 sample is deleted or whether innovation input and innovation output are used as dependent variables, the coefficient of *TREAT*POST* is negative and significant at the 1 % level, indicating that the capital market gives more negative feedback to existing discretionary halts. The above results also pass placebo tests.

To further verify the effectiveness of the DID model, we conduct a dynamic effect test. The results are shown in Fig. 2. Before the policy was released, the confidence interval of the year dummies' coefficients includes 0, indicating that the DID model passes the parallel trend test, and after the policy implementation, the coefficients of the year dummies are significantly less than 0, indicating that after the introduction of the Shanghai and Shenzhen Stock Exchanges' policies in 2016, existing discretionary halts have a greater negative impact on corporate innovation. These results further confirm that after the unreasonable use of trading suspension tools is effectively restricted, discretionary halts are more easily identified by companies' stakeholders. Consequently, stricter punishments can be imposed on such behavior, which affects companies' long-term development and daily operations. This also indicates that the implementation of the policy makes it more difficult for companies to conceal discretionary halts, and thus, market participants are able to identify companies' violations and react accordingly.

Table 9
Impact of the Guidance of the Shanghai and Shenzhen Stock Exchanges in 2016.

Variables	Including 2016		Excluding 2016	
	(1) *RD/TA*	(2) *PATENT*	(3) *RD/TA*	(4) *PATENT*
TREAT	–0.001	–0.012	–0.001	–0.016
	(–1.496)	(–0.276)	(–1.491)	(–0.357)
POST	0.004***	–1.741***	0.004***	–1.747***
	(4.619)	(–19.875)	(4.746)	(–19.287)
*TREAT*POST*	–0.002***	–0.164**	–0.003***	–0.161*
	(–3.206)	(–2.420)	(–3.512)	(–1.948)
CONTROLS	YES	YES	YES	YES
Industry	YES	YES	YES	YES
Observations	6512	6512	5139	5139
Adj. R^2	0.293	0.454	0.300	0.464

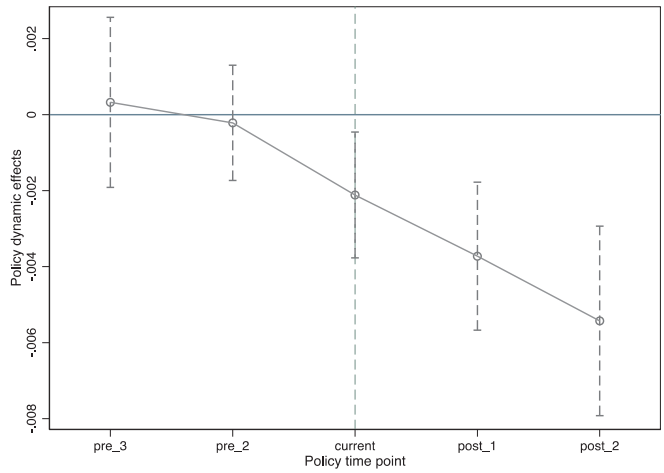

Fig. 2. Dynamic Effects.

4.7. Additional analysis

In China's capital market, there are a large number of normal suspensions in addition to discretionary halts. To further mitigate the impact of measurement errors on the empirical results and enhance the robustness of the conclusions, we differentiate between normal and discretionary stock halts. Compared with normal suspensions, discretionary halts exhibit characteristics such as higher suspension frequency, longer suspension durations and insufficient information disclosure. This also implies that arbitrary suspensions have a greater impact on the trading rights of stocks and a stronger influence on revelatory price efficiency. Therefore, simultaneously examining both discretionary and normal trading suspensions makes the empirical results more difficult to observe. We rerun the regressions using the numbers of normal trading suspensions and discretionary halts as independent variables. The number of normal trading suspensions (*NO_NORHALT*) is equal to the natural logarithm of the total number of normal suspensions plus 1 for each company in a given year. The results are shown in Table 10. Columns (1) and (2) list the results with *NO_ABNORHALT* as the independent variable. Columns (3) and (4) list the results using both *NO_ABNORHALT* and *NO_NORHALT* as independent variables. When R&D input is used as a dependent variable, the coefficients of *NO_ABNORHALT* and *NO_NORHALT* are both negative and significant at the 1 % level. The difference between the coefficients is –0.001, and the F-test of the coefficient difference is significant at the 1 % level. With innovation output as the dependent variable, the coefficient of *NO_ABNORHALT* is negative and significant at the 1 % level, the coefficient of *NO_NORHALT* is not significant and the F-test of the difference between these two coefficients is significant at the 1 % level. These results indicate that both normal trading suspension and discretionary halts

Table 10
Additional Analysis.

Variables	(1) *RD/TA*	(2) *PATENT*	(3) *RD/TA*	(4) *PATENT*
NO_ABNORHALT	–0.002***	–0.165***	–0.002***	–0.167***
	(–6.261)	(–5.171)	(–6.920)	(–5.076)
NO_NORHALT			–0.001***	–0.012
			(–5.948)	(–0.576)
CONTROLS	YES	YES	YES	YES
Year	YES	YES	YES	YES
Industry	YES	YES	YES	YES
Observations	36,651	36,651	36,651	36,651
Adj. R^2	0.390	0.514	0.391	0.514
F-test			–0.001***	–0.155***

temporarily interrupt stock trading, resulting in a loss of trading time, hindering the "learning by doing" mechanism of stock trading and reducing the revelatory price efficiency. This makes it more difficult for decision-makers such as managers and investors to accurately identify innovative projects; thus, both types of suspensions have a negative impact on corporate innovation. Compared with normal trading suspensions, discretionary halts lead to greater information asymmetry because of their higher frequency, longer duration and insufficient information disclosure, resulting in investors demanding higher risk compensation. Furthermore, discretionary halts provide opportunities for opportunistic behavior by insiders, manifested by higher levels of tunneling by major shareholders, more perks obtained by managers as risk compensation and a reduced focus on long-term value growth by insiders. Therefore, the coefficients of discretionary halts are significantly larger, indicating that discretionary halts have stronger negative effects on corporate innovation and seriously affect the long-term value of the company.

5. Conclusion

Because stock prices absorb the decision-making information of a large number of traders in the market, they comprehensively reflect the fundamentals of listed companies, industry prospects and macroeconomic trends (Subrahmanyam and Titman, 1999). They provide information value and can serve as information sources for stakeholders' decision-making, and knowing whether stock trading barriers impair the efficiency of secondary market stock prices in absorbing and integrating new information is a prerequisite for understanding and applying revelatory price efficiency and managers' learning effects based on stock prices. In the process of capital market development and system improvement in China, the prominent phenomenon of discretionary halts provides an opportunity to study this issue. Because the loss of non-institutional stock circulation rights has a wider impact in terms of situation, system and scope than that of institutional stock circulation rights, studying its economic consequences holds important and far-reaching significance. The temporary loss of stock circulation rights caused by discretionary halts reduces revelatory price efficiency and hinders the transmission of stock price information. This leads to more serious tunneling by major shareholders and provides opportunities for collusion by insiders to infringe on the interests of minority investors. This not only directly affects the stock trading of listed companies in the secondary market but also has a real negative impact on companies' daily production and operation decisions. Specifically, this paper explores the effect of discretionary halts on companies' long-term value and product market competitiveness from the perspective of innovation. Previous studies find that the more times a listed company discretionarily suspends trading, the lower its R&D investment and innovation output are. Studies also find that discretionary halts hinder the transmission of information, reduce revelatory price efficiency, increase the difficulty of managers' work and make it difficult for decision-makers such as managers and investors to accurately identify R&D projects. Additionally, discretionary halts worsen the information environment and lead to a greater degree of information asymmetry between external investors and insiders, which raises investors' requirements for returns, and thus companies face greater financial constraints in innovation. Moreover, discretionary halts intensify managers' concerns regarding future career development, resulting in higher agency costs and, subsequently, in insufficient attention from insiders to innovation, making it difficult to effectively implement innovation decisions. Cross-sectional tests reveal that the impact of discretionary halts on corporate innovation investment decisions is more significant in samples with higher shareholding ratios of major shareholders, non-state-owned enterprises and lower shareholding ratios of institutional investors, indicating that the stronger the motivation and ability of large shareholders to engage in tunneling, the weaker the guarantee mechanism for innovation projects, and the weaker the supervisory role of external investors, the more severe the damage to corporate innovation caused by discretionary halts. On this basis, we examine the policy effect of the guidance documents issued by the Shanghai and Shenzhen Stock Exchanges in 2016, and we find that with the implementation of the policy to generally restrict the phenomenon of discretionary halts, the negative effects of such discretionary halts on corporate innovation are even more prominent. This may be attributable to the fact that the guidelines establish a public notification system for discretionary halts, making it easier for external stakeholders to identify instances of non-compliance by companies and to react accordingly.

The findings of this paper enrich the research on the revelatory price efficiency of the secondary market. Starting from the frequent discretionary halts in China's capital market, we explore the suspension and lack

of stock liquidity, especially whether discontinuous changes in liquidity harm the revelatory price efficiency in absorbing and integrating new information, thereby harming companies' substantive decision-making. These conclusions remind readers of the importance of considering the situation of stock circulation rights when examining the revelatory price efficiency of the secondary market. We further analyze the impacting mechanism of non-institutional stock circulation rights losses at the enterprise level, and we expand the research on the economic consequences of stock suspensions, especially discretionary halts. Unlike studies that focus on the impact of suspensions on individual stocks and stock market transactions, from the perspective of the daily production and operation decisions of enterprises we explore the impact on corporate innovation investment, and we find that trading behaviors in the secondary stock market can have a real impact on corporate decision-making. We also expand the determinants of corporate innovation and confirm the correlation between corporate stock market and product market decisions

The conclusions of this paper also have practical significance. First, for listed companies, unnecessary suspensions, especially discretionary halts, should be reduced. Listed companies should actively abide by various laws and regulations and appropriately use market trading tools to avoid the loss of long-term value. Second, for policy-makers, the introduction of policies not only addresses specific problems but also affects the degree of attention from market participants toward certain behaviors of listed companies. To effectively protect the rights and interests of listed companies and their stakeholders and to promote the sustainable and stable development of the capital market, it is necessary to strengthen and clarify regulations regarding trading suspensions. Quantitative provisions should be established for suspension applications, trading suspension duration and information disclosure during the suspension period to reduce opportunities for corporate discretion. Finally, for regulatory agencies, it is important to have a proper understanding of the principles of policy formulation, grasp the policy direction and increase supervision efforts to reduce negative impacts and improve market efficiency and vitality. In particular, early intervention is required for activities, where listed companies have independent operating authority and regulatory agencies such as the China Securities Regulatory Commission and exchanges can detect and approve.

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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Private information and investment-q sensitivity: Evidence from new products

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ABSTRACT

This study shows that a decline in investment efficiency due to information asymmetry may not necessarily devalue a firm but may enhance its value instead. Firms base their investment decisions on both public and private information. However, effectively transmitting private information to investors in a competitive market is quite challenging, as it leads to stock prices inadequately reflecting a firm's true value. Simultaneously, firms must invest to achieve their business objectives, which results in a deviation between a firm's actual investment level and the market's expected investment level, thereby reducing investment-q sensitivity. However, this deviation does not imply a waste of societal resources; instead, it improves a firm's core competitiveness in the product market. We consider the future launch of new products as a proxy for firm private information. We find that (1) private information is negatively associated with investment-q sensitivity, and that the greater the sales of the new product, the lower the investment-q sensitivity; (2) the negative effect is more pronounced for firms with higher revenue volatility and ownership concentration than for those with lower revenue volatility and ownership concentration. This study helps us to further understand how to evaluate firm investment efficiency from the perspective of private information and provides empirical evidence of the costs of the new product launch process.

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1. Introduction

We examine the effect of private information on a firm's investment-q sensitivity and its underlying mechanisms in the context of new product launches. According to corporate finance theory, the problem of adverse selection arises because private information cannot be conveyed effectively to investors (Myers & Majluf, 1984). According to the efficient market hypothesis, stock prices reflect information about a firm's value creation and affect the firm's investment decisions. Tobin's Q theory (Tobin, 1969) suggests that a firm's investment should depend on its investment opportunities, specifically the q value, which is measured as the ratio of firm value to asset replacement costs. Consequently, when making investment decisions in line with the market's expectations, firms exhibit a high investment-q sensitivity, which indicates high investment efficiency. Conversely, a decline in investment-q sensitivity indicates decreased investment efficiency. Stein (2003) finds that agency problems lead to a decrease in a firm's investment-q sensitivity. However, we posit that the inherent information asymmetry between firms and the capital market also reduces firm investment efficiency. Indeed, private information leads to the incorrect evaluation of a firm's investment opportunities and prevents the market from correctly estimating the optimal investment level. In contrast, a firm must invest to achieve its business goals, which results in a deviation between the firm's actual investment level and the market's expected investment level, manifested as less efficient investment. However, such "inefficient investment" does not necessarily imply a waste of societal resources; instead, it can increase a firm's competitiveness in the product market. Therefore, this study demonstrates that a decline in investment efficiency is the result of both agency problems and information asymmetry and may lead to firm value-enhancing investments in certain contexts. We then explore the effect and mechanisms of private information on a firm's investment-q sensitivity by emphasizing the role of information asymmetry between a firm and the capital market in "inefficient investments."

There is anecdotal evidence about such "inefficient investments." Huawei's decision to independently develop microchips in the 1990s caused considerable confusion in the market. However, Huawei insisted that research on microchips must continue even if microchips did not have a clearly defined role at the time. Later, in trade disputes, the initial seemingly useless investment proved to be highly effective. During the early stages of microchip development, it was difficult for Huawei to disclose detailed information about its microchip investment to the market, and investors were unable to understand the importance of the investment. This led to the formation of different rational expectations by the capital market and the management regarding Huawei's microchip investment and a discrepancy between actual investment level and the market's expected investment level, manifested by a low investment-q sensitivity.

nformation for decision-making. If a firm discloses full information about its future decisions to the market, the stock price can reasonably reflect the firm's value creation. Without agency issues, the actual investment level of a firm does not deviate from the market's expected investment level, and the firm's investment-q sensitivity does not decrease. However, if a firm finds it difficult to disclose all of its investment-related information, which constitutes private information, the stock price-based firm value cannot reflect all the information related to future investments. In this case, the market's expected investment level is not the optimum investment level, and the decrease in investment-q sensitivity does not simply manifest as a decline in firm investment efficiency.

We further analyze the effect of revenue volatility and ownership concentration on the relationship between private information and investment-q sensitivity. Increased volatility in revenue from existing products increases market uncertainty about a firm's stability and information disclosure costs and decreases a firm's voluntary information disclosure. This leads to greater private information with the firm. Moreover, higher ownership concentration allows a firm to access financing at a comparatively low cost (Zhang et al., 2016), reducing its reliance on the capital market and the need for information disclosure. Ownership concentration also reduces concerns about managerial turnover, thereby encouraging managers to pursue high-risk, innovative investments (Parthiban et al., 2001; Faccio et al., 2011; Tang and Zuo, 2014). The combined effect of private information and investment intention exacerbates the adverse influence of private information on a firm's investment-q sensitivity. Consequently, as revenue volatility and ownership concentration increase further, the decrease in investment-q sensitivity caused by private information becomes more pronounced.

New products help firms to increase their competitiveness in the market and create firm value. The development, trial, production, and mass production of new products require considerable investments by a firm to ensure a successful market launch and penetration. Hence, the investment information regarding new products becomes crucial private information about a firm's operations. We consider the news of the future launch of a new product as a proxy for private information. We find that (1) private information is negatively associated with investment-q sensitivity, and that the greater the new product sales, the lower the investment-q sensitivity; and (2) the negative effect is more pronounced for firms with higher revenue volatility and ownership concentration than for those with lower revenue volatility and ownership concentration.

Our study makes the following three contributions to the literature. First, we reveal the alternative mechanisms that influence investment-q sensitivity. Studies measure a firm's investment opportunities using the q value, that is, the ratio of a firm's market value to its asset replacement cost (Tobin, 1969), and argue that agency problems cause the actual investment level to deviate from the market's expected investment level, leading to a decline in investment-q sensitivity. However, we find that information asymmetry can also reduce investment-q sensitivity, which signifies investment inefficiency. However, this decline does not necessarily impair firms' long-term development and may even increase their competitiveness in the product market.

Second, we introduce a new metric to measure private information. The measurement of private information and its effect on firm financial decision-making are under explored in the literature. We use new products as a proxy for private information and provide important insights for expanding the research on private information.

Third, we explore two types of "inefficient investments" and provide insights for a greater understanding of corporate investment. Firms must invest in advance for new product development. However, private information prevents the capital market from formulating appropriate expectations regarding a firm's investment activities, leading to a deviation between the actual firm investment level and the market's expected investment level. Seemingly "inefficient investments" may indicate new product launches. Further research is warranted to distinguish between the two sources of "inefficient investments": agency problems and private information. We provide a greater understanding of the relationship between firm investment and firm value in the capital market and clarify whether it indeed reflects an inefficient investment.

The remainder of this paper is structured as follows: Section 2 presents the hypotheses development, Section 3 presents the research design, Section 4 presents the empirical results, Section 5 presents the robustness tests, and Section 6 concludes.

2. Hypothesis development

2.1. Private information and investment-q sensitivity

Because of regulatory obligations and the desire to signal competitiveness, firms disclose information about their production and operations to the market. However, full disclosure may decrease a firm's market competitiveness, as competitors may replicate its innovations (Hughes & Pae, 2015). To reduce the pressure of competition, firms refrain from disclosing all of their investment information to the capital market (Xue & Wang, 2001; Hughes & Pae, 2015), which then becomes firm private information.[1] Private information is the basis for market and firm decision-making and considerably influences the rational expectations of firms and the market concerning firm investment activities.

The correlation between high returns and high investment risks considerably influences stock pricing. To address this, the Shanghai and Shenzhen Stock Exchanges have implemented several regulations pertaining to the disclosure of R&D activities to inform investors about potential risks, decrease information asymmetry between firms and the market, and maintain stock market stability. Firms need substantial funds to sustain their investment endeavors (Jian et al., 2010). They seek external finance if their internal funds fall short. Disclosure of firm information to the capital market is an important way to gain investor confidence and conveys

[1] Private information can be of two types: production-related and production-unrelated, such as internal trading information. This study assumes that the term "private information" is related to production and operations.

positive signals about the firm, which enhances firms' financing capabilities (Douglas & Robert, 1991; Botosan, 1997; Wiedman, 2000; Robert, 2001; Han & Yue, 2016).

Firms disclose future investment plans to convey positive signals regarding their prospects and increase their share price by influencing the market's expectations. However, regulations typically do not require disclosure of specific investment details, such as product pricing, production volume, and expected market share. Full investment disclosure could erode a firm's competitive edge (Hughes & Pae, 2015) by jeopardizing a firm's market share, profitability, and investment returns if competitors gain access to a firm's proprietary information and take proactive steps to counter the threat. When projects are in the early innovation stage, in which R&D outcomes are highly uncertain, firms routinely withhold information about their initial investment. Despite regulatory requirements for disclosing investment-related information, firms are genereally reluctant to provide details, such as the expected investment scale and funding sources.

Information is the basis for decision-making by the capital market and firms. In an efficient market, stock prices accurately reflect information about a firm's value. According to Tobin's Q theory (Tobin,'969), a firm's investment level depends on its investment opportunities, specifically the q value, which is measured as the ratio between a firm's market value a'd its asset replacement cost. When the q value is low, investment should be decreased, whereas a high q value justifies increasing investment. Firms that align their investment level with the market's expectations tend to display a heightened investment-q sensitivity, whereas a decrease in this sensitivity s"gnifies a decline in investment efficiency. Agency problems can lead to a considerable decrease in investment-q sensitivity (Stein, 2003). However, we posit that the inherent information asymmetry between firms and the capital market is a barrier to full information disclosure, which results in a decrease in the firm's investment-q sensitivity.

If a firm cannot fully disclose information about its production and operations, the firm's valuation based on its stock price may lack crucial investment-related information. This deficiency can lead to market misjudgments regarding a firm's investment opportunities. Although firms must invest to enhance their competitiveness in the product market, constraints in disclosing private production-related information result in different rational evaluations by the capital market and the firm regarding the same economic activity. This discrepancy leads to a deviation between a firm's actual investment level and the market's expected investment level, thereby decreasing the firm's investment-q sensitivity. Therefore, we propose the following hypothesis:

Hypothesis 1. Production-related private information decreases firms' investment-q sensitivity.

2.2. Revenue volatility

A firm experiencing high revenue volatility faces increased uncertainty in the product market, which undermines the capital market's confidence in the firm. This heightened uncertainty often leads to an increase in the cost of information disclosure. Consequently, a firm may reduce its voluntary information disclosure as a strategic response. The inherent instability in a firm's operations decreases investor confidence in new investments. Even if a firm discloses its future investment plans, investors may perceive an increased risk of failure, leading to negative market feedback. This creates a loop in which the negative feedback further increases the cost of disclosing future investment plans. Consequently, a firm faces an increased cost of disclosing such plans, which leads to a greater withholding of private information. This cycle exacerbates the adverse effect of private information on investment-q sensitivity.

Increased revenue volatility also compels firms to vigorously address their existing operational constraints while actively pursuing new product development. This strategic approach improves a firm's competitiveness in the product market. Furthermore, the opportunity cost of launching new products decreases for firms experiencing considerable revenue fluctuations in their current product lines. Firms tend to proactively innovate, by aligning their product offerings with evolving consumer demands to reduce the business risks stemming from market fluctuations.

Conversely, when a firm remains profitable in its operations, success in the product market reinforces a tendency to preserve the existing organizational structure and decision-making processes (Connie, 1991). The entrenched human capital within the management team and established cognitive models may impede a firm's engagement in and responsiveness to innovative activities (Christensen and Overdorf, 2000). Consequently, a

firm often adheres to established strategies, exhibiting greater resistance to undertaking new investment projects.

As revenue volatility increases, the motivation for full information disclosure decreases, while the need to invest in new products for enhanced market competitiveness increases. Consequently, when faced with the challenge of disclosing all future investment information to the market due to increased volatility, the adverse effect of private information is exacerbated, resulting in a notable decrease in investment-q sensitivity. Hence, we propose the following hypothesis:

Hypothesis 2. The negative effect of private information on firm investment-q sensitivity is more pronounced for firms with higher revenue volatility than for those with lower revenue volatility.

2.3. Ownership concentration

Revenue volatility decreases a firm's inclination to voluntarily disclose information while increasing its incentive to invest in new products. Moreover, the presence of controlling shareholders in the firm's ownership helps reduce a firm's reliance on the capital market, thereby reducing the need for voluntary information disclosure. This ownership structure also offers a secure foundation for investing in new products.

Financing is one of the reasons for a firm's information disclosure to the capital market. The actions of major shareholders serve as signals regarding a firm's fundamentals and its prospects, which profoundly affect the capital market's confidence in the firm. This allows a firm to reduce its dependence on the capital market, thereby reducing the need for voluntary information disclosure and facilitating access to financing at a relatively low cost.

Product innovation is crucial for firms to survive and sustain their competitiveness. However, the launch of new products demands considerable time and resources and carries substantial risks, which may impede the fulfillment of a firm's short-term objectives. Moreover, managers are often reluctant to pursue high-risk investment projects owing to concerns about their career growth, and instead favor investments that yield consistent performance (Parthiban et al., 2001). According to agency theory, the phenomena of free riding and voting with one's feet can often be observed in firms with dispersed ownership, which result in decreased risk-taking and increased myopic behavior among managers. Consequently, dispersed ownership reduces the incentive to prioritize a firm's long-term interests.

Because of the difference between the risk preferences of shareholders and managers, shareholders are more concerned with projects that create long-term firm value and are more willing to incentivize managers to undertake innovative activities (Tang and Zuo, 2014). A highly concentrated firm ownership structure notably decreases the management's myopic tendencies and encourages substantial long-term R&D investments (Faccio et al., 2011). Long-term shareholding by controlling shareholders increases managerial stability and provides incentives for engaging in innovative pursuits (Luo et al., 2022). Moreover, highly concentrated ownership increases firm decision-making efficiency. Conversely, a dispersed ownership structure leads to conflicting interests among shareholders, leading to a goal discrepancy among stakeholders (Qiao & Zhou, 2007; Gantchev and Chakraborty, 2013). Reducing internal disputes reduces internal negotiation costs, thus increasing firm decision-making efficiency and establishing a robust framework for improving a firm's production and operations processes.

An increase in the ownership concentration of controlling shareholders leads to reduced financing costs for the firm, reliance on the capital market, and need for extensive information disclosure. Simultaneously, this concentration may reduce management's concerns about layoffs, enhance decision-making efficiency, and incentivize management to engage in high-risk investments, such as R&D for new products. Nonetheless, the combined effect of these factors may exacerbate the negative effects of private information, further decreasing a firm's investment-q sensitivity. Consequently, we propose the following hypothesis:

Hypothesis 3. The negative effect of private information on investment-q sensitivity is more pronounced for firms with higher ownership concentration than for those with dispersed ownership.

3. Research design

3.1. Sample selection and data sources

We use data from Chinese A-share listed firms from 2005 to 2020. All of the data are obtained from the China Stock Market and Accounting Research database. Following the literature (Shen et al., 2012, Wan et al., 2012; Yu et al., 2014, Zhang et al., 2016), the following observations are excluded: (1) firms in the financial and insurance industries; (2) firms with negative net assets; (3) firms that are in the process of floating an IPO; (4) firms designated as special treatment (ST and *ST) firms; (5) firms with missing values; and (6) firms that did not launch a new product in a given industry-year. All of the continuous variables are winsorized at the 1st and 99th percentiles to mitigate the effect of outliers. Our final sample includes 25,497 observations.

3.2. Variables and the Model

(1) Independent Variables
(2) Control Variables

Following Chen and Xie, 2011, Shen et al., 2012, Zhang et al., 2016, we include the following financial and corporate governance factors, which are known to influence firm investment efficiency, as the control variables: firm size (*Size*), measured as the natural logarithm of total assets; financial risk (*Lev*), measured as the ratio of total liabilities to total assets at the end of the year; ownership concentration (*Top1*), measured as the proportion of shares held by the largest shareholder divided by the total number of shares; noncurrent assets (*Fix*), measured as the ratio of net property, plant, and equipment to total assets; listing age (*Age*), measured as the natural logarithm of the number of years that a firm has been listed on a stock exchange; growth (*SG*), measured as the percentage change in sales revenue; equity nature (*Prvt*), measured as a dummy variable that takes a value of 1 for non-state-owned enterprises and 0 for state-owned enterprises; and separation of ownership and control (*Separation*), measured as the difference between controlling rights and ownership rights.

Prodvol (revenue volatility) is a dummy variable that takes a value of 1 when the standard deviation of a firm's sales revenue over the previous 3 years is above the annual industry median, indicating high uncertainty in existing product revenue. Conversely, *Prodvol* takes a value of 0 when the standard deviation is below the annual industry median value. *Prodvol* signifies instability in a firm's sales revenue and reflects fluctuations in market demand or preferences for a firm's products. Firms characterized by high revenue volatility lack a consistent market share in the product market. Table 1 presents the definitions of all the variables.

(3) Model Design

Based on Tobin's Q theory (Tobin, 1969), we adopt the investment-q sensitivity model (Chen et al., 2011; Wan et al., 2012; Yu et al., 2014) to examine the effect of private information on a firm's investment efficiency before a new product launch. The introduction of new products typically demands substantial early-stage investments in fixed and intangible assets and other product costs. Therefore, we use net cash flow (depreciation and amortization expenses) for the acquisition and construction of fixed, intangible, and other long-term assets as a measure of a firm's actual investment scale, and normalize the total assets at the end of the period. Tobin's Q (*TQ*) represents firm value (investment opportunity) and is measured as the market price of the firm/firm asset replacement cost = (Price per share at the end of the year * outstanding shares at the end of the year + net assets per share at the end of the year * non-tradable shares at the end of the year + total liabilities at the end of the year)/total assets at the end of the year.

In an efficient market, stock prices mirror a firm's value creation ability, but in practice, information asymmetry between firms and the capital market often leads to a bias in stock pricing. When a firm is unable to disclose all of the new product investment-related information to the capital market, it ends up hoarding private information. In this scenario, a firm's stock price may inaccurately reflect its value, resulting in a divergence between the firm's actual investment level and the market's expected investment level, which reduces

Table 1
Variable Definitions.

Variable name	Variable symbol	Description
Investment-q sensitivity	*Invest1*	(Net cash flow paid for the acquisition and construction of fixed assets, intangible assets and other long-term assets)/Total assets at the end of the period
	Invest2	(Net cash flow paid for the acquisition and construction of fixed assets, intangible assets and other long-term assets - depreciation and amortization expense)/Total assets at the end of the period
	TQ	(Price per share at the end of the year * the number of outstanding shares at the end of the year + net assets per share at the end of the year * non-tradable shares at the end of the year + total liabilities at the end of the year)/Total assets at the end of the year
Private information	*Newprod*	Takes a value of 1 when a new product is launched in period t, otherwise takes a value of 0
	Sratnew	The proportion of new product sales revenue to total revenue
Revenue volatility	*Prodvol*	Takes a value of 1 if the standard deviation of the firm's sales revenue in the previous 3 years is greater than the annual industry median, otherwise takes a value of 0
Ownership concentration	*Top1*	The number of shares held by the largest shareholder/total number of shares of the firm
Fixed assets	*Fix*	Fixed Assets/Total Assets
Size	*Size*	The natural logarithm of total assets
Debt-to-asset ratio	*Lev*	Liabilities/Total Assets
Age of the business	*Age*	The natural logarithm of the number of years that a firm has been listed
Growth	*SG*	(Current year's operating income - previous year's operating income)/Previous year's operating income
Nature of property rights	*Prvt*	Takes a value of 1 for non-state-owned enterprises, Takes a value of 0 for state-owned enterprises
Separation of ownership and control	*Separation*	The difference between controlling rights and ownership rights

investment-q sensitivity. We use Model (1) to test Hypothesis 1; α_3 should be significant and negative to support Hypothesis 1. The model controls for industry and year fixed effects, and standard errors are clustered at the firm level.

$$\begin{aligned} Invest_{i,t-1} = {} & \alpha_0 + \alpha_1 Newprod(Sratnew)_{i,t} + \alpha_2 TQ_{i,t-2} + \alpha_3 Newprod(Sratnew)_{i,t} * TQ_{i,t-2} + \alpha_4 Lev_{i,t-2} \\ & + \alpha_5 Fix_{i,t-2} + \alpha_6 Age_{i,t-2} + \alpha_7 Size_{i,t-2} + \alpha_8 SG_{i,t-2} + \alpha_9 Prvt_{i,t-2} + \alpha_{10} Top1_{i,t-2} \\ & + \alpha_{11} Seperation_{i,t-2} + Industry + Year + \varepsilon_i \end{aligned} \quad (1)$$

We use two variables to measure investment-q sensitivity. $Invest1_{i,t-1}$ is measured as the net cash flow paid for the acquisition and construction of fixed assets, intangible assets and other long-term assets of a firm in period *t*-1, and is normalized by total assets at the end of the period. $Invest2_{i,t-1}$ considers the effect of depreciation of fixed assets, oil and gas assets, and productive biological assets as well as amortization of intangible assets and long-term amortized expenses. Private information in period t-1 is denoted by $Newprod_{i,t}$ and $Sratnew_{i,t}$. If a firm launches a new product in period t, it is considered that the firm had private information about new product investment in period t-1. Given that a firm's investment activities may be influenced by its financial characteristics in the previous period, *TQ* and other control variables in Model (1) are lagged by 2 years.

Model (2) is formulated to test Hypotheses 2 and 3 and includes *Prodvol*, *Top1*, and their interaction terms. The definitions of other variables are the same as those used in Model (1). The coefficients on the three cross-multiplication terms $Newprod(Sratnew)_{i,t} * TQ_{i,t-2} * Prodvol_{i,t-2}$ and $Newprod(Sratnew)_{i,t} * TQ_{i,t-2} * Top1_{i,t-2}$ are expected to be significant and negative.

$$
\begin{aligned}
Invest_{i,t-1} = {} & \alpha_0 + \alpha_1 Newprod(Sratnew)_{i,t} + \alpha_2 TQ_{i,t-2} + \alpha_3 Prodvol_{i,t-2} \\
& + \alpha_4 Newprod(Sratnew)_{i,t} * TQ_{i,t-2} + \alpha_5 Prodvol_{i,t-2} * TQ_{i,t-2} \\
& + \alpha_6 Newprod(Sratnew)_{i,t} * Prodvol_{i,t-2} + \alpha_7 Newprod(Sratnew)_{i,t} * TQ_{i,t-2} * Prodvol_{i,t-2} \\
& + \alpha_8 Top1_{i,t-2} + \alpha_9 Top1_{i,t-2} * TQ_{i,t-2} + \alpha_{10} Newprod(Sratnew)_{i,t} * Top1_{i,t-2} \\
& + \alpha_{11} Newprod(Sratnew)_{i,t} * TQ_{i,t-2} * Top1_{i,t-2} + \alpha_{12} Lev_{i,t-2} + \alpha_{13} Fix_{i,t-2} + \alpha_{14} Age_{i,t-2} \\
& + \alpha_{15} Size_{i,t-2} + \alpha_{16} SG_{i,t-2} + \alpha_{17} Prvt_{i,t-2} + \alpha_{18} Seperation_{i,t-2} + Industry + Year + \varepsilon_i
\end{aligned} \tag{2}
$$

4. Empirical results

4.1. Descriptive statistics

Table 2 presents the descriptive statistics of the main variables used in the model. Average *Newprod* is 10.5 % per year, which indicates that approximately 10 % of the sample firms introduce new products annually. This observation also illustrates the low success rate of new products in the product market. The distribution of the other variables is generally consistent with the findings in the literature.

4.2. Regression results

Table 3 reports the results of Model (1). Columns (1) and (2) report the regression results of the relationship between private information and investment efficiency, in which firm real investment is denoted by $Invest1_{i,t-1}$. The coefficients of $TQ_{i,t-2}\_Sratnew_{i,t}$ and $TQ_{i,t-2}\_Newprod_{i,t}$ are both negative at the 1 % significance level. This indicates that when a firm cannot effectively transmit the relevant private information to the market before a new product is launched, the market and the firm formulate different rational evaluations of the firm's investment activities. The firm's real investment may deviate from the market's expected level, which is manifested in a decrease in investment-q sensitivity, resulting in the dilemma of private information. Similarly, columns (3) and (4) report the regression results of the relationship between private information and investment efficiency, in which corporate real investment is denoted by $Invest2_{i,t-1}$. The results are similar to those reported in columns (1) and (2). Thus, Hypothesis 1 is supported.

Table 2
Descriptive statistics of major variables.

Variable	Observations	mean	standard deviation	minimum	25 % quantile	median	75 % quantile	maximum
Invest1	25,497	0.046	0.049	−0.040	0.012	0.032	0.066	0.234
Invest2	25,497	0.021	0.047	−0.083	−0.006	0.008	0.038	0.206
Sratnew	25,497	0.009	0.045	0.000	0.000	0.000	0.000	0.343
Newprod	25,497	0.105	0.306	0.000	0.000	0.000	0.000	1.000
Fix	25,497	0.279	0.196	0.002	0.126	0.242	0.403	0.797
Size	25,497	22.091	1.284	19.511	21.187	21.929	22.819	26.063
Lev	25,497	0.456	0.203	0.060	0.300	0.457	0.610	0.895
Age	25,497	2.280	0.620	1.099	1.792	2.398	2.773	3.258
SG	25,497	0.205	0.538	−0.608	−0.021	0.113	0.283	3.807
Prvt	25,497	0.530	0.499	0.000	0.000	1.000	1.000	1.000
Seperation	25,497	0.050	0.078	0.000	0.000	0.000	0.089	0.291
Top1	25,497	0.355	0.149	0.093	0.236	0.333	0.459	0.743
Prodvol	25,497	0.525	0.499	0.000	0.000	1.000	1.000	1.000
TQ	25,497	2.000	1.303	0.883	1.202	1.561	2.280	8.600

Table 3
Main regression results.

Variable	(1)	(2)	(3)	(4)
	$Invest1_{i,t-1}$	$Invest1_{i,t-1}$	$Invest2_{i,t-1}$	$Invest2_{i,t-1}$
$Sratnew_{i,t}$	0.037***		0.051***	
	(3.13)		(4.17)	
$Newprod_{i,t}$		0.006***		0.009***
		(3.69)		(4.81)
$TQ_{i,t-2}$	0.003***	0.003***	0.003***	0.003***
	(6.77)	(6.82)	(7.58)	(7.66)
$TQ_{i,t-2}\_Sratnew_{i,t}$	−0.015***		−0.017***	
	(−4.46)		(−4.95)	
$TQ_{i,t-2}\_Newprod_{i,t}$		−0.002***		−0.003***
		(−3.61)		(−4.05)
$Fix_{i,t-2}$	0.082***	0.082***	0.026***	0.026***
	(23.09)	(23.03)	(7.53)	(7.49)
$Size_{i,t-2}$	0.007***	0.007***	0.007***	0.007***
	(12.65)	(12.70)	(13.87)	(13.94)
$Lev_{i,t-2}$	−0.021***	−0.021***	−0.020***	−0.020***
	(−8.63)	(−8.64)	(−7.84)	(−7.85)
$Age_{i,t-2}$	−0.016***	−0.016***	−0.017***	−0.017***
	(−20.39)	(−20.33)	(−22.01)	(−21.93)
$SG_{i,t-2}$	0.005***	0.005***	0.006***	0.006***
	(9.29)	(9.24)	(10.18)	(10.12)
$Prvt_{i,t-2}$	0.004***	0.004***	0.004***	0.004***
	(3.35)	(3.29)	(3.26)	(3.18)
$Seperation_{i,t-2}$	−0.001	−0.001	−0.005	−0.005
	(−0.13)	(−0.14)	(−0.79)	(−0.79)
$Top1_{i,t-2}$	−0.003	−0.003	−0.006*	−0.006*
	(−0.96)	(−0.93)	(−1.72)	(−1.68)
Constant	−0.073***	−0.073***	−0.093***	−0.094***
	(−6.28)	(−6.35)	(−8.09)	(−8.19)
Observations	25,497	25,497	25,497	25,497
Adjusted R-squared	0.239	0.239	0.132	0.133
Industry	YES	YES	YES	YES
Year	YES	YES	YES	YES

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. Standard errors are clustered at the firm level.

4.3. Cross-Sectional heterogeneity test

Next, we introduce firm heterogeneity to further study the mechanisms of the effect of private information on a firm's investment-q sensitivity. Specifically, we investigate how revenue volatility and ownership concentration shape the relationship between private information and investment-q sensitivity. Table 4 presents the results.

Columns (1) and (2) of Table 4 report the regression results of how $Newprod_{i,t}$ affects firm investment efficiency in the context of high versus low revenue volatility and high versus low ownership concentration. The coefficient of $TQ_{i,t-2}\_Vol_{i,t-2}\_Newprod_{i,t}$ is significant and negative at 10 % and 5 % level respectively, indicating that with an increase in revenue volatility, the cost of disclosing information about new products to the market increases. Despite the existence of private information, firms still engage in activities, such as investing in new products, thereby exacerbating adverse selection associated with private information. Consequently, the decrease in a firm's investment sensitivity becomes more pronounced. Thus, Hypothesis 2 is supported. The coefficient of $TQ_{i,t-2}\_Top1_{i,t-2}\_Newprod_{i,t}$ is also significant and negative at 1 % and 5 % level respectively. This indicates that ownership concentration reduces a firm's reliance on the capital market, thereby decreasing its need to access finance through voluntary information disclosure. This also exacerbates adverse selection associated with private information, leading to a decrease in a firm's investment-q sensitivity. Thus, Hypothesis 3 is

Table 4
Heterogeneity test regression results.

Variable	(1)	(2)	(3)	(4)
	$Invest1_{i,t-1}$	$Invest2_{i,t-1}$	$Invest1_{i,t-1}$	$Invest2_{i,t-1}$
$Newprod_{i,t}$	−0.010**	−0.006	–	–
	(−2.06)	(−1.30)	–	–
$TQ_{i,t-2}$	0.001*	0.001*	–	–
	(1.67)	(1.68)	–	–
$Prodvol_{i,t-2}$	0.004***	0.005***	–	–
	(3.34)	(3.89)	–	–
$Top1_{i,t-2}$	−0.012**	−0.016***	–	–
	(−2.28)	(−2.99)	–	–
$TQ_{i,t-2}\_Newprod_{i,t}$	0.003*	0.002	–	–
	(1.78)	(1.37)	–	–
$Vol_{i,t-2}\_Newprod_{i,t}$	0.006*	0.006*	–	–
	(1.72)	(1.73)	–	–
$TQ_{i,t-2}\_Prodvol_{i,t-2}$	−0.000	0.000	–	–
	(−0.00)	(0.15)	–	–
$Top1_{i,t-2}\_Newprod_{i,t}$	0.036***	0.033***	–	–
	(3.17)	(2.78)	–	–
$TQ_{i,t-2}\_Top1_{i,t-2}$	0.004*	0.005**	–	–
	(1.94)	(2.26)	–	–
$TQ_{i,t-2}\_Vol_{i,t-2}\_Newprod_{i,t}$	−0.002*	−0.003**	–	–
	(−1.91)	(−2.04)	–	–
$TQ_{i,t-2}\_Top1_{i,t-2}\_Newprod_{i,t}$	−0.011***	−0.010**	–	–
	(−2.65)	(−2.33)	–	–
$Sratnew_{i,t}$	–	–	−0.038	−0.018
	–	–	(−1.09)	(−0.49)
$TQ_{i,t-2}$	–	–	0.002**	0.002*
	–	–	(2.00)	(1.95)
$Prodvol_{i,t-2}$	–	–	0.004***	0.005***
	–	–	(3.53)	(4.07)
$Top1_{i,t-2}$	–	–	−0.009*	−0.013***
	–	–	(−1.84)	(−2.58)
$TQ_{i,t-2}\_Sratnew_{i,t}$	–	–	0.014	0.012
	–	–	(1.16)	(0.95)
$Vol_{i,t-2}\_Sratnew_{i,t}$	–	–	0.048**	0.049**
	–	–	(2.03)	(1.98)
$TQ_{i,t-2}$_Provol	–	–	−0.000	0.000
	–	–	(−0.14)	(0.05)
$Top1_{i,t-2}\_Sratnew_{i,t}$	–	–	0.140*	0.116
	–	–	(1.65)	(1.33)
$TQ_{i,t-2}\_Top1_{i,t-2}$	–	–	0.003*	0.004**
	–	–	(1.67)	(2.04)
$TQ_{i,t-2}\_Vol_{i,t-2}\_Sratnew_{i,t}$	–	–	−0.015*	−0.019**
	–	–	(−1.93)	(−2.25)
$TQ_{i,t-2}\_Top1_{i,t-2}\_Sratnew_{i,t}$	–	–	−0.064**	−0.056*
	–	–	(−2.13)	(−1.80)
$Fix_{i,t-2}$	0.083***	0.027***	0.083***	0.027***
	(23.19)	(7.84)	(23.28)	(7.89)
$Size_{i,t-2}$	0.007***	0.007***	0.007***	0.007***
	(12.62)	(13.93)	(12.55)	(13.83)
$Lev_{i,t-2}$	−0.022***	−0.021***	−0.022***	−0.020***
	(−8.90)	(−8.17)	(−8.87)	(−8.13)
$Age_{i,t-2}$	−0.015***	−0.017***	−0.015***	−0.017***
	(−19.49)	(−20.99)	(−19.53)	(−21.05)
$SG_{i,t-2}$	0.005***	0.006***	0.005***	0.006***
	(9.00)	(9.84)	(9.02)	(9.89)

Table 4 (*continued*)

Variable	(1)	(2)	(3)	(4)
	$Invest1_{i,t-1}$	$Invest2_{i,t-1}$	$Invest1_{i,t-1}$	$Invest2_{i,t-1}$
$Prvt_{i,t-2}$	0.004***	0.003***	0.004***	0.003***
	(3.08)	(2.93)	(3.16)	(3.03)
$Seperation_{i,t-2}$	−0.001	−0.005	−0.001	−0.005
	(−0.14)	(−0.79)	(−0.14)	(−0.80)
Constant	−0.072***	−0.092***	−0.072***	−0.092***
	(−6.20)	(−8.05)	(−6.18)	(−8.00)
Observations	25,497	25,497	25,497	25,497
Adjusted R-squared	0.241	0.136	0.241	0.135
Industry	YES	YES	YES	YES
Year	YES	YES	YES	YES

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. Standard errors are clustered at the firm level.

Table 5
PSM results.

Variable	(1)	(2)	(3)	(4)
	$Invest1_{i,t-1}$	$Invest2_{i,t-1}$	$Invest1_{i,t-1}$	$Invest2_{i,t-1}$
$Sratnew_{i,t}$	0.030**	0.041***		
	(2.14)	(2.89)		
$TQ_{i,t-2}$	0.002**	0.002**	0.006***	0.007***
	(2.29)	(2.48)	(2.74)	(3.11)
$TQ_{i,t-2}$_$Sratnew_{i,t}$	−0.016***	−0.019***		
	(−3.64)	(−4.08)		
$Newprod_{i,t}$			0.011***	0.014***
			(2.71)	(3.45)
$TQ_{i,t-2}Newprod_{i,t}$			−0.007***	−0.008***
			(−2.90)	(−3.29)
$Fix_{i,t-2}$	0.082***	0.026***	0.082***	0.027***
	(11.90)	(3.94)	(11.97)	(4.03)
$Size_{i,t-2}$	0.004***	0.005***	0.005***	0.005***
	(4.44)	(4.62)	(4.43)	(4.76)
$Lev_{i,t-2}$	−0.015***	−0.011**	−0.015***	−0.010**
	(−3.10)	(−2.15)	(−2.97)	(−2.00)
$Age_{i,t-2}$	−0.009***	−0.011***	−0.009***	−0.011***
	(−5.72)	(−6.59)	(−5.56)	(−6.39)
$SG_{i,t-2}$	0.005***	0.005***	0.004***	0.005***
	(3.33)	(3.88)	(3.11)	(3.58)
$Prvt_{i,t-2}$	0.006***	0.006**	0.006**	0.006**
	(2.66)	(2.43)	(2.43)	(2.04)
$Seperation_{i,t-2}$	0.009	0.003	0.007	0.002
	(0.92)	(0.33)	(0.78)	(0.25)
$Top1_{i,t-2}$	−0.006	−0.014**	−0.006	−0.013**
	(−0.89)	(−2.09)	(−0.82)	(−2.01)
Constant	−0.026	−0.038*	−0.039	−0.057**
	(−1.16)	(−1.70)	(−1.58)	(−2.28)
Observations	5,350	5,350	5,350	5,350
Adjusted R-squared	0.284	0.137	0.284	0.137
Industry	YES	YES	YES	YES
Year	YES	YES	YES	YES

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. Standard errors are clustered at the firm level.

Table 6
Results of the placebo test.

Variable	(1)	(2)	(3)	(4)
	$Invest1_{i,t-1}$	$Invest2_{i,t-1}$	$Invest1_{i,t-1}$	$Invest2_{i,t-1}$
$LNew_{i,t-2}$	−0.001	−0.000		
	(−0.52)	(−0.11)		
$TQ_{i,t-2}$	0.002***	0.002***	0.002***	0.002***
	(3.20)	(3.87)	(3.14)	(3.69)
$TQ_{i,t-2}$_$LNew_{i,t-2}$	0.000	−0.000		
	(0.27)	(−0.28)		
$LSRNew_{i,t-2}$			−0.024	−0.020
			(−1.35)	(−1.18)
$TQ_{i,t-2}$_$LSRNew_{i,t-2}$			0.006	0.005
			(0.82)	(0.65)
$Fix_{i,t-2}$	0.082***	0.027***	0.082***	0.027***
	(16.40)	(5.12)	(16.39)	(5.11)
$Size_{i,t-2}$	0.007***	0.008***	0.007***	0.008***
	(9.03)	(9.75)	(9.03)	(9.75)
$Lev_{i,t-2}$	−0.014***	−0.014***	−0.014***	−0.015***
	(−3.88)	(−3.87)	(−3.90)	(−3.89)
$Age_{i,t-2}$	−0.016***	−0.017***	−0.016***	−0.017***
	(−15.45)	(−15.99)	(−15.45)	(−15.99)
$SG_{i,t-2}$	0.004***	0.005***	0.004***	0.005***
	(4.07)	(4.84)	(4.13)	(4.87)
$Prvt_{i,t-2}$	0.004**	0.002	0.004**	0.002
	(2.14)	(1.23)	(2.14)	(1.22)
$Seperation_{i,t-2}$	−0.000	−0.003	−0.001	−0.003
	(−0.04)	(−0.35)	(−0.08)	(−0.38)
$Top1_{i,t-2}$	−0.000	−0.002	−0.000	−0.002
	(−0.03)	(−0.47)	(−0.04)	(−0.48)
Constant	−0.066***	−0.087***	−0.065***	−0.086***
	(−3.86)	(−4.87)	(−3.83)	(−4.84)
Observations	8,620	8,620	8,620	8,620
Adjusted R-squared	0.236	0.141	0.237	0.141
Industry	YES	YES	YES	YES
Year	YES	YES	YES	YES

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. Standard errors are clustered at the firm level.

supported. Columns (3) and (4) of Table 4 report the regression results of how $Sratnew_{i,t}$ affects firm investment efficiency in the context of high versus low revenue volatility and high versus low ownership concentration. The results are similar to those reported in columns (1) and (2) of Table 4, which support Hypotheses 2 and 3.

5. Robustness tests

5.1. Propensity score matching

To reduce sample selection bias, we adopt propensity score matching (PSM) to pair all observations in the original sample using 1:1 matching with replacement. Next, we re-run the model using the matched sample. The firms that launched a new product are used as the treatment group, while firms that did not launch any new products in the same period are selected for PSM, so that the two groups of firms are the same or close to each other in terms of firm characteristics. That is, the only difference between the two groups of firms is whether they launched a new product in the market. The control variables used in the matching model are factors that influence new product launch: *Size*, *Lev*, *Top1*, *Fix*, *Age*, *SG*, and *Prvt*. In all, 5,350 firm-year observations are successfully matched after excluding mismatched samples.

Table 7
Alternative proxy for investment level.

Variable	(1)	(2)	(3)	(4)
	$AveInvest1_{i,t-1}$	$AveInvest2_{i,t-1}$	$AveInvest1_{i,t-1}$	$AveInvest2_{i,t-1}$
$TQ_{i,t-2}$	0.002***	0.002***	0.002***	0.002***
	(5.55)	(5.05)	(5.58)	(5.16)
$Sratnew_{i,t}$	0.029***	0.041***		
	(2.82)	(3.74)		
$TQ_{i,t-2}$_$Sratnew_{i,t}$	−0.011***	−0.013***		
	(−3.00)	(−3.57)		
$Newprod_{i,t}$			0.005***	0.007***
			(3.46)	(4.64)
$TQ_{i,t-2}$_$Newprod_{i,t}$			−0.001***	−0.002***
			(−2.94)	(−3.58)
$Fix_{i,t-2}$	0.118***	0.064***	0.117***	0.064***
	(33.72)	(18.30)	(33.67)	(18.27)
$Size_{i,t-2}$	0.007***	0.008***	0.007***	0.008***
	(14.19)	(14.71)	(14.23)	(14.78)
$Lev_{i,t-2}$	−0.014***	−0.012***	−0.014***	−0.012***
	(−6.00)	(−4.87)	(−6.01)	(−4.88)
$Age_{i,t-2}$	−0.019***	−0.022***	−0.019***	−0.022***
	(−25.39)	(−28.08)	(−25.33)	(−28.01)
$SG_{i,t-2}$	0.004***	0.005***	0.004***	0.005***
	(9.15)	(9.99)	(9.07)	(9.89)
$Prvt_{i,t-2}$	0.006***	0.006***	0.006***	0.006***
	(5.31)	(5.43)	(5.26)	(5.36)
$Seperation_{i,t-2}$	−0.004	−0.008	−0.004	−0.008
	(−0.78)	(−1.43)	(−0.78)	(−1.43)
$Top1_{i,t-2}$	−0.006**	−0.010***	−0.006**	−0.010***
	(−2.03)	(−3.25)	(−2.01)	(−3.22)
Constant	−0.095***	−0.115***	−0.095***	−0.116***
	(−8.77)	(−9.95)	(−8.83)	(−10.03)
Observations	25,497	25,497	25,497	25,497
Adjusted R-squared	0.407	0.261	0.407	0.261
Industry	YES	YES	YES	YES
Year	YES	YES	YES	YES

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. Standard errors are clustered at the firm level.

Table 5 presents the regression results of the matched sample. The coefficients on $TQ_{i,t-2}$_$Sratnew_{i,t}$ and $TQ_{i,t-2}Newprod_{i,t}$ continue to be negative at the 1 % significance level, indicating that private information may lead to the formation of different expectations by firms and the capital market about firm investment activity, thus reducing firms' investment-q sensitivity. This shows that our main results hold after controlling for sample selection bias.

5.2. Placebo test

Thus far, we have shown that private information makes it difficult for stock prices to accurately reflect firm value creation through a firm's future investment decisions. This limitation prevents the market from precisely forecasting a firm's investment level, leading to a deviation between the actual investment level and the market's expected investment level. This discrepancy decreases a firm's investment-q sensitivity.

However, when a new product is launched in the market, its investment information no longer remains exclusive or private. Instead, the details of the new product investment become integrated into the stock price. Consequently, the market can anticipate this new product investment, thereby aligning a firm's actual investment level more closely with the market's expectations. This alignment implies that a firm's investment q-value sensitivity does not decrease.

Table 8
Robustness test: Fixed effects.

Variable	(1)	(2)	(3)	(4)
	$Invest1_{i,t-1}$	$Invest1_{i,t-1}$	$Invest2_{i,t-1}$	$Invest2_{i,t-1}$
$TQ_{i,t-2}$	0.002***	0.002***	0.003***	0.003***
	(5.22)	(5.26)	(6.05)	(6.11)
$Sratnew_{i,t}$	0.044***		0.056***	
	(3.84)		(4.70)	
$TQ_{i,t-2}$_$Sratnew_{i,t}$	−0.015***		−0.017***	
	(−4.51)		(−4.95)	
$Newprod_{i,t}$		0.007***		0.009***
		(4.36)		(5.11)
$TQ_{i,t-2}$_$Newprod_{i,t}$		−0.002***		−0.002***
		(−3.46)		(−3.80)
$Fix_{i,t-2}$	−0.008	−0.008	−0.050***	−0.050***
	(−1.55)	(−1.59)	(−9.49)	(−9.53)
$Size_{i,t-2}$	0.004***	0.004***	0.005***	0.005***
	(4.65)	(4.66)	(4.83)	(4.83)
$Lev_{i,t-2}$	−0.037***	−0.037***	−0.039***	−0.039***
	(−10.33)	(−10.32)	(−10.12)	(−10.11)
$Age_{i,t-2}$	−0.023***	−0.023***	−0.026***	−0.026***
	(−11.76)	(−11.72)	(−12.52)	(−12.46)
$SG_{i,t-2}$	0.003***	0.003***	0.003***	0.003***
	(4.94)	(4.86)	(5.66)	(5.57)
$Prvt_{i,t-2}$	0.008***	0.008***	0.010***	0.010***
	(3.06)	(3.06)	(3.21)	(3.21)
$Seperation_{i,t-2}$	−0.020**	−0.020**	−0.024**	−0.024**
	(−2.18)	(−2.20)	(−2.44)	(−2.45)
$Top1_{i,t-2}$	0.014**	0.014**	0.017***	0.017***
	(2.47)	(2.49)	(2.74)	(2.77)
Constant	0.005	0.005	−0.014	−0.014
	(0.24)	(0.23)	(−0.64)	(−0.64)
Observations	25,037	25,037	25,037	25,037
Adjusted R-squared	0.434	0.434	0.331	0.331
Firm	YES	YES	YES	YES
Industry#Year	YES	YES	YES	YES

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. Standard errors are clustered at the firm level.

Therefore, in the placebo test, we exclude firms that did not launch a new product for 3 consecutive years. The explanatory variables are $LNew_{i,t-2}$, which takes a value of 1 when a new product is launched in period t-2, and 0 otherwise, and $LSRNew_{i,t-2}$, which is measured as the ratio of new product sales revenue to total revenue in period t-2. Model (3) includes the same control variables and dependent variable as Model (2). It also controls for industry and year fixed effects. Standard errors are clustered at the firm level. Model (3) is formulated as follows, and we expect α_3 to be nonsignificant.

$$Invest_{i,t-1} = \alpha_0 + \alpha_1 LNew(LSRNew)_{i,t-2} + \alpha_2 TQ_{i,t-2} + \alpha_3 LNew(LSRNew)_{i,t-1} * TQ_{i,t-2} + \alpha_4 Controls_{i,t-2} + Industry + Year + \varepsilon_i \quad (3)$$

Table 6 reports the results of the placebo test. Columns (1) and (2) show the regression results of $LNew_{i,t-2}$ and columns (3) and (4) show the regression results of $LSRNew_{i,t-2}$. The coefficient of the interaction terms $TQ_{i,t-2}$_$LNew_{i,t-2}$ and $TQ_{i,t-2}$_$LSRNew_{i,t-2}$ are both nonsignificant, indicating that when the investment information of a firm is incorporated into its stock price, the firm's investment level aligns closely with the market's expected investment level, thereby leading to no significant effect on the firm's investment efficiency. These results are consistent with our expectations.

Table 9
Ruling out the effect of technology-oriented firms.

Variable	(1)	(2)	(3)	(4)
	$Invest1_{i,t-1}$	$Invest1_{i,t-1}$	$Invest2_{i,t-1}$	$Invest2_{i,t-1}$
$Sratnew_{i,t}$	0.042***		0.056***	
	(3.03)		(3.90)	
$Newprod_{i,t}$		0.009***		0.012***
		(4.69)		(5.76)
$TQ_{i,t-2}$	0.002***	0.002***	0.003***	0.003***
	(4.64)	(4.84)	(5.53)	(5.79)
$TQ_{i,t-2}\_Sratnew_{i,t}$	−0.017***		−0.019***	
	(−4.20)		(−4.70)	
$TQ_{i,t-2}\_Newprod_{i,t}$		−0.003***		−0.003***
		(−3.98)		(−4.61)
$Fix_{i,t-2}$	0.074***	0.074***	0.020***	0.020***
	(18.76)	(18.69)	(5.33)	(5.29)
$Size_{i,t-2}$	0.006***	0.006***	0.007***	0.007***
	(10.79)	(10.86)	(12.00)	(12.10)
$Lev_{i,t-2}$	−0.022***	−0.022***	−0.019***	−0.019***
	(−7.91)	(−7.91)	(−6.83)	(−6.83)
$Age_{i,t-2}$	−0.016***	−0.016***	−0.017***	−0.017***
	(−16.34)	(−16.25)	(−17.38)	(−17.28)
$SG_{i,t-2}$	0.005***	0.005***	0.006***	0.006***
	(7.48)	(7.41)	(8.47)	(8.39)
$Prvt_{i,t-2}$	0.003**	0.003**	0.003**	0.003**
	(2.12)	(2.04)	(2.14)	(2.04)
$Seperation_{i,t-2}$	−0.002	−0.002	−0.006	−0.006
	(−0.36)	(−0.36)	(−0.93)	(−0.93)
$Top1_{i,t-2}$	−0.002	−0.002	−0.005	−0.005
	(−0.47)	(−0.43)	(−1.23)	(−1.18)
Constant	−0.060***	−0.061***	−0.084***	−0.085***
	(−4.65)	(−4.74)	(−6.50)	(−6.63)
Observations	18,049	18,049	18,049	18,049
Adjusted R-squared	0.247	0.247	0.126	0.126
Industry	YES	YES	YES	YES
Year	YES	YES	YES	YES

Note: ***, ** and * indicate significant at the 1%, 5% and 10% levels, respectively. Standard errors are clustered by firms.

5.3. Alternative proxy for investment level

Considering the chronology of a firm's investment and the launch of new products, wherein investments precede new product launches, we measure investment scale as the average firm investment level (*Aveinvest*) in periods t-1, t-2, and t-3 for the robustness test. Table 7 shows that the coefficients of $TQ_{i,t-2}\_Sratnew_{i,t}$ and $TQ_{i,t-2}\_Newprod_{i,t}$ are negative at the 1 % significance level, which indicates that our results hold for the alternative proxy for investment level.

5.4. Fixed effects

We also control for firm fixed effects to address the problem of missing time-invariant variables. Given that it is better not to simultaneously include firm and industry fixed effects in the model, we control for firm fixed effects and industry-year fixed effects in the regression model. Table 8 shows that the coefficients of $TQ_{i,t-2}\_Sratnew_{i,t}$ and $TQ_{i,t-2}\_Newprod_{i,t}$ are negative at the 1 % significance level, which indicates that our results hold for firm fixed effects.

5.5. Ruling out the effect of Technology-Oriented firms

Given that technology-oriented firms allocate substantial funds to R&D investment annually, the market expects these firms to consistently maintain such R&D investments. This unique characteristic may influence how the market values the investment activities of technology firms. Therefore, for the robustness test, we exclude firms with R&D investment above the annual median level. Table 9 shows that the results continue to be consistent with our main conclusion.

6. Conclusion

We investigate the influence of private information on a firm's investment-q sensitivity in the context of new product launches, using new products as a proxy for measuring private information. We find that firms' investment-q sensitivity considerably decreases before a new product is launched. Furthermore, the greater the sales of the new products, the lower the investment-q sensitivity: the greater the revenue volatility and ownership concentration of a firm, the greater the decrease in investment-q sensitivity. As a firm's revenue volatility increases, information disclosure costs also increase, resulting in a greater inclination for new product development. This intensifies the adverse effects of private information, resulting in a decreased investment-q sensitivity for firms before a product launch. Moreover, higher ownership concentration tends to reduce a firm's reliance on the capital market, which reduces the need to disclose new product investment details to the market. The compounded effect of private information and investment intention aggravates the negative influence of private information on a firm's investment-q sensitivity. Thus, as ownership concentration increases, the decrease in investment-q sensitivity due to private information becomes more pronounced.

Our findings offer a new perspective on inefficient firm investments and provide empirical evidence for the private information dilemma when launching a new product. Typically, stock-based firm valuation is used to assess investment opportunities. This suggests that agency issues may cause firms' investments to deviate from the market's expected investment level, manifested as a decrease in investment-q sensitivity. However, our findings show that when management possesses private information related to production and operations that cannot be effectively transmitted to the market, a firm's market value fails to accurately reflect its investment opportunities. This leads to a discrepancy between the firm's real investment scale and the market's expected investment level, reducing the firm's investment-q sensitivity. Nevertheless, such a decrease in investment efficiency does not indicate a wastage of societal resources; on the contrary, it improves a firm's competitiveness in the product market.

Our study theoretically contributes to a greater comprehension of the relationship between private information and investment efficiency. We show that information asymmetry influences "inefficient investments." Consequently, evaluating firm investment efficiency requires considering both managerial agency problems and the effect of information asymmetry between the firm and the capital market. Moreover, our findings show that the local government can improve information disclosure, thereby improving the informational efficiency of stock prices. This allows for a more accurate reflection of firm investment efficiency and creates a positive cycle in the capital market by facilitating more precise assessments of investment opportunities and a more informed investment environment.

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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Digital technology, the industrial internet, and cost stickiness

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ABSTRACT

The deep integration of digital technology with the real economy has reconstructed production systems. We explore the impact of digital technology on the resource allocation behavior and efficiency of manufacturing enterprises. Using a sample of Chinese A-share listed manufacturing firms over the 2010–2021 period, we find that digital technology alleviates cost stickiness, especially in enterprises with a high level of Industrial Internet platform usage. This effect occurs by optimizing the labor force structure and improving the economic benefits of labor capital investment. Heterogeneity analysis shows that this effect is pronounced in enterprises with high levels of labor intensity and business complexity. Our findings shed new light on the consequences and mechanism of enterprise cost optimization that is driven by technology-driven reforms.

1. Introduction

Diminishing domestic demographic dividends, coupled with escalating production costs, have increasingly posed cost management challenges for manufacturing enterprises in China. To ensure high-quality development, these enterprises must efficiently allocate operational resources and promptly adjust their business models. Such changes also facilitate cost maintenance with moderate elasticity in a dynamic macroeconomic environment. For enterprises, it is also essential to advance their ability to resist dynamic risks. During a

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group study session of the Central Political Bureau on October 18, 2021, Chinese Communist Party (CCP) General Secretary Xi Jinping emphasized the need to fully leverage the advantages of massive data and diverse application scenarios and thus promote the deep integration of digital technology with the real economy. This proposed integration is intended to consolidate digital technology resources and traditional production factors.

The integration of digital technology into real enterprises is also attracting attention. For enterprises, big data is transitioning from a potential to a tangible production factor (Xie et al., 2020). "Internet+" technology, which uses modern communication technologies, encourages enterprises to engage in "cross-border operations," thereby enhancing the scientific aspects and precision of corporate governance (Zhao et al., 2020). Artificial intelligence provides precise data analysis to support enterprises' cost control and investment decisions (Wu and Tian, 2022; Yue and Gu, 2022). The Internet of Things, by preventing the adoption of aggressive expansion strategies, strengthens management's forecasting capabilities (Tan and Wang, 2021). At the industry level, digital technology actively reduces transaction costs, enhances operational and innovation efficiency, and drives industrial structural upgrades (Cha and Zuo, 2017; Huang et al., 2019; Liu and Zhang, 2021). Previous studies lay a solid theoretical foundation upon which to explore the relationship between technological innovation and the consequences of enterprise resource allocation. However, unlocking the black box through which digital technology improves an enterprise's cost structure requires additional microeconomic empirical evidence that is closely related to practical scenarios.

In essence, the integration of digital technology into real enterprises revolves around the application of infrastructure technologies such as big data, artificial intelligence, blockchain, and cloud computing. This integration is manifested through technological innovations in microcomputer systems, numerical control technologies, and communication devices. Beyond the current body of research, further empirical evidence is needed to identify the specific micro-level applications of digital technology. One crucial focus is the identification of measurement methods that closely match practical scenarios of digital technology applications in manufacturing enterprises. In addition, digital technology not only is a novel production factor but also empowers traditional production factors. Specifically, it provides capabilities for information transmission and data analysis and improves the effective allocation and utilization of resources. Against this background, it is necessary to further illuminate the inherent relationship between the application of digital technology and changes in cost structures.

Accordingly, we investigate the impact of digital technology application on cost stickiness from the perspective of labor factor empowerment. We select a sample of Chinese A-share listed manufacturing firms over the 2010–2021 period and use the word embedding model, which captures the practical application of digital technologies in manufacturing enterprises. We find that digital technology alleviates cost stickiness, which mainly exists in enterprises that have a high level of Industrial Internet platform usage. Our main results hold after conducting a series of robustness and endogeneity tests. We further investigate the mechanisms underlying the curbing effect of digital technology on cost stickiness, namely increasing the employment of high-skilled laborers and improving the economic benefits of labor capital investment. Heterogeneity tests show that this curbing effect is pronounced in enterprises with high levels of labor intensity and business complexity.

This study makes several contributions. First, we contribute to the literature on cost stickiness by revealing the consequences of technological innovations that drive firms' cost structure optimization. Based on evidence provided by Anderson et al. (2003), most studies explore the influences of stickiness, such as executives' opportunistic motives, optimistic expectations, and labor protection (Chen et al., 2012; Dierynck et al., 2012; Kama and Weiss, 2013; Xie and Hui, 2014; Liang, 2015; Banker et al., 2013; Liu and Liu, 2014). As a new production factor, digital technology is important as a means of empowering the labor force and optimizing traditional production factor systems. From the perspective of labor force empowerment, we explore how digital technology application affects firms' cost structure optimization and its consequences, and help broaden research on firms' cost stickiness. This paper also sheds new light on manufacturing enterprises' cost reduction and risk control.

Second, we broaden the research perspective on labor force empowerment by analyzing the important process by which digital technology is used to optimize firms' cost structure. Academic studies on the consequences of digital technology application are abundant. Research in this area is conducted from various

perspectives, including operational efficiency, specialization and division of labor, and service transformation. The integration of digital technology into traditional brick-and-mortar firms has structural impacts on labor factors (Brynjolfsson et al., 2018; Acemoglu and Restrepo, 2019; Agrawal et al., 2019). From this perspective, we reveal the process by which the application of digital technology prompts firms to increase the hiring of high-skilled labor and enhance the economic efficiency of their labor capital. Thus, this study provides new insights into the relationship between digital technology and the labor skill premium.

Third, we provide empirical evidence demonstrating how regional Industrial Internet platforms can enhance enterprises' digital technology application by exploring the external synergistic conditions surrounding digital technology micro-application. In contrast to previous studies, which reveal the effect of the construction of Industrial Internet platforms on manufacturing enterprises through theoretical explorations and case studies, the current study provides empirical evidence (Cai and Qi, 2021; Chen et al., 2022; Sun et al., 2022; Du and Cao, 2022). Specifically, we provide evidence of the impact of regional Industrial Internet platforms on the relationship between digital technology and enterprises' cost stickiness based on the list of pilot demonstration projects involving Industrial Internet integration, which is published by the Ministry of Industry and Information Technology.

The remainder of the paper is structured as follows. Section 2 provides a review of the relevant literature and a theoretical analysis. Section 3 presents our research design. Section 4 presents our empirical tests and analysis. Section 5 concludes the paper.

2. Theoretical foundations and hypothesis formulation

Theoretically, the expected business volume determines the input and effectiveness of various resources. Anderson et al. (2003) observes that as an enterprise's revenue increases, the magnitude of the increase in its cost expenses exceeds the decline in revenue, causing the changes between the two factors to be asymmetric. Labor, a quasi-fixed production factor, introduces adjustment costs to enterprises (Oi, 1962; Manning, 2003). When sales revenue declines, management performs a cost–benefit analysis regarding the adjustment of short-term redundant resources. Reducing fixed assets or human capital is anticipated to incur higher acquisition costs in the future. An increase in adjustment costs typically reduces management's willingness to make cost and capacity adjustments, exacerbating cost stickiness (Jaramillo et al., 1993; Pfann and Palm, 1993; Palm and Pfann, 1997; Goux et al., 2001; Balakrishnan et al., 2004; Sun and Liu, 2004; Cooper and Haltiwanger, 2006; Banker and Chen, 2006; Liu, 2006; Calleja et al., 2006; Kong et al., 2007; Liu and Wang, 2009). The cited studies show that the labor adjustment cost has a significant influence on an enterprise's cost structure and level, leading to the adjustment cost hypothesis in labor economics (Anderson et al., 2003; Ghaly et al., 2017).

Compared with traditional financial capital elements, labor is less fixed and has a weaker long-term nature; its specificity generates adjustment costs for firms. Specifically, activities such as layoffs, recruitment, and training increase the expenses of enterprises, especially those reliant on skilled labor. A shortage in the labor market extends the time required to replace skilled workers with new employees, with increasingly significant negative impacts on production operations (Manning, 2003; Dolfin, 2006). A decline in market demand triggers layoffs to reduce costs. However, layoffs can also reduce investors' confidence and cause fluctuations in an enterprise's stock price (Farber and Hallock, 2009). Under these circumstances, management's motivation to reduce labor costs is diminished and its labor capital mobility decreases. This effect of labor not only amplifies an enterprise's operational risk but also adversely affects its financial decisions regarding, for example, debt levels and cash holdings (Oi, 1962; Dixit, 1997; Agrawal and Matsa, 2013).

Digital technologies, such as big data, the Internet, the Internet of Things, and artificial intelligence, are gradually exerting a multiplier effect in terms of enhancing the production efficiency of real enterprises. By empowering labor factors, these technologies alleviate cost stickiness in manufacturing enterprises. Characteristically, these digital technologies are biased towards technology (Autor et al., 2013), specifically the autonomous performance of programmatic tasks and activities and the independent collection and storage of data. Moreover, these technologies can perform repetitive work tasks that require physical strength and low-to-moderate cognitive skills (Acemoglu and Restrepo, 2018, 2020; Graetz and Michaels, 2018). Accordingly, they

reduce firms' reliance on low-skilled labor, enhance firms' bargaining power in labor–capital relationships (Arnoud, 2018), and significantly mitigate management's concerns about cost adjustments. Accordingly, enterprises have a strong motivation to optimize the structure of labor factor allocation (Hershbein and Kahn, 2018; Zhang, 2019; Jaimovich and Siu, 2020). Furthermore, alleviating cost stickiness can be achieved by reducing the employment of low-skilled laborers.

Digital technology also offers possibilities for cost stickiness reduction through synergy with labor factors to enhance the economic benefits of labor capital. Applications such as big data, the Internet, the Internet of Things, cloud computing, artificial intelligence, and blockchain have recently become integral to productivity. These applications foster a complementary relationship between digital technologies and skilled labor factors (Flug and Hercowitz, 2000; Acemoglu and Autor, 2011; Weinberger, 2014). Changes in work structure facilitate the creation of new job roles, directing high-skilled labor toward innovation to offset the negative impact of technological innovation on total factor productivity. (Yu and Wei, 2021). These effects promote the skill premium of labor factors (Acemoglu and Restrepo, 2019; Humlum, 2019) and enhance the adaptability of labor to new workflows and organizational patterns (Hitt and Brynjolfsson, 1997; Bresnahan et al., 2002; Wang et al., 2006). Thereby, effectively alleviating cost stickiness within enterprises.

Undeniably, the integration of digital technology into real enterprises is a vital step toward embedding a culture of innovation in an organizational structure. A culture characterized by moderation and entrenched fixed thinking tends to promote inertia in both ideology and behavior. Such inertia relies on the accumulated knowledge of the existing workforce and the habitual utilization of traditional technologies. Accordingly, enterprises face adjustment costs related to digital technology innovation. Nevertheless, the extent to which digital technology effectively enhances cost efficiency in manufacturing enterprises remains unparalleled.

According to reports by the TCL Research Institute,[1] the core exposure process technology used by Huaxing Optoelectronics before 2019 required a substantial workforce to identify defects during inspections. On average, each factory required 50–100 employees to categorically examine 300,000–600,000 images daily. This task heavily relied on the experiential judgment of employees, with variable accuracy. Challenges such as a high labor demand, lengthy training and onboarding periods, and elevated turnover rates persisted for a long time. In 2019, Huaxing Optoelectronics, Goertek, and the TCL Research Institute collaborated in the research and deployment of the Tianshu AI-based Automatic Defect Classification (ADC) System, which played a pivotal role in cost reduction and efficiency enhancement.

The ADC system increased the speed of identifying images with defects by 5–10 times and increased the accuracy from 85 % (human eye) to over 90 %, significantly reducing rework costs. Additionally, the ADC system has replaced the work of over 400 defect inspectors, resulting in annual operational cost savings of millions of RMB for the factories. In other words, digital technology is driving profound transformations of production methodologies by consistently lowering operational costs and providing conditions to alleviate cost stickiness. We propose the following hypothesis.

H1: Digital technology applications alleviate cost stickiness.

Technological innovation is an important means by which firms can grow rapidly and break through development bottlenecks (Sebastian et al., 2017). However, the "digital gap" poses a significant barrier to enterprises in the process of technological innovation (Du and Cao, 2022). Industrial Internet platforms play an important role in helping enterprises to address the challenges of digital technological innovation, thereby enhancing their performance and competitiveness in digitization (Li et al., 2018). These platforms are integrated systems that connect people, machinery, objects, and networks by incorporating cloud computing and IoT technologies into the manufacturing industry cloud system (Wollschlaeger et al., 2017). They are an open, data-oriented, and professional service platforms that support the personalized, networked, and intelligent development needs of the manufacturing industry (Mayer et al., 2017), and provide a system for the collection, aggregation, and analysis of massive quantities of data, thus supporting ubiquitous connections, an elastic supply, and the efficient allocation of manufacturing resources in an ecosystem. Since 2017,

[1] https://magazine.tcl.com/article.

the Chinese central government's work reports[2] have included relevant opinions on "promoting high-quality development of the manufacturing industry through the Industrial Internet." Some excellent platforms, such as Haier Group's COSMPlat (COSMPlat, 2017), Sany Group's ROOTCLOUD (ROOTCLOUD, 2017), and the UFIDA Industrial Internet platform (UFIDA JINGZHI, 2019) have been selected repeatedly for inclusion on the Ministry of Industry and Information Technology's Cross-industry and Cross-field Industrial Internet Platform List. Industrial Internet platforms provide the foundation, support and resources while stimulate and promote the continuous development and advancement of innovation through key links (e.g., exploratory bridging, resource storage, data activation, spatial expansion, inclusive evolution, and ecological feedback). Thus, Industrial Internet platforms can promote manufacturing enterprises' successful realization of digital transformation (Du and Cao, 2022), growth, and value creation (Ma et al., 2020; Wei and Li, 2020; Lu and Chen, 2023).

Furthermore, Industrial Internet platforms reduce the information search costs imposed on enterprises in the value chain, industrial chain, and factor chain. They also decrease the manual input required for procedural steps. Moreover, these platforms establish a system of industry synergy that promotes competition and empowers the efficiency of enterprise resource allocation, thereby providing external conditions for alleviating cost stickiness. From the perspective of sharing, an Industrial Internet platform comprehensively collects regional data on production factors (i.e., equipment, software, and personnel), thereby enhancing enterprises' motivation and ability to share resources with each other. For example, Haier's COSMO platform enables resource synergy through collaborative components, production modules and third-party cooperation within connected factories. It also facilitates the sharing of software, equipment, logistics, and components among these connected factories. Additionally, the COSMO platform enables data collaboration between connected factories, production equipment, and smart products through the Industrial Internet of Things cloud, thereby helping relevant small and medium enterprises to achieve optimization of equipment, processes, planning, materials, supply chain, production routes, and operations (Lv et al., 2019). This platform not only integrates common service resources (e.g., logistics, warehousing, solution information, financial capital, and testing certification), but also strengthens enterprises' intensive and personalized production and service capabilities. It also promotes improved supply demand matching between enterprises and more precise enterprise production efficiency and supply capacity. These improvements enhance the effectiveness of digital technology in diverse scenarios, thereby enhancing the alleviation of enterprises' cost stickiness.

From the perspective of intelligence, an Industrial Internet platform possesses data analytics capabilities rooted in industrial knowledge mechanisms. Such a platform establishes a collaborative and interactive manufacturing ecosystem by connecting networks and devices. It incorporates data collection, analysis, modeling, and decision-making, thereby enhancing enterprises' intelligent manufacturing capabilities and providing the essential conditions for energy-efficient and cost-effective operations. According to the information disclosure on UFIDA's website,[3] Fujian Petrochemical has utilized the UFIDA Industrial Internet platform to create a smart factory, leading to the integration of production and operation and resulting in a 30 % increase in collaborative efficiency. The integration of production planning, workshop scheduling, workshop tasks, and various production processes led to a 20 % improvement in the scheduling efficiency. Additionally, the equipment idling rate was reduced and energy conservation was realized through industrial application, resulting in a cost savings of 1.6 million RMB over one year. In addition, Industrial Internet platforms promote the solidification, accumulation, and repeated use of knowledge, thus alleviating challenges such as a high level of differentiation between equipment and the system, complex operations, diverse demands, and cultural constraints (Chen et al., 2022). In turn, enterprises' digital technology application capabilities are activated, and the ability of digital technology applications to alleviate cost stickiness is reinforced. Based on the above information, we propose the following hypothesis.

[2] On November 27, 2017, the State Council officially issued the *Guiding Opinions on Deepening the Development of Industrial Internet in the Context of "Internet Plus Advanced Manufacturing."* This document outlines the three-stage development goals, corresponding main tasks, and supportive measures for the development of a domestic industrial internet. It emphasizes the construction of cross-industry and cross-domain platforms; the establishment of a group of enterprise-level platforms to support the digitalization, networking, and intelligent transformation of enterprises; and the improvement of requirements for a smart manufacturing ecosystem.

[3] https://jingzhi.yonyoucloud.com/#/platform_Jingzhi/case.

H2: The positive effect of digital technology applications on cost stickiness is more pronounced in firms with a high (vs. low) level of Industrial Internet platform use.

3. Research design

3.1. Sample selection

Our initial sample consists of public manufacturing firms listed on the Chinese A-share market over the 2010–2021 period. We apply the following criteria to screen the research sample. (1) We delete observations classified as special treatment (labeled as ST/*ST/PT) because of financial distress or other specific reasons. (2) We exclude firms with less than 3 consecutive years of observations to ensure that we can capture dynamic changes. (3) We winsorize all continuous variables at the 1st and 99th percentiles to reduce the effects of outliers. As a result, our final sample consists of 22,552 firm-year observation. We obtain financial information from the China Stock Market & Accounting Research database and annual reports from the CNINFO Network.

3.2. Variable construction

3.2.1. Measures of cost stickiness

We use the classical model developed by Anderson et al. (2003) to estimate the degree of cost stickiness. Specifically, our dependent variable is the log change in operation cost ($\Delta lncost_{it}$), calculated as the natural logarithm of the ratio of the operating costs in year t to the operating costs in year t–1. Our independent variable is the contemporaneous log change in sales revenue ($\Delta lnsale_{it}$), calculated as the natural logarithm of the ratio of sales revenue in year t to the sales revenue in year t–1. We identify a firm as exhibiting cost stickiness if the operating costs decrease less when sales revenue falls than they increase when sales revenue rises by an equivalent amount.

3.2.2. Measures of digital technology

Following Mikolov et al. (2013), we proxy for digital technology using the Word2Vec natural language processing method.

First, we extract high-frequency keywords related to digital technology terms from the core competitiveness description sections of annual reports.

Then, we set a seed vocabulary according to the high-frequency keywords. Specifically, *intelligentization, robot*, *artificial intelligence*, *digitalization*, *digital technology*, *5G*, *big data*, *cloud computing*, *base station*, *new energy*, and *blockchain* are selected as the seed vocabulary of digital technology.

Next, we expand similar words in the seed vocabulary. The top 10 words with the highest similarity scores are selected as a set of similar words from which repeated words are removed. We then calculate the frequencies of words related to digital technology from the core competitiveness sections of annual reports over the 2010–2021 period and standardize the effective words after removing invalid words from the text of core competitiveness sections.

Finally, we test the validity of our measure of digital technology. The Word2Vec natural language processing method uses dense real-valued vectors to represent words according to the context. These vectors generate a word vector space. Within this space, the distance between word vectors represents the semantic similarity of the words. A shorter distance between word vectors indicates that the words are more semantically similar. Therefore, we select word sets with a similarity coefficient exceeding 0.4 and map a word network. A thicker and denser connection between words indicates a larger correlation coefficient. Figs. 1 and 2 present the network maps of similar digital technology words in the fiscal years 2010 and 2021, respectively. Compared with Fig. 1, Fig. 2 contains more detailed words and depicts a denser network and stronger correlations between similar words. These changes vividly reveal the rapid development of digital technology in recent years and validate our proxy for digital technology. Using the Word2Vec Natural language processing method, we search broadly for digital technology seed vocabulary in annual reports and obtain similar words consistent with the meanings of the seed words, helping us to comprehensively measure digital technology in firms. As

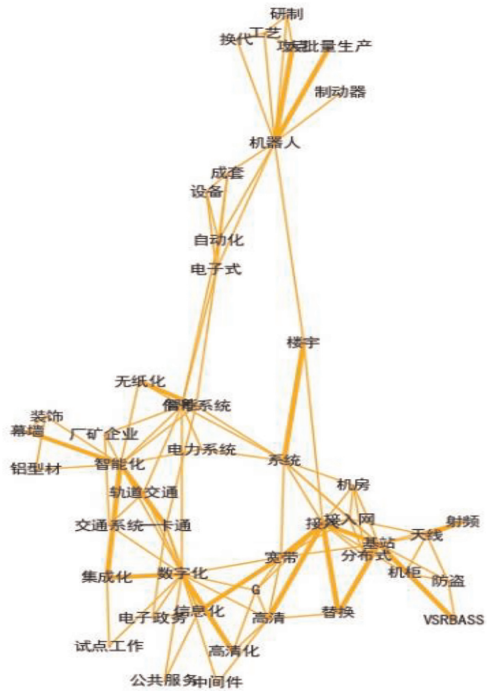

Fig. 1. Network graph of similar digital technology words in 2010.

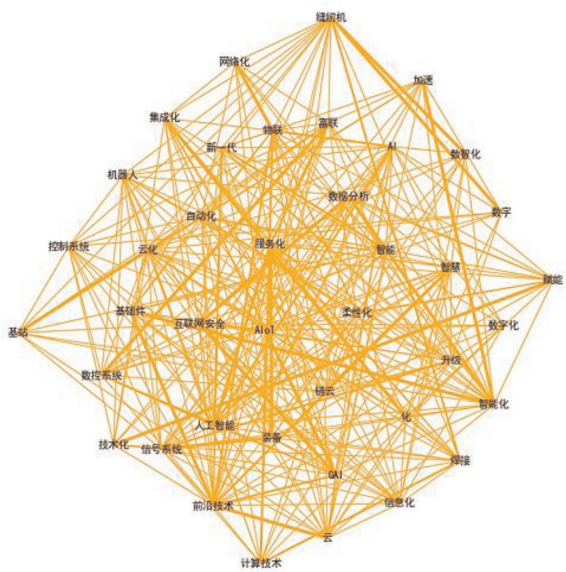

Fig. 2. Network graph of similar digital technology words in 2021.

shown in Table 1, these similar words objectively depict the scenarios of digital technology application in production practice and further enhance the effectiveness of our measure of digital technology.

3.2.3. Moderator variable

Since 2017, the Ministry of Industry and Information Technology has published a list of Industrial Internet pilot demonstration projects. In accordance with this list, we calculate the numbers of Industrial Internet pilot

Table 1
Similar words in digital technology.

Similar words	Similarity
Power station	0.607102
Converge	0.590356
Frequency channel	0.581762
Heating, ventilation, and air conditioning	0.581410
Sliding rail	0.580501
Assess	0.570911
Image	0.570342
Shelter	0.568766
Code	0.566611
Curtain wall	0.566065
Temperature control	0.558451
Voltage-dependent resistor	0.556963
Ultrasonic	0.553762
Heating	0.539559
Integrate	0.539034
Low noise	0.537688
Control technology	0.532261
Radiography	0.523227
High-definition	0.519978
High-energy	0.519155
Energy conservation	0.517062
Renewable energy	0.516122
Wire and cable	0.488917
Cleaning	0.482952
Correlation	0.482228
Signal processing	0.482144
Cyclic delay diversity	0.476388
Management software	0.469342
Grid	0.469091
Terminal	0.467150
Sub-item	0.466211

demonstration projects in different cities (*IIP*). Then, we partition the sample into two sub-samples according to the median of *IIP*.

3.2.4. Control variables

Following prior research (Anderson et al., 2003; Banker and Byzalov, 2014), we set several control variables. We control for asset intensity (*AInt*) and employee intensity (*EInt*) to capture the financial capital and human capital adjustment costs, respectively, as Anderson et al. (2003) argue that adjustment costs are higher for firms that rely more on assets owned and people employed than for firms that rely more on materials and services purchased. *AInt* is calculated as the ratio of total assets to sales revenue. *EInt* is calculated as the ratio of the total number of employees to sales revenue in millions. Next, we control for several variables related to managerial expectations about the permanency of a decline in sales revenue and, consequently, their willingness to cut slack resources and aggressiveness in this process. The successive sales revenue decrease (*Suc*) and GDP growth (*GGDP*) are included because prior research (Anderson et al., 2003) documents that managers are less optimistic about future demand after a consecutive sales decrease and are more optimistic after a period of macroeconomic growth. *Suc* is a dummy variable that equals 1 if the sales revenue for firm *i* decreases in both year *t* and year *t–1*, and 0 otherwise. *GGDP* is the GDP growth rate in year *t* for the province in which firm *i* is headquartered. Chen et al. (2012) find that cost stickiness increases with agency problems, while strong corporate governance mitigates agency-based cost stickiness. We thus add management expenses (*MR*) as a proxy for agency costs; this is calculated as the ratio of management expenses to sales revenue. CEO duality (*Dual*) is included to control for traditional corporate governance. In particular, a CEO who also holds the chairman position is more powerful than a CEO without a dual role, and this power reduces the strength

of board monitoring. *Dual* is a dummy variable that equals 1 if the CEO also serves as chairman of the board, and 0 otherwise. Moreover, we control for managerial opportunism (*Opportunism*) and optimism (*Optimism*), given that greater levels of both result in higher cost stickiness (Chen et al., 2012; Dierynck et al., 2012). *Opportunism* is calculated as the natural logarithm of the sum of the top three executives' compensation. *Optimism* is the comprehensive production and management climate index of an enterprise.

We also control for other firm characteristics. Firm age (*Age*) is calculated as the natural logarithm of 1 plus the fiscal year, minus a firm's initial public offering (IPO) year. Firm size (*Size*) is calculated as the natural logarithm of the total assets and reflects the operational scale and market competitiveness of a firm. Capital structure (*Lev*) is measured as the ratio of total liabilities to total assets and reveals a firm's ability to access external funds. Turnover of total capital (*Tat*) is calculated as the ratio of sales revenue to total assets. Return on assets (*ROA*) is calculated as the ratio of net profit to total assets. Earnings volatility (*Risk*) is calculated as the income before income tax divided by total assets, after which the 3-year volatility is determined. All variables are defined in Table 2.

3.3. Model specification

We estimate the following models to investigate the effect of digital technology on cost stickiness:

$$\begin{aligned}\Delta \ln \cos t_{i,t} = {} & \beta_0 + \beta_1 \Delta \ln sale_{i,t} + \beta_2 Dec_{i,t} \times \Delta \ln sale_{i,t} + \beta_3 Dec_{i,t} \\ & + \beta_4 Dec_{i,t} \times \Delta \ln sale_{i,t} \times Suc_{i,t} + \beta_5 Dec_{i,t} \times \Delta \ln sale_{i,t} \times AInt_{i,t} \\ & + \beta_6 Dec_{i,t} \times \Delta \ln sale_{i,t} \times EInt_{i,t} + \beta_7 Dec_{i,t} \times \Delta \ln sale_{i,t} \times GGDP_{i,t} \\ & + \beta_8 Suc_{i,t} + \beta_9 AInt_{i,t} + \beta_{10} EInt_{i,t} + \beta_{11} GGDP_{i,t} + \beta_{12} Age_{i,t} \\ & + \beta_{13} Size_{i,t} + \beta_{14} Lev_{i,t} + \beta_{15} Tat_{i,t} + \beta_{16} ROA_{i,t} + \beta_{17} Risk_{i,t} + \beta_{18} MR_{i,t} \\ & + \beta_{19} Dual_{i,t} + \beta_{20} Opportunism_{i,t} + \beta_{21} Optimism_{i,t} \\ & + \mathrm{FE}Industry + \mathrm{FE}Year + \mathrm{FEFirm} + \varepsilon_{\mathrm{i,t}}\end{aligned} \tag{1}$$

Table 2
Variable definitions.

Variable	Definition
DT	The frequency of keywords related to digital technology, derived from the core competitiveness description sections of annual reports.
IIP	The numbers of Industrial Internet platform pilot demonstration projects in different cities.
△*lncost*	The natural logarithm of the ratio of the operating costs in year *t* to the operating costs in year *t*–1.
△*lnsale*	The natural logarithm of the*t* ratio of the sales revenue in year *t* to the sales revenue in year *t*–1.
Dec	A dummy variable that equals 1 if the sales revenue in year *t* is less than that in year *t*–1, and 0 otherwise.
Suc	A dummy variable that equals 1 if the sales revenue for firm *i* decreases in both year *t* and year *t*–1, and 0 otherwise.
AInt	The ratio of total assets to sales revenue.
EInt	The ratio of the total number of employees to sales revenue in millions.
GGDP	The current GDP minus the previous GDP, divided by the previous GDP.
Age	The natural logarithm of the fiscal year minus a firm's IPO year.
Size	The natural logarithm of total assets.
Lev	The ratio of total liabilities to total assets.
Tat	The ratio of sales revenue to total assets.
ROA	The ratio of net profit to total assets.
Risk	The income before income tax, divided by total assets; 3-year volatility is then calculated.
MR	The ratio of management expenses to sales revenue.
Dual	A dummy variable that equals 1 if the CEO also serves as chairman of the board, and 0 otherwise.
Opportunism	The natural logarithm of the sum of the top three executives' compensation.
Optimism	The comprehensive production and management climate index of an enterprise.

Note: This table presents details on how each variable is measured.

$$\begin{aligned}\Delta \ln \cos t_{i,t} = {} & \beta_0 + \beta_1 \Delta \ln sale_{i,t} + \beta_2 Dec_{i,t} \times \Delta \ln sale_{i,t} + \beta_3 Dec_{i,t} \\ & + \beta_4 Dec_{i,t} \times \Delta \ln sale_{i,t} \times DT_{i,t} + \beta_5 Dec_{i,t} \times \Delta \ln sale_{i,t} \times Suc_{i,t} \\ & + \beta_6 Dec_{i,t} \times \Delta \ln sale_{i,t} \times AInt_{i,t} + \beta_7 Dec_{i,t} \times \Delta \ln sale_{i,t} \times EInt_{i,t} \\ & + \beta_8 Dec_{i,t} \times \Delta \ln sale_{i,t} \times GGDP_{i,t} + \beta_9 DT_{i,t} + \beta_{10} Suc_{i,t} \\ & + \beta_{11} AInt_{i,t} + \beta_{12} EInt_{i,t} + \beta_{13} GGDP_{i,t} + \beta_{14} Age_{i,t} + \beta_{15} Size_{i,t} \\ & + \beta_{16} Lev_{i,t} + \beta_{17} Tat_{i,t} + \beta_{18} ROA_{i,t} + \beta_{19} Risk_{i,t} + \beta_{20} MR_{i,t} \\ & + \beta_{21} Dual_{i,t} + \beta_{22} Opportunism_{i,t} + \beta_{23} Optimism_{i,t} \\ & + \mathrm{FE}Industry + \mathrm{FE}Year + \mathrm{FE}\mathrm{Firm} + \varepsilon_{i,t}\end{aligned} \tag{2}$$

where i denotes the firm, and t denotes the year. $\Delta lncost_{i,t}$ is the natural logarithm of the ratio of the operating costs in year t to the operating costs in year t–1. $\Delta lnsale_{it}$ is the natural logarithm of the ratio of the sales revenue in year t to the sales revenue in year t–1. $Dec_{i,t}$ is a dummy variable that equals 1 if the sales revenue in year t is less than that in year t–1, and 0 otherwise. Because the value of $Dec_{i,t}$ is 0 when revenue increases, the coefficient β_1 represents the percent increase in operating costs with each 1 % increase in sales revenue. Because the value of $Dec_{i,t}$ is 1 when revenue decreases, the sum of the coefficients $\beta_1 + \beta_2$ is the percent decrease in operating costs with each 1 % decrease in sales revenue. If $\beta_2 = 0$, the upward and downward changes in operating costs are equally balanced. If $\beta_1 < 0$, the degree of cost reduction is lower than the degree of cost increases when sale revenue changes, indicating sticky operating costs.

Equation (2) interacts digital technology (DT) with $Dec_{i,t}$*$\Delta lncost_{i,t}$ to test whether digital technology reduces cost stickiness. If β_4 is significant and positive, then cost stickiness decreases as DT increases.

To test the impact of the Industrial Internet platform on the association between digital technology and cost stickiness, we re-estimate Equation (2) for the two sub-samples partitioned according to the median of IIT.

4. Empirical results

4.1. Descriptive statistics and correlation analysis

Table 3 reports the descriptive statistics of the main variables. DT has a mean (median) value of 0.011 (0.007) and a standard deviation of 0.011. $\Delta lncost$ has a mean (median) value of 0.121 (0.113), and $\Delta lnsale$ has a mean (median) value of 0.113 (0.108), suggesting that the operating costs and sales revenue both increase by year, although the operating costs increase more sharply. Dec has a mean (median) value of 0.353 (0.00), suggesting that approximately 35.3 % of the firm-years exhibit a decline in sales revenue. Suc has a mean (median) value of 0.114 (0.00), suggesting that in 11.4 % of the firm-years, the sales revenues continue to follow the declining trend from the previous year. The provinces in which the sample firms were located experienced a high average annual GDP growth rate of 10.3 %, indicating the rapid growth of the Chinese economy over the sample period.

Table 4 summarizes the magnitudes and significance levels of the correlation coefficients on the main variables. The results reveal no strong correlations between the variables, thus avoiding the risk of estimation errors due to multicollinearity.

4.2. Baseline regression results

Table 5 reports the baseline regression results pertaining to the effect of digital technology on cost stickiness and the impact of the Industrial Internet platform on this relationship. Column (1) presents the results of Equation (1). The coefficient on $\Delta lnsale$ is significant and positive ($\beta_1 = 0.5749$, $t = 156.03$) while the coefficient on Dec*$\Delta lnsale$ is significant and negative ($\beta_2 = -0.5175$, $t = -28.53$), showing that the operation costs increase by about 0.57 % for each 1 % increase in sales revenue, whereas the operation costs decrease by only about 0.06 % ($\beta_1 + \beta_2 = -0.06$) per 1 % decrease in sales revenue over our sample period. The results support the prevalence of cost stickiness in the manufacturing firms. Column (2) presents the results of Equation (2),

Table 3
Descriptive statistics.

	N	Mean	P50	SD	P25	P75
△*lncost*	22,552	0.121	0.113	0.371	–0.028	0.265
△*lnsale*	22,552	0.113	0.108	0.352	–0.028	0.252
DT	22,552	0.011	0.007	0.011	0.003	0.015
IIP	22,552	7.763	6	5.551	4	10
Dec	22,552	0.353	0.000	0.478	0.000	1.000
Suc	22,552	0.114	0.000	0.318	0.000	0.000
AInt	22,552	0.555	0.331	0.731	0.154	0.645
EInt	22,552	0.001	0.001	0.001	0.001	0.001
GGDP	22,552	0.103	0.100	0.075	0.060	0.147
Age	22,552	9.427	8	7.125	3	15
Size	22,552	21.994	21.778	1.447	20.991	22.725
Lev	22,552	0.454	0.443	0.227	0.277	0.612
Tat	22,552	0.613	0.515	0.447	0.323	0.766
ROA	22,552	0.033	0.036	0.076	0.012	0.066
Risk	22,552	0.042	0.020	0.066	0.010	0.045
MR	22,552	0.106	0.074	0.132	0.044	0.117
Dual	22,552	0.283	0	0.450	0	1
opportunism	22,552	14.412	14.381	0.727	13.938	14.839
Optimism	22,552	120.625	121.915	4.536	119.5	123.4

Note: This table provides the summary statistics of the key variables. The sample size, mean, median (P50), standard deviation (SD), 25th percentile (P25), and 75th percentile (P75) are reported. The sample spans the 2010–2021 period and includes 22,552 firm-year observations. All continuous variables are winsorized at the 1st and 99th percentiles.

estimated using the full sample. As expected, the coefficient on *Dec*Δlnsale*DT* is positive and significant, suggesting that digital technology mitigates cost stickiness. Column (3) presents the results of Equation (2), estimated using the sub-sample of firms with a high *IIP*, the coefficient on *Dec*Δlnsale*DT* is significant and positive at the 1 % level. Column (4) presents the results of Equation (2) estimated using the sub-sample of firms with a low *IIP*; the coefficient on *Dec*Δlnsale*DT* is not significant. Taken together, these results show that digital technology enables manufacturing firms to reduce cost stickiness, and the effect is more pronounced in firms with a high *IIP*.

4.3. Robustness tests

4.3.1. Alternative measure of digital technology

The generalizability of our findings hinges on the measures we use to capture digital technology. In baseline regressions, we use a continuous variable (*DT*) to proxy for digital technology. To enhance the credibility of our results, we replace the continuous variable with a dummy variable (*D_DT*) that equals 1 if *DT* is above the median, and 0 otherwise. Columns (1)–(3) of Table 6 report the results. The coefficient on *Dec*Δlnsale*DT*, estimated using the full sample, is significant and positive at the 5 % level ($\beta_4 = 0.0024$, $t = 1.99$). The coefficient on *Dec*Δlnsale*DT* for the sub-sample with a high *IIP* is significant and positive at the 5 % level ($\beta_4 = 0.0642$, $t = 2.45$). The coefficient on *Dec*Δlnsale*DT* for the sub-sample with a low *IIP* is not significant. These results imply that the baseline findings hold when we use an alternative measure of digital technology.

4.3.2. Excluding sample observations prior to 2015

Firms' use of digital technology has improved substantially in recent years due to macroeconomic policy support. Specifically, in 2015, the Fifth Plenary Session of the 18th Central Committee of the CCP proposed the implementation of a network power strategy and big data strategy. Since then, substantial macro guidance policies have been continuously enacted, refined, and implemented. The integration of digital technology in real enterprises has progressed. For example, in May 2016, the Central Committee of the CCP and The State Council issued the *Outline of the National Strategy for Innovation-driven Development*, setting the digital economy as a main focus of development. In December 2016, the State Council delivered the *National Strategic*

Table 4
Correlation analysis.

	A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	I	*J*	*K*	*L*	*M*	*N*	*O*	*P*	*Q*	*R*	*S*
△lncost (A)	1.000																		
△lnsale (B)	0.936***	1.000																	
DT (C)	0.048***	0.049***	1.000																
IIP (D)	–0.013**	– 0.023***	0.209***	1.000															
Dec (E)	– 0.593***	– 0.637***	– 0.052***	– 0.023***	1.000														
Suc (F)	– 0.396***	– 0.424***	– 0.058***	– 0.013***	0.485***	1.000													
AInt (G)	– 0.020***	– 0.019***	–0.013**	–0.003	0.007	0.014***	1.000												
EInt (H)	– 0.020***	– 0.019***	–0.007	–0.003	0.007	0.014***	0.999***	1.000											
GGDP (I)	0.016***	0.016***	0.014**	– 0.062***	– 0.015***	–0.007	–0.001	–0.001	1.000										
Age (J)	– 0.118***	– 0.105***	– 0.051***	0.073***	– 0.056***	0.110***	–0.002	–0.002	– 0.024***	1.000									
Size (K)	0.070***	0.076***	0.029***	0.168***	– 0.181***	– 0.083***	–0.005	–0.005	– 0.037***	0.331***	1.000								
Lev (L)	– 0.042***	– 0.038***	– 0.028***	– 0.054***	– 0.036***	0.050***	0.015***	0.015***	0.028***	0.310***	0.361***	1.000							
Tat (M)	0.133***	0.149***	0.010	– 0.048***	– 0.110***	– 0.119***	–0.007	–0.007	0.009*	0.007	– 0.027***	0.079***	1.000						
ROA (N)	0.251***	0.321***	0.009	–0.005	– 0.205***	– 0.253***	– 0.025***	– 0.026***	0.001	– 0.178***	– 0.043***	– 0.402***	0.134***	1.000					
Risk (O)	– 0.138***	– 0.152***	– 0.040***	0.003	0.178***	0.201***	0.018***	0.019***	0.004	0.034***	– 0.253***	0.158***	– 0.057***	– 0.377***	1.000				
MR (P)	– 0.271***	– 0.292***	0.007	– 0.070***	0.183***	0.231***	0.035***	0.036***	0.015***	0.041***	– 0.295***	0.028***	– 0.339***	– 0.325***	0.369***	1.000			
Dual (Q)	0.037***	0.034***	0.038***	0.056***	0.024***	– 0.025***	– 0.078***	0.062***	–0.012*	– 0.244***	– 0.188***	– 0.159***	– 0.025***	0.053***	0.043***	0.028***	1.000		
Opportunism (R)	0.047***	0.049***	0.074***	0.282***	– 0.102***	– 0.096***	– 0.128***	– 0.232***	– 0.124***	0.089***	0.484***	0.115***	0.044***	0.147***	– 0.098***	– 0.128***	0.007	1.000	
Optimism (S)	0.036***	0.025***	0.073***	0.232***	– 0.053***	– 0.098***	– 0.054***	–0.014**	0.278***	– 0.045***	– 0.042***	0.003	0.060***	0.024***	0.065***	– 0.072***	0.002	– 0.007	1.000

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

Table 5
Baseline results from analysis of the effect of digital technology on cost stickiness.

	Dep. Var. = △*lncost*			
	Full sample		High *IIP*	Low *IIP*
	(1)	(2)	(3)	(4)
△*lnsale*	0.5749***	0.5988***	0.7099***	0.5650***
	(156.03)	(137.58)	(76.10)	(97.56)
*Dec**△*lnsale*	–0.5175***	–0.5181***	–0.5949***	–0.5073***
	(–28.53)	(–24.54)	(–16.28)	(–15.28)
Dec	–0.0783***	–0.0718***	–0.0500***	–0.0708***
	(–20.10)	(–16.35)	(–7.23)	(–11.01)
*Dec**△*lnsale***DT*	–	4.4317***	3.5865***	1.3602
	–	(5.48)	(2.97)	(1.00)
DT	–	0.2632*	–0.3820	0.3007
	–	(1.76)	(–1.31)	(1.00)
*Dec**△*lnsale***Suc*	–0.0260	–0.0205	0.0140	–0.0527*
	(–1.55)	(–1.08)	(0.46)	(–1.86)
Suc	–0.0075	–0.0079	0.0153	–0.0142
	(–1.35)	(–1.27)	(1.45)	(–1.61)
*Dec**△*lnsale***AInt*	–0.0086***	–0.0087**	–0.0382***	–0.0057
	(–3.09)	(–2.52)	(–2.66)	(–1.30)
AInt	–0.0046*	–0.0003	–0.0188	–0.0002
	(–1.71)	(–0.10)	(–1.64)	(–0.06)
*Dec**△*lnsale***EInt*	1.0373***	0.5920	–3.8475	–1.1478
	(5.42)	(1.62)	(–0.75)	(–0.45)
EInt	1.1482***	–0.5748	–7.7551	0.5724
	(3.55)	(–0.53)	(–1.63)	(0.35)
Dec *△*lnsale***GGDP*	0.0020	0.0331	–0.0774	0.3871***
	(0.15)	(1.60)	(–1.20)	(3.84)
GGDP	0.0037	–0.0026	–0.0086	0.0001
	(1.12)	(–0.58)	(–1.26)	(0.01)
Age	–0.0022***	–0.0027***	–0.0332***	–0.0811***
	(–3.93)	(–3.54)	(–5.48)	(–2.61)
Size	0.0085***	0.0150***	–0.0031	0.0282***
	(3.02)	(3.96)	(–0.31)	(5.26)
Lev	0.0081*	–0.0287***	–0.0137	–0.0356***
	(1.67)	(–3.16)	(–0.50)	(–3.09)
Tat	0.0124***	0.0159***	0.0069	0.0345***
	(2.78)	(2.93)	(0.56)	(4.33)
ROA	0.0065***	–0.0689***	–0.0998***	–0.0683***
	(3.38)	(–8.29)	(–5.88)	(–6.15)
Risk	0.0033	0.0022	0.0520***	–0.0002
	(1.43)	(0.86)	(3.69)	(–0.05)
MR	–0.0001	0.0025	0.0219*	0.0014
	(–0.27)	(1.38)	(1.72)	(0.58)
Dual	–0.0078**	–0.0099**	–0.0130	–0.0004
	(–1.98)	(–2.15)	(–1.54)	(–0.06)
Opportunism	0.0032	0.0017	–0.0091	0.0049
	(0.94)	(0.42)	(–1.12)	(0.85)
Optimism	0.0002	–0.0002	–0.0565***	–0.1123**
	(0.91)	(–0.59)	(–5.11)	(–2.51)
_cons	–0.1566	–0.2289	7.8064***	14.2579**
	(–1.61)	(–1.62)	(5.43)	(2.41)

(*continued on next page*)

Table 5 (*continued*)

	Dep. Var. = $\triangle lncost$			
	Full sample		High *IIP*	Low *IIP*
	(1)	(2)	(3)	(4)
FE_Industry	Yes	Yes	Yes	Yes
FE_Year	Yes	Yes	Yes	Yes
FE_Firm	Yes	Yes	Yes	Yes
N	22,552	22,552	9,439	13,113
$AdjR^2$	0.7907	0.7982	0.8138	0.7918

Note: This table presents the baseline results of the regression of the effect of digital technology on cost stickiness and the impact of the Industrial Internet platform on this relationship. Our sample spans the 2010–2021 period and includes 22,552 firm-year observations. Column (1) reports the regression results of Equation (1), suggesting that manufacturing firms experience cost stickiness. Column (2) reports the regression results of Equation (2) for the full sample, suggesting that digital technology reduces cost stickiness. Column (3) and (4) report the regression results of Equation (2) for sub-samples stratified by the level of Industrial Internet platform use, suggesting that the reduction in cost stickiness mainly occurs in firms with a high level of platform use.
***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Emerging Industries Development Plan During the 13th Five-Year Plan Period, which included the digital creative industry for the first time. In 2017, the 19th National Congress of the CCP proposed to promote the deep integration of digital technology with the real economy to build a digital China. To alleviate the problem of variable distribution of digital technology, we exclude the sample prior to 2015 and re-estimate Equation (2) over the 2015–2021 period. Columns (4)–(6) of Table 6 report the results. The coefficient on *Dec*Δlnsale*DT*, estimated using the full sample, is significant and positive at the 1 % level ($\beta_4 = 2.6051$, $t = 3.73$), suggesting that digital technology mitigates cost stickiness. The coefficient on *Dec*Δlnsale*DT* for the sub-sample with a high *IIP* is significant and positive at the 1 % level ($\beta_4 = 3.0356$, $t = 2.78$). The coefficient on *Dec*Δlnsale*DT* for the sub-sample with a low *IIP* is not significant. These results show that our main results remain robust when the early sample years are excluded.

4.3.3. Impact of cultural friction

Cultural friction may lead to adjustment costs, thus reinforcing cost stickiness. Peace culture means equal love, care, and respect for everyone. A firm with peace culture is more inclined to protect the legitimate rights and interests of every employee, which may prevent the firm from dismissing redundant labor and adjusting the human capital structure timely. We follow Li et al. (2021) and extract high-frequency keywords related to peace culture (*culture*) from the annual reports. The keywords include *human-oriented*, *rights and interests*, *equality*, *employee*, *protection*, *kindness*, *love*, and *all staff*. A higher word frequency indicates a stronger impact of peace culture on the firm, which would depress optimization of the labor force structure and mitigate the effect of digital technology on cost stickiness. We include *culture* and the interaction variable *Dec*Δlnsale*Culture* in Equation (2). Columns (7)–(9) of Table 6 report the results. The coefficient on *Dec*Δlnsale*DT* for the full sample is significant and positive at the 1 % level ($\beta_4 = 4.2118$, $t = 5.19$). The coefficient on *Dec*Δlnsale*DT* for the sub-sample with a high *IIP* is significant and positive at the 1 % level ($\beta_4 = 3.4122$, $t = 3.12$). The coefficient on *Dec*Δlnsale*DT* for the sub-sample with a low *IIP* is not significant. The magnitudes of the coefficients are similar to those in the baseline analysis, as reported in Table 5.

The coefficient on *Dec*Δlnsale*Culture* for the full sample is significant and negative at the 1 % level ($\beta = -3.7064$, $t = -2.95$). The coefficient on *Dec*Δlnsale*Culture* for the sub-sample with a high *IIP* is positive but not significant. The coefficient on *Dec*Δlnsale*Culture* for the sub-sample with a low *IIP* is significant and negative at the 1 % level ($\beta = -6.9148$, $t = -4.77$). These results show that cultural friction only exacerbates cost stickiness in firms with a low *IIP*. Overall, the curbing effect of digital technology on cost stickiness remains after considering the potential impact of cultural friction.

Table 6
Results of robustness tests.

	Dep. Var. = △*lncost*								
	Alternative measure of digital technology			Removal of sample data prior to 2015			Inclusion of impact of cultural friction		
	Full sample (1)	High *IIP* (2)	Low *IIP* (3)	Full sample (4)	High *IIP* (5)	Low *IIP* (6)	Full sample (7)	High *IIP* (8)	Low *IIP* (9)
△*lnsale*	0.9718***	0.9420***	0.9843***	0.9879***	0.9713***	0.9910***	0.5981***	0.9747***	0.9885***
	(200.19)	(88.05)	(161.59)	(169.50)	(90.55)	(114.74)	(137.19)	(90.89)	(143.25)
*Dec**△*lnsale*	–0.1241***	–0.2586***	–0.0974***	–0.0365**	–0.0440*	–0.0309	–0.5128***	–0.0789**	0.0581**
	(–4.53)	(–3.65)	(–3.01)	(–2.37)	(–1.76)	(–1.24)	(–24.23)	(–2.30)	(2.14)
Dec	0.0058*	–0.0086	0.0081*	0.0049	0.0010	0.0085	–0.0725***	0.0016	0.0108**
	(1.77)	(–1.44)	(1.92)	(1.20)	(0.15)	(1.34)	(–16.48)	(0.25)	(2.13)
*Dec**△*lnsale***DT/D_DT*	0.0224**	0.0642**	0.0130	2.6051***	3.0356***	–0.0825	4.2118***	3.4122***	–1.0405
	(1.99)	(2.45)	(0.93)	(3.73)	(2.78)	(–0.07)	(5.19)	(3.12)	(–0.99)
DT/D_DT	–0.0001	0.0045	–0.0030	0.0097	–0.1525	0.0495	0.2629*	–0.0255	–0.3458*
	(–0.06)	(0.90)	(–1.01)	(0.06)	(–0.58)	(0.17)	(1.76)	(–0.10)	(–1.92)
*Dec**△*lnsale***Suc*	–0.0029	0.0366	–0.0239	0.0014	0.0164	–0.0295	–0.0172	0.0162	–0.0074
	(–0.18)	(1.16)	(–1.20)	(0.08)	(0.60)	(–1.12)	(–0.91)	(0.59)	(–0.33)
Suc	–0.0039	0.0190**	–0.0077	–0.0001	0.0226**	–0.0112	–0.0071	0.0229**	–0.0060
	(–0.86)	(2.12)	(–1.36)	(–0.02)	(2.37)	(–1.32)	(–1.14)	(2.39)	(–0.87)
*Dec**△*lnsale***AInt*	–0.0003	–0.0070	0.0013	–0.0037	–0.0271**	–0.0047	–0.0092***	–0.0272**	–0.0011
	(–0.11)	(–0.31)	(0.47)	(–1.17)	(–2.09)	(–1.13)	(–2.64)	(–2.09)	(–0.33)
AInt	0.0036	–0.0278**	0.0048*	0.0017	–0.0096	–0.0013	–0.0003	–0.0099	0.0039
	(1.51)	(–2.53)	(1.81)	(0.55)	(–0.93)	(–0.30)	(–0.09)	(–0.96)	(1.17)
*Dec**△*lnsale***EInt*	–0.0093	–0.0153	0.3227	0.9899	7.0847	4.0015*	0.5940	7.1852	1.9913
	(–0.08)	(–1.70)	(0.24)	(3.05)	(1.60)	(1.83)	(1.62)	(1.62)	(1.03)
EInt	0.1713	10.4517*	–0.3342	0.9231	1.0703	2.0908	–0.6548	1.2862	0.5420
	(0.23)	(1.78)	(–0.42)	(0.92)	(0.25)	(1.34)	(–0.60)	(0.30)	(0.42)
Dec *△*lnsale***GGDP*	0.0388**	–0.0213	0.0447***	0.0273	–0.0651	0.3683***	0.0296	–0.0561	0.4183***
	(2.45)	(–0.14)	(2.71)	(1.58)	(–1.12)	(4.18)	(1.43)	(–0.97)	(5.34)
GGDP	–0.0012	0.0013	–0.0007	–0.0003	0.0033	0.0030	–0.0027	0.0026	0.0048
	(–0.49)	(0.27)	(–0.23)	(–0.07)	(0.53)	(0.28)	(–0.59)	(0.41)	(0.53)
Dec *△*lnsale***Culture*	–	–	–	–	–	–	–3.7064***	1.8798	–6.9148***
	–	–	–	–	–	–	(–2.95)	(1.05)	(–4.77)
Culture	–	–	–	–	–	–	0.1523	–0.1164	0.2233
	–	–	–	–	–	–	(0.48)	(–0.22)	(0.66)
Age	–0.0634***	–0.0223***	–0.0833***	0.0128***	–0.0198***	0.0143***	–0.0029***	0.0000	–0.0008
	(–5.65)	(–4.46)	(–3.98)	(4.93)	(–3.61)	(2.82)	(–3.80)	(0.02)	(–0.95)
Size	0.0150***	0.0291***	0.0129***	0.0100**	0.0221**	–0.0007	0.0162***	0.0229**	0.0056
	(5.74)	(2.97)	(3.85)	(2.48)	(2.49)	(–0.12)	(4.24)	(2.56)	(1.34)
Lev	–0.0026	–0.0306	0.0006	–0.0230**	–0.0613**	–0.0185	–0.0288***	–0.0626**	–0.0237***
	(–0.54)	(–1.12)	(0.11)	(–1.99)	(–2.53)	(–1.08)	(–3.18)	(–2.57)	(–2.63)
Tat	0.0100**	0.0156	0.0109**	0.0103**	0.0215**	0.0212***	0.0167***	0.0178	0.0171***
	(2.32)	(1.11)	(2.05)	(2.04)	(2.00)	(2.70)	(3.06)	(1.64)	(2.76)

(*continued on next page*)

Table 6 (*continued*)

	Dep. Var. = △*lncost*								
	Alternative measure of digital technology			Removal of sample data prior to 2015			Inclusion of impact of cultural friction		
	Full sample (1)	High *IIP* (2)	Low *IIP* (3)	Full sample (4)	High *IIP* (5)	Low *IIP* (6)	Full sample (7)	High *IIP* (8)	Low *IIP* (9)
ROA	–0.0064**	–0.2971***	–0.0144***	–0.1041***	–0.0999***	–0.1147***	–0.0693***	–0.0984***	–0.0669***
	(–2.01)	(–12.02)	(–2.77)	(–12.33)	(–6.72)	(–9.34)	(–8.34)	(–6.60)	(–7.72)
Risk	–0.0164***	–0.1704***	–0.0232***	–0.0002	–0.0073	–0.0019	0.0026	–0.0078	0.0002
	(–3.33)	(–3.92)	(–4.39)	(–0.09)	(–0.65)	(–0.85)	(1.45)	(–0.69)	(0.09)
MR	0.0271***	–0.2343***	0.0425***	0.0018	0.0436***	–0.0001	0.0022	0.0444***	0.0002
	(5.19)	(–5.25)	(4.73)	(0.83)	(3.43)	(–0.04)	(0.85)	(3.47)	(0.08)
Dual	–0.0004	0.0036	–0.0023	–0.0068	–0.0059	0.0015	–0.0094**	–0.0061	–0.0033
	(–0.13)	(0.51)	(–0.57)	(–1.55)	(–0.78)	(0.22)	(–2.05)	(–0.80)	(–0.65)
Opportunism	–0.0051*	–0.0011	–0.0059	–0.0017	–0.0162**	0.0022	0.0022	–0.0165**	0.0022
	(–1.84)	(–0.16)	(–1.64)	(–0.44)	(–2.21)	(0.36)	(0.54)	(–2.25)	(0.49)
Optimism	–0.0870***	–0.0365***	–0.1176***	–0.0060***	–0.0397***	–0.0055**	–0.0002	0.0001	0.0010***
	(–5.36)	(–4.02)	(–3.89)	(–5.29)	(–3.98)	(–2.38)	(–0.70)	(0.02)	(3.45)
_cons	11.1688***	4.1396***	15.2840***	0.2031	4.8275***	0.3103	–0.2589*	–0.2750	–0.3678***
	(5.24)	(3.47)	(3.83)	(1.11)	(3.71)	(1.08)	(–1.83)	(–1.01)	(–2.62)
FE_Industry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
FE_Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
FE_Firm	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	22,552	9,439	13,113	18,650	9,439	9,211	22,552	9,439	13,113
AdjR^2	0.8908	0.8793	0.8923	0.8671	0.8478	0.8746	0.7983	0.8475	0.8733

Note: This table reports the results of robustness tests. The sample spans the 2010–2021 period and includes 22,552 firm-year observations, consistent with the baseline regressions. Columns (1)–(3) present the results obtained using an alternative measure of digital technology. Columns (4)–(6) present the results after removing sample data prior to 2015. Columns (7)–(9) present the results after including the impact of cultural friction.

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

4.4. Endogeneity tests

4.4.1. Excluding industries with a high level of digital technology

Differences in industry characteristics may lead to considerable variation in the application of digital technology. For example, the annual reports of industries that produce digital, intelligent, and Internet products contain a high frequency of words related to digital technology. To alleviate the problem of sample self-selection, we exclude firm-year observations from the intelligent, electronic manufacturing and information industries. Columns (1)–(3) of Table 7 report the results. The coefficient on *Dec*Δlnsale*DT* for the full sample is significant and positive at the 1 % level ($\beta_4 = 2.4497$, $t = 3.38$), suggesting that digital technology reduces cost stickiness. The coefficient on *Dec*Δlnsale*DT* for the sub-sample with a high *IIP* is significant and positive at the 1 % level ($\beta_4 = 3.5514$, $t = 2.78$). The coefficient on *Dec*Δlnsale*DT* for the sub-sample with a low *IIP* is not significant, indicating that the effect of digital technology is mainly observed in firms with a high *IIP*.

4.4.2. Excluding the top 20 % firms by digital technology level

The baseline results may be driven by firms with a high level of digital technology. We delete from the sample the top 20 % of firms by digital technology level. Columns (4)–(6) of Table 7 report the results. The coefficient on *Dec*Δlnsale*DT* for the full sample is significant and positive at the 1 % level ($\beta_4 = 2.7192$, $t = 3.32$), suggesting that digital technology reduces cost stickiness. The coefficient on *Dec*Δlnsale*DT* for the sub-sample with a high *IIP* is significant and positive at the 5 % level ($\beta_4 = 2.9198$, $t = 2.15$). The coefficient on *Dec*Δlnsale*DT* for the sub-sample with a low *IIP* is not significant, indicating that the effect of digital technology is more pronounced in firms with a high *IIP*.

4.4.3. Region fixed effects

In the baseline regressions, we control for time, industry, and firm fixed effects. To alleviate the problem of omitted variables, we include region fixed effects and re-estimate Equation (3) to control for future time-invariant regional characteristics that may influence cost stickiness. Columns (7)–(9) of Table 7 report the results. The coefficient on *Dec*Δlnsale*DT* for the full sample is significant and positive at the 1 % level ($\beta_4 = 2.3427$, $t = 3.59$), suggesting that digital technology reduces cost stickiness. The coefficient on *Dec*Δlnsale*DT* for the sub-sample with a high *IIP* is significantly positive at the 1 % level ($\beta_4 = 2.8850$, $t = 2.64$). The coefficient on *Dec*Δlnsale*DT* for the sub-sample with a low *IIP* is not significant, indicating that the observed effect is more pronounced in firms with a high *IIP*.

4.4.4. Instrumental variable method

Both digital technology application and cost control behaviors are derived from internal production and operation activities. To address the problem of mutual causality between digital technology and cost stickiness, we adopt two instrumental variables (IVs): (1) the industry average degree of digital technology (*Mean_DT*), and (2) the climate index of information technology industry (*IT_Industry Index*) for the province in which the firm is headquartered. A reasonable and effective IV must satisfy the principles of both relevance and exogeneity. Regarding relevance, the industrial degree of digital technology usage is closely related to a firm's level of digital technology application. The computer technology industry in a region also positively affects the degree of digital technology usage of local firms. At higher values of *IT_Industry Index*, firms are better able to accelerate their digital transformation. Moreover, industry average degree of digital technology application and the development of information technology industry hardly affect firms' cost stickiness, thus satisfying the exogeneity of the IVs.

We use the interaction term of the two newly introduced variables as our joint IV (*IV*). Table 8 presents the results. Column (1) reveals that the IVs *Mean_DT* and *IT_Industry Index* are strongly correlated with digital technology (*Digital_T*), suggesting that the instrumental variables meet the requirement of correlation. The F-statistic for the weak IV test is significantly greater than the critical value. In the second stage regression, the coefficients on *Dec*Δlnsale*IV* for the full sample and the sub-sample with a high *IIP* are positive and significant. The coefficient on *Dec*Δlnsale*IV* for the sub-sample with a low *IIP* is not significant. The results suggest that the association between digital technology and cost stickiness remains after mitigating the reverse causality problem.

Table 7
Results of endogeneity tests.

	Dep. Var. = △*lncost*								
	Excluding industries with a high level of digital technology			Removal of the top 20 % according to digital technology use			Region fixed effects		
	Full sample (1)	High *IIP* (2)	Low *IIP* (3)	Full sample (4)	High *IIP* (5)	Low *IIP* (6)	Full sample (7)	High *IIP* (8)	Low *IIP* (9)
△*lnsale*	0.9809***	0.9711***	0.9837***	0.6848***	0.7251***	0.6836***	0.9877***	0.9703***	0.9930***
	(174.92)	(82.54)	(132.58)	(135.00)	(72.96)	(92.46)	(190.47)	(90.04)	(144.21)
*Dec**△*lnsale*	–0.0280*	–0.0534**	–0.0225	–0.6229***	–0.6594***	–0.4595***	–0.0377***	–0.0467*	–0.0470**
	(–1.89)	(–1.97)	(–1.03)	(–21.60)	(–13.40)	(–8.39)	(–2.68)	(–1.85)	(–2.25)
Dec	0.0031	–0.0014	0.0073	–0.0556***	–0.0485***	–0.0521***	0.0058	0.0007	0.0109**
	(0.80)	(–0.21)	(1.34)	(–11.93)	(–6.70)	(–7.32)	(1.59)	(0.11)	(2.16)
*Dec**△*lnsale***DT*	2.4497***	3.5514***	–0.3683	2.7192***	2.9198**	1.6859	2.3427***	2.8850***	–0.4101
	(3.38)	(2.78)	(–0.33)	(3.32)	(2.15)	(1.12)	(3.59)	(2.64)	(–0.39)
DT	–0.0034	–0.1574	0.0814	–0.0271	–0.3551	0.1820	0.0021	–0.1807	0.0181
	(–0.02)	(–0.53)	(0.32)	(–0.15)	(–1.22)	(0.62)	(0.01)	(–0.68)	(0.08)
*Dec**△*lnsale***Suc*	0.0056	0.0276	–0.0090	–0.0071	–0.0205	–0.0057	0.0018	0.0119	–0.0130
	(0.34)	(0.93)	(–0.39)	(–0.33)	(–0.60)	(–0.17)	(0.11)	(0.43)	(–0.60)
Suc	–0.0003	0.0241**	–0.0050	–0.0021	0.0139	–0.0092	–0.0008	0.0216**	–0.0065
	(–0.05)	(2.31)	(–0.68)	(–0.31)	(1.25)	(–0.92)	(–0.16)	(2.27)	(–0.96)
*Dec**△*lnsale***AInt*	–0.0017	–0.0260*	0.0004	–0.0021	–0.0100	–0.0020	–0.0009	–0.0283**	0.0021
	(–0.54)	(–1.87)	(0.09)	(–0.57)	(–0.54)	(–0.39)	(–0.33)	(–2.18)	(0.62)
AInt	0.0037	–0.0107	0.0046	0.0019	–0.0137	0.0023	0.0053*	–0.0097	0.0070**
	(1.19)	(–0.94)	(1.09)	(0.53)	(–1.14)	(0.45)	(1.90)	(–0.95)	(2.04)
*Dec**△*lnsale***EInt*	0.8061**	6.5469	0.9229	0.4324	–1.9978	–2.8000	0.7496**	7.6403*	0.4510
	(2.42)	(1.38)	(0.44)	(1.14)	(–0.29)	(–1.01)	(2.58)	(1.72)	(0.24)
EInt	0.4827	0.5344	0.1300	–2.1676	–0.1831	1.1924	0.3242	1.2478	–0.3970
	(0.47)	(0.11)	(0.08)	(–0.00)	(–0.03)	(0.64)	(0.37)	(0.29)	(–0.31)
Dec *△*lnsale***GGDP*	0.0325*	–0.0571	0.4038***	0.0056	–0.0074	0.2147	0.1436***	0.0080	0.7422***
	(1.88)	(–0.93)	(4.94)	(0.28)	(–0.08)	(1.43)	(3.12)	(0.13)	(7.02)
GGDP	0.0012	0.0061	0.0041	–0.0030	–0.0131**	0.0136	0.0016	0.0038	0.0201*
	(0.32)	(0.92)	(0.44)	(–0.65)	(–1.97)	(0.77)	(0.34)	(0.60)	(1.96)
Age	0.0120	–0.0034	0.0127	0.0062	–0.0086	–0.0007	0.0111	–0.0062	0.0135
	(1.45)	(–0.30)	(0.43)	(0.59)	(–0.61)	(–0.02)	(1.44)	(–0.57)	(0.47)
Size	0.0102***	0.0147	0.0086*	0.0063	0.0034	0.0066	0.0096***	0.0207**	0.0043
	(2.99)	(1.48)	(1.87)	(1.41)	(0.32)	(0.99)	(3.06)	(2.32)	(1.00)
Lev	–0.0264***	–0.0684***	–0.0258***	–0.0356***	–0.0407	–0.0215	–0.0268***	–0.0582**	–0.0254***
	(–3.39)	(–2.58)	(–2.74)	(–2.58)	(–1.33)	(–1.01)	(–3.67)	(–2.39)	(–2.85)
Tat	0.0104**	0.0216*	0.0143**	0.0134**	–0.0113	0.0359***	0.0099**	0.0218**	0.0121**
	(2.24)	(1.89)	(2.21)	(2.23)	(–0.90)	(3.77)	(2.22)	(1.99)	(1.96)
ROA	–0.0756***	–0.0966***	–0.0696***	–0.1587***	–0.2815***	–0.1274***	–0.0747***	–0.0976***	–0.0653***
	(–10.76)	(–6.10)	(–7.65)	(–12.03)	(–10.02)	(–7.31)	(–11.21)	(–6.54)	(–7.63)
Risk	0.0020	0.0441***	0.0001	0.0025	0.0642***	0.0002	0.0020	0.0413***	0.0001

Table 7 (*continued*)

	Dep. Var. = △*lncost*								
	Excluding industries with a high level of digital technology			Removal of the top 20 % according to digital technology use			Region fixed effects		
	Full sample (1)	High *IIP* (2)	Low *IIP* (3)	Full sample (4)	High *IIP* (5)	Low *IIP* (6)	Full sample (7)	High *IIP* (8)	Low *IIP* (9)
	(0.94)	(3.29)	(0.02)	(1.08)	(4.13)	(0.07)	(0.98)	(3.23)	(0.03)
MR	0.0005	–0.0058	0.0008	0.0013	0.0067	–0.0000	0.0006	–0.0083	0.0013
	(0.29)	(–0.47)	(0.32)	(0.68)	(0.43)	(–0.01)	(0.43)	(–0.74)	(0.71)
Dual	–0.0083**	–0.0048	–0.0047	–0.0119**	–0.0224**	–0.0039	–0.0071*	–0.0058	–0.0016
	(–2.05)	(–0.57)	(–0.85)	(–2.44)	(–2.48)	(–0.55)	(–1.90)	(–0.76)	(–0.31)
Opportunism	–0.0013	–0.0190**	0.0024	0.0079*	–0.0062	0.0146**	–0.0019	–0.0161**	–0.0001
	(–0.37)	(–2.37)	(0.50)	(1.75)	(–0.73)	(2.16)	(–0.57)	(–2.19)	(–0.02)
Optimism	0.0184	–0.0101	0.0183	0.0122	–0.0022	0.0022	0.0175	–0.0121	0.0191
	(1.55)	(–0.43)	(0.43)	(0.81)	(–0.08)	(0.04)	(1.58)	(–0.55)	(0.46)
_cons	–2.7033*	1.2344	–2.7278	–1.8428	0.8198	–0.6706	–2.6431*	1.3478	–2.7415
	(–1.72)	(0.41)	(–0.48)	(–0.93)	(0.22)	(–0.08)	(–1.80)	(0.48)	(–0.50)
FE_Industry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
FE_Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
FE_Firm	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
FE_city	–	–	–	–	–	–	Yes	Yes	Yes
N	20,349	8,380	11,969	16,771	6,216	10,555	22,552	9,439	13,113
AdjR^2	0.8620	0.8414	0.8680	0.8288	0.8254	0.8299	0.8696	0.8485	0.8768

Note: This table reports the results of robustness tests. Columns (1)–(3) present the results after excluding industries with a high level of digital technology use. Columns (4)–(6) present the results after removing the top 20% of the sample according to digital technology use. Columns (7)–(9) present the results after controlling for region fixed effects.
***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Table 8
Results of endogeneity tests.

	Instrumental variable method			
	Dep. Var. = *DT*	Dep. Var. = △*lncost*		
	Full sample (1)	Full sample (2)	High *IIP* (3)	Low *IIP* (4)
△*lnsale*	–	0.9900***	0.9833***	0.9948***
	–	(213.41)	(134.84)	(165.30)
Dec△*lnsale*	–	–0.0731***	–0.0849***	–0.0585**
	–	(–4.16)	(–3.14)	(–2.54)
Dec	–	0.0073**	0.0036	0.0117**
	–	(2.07)	(0.74)	(2.31)
Dec△*lnsale*IV*	–	0.0571***	0.0774***	0.0210
	–	(4.71)	(4.25)	(1.24)
Dec△*lnsale*Suc*	–	–0.0089	0.0041	–0.0131
	–	(–0.62)	(0.21)	(–0.61)
Suc	–	–0.0065	0.0033	–0.0146**
	–	(–1.36)	(0.48)	(–2.17)
Dec△*lnsale*AInt*	–	–0.0028	–0.0094**	–0.0009
	–	(–1.39)	(–1.86)	(–0.40)
Aint	–	–0.0002	–0.0016	0.0008
	–	(–0.14)	(–0.71)	(0.39)
Dec△*lnsale*EInt*	–	1.3979***	1.3195***	0.2719
	–	(6.26)	(4.05)	(0.14)
Eint	–	2.8493***	1.4238	3.3108***
	–	(3.95)	(1.05)	(3.07)
Dec *△*lnsale*GGDP*	–	0.0286*	0.0144	0.3580***
	–	(1.91)	(0.94)	(4.99)
GGDP	–	–0.0006	0.0007	0.0034
	–	(–0.18)	(0.21)	(0.30)
Age	–	–0.0010***	–0.0009***	–0.0009***
	–	(–6.77)	(–4.76)	(–4.40)
Size	–	0.0026***	0.0029**	0.0024**
	–	(2.62)	(2.01)	(1.73)
Lev	–	–0.0153***	–0.0142*	–0.0160***
	–	(–3.17)	(–1.79)	(–2.58)
Tat	–	–0.0010	–0.0053*	0.0024
	–	(–0.51)	(–1.88)	(0.89)
ROA	–	–0.0712***	–0.0877***	–0.0618***
	–	(–11.92)	(–8.72)	(–8.04)
Risk	–	0.0183***	0.0152**	0.0184**
	–	(3.47)	(2.33)	(2.08)
MR	–	–0.0034***	–0.0008	–0.0041**
	–	(–2.75)	(–0.35)	(–2.44)
Dual	–	0.0001	–0.0003	0.0006
	–	(0.06)	(–0.12)	(0.19)
Opportunism	–	–0.0021	–0.0020	–0.0024
	–	(–1.30)	(–0.84)	(–1.07)
Optimism	–	0.0017***	–0.0022*	0.0022***
	–	(5.61)	(–1.74)	(5.60)
Mean_DT	1.3027***	9.9801**	–20.5807**	23.0134***
	(4.44)	(2.19)	(–2.33)	(3.17)
IT_Industry Index	0.0001***	–0.0004**	–0.0040***	–0.0003
	(8.40)	(–2.10)	(–3.85)	(–1.40)
IV	–	–0.0731**	0.1656**	–0.1732***
	–	(–2.17)	(2.46)	(–3.23)
_cons	–0.0060***	–0.1644***	0.7855***	–0.2231***
	(38.21)	(–3.49)	(3.20)	(–3.80)

Table 8 (*continued*)

	Instrumental variable method			
	Dep. Var. = *DT*	Dep. Var. = △*lncost*		
	Full sample (1)	Full sample (2)	High *IIP* (3)	Low *IIP* (4)
FE_Industry	Yes	Yes	Yes	Yes
FE_Year	Yes	Yes	Yes	Yes
N	22,552	22,552	9,439	13,113
adjR^2	0.4173	–	–	–
Wald F stat	–	5219.866	3343.126	4119.952
Sargan stat	–	0.001	0.001	0.001

Note: This table reports the results of the instrumental variable analysis. Column (1) presents the first-stage regression results, which suggest that the instrumental variables meet the requirement of correlation. Columns (2)–(4) present the second-stage regression results. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

4.4.5. Alternative test model

Following Weiss (2010), we apply an alternative model to measure cost stickiness:

$$CS_{i,t} = \log\left(\frac{\Delta COST}{\Delta SALE}\right)_{i,up} - \log\left(\frac{\Delta COST}{\Delta SALE}\right)_{i,down} \tag{3}$$

where *up* denotes the most recent of the last four quarters in which sales revenue decreases, and *down* denotes the most recent of the last four quarters in which sales revenue increases. *SALE* represents sales revenue, and *ΔSALE* refers to the difference in sales revenue between the current quarter and the previous quarter. *COST* represents the operating cost, and *ΔCOST* refers to the difference in the operating cost between the current quarter and the previous quarter. A greater value of $CS_{i,t}$ indicates a higher degree of cost stickiness. Then, we implement the following regression model:

$$\begin{aligned} CS_{i,t} = {} & \beta_0 + \beta_1 DT_{i,t-1} + \beta_2 AInt_{i,t} + \beta_3 EInt_{i,t} + \beta_4 GGDP_{i,t} + \beta_5 Age_{i,t} + \beta_6 Size_{i,t} \\ & + \beta_7 Lev_{i,t} + \beta_8 Tat_{i,t} + \beta_9 ROA_{i,t} + \beta_{10} Risk_{i,t} + \beta_{11} MR_{i,t} + \beta_{12} Durl_{i,t} \\ & + \beta_{13} Opportunism_{i,t} + \beta_{14} Optimism_{i,t} + + \mathrm{FE}Industry + \mathrm{FE}Year + \mathrm{FEFirm} + \varepsilon_{i,t} \end{aligned} \tag{4}$$

The dependent variable is cost stickiness ($CS_{i,t}$). The independent variable is one-period lagged digital technology ($DT_{i,t-1}$), calculated as the frequency of keywords related to digital technology in the core competitiveness description sections of annual reports. The control variables remain consistent with the baseline regressions (Table 2 presents the variable definitions). The variables *IndustryEffect* and *YearEffect* refer to the industry and year fixed effects, respectively.

Table 9 reports the results. Column (1) presents the results of Equation (4) estimated using the full sample, and the coefficient on DT_{t-1} is significant and negative at the 10 % level ($\beta = -0.3789$, $t = -1.73$). Column (2) presents the results of Equation (4) estimated using the sub-sample with a high *IIP*, and the coefficient on DT_{t-1} is significant and negative at the 10 % level ($\beta = -0.5176$, $t = -1.81$). Column (3) presents the results of Equation (4) estimated using the sub-sample with a low *IIP*, and the coefficient on DT_{t-1} is not significant. These results show that digital technology enables manufacturing firms to reduce cost stickiness, and the effect is more pronounced in firms with a high *IIP*.

4.5. Mechanism analysis

In this section, we further investigate the mechanisms underlying the curbing effect of digital technology on cost stickiness. Digital technology is subject to technology bias, which improves the demand for highly skilled

Table 9
Results of endogeneity tests.

	Dep. Var. = *CS*		
	High *IIP* (1)	High *IIP* (2)	Low *IIP* (3)
DT_{t-1}	–0.3789*	–0.5176*	–0.6525
	(–1.73)	(–1.81)	(–1.43)
AInt	–0.0269	0.0286	–0.0534*
	(–1.15)	(0.93)	(–1.69)
EInt	7.9470*	–3.5457	10.7191*
	(1.76)	(–0.21)	(1.80)
GGDP	0.0617	–0.0294	0.1223*
	(1.43)	(–0.51)	(1.72)
Age	–0.0216*	–0.0199	–0.0318
	(–1.91)	(–1.45)	(–1.29)
Size	–0.0139	–0.0208	–0.0224
	(–1.37)	(–0.92)	(–1.27)
Lev	0.0616**	–0.0430	0.0954**
	(2.04)	(–0.64)	(2.07)
Tat	–0.0287	–0.0149	–0.0323
	(–1.56)	(–0.60)	(–1.05)
ROA	0.3105***	0.3889***	0.2191*
	(4.78)	(4.61)	(1.93)
Risk	0.0021	–0.0023	–0.0019
	(0.11)	(–0.03)	(–0.07)
MR	–0.0746	–0.1783	0.0174
	(–0.64)	(–0.79)	(0.10)
Dual	–0.0084	0.0062	–0.0113
	(–1.14)	(0.52)	(–1.03)
Opportunism	–0.0066	–0.0064	–0.0108
	(–0.90)	(–0.62)	(–0.96)
Optimism	–0.0614*	–0.0057	–0.0930
	(–1.66)	(–0.21)	(–1.18)
_cons	8.2383*	1.9091	12.4346
	(1.77)	(0.54)	(1.26)
FE_Industry	Yes	Yes	Yes
FE_Year	Yes	Yes	Yes
FE_Firm	Yes	Yes	Yes
N	22,552	22,552	9,439
$AdjR^2$	0.0339	0.0674	0.0359

Note: This table reports the results obtained using an alternative measure of cost stickiness. We adopt an alternative model to measure cost stickiness as proposed by Weiss (2010). The independent variable is one-period lagged digital technology ($DT_{i,t-1}$), also measured as the frequency of keywords related to digital technology in the core competitiveness description sections of annual reports. The control variables remain consistent with the baseline regressions. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

labor and enables firms to reduce redundant labor, thus reducing cost stickiness. The proportion of highly skilled employees in the labor force (*LS*) is calculated as the ratio of the number of employees with a bachelor's degree or above to the total number of employees. Digital technology also enables collaborative innovation with labor capital and improves the economic benefits of labor capital, thus reducing cost stickiness. The economic benefit of labor investment (*LE*) is calculated as the ratio of the change in sales revenue to the change in labor cost. To test the above analysis, we implement the following regression model:

Table 10
Results of mechanism analysis.

	Dep. Var. = △*lncost*	
	Optimization of labor force structure	Increased economic benefits of labor force
	(1)	(2)
△*lnsale*	0.5993***	0.5932***
	(136.77)	(130.48)
Dec△*lnsale*	–0.5282***	–0.5223***
	(–24.95)	(–23.91)
Dec	–0.0706***	–0.0714***
	(–16.01)	(–15.59)
Dec△*lnsale*DT*	3.2964***	3.4587***
	(3.87)	(4.15)
Dec△*lnsale*DT*LS*	0.0573**	–
	(2.10)	–
LS	–0.0004**	–
	(–2.37)	–
Dec△*lnsale*DT*LE*	–	0.0116***
	–	(2.96)
LE	–	0.0001***
	–	(3.71)
Dec△*lnsale*Suc*	–0.0175	–0.0170
	(–0.93)	(–0.86)
Suc	–0.0086	–0.0105
	(–1.39)	(–1.60)
Dec△*lnsale*AInt*	–0.0076**	–0.0070*
	(–2.15)	(–1.92)
Aint	0.0013	0.0012
	(0.39)	(0.34)
Dec△*lnsale*EInt*	0.4850	0.4560
	(1.32)	(1.21)
Eint	–806.3879	–1017.8858
	(–0.74)	(–0.90)
*Dec *△*lnsale*GGDP*	0.1510***	0.1448**
	(2.65)	(2.48)
GGDP	–0.0032	–0.0050
	(–0.57)	(–0.84)
Age	–0.0830***	–0.0727***
	(–5.38)	(–4.45)
Size	0.0154***	0.0143***
	(3.97)	(3.52)
Lev	–0.0267***	–0.0266***
	(–2.96)	(–2.83)
Tat	0.0175***	0.0159***
	(3.17)	(2.77)
ROA	–0.0692***	–0.0691***
	(–8.36)	(–8.17)
Risk	0.0023	0.0004
	(0.89)	(0.16)
MR	0.0028	0.0032*
	(1.55)	(1.70)
Dual	–0.0088*	–0.0106**
	(–1.93)	(–2.18)
Opportunism	0.0023	0.0035
	(0.57)	(0.82)
Optimism	–0.1156***	–0.1023***
	(–5.28)	(–4.44)
_cons	14.8317***	13.0927***
	(5.14)	(4.29)

(*continued on next page*)

Table 10 (*continued*)

	Dep. Var. = △*lncost*	
	Optimization of labor force structure (1)	Increased economic benefits of labor force (2)
FE_Industry	Yes	Yes
FE_Year	Yes	Yes
FE_Firm	Yes	Yes
N	22,552	22,552
$AdjR^2$	0.8016	0.8028

Note: This table reports the results of mechanism tests. In column (1), the highly skilled labor force (*LS*) is calculated as the ratio of the number of employees with a bachelor's degree or above to the total number of employees. In column (2), the economic benefits of labor investment (*LE*) is calculated as the ratio of the change in sales revenue to the change in labor cost. Overall, these results validate our conjecture that digital technology mitigates cost stickiness by optimizing the labor force structure and increasing the economic benefits of the labor force.
***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

$$\begin{aligned}\Delta \ln \cos t_{i,t} = {} & \beta_0 + \beta_1 \Delta \ln sale_{i,t} + \beta_2 Dec_{i,t} \times \Delta \ln sale_{i,t} + \beta_3 Dec_{i,t} \\ & + \beta_4 Dec_{i,t} \times \Delta \ln sale_{i,t} \times DT_{i,t} + \beta_5 Dec_{i,t} \times \Delta \ln sale_{i,t} \times DT_{i,t} \times LS_{i,t} \\ & + \beta_6 Dec_{i,t} \times \Delta \ln sale_{i,t} \times Suc_{i,t} + \beta_7 Dec_{i,t} \times \Delta \ln sale_{i,t} \times AInt_{i,t} \\ & + \beta_8 Dec_{i,t} \times \Delta \ln sale_{i,t} \times EInt_{i,t} + \beta_9 Dec_{i,t} \times \Delta \ln sale_{i,t} \times GGDP_{i,t} \\ & + \beta_{10} LS_{i,t} + \beta_{11} Suc_{i,t} + \beta_{12} AInt_{i,t} + \beta_{13} EInt_{i,t} + \beta_{14} GGDP_{i,t} \\ & + \beta_{15} Age_{i,t} + \beta_{16} Size_{i,t} + \beta_{17} Lev_{i,t} + \beta_{18} Tat_{i,t} + \beta_{19} ROA_{i,t} \\ & + \beta_{20} Risk_{i,t} + \beta_{21} MR_{i,t} + \beta_{22} Dual_{i,t} + \beta_{23} Opportunism_{i,t} + \beta_{24} Optimism_{i,t} \\ & + \mathrm{FE}Industry + \mathrm{FE}Year + \mathrm{FEFirm} + \varepsilon_{i,t}\end{aligned} \tag{5}$$

$$\begin{aligned}\Delta \ln \cos t_{i,t} = {} & \beta_0 + \beta_1 \Delta \ln sale_{i,t} + \beta_2 Dec_{i,t} \times \Delta \ln sale_{i,t} + \beta_3 Dec_{i,t} \\ & + \beta_4 Dec_{i,t} \times \Delta \ln sale_{i,t} \times DT_{i,t} + \beta_5 Dec_{i,t} \times \Delta \ln sale_{i,t} \times DT_{i,t} \times LE_{i,t} \\ & + \beta_6 Dec_{i,t} \times \Delta \ln sale_{i,t} \times Suc_{i,t} + \beta_7 Dec_{i,t} \times \Delta \ln sale_{i,t} \times AInt_{i,t} \\ & + \beta_8 Dec_{i,t} \times \Delta \ln sale_{i,t} \times EInt_{i,t} + \beta_9 Dec_{i,t} \times \Delta \ln sale_{i,t} \times GGDP_{i,t} \\ & + \beta_{10} LE_{i,t} + \beta_{11} Suc_{i,t} + \beta_{12} AInt_{i,t} + \beta_{13} EInt_{i,t} + \beta_{14} GGDP_{i,t} \\ & + \beta_{15} Age_{i,t} + \beta_{16} Size_{i,t} + \beta_{17} Lev_{i,t} + \beta_{18} Tat_{i,t} + \beta_{19} ROA_{i,t} \\ & + \beta_{20} Risk_{i,t} + \beta_{21} MR_{i,t} + \beta_{22} Dual_{i,t} + \beta_{23} Opportunism_{i,t} + \beta_{24} Optimism_{i,t} \\ & + \mathrm{FE}Industry + \mathrm{FE}Year + \mathrm{FEFirm} + \varepsilon_{i,t}\end{aligned} \tag{6}$$

Table 10 reports the results. The coefficient on *Dec*Δlnsale*DT*LS* is significant and positive at the 5 % level ($\beta = 0.0573$, $t = 2.10$), suggesting that digital technology mitigates cost stickiness by optimizing the labor force structure. The coefficient on *Dec*Δlnsale*DT*LE* is significant and positive at the 1 % level ($\beta = 0.0116$, $t = 2.96$), suggesting that digital technology mitigates cost stickiness by increasing the economic benefits of the labor force.

4.6. Heterogeneity analysis

4.6.1. Labor intensity

Compared with firms with a low level of labor intensity, firms with a high level of labor intensity have more financial risks (Chen et al., 2014), less operational elasticity (Liao and Chen, 2014), and insufficient investment (Lu et al., 2015). Studies (Banker et al., 2013; Liu et al., 2014) demonstrate that the enactment of Chinese Labor Contract Law has strengthened firms' incentive to replace their labor forces with machinery and equipment. Labor intensity increases the adjustment costs (i.e., employment, training, and dismissal) and intensifies

Table 11
Results of heterogeneity analysis.

	Dep. Var. = △*lncost*			
	Labor intensity		Business complexity	
	High (1)	Low (2)	High (3)	Low (4)
△*lnsale*	0.9979***	0.9978***	0.5839***	0.6687***
	(190.86)	(144.03)	(104.15)	(79.60)
*Dec**△*lnsale*	–0.0476**	0.0015	–0.5373***	–0.6449***
	(–2.50)	(0.08)	(–17.39)	(–18.09)
Dec	0.0019	0.0086	–0.0767***	–0.0474***
	(0.49)	(1.56)	(–13.79)	(–6.32)
*Dec**△*lnsale***DT*	3.0909***	1.3974*	5.0158***	–0.0889
	(3.82)	(1.69)	(4.71)	(–0.07)
DT	0.0997	–0.0283	0.1408	–0.0809
	(0.81)	(–0.15)	(0.59)	(–0.23)
*Dec**△*lnsale***Suc*	0.0693***	–0.0348*	–0.0215	0.0097
	(3.25)	(–1.85)	(–0.85)	(0.32)
Suc	0.0072	–0.0084	–0.0023	–0.0020
	(1.29)	(–1.20)	(–0.29)	(–0.20)
*Dec**△*lnsale***AInt*	–0.0859***	–0.0011	–0.0799***	0.0051
	(–9.15)	(–0.40)	(–6.31)	(0.98)
AInt	–0.0030	0.0024	–0.0090	0.0147***
	(–1.37)	(0.95)	(–1.21)	(2.63)
*Dec**△*lnsale***EInt*	4.5710***	–3.0578*	2.5622***	–0.0011***
	(11.19)	(–1.70)	(4.00)	(–3.26)
EInt	3.1956***	0.6768	–3.9347***	–0.0014***
	(4.15)	(0.61)	(–2.60)	(–4.05)
Dec *△*lnsale***GGDP*	0.1466**	0.0265	0.0679***	0.3283**
	(2.44)	(1.49)	(2.65)	(2.36)
GGDP	–0.0022	0.0007	0.0063	–0.0078
	(–0.46)	(0.15)	(1.04)	(–0.93)
Age	–0.0004**	–0.0014***	0.0224**	–0.0072
	(–2.32)	(–5.49)	(2.09)	(–0.33)
Size	0.0043***	–0.0042*	0.0130**	0.0066
	(3.33)	(–1.90)	(2.29)	(0.82)
Lev	–0.0507***	–0.0072	–0.0571***	–0.0220**
	(–6.80)	(–1.08)	(–3.19)	(–1.97)
Tat	0.0027	–0.0019	0.0092	0.0316***
	(1.07)	(–0.58)	(1.25)	(2.88)
ROA	–0.2326***	–0.0564***	–0.1114***	–0.0567***
	(–15.13)	(–7.61)	(–7.43)	(–5.36)
Risk	–0.1772***	0.0029	0.0004	0.0106
	(–7.85)	(1.35)	(0.14)	(1.19)
MR	–0.0039***	–0.0304***	0.0090***	–0.0209**
	(–2.93)	(–4.39)	(3.38)	(–2.44)
Dual	–0.0000	0.0007	–0.0043	–0.0212**
	(–0.00)	(0.22)	(–0.72)	(–2.55)
Opportunism	–0.0002	0.0013	–0.0040	0.0029
	(–0.09)	(0.45)	(–0.73)	(0.38)
Optimism	–0.0018	–0.0037**	0.0320**	–0.0052
	(–0.93)	(–2.26)	(2.07)	(–0.16)
_cons	0.1917	0.5600***	–4.3260**	0.5787
	(0.81)	(2.59)	(–2.11)	(0.14)
Sue Test	–	–	chi2(1) = 5.53	
	–	–	Prob > chi2 = 0.0186	

(*continued on next page*)

Table 11 (*continued*)

	Dep. Var. = $\triangle lncost$			
	Labor intensity		Business complexity	
	High (1)	Low (2)	High (3)	Low (4)
FE_Industry	Yes	Yes	Yes	Yes
FE_Year	Yes	Yes	Yes	Yes
FE_Firm	Yes	Yes	Yes	Yes
N	10,847	11,705	14,456	8,096
$AdjR^2$	0.8852	0.8718	0.7936	0.8266

Note: This table reports the results of heterogeneity analysis. Columns (1) and (2) present the results of the analysis of labor intensity heterogeneity. Labor intensity is calculated as the ratio of the logarithm of cash paid to and for employees to the logarithm of sales revenue. Columns (3) and (4) present the results of the analysis of business complexity heterogeneity. Business complexity is calculated as the sum of the number of subsidiaries, joint ventures and associated companies.
***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

operational uncertainty. Dismissing employees is costly because employers must pay severance costs. Employers also lose their investments in firm-specific training if employees are released when demand falls and new employees must be hired when demand subsequently increases. In addition, firms experience productivity losses because morale declines when employees are laid off, and they may experience more turnover due to the erosion of employees' loyalty. Therefore, we expect the mitigating effect of digital technology on cost stickiness to be pronounced in labor-intense firms. Labor intensity is calculated as the ratio of the logarithm of cash paid to and for employees to the logarithm of sales revenue. A higher value indicates a higher labor intensity. Then, we partition the full sample into two sub-samples according to the median of labor intensity. Columns (1) and (2) of Table 11 report the results. The coefficient on *Dec*Δlnsale*DT* for the full sample is significant and positive at the 1 % level ($\beta = 3.0909$, $t = 3.82$). The coefficient on *Dec*Δlnsale*DT* for the sub-sample of firms with high labor intensity is significant and positive at the 10 % level ($\beta = 1.3974$, $t = 1.69$), whereas the coefficient on *Dec*Δlnsale*DT* for the sub-sample of firms with low labor intensity is not significant. The results confirm our expectation that the effect of digital technology on cost stickiness mainly occurs in firms with a high level of labor intensity.

4.6.2. Business complexity

Product diversification and a complex organizational environment increase firms' adjustment costs. On one hand, a higher level of business complexity makes information asymmetry more prominent and increases management's opportunistic motivation to build an empire. On the other hand, business complexity makes it difficult for a firm to effectively allocate its resources and increases the firm's costs. In this scenario, digital technology directly acts on productivity and optimizes cost control. It also enables firms to predict the operating environment and optimize information communication, and consequently alleviate the cost stickiness caused by management's optimistic expectations and the agency problem. We calculate business complexity as the sum of the number of a firm's subsidiaries, joint ventures, and associated companies. Then, we partition the total sample into two sub-samples according to the median of business complexity. Columns (3) and (4) of Table 11 report the results. The coefficient on *Dec*Δlnsale*DT* for the sub-sample of firms with high business complexity is significant and positive at the 1 % level ($\beta = 5.0158$, $t = 4.71$), whereas the coefficient on *Dec*Δlnsale*DT* for the sub-sample of firms with low business complexity is not significant. Consistent with our conjecture, the effect of digital technology on cost stickiness is more pronounced for firms with high (vs. low) business complexity.

5. Conclusion

Using a sample of Chinese A-share listed manufacturing firms over the 2010–2021 period, we explore the impact of digital technology on cost stickiness from the perspective of labor force empowerment. We find that

digital technology generally alleviates cost stickiness. This effect mainly occurs in enterprises with a high level of Industrial Internet platform usage. Our main results hold through a series of robustness and endogeneity tests. We further investigate the mechanisms underlying the curbing effect of digital technology on cost stickiness, namely increased employment of highly skilled laborers and improved economic benefits of labor capital investment. Heterogeneity tests show that the effect of digital technology on cost stickiness is pronounced in enterprises with high levels of labor intensity and business complexity.

The practical implications of our conclusions are as follows. First, we provide inspiration for enterprises to optimize their cost control and increase their skill premium by applying digital technology. Digital technology is pivotal to the integration of the digital and real economies, providing opportunities for manufacturing enterprises to achieve high-quality development. When embedded in the operations of real enterprises, digital technology optimizes the labor structure, facilitates production resource allocation, reduces cost stickiness, and enhances adaptability between internal cost control and external changes, thus improving firms' ability to take risks in a dynamic economic environment. Under the assumption of steady-state economic growth, if laborers are remunerated according to their productivity and technological progress is neutral, the labor income share should remain unchanged. Digital technology escalates differences in labor productivity, leading to new problems in the labor market such as differences in demand for skilled vs. non-skilled labor. However, the complementary effects of digital technology and highly skilled labor enable enterprises to optimize their labor structure and increase their skill premium.

Second, our results provide guidance for local governments and relevant departments in building Industrial Internet platforms. Enterprises vary in their foundations and the environments in which they adopt digital technology, and the process and effects of such adoption vary accordingly. Industrial Internet platforms enable collaborative and interactive ecological manufacturing systems, digital economy networks and reduce marginal costs, fostering ecological sharing among enterprises and providing external support to improve resource allocation efficiency. Local governments and relevant departments should assist with cooperation between key industries and leading Internet enterprises, accelerate the digitalization of key points in the value chain (i.e., procurement, research and development, production, marketing, and services) and construct Industrial Internet platforms based on data resources. Governments also should enact targeted policies (i.e., tax reductions and financial subsidies) and implement flexible digital services to meet the developmental demands of multiple and varied enterprises.

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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Registration system reform and initial public offering ownership preference: Evidence from China

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ABSTRACT

Whether registration system reform (RSR) can curb administrative intervention and create a fair market environment has long been a concern in China. We explore this issue from the perspective of the initial public offering (IPO) preference based on the entropy balancing method, and findings are as follows. First, an IPO ownership preference exists under approval system. That is, state-owned enterprises (SOEs) are more likely than private enterprises to obtain IPO approval. However, RSR significantly changes this preference, especially for non-politically connected private enterprises. Second, the post-IPO market performance of SOEs is inferior to that of private enterprises under approval system, thus excluding the view that approval is prioritized for SOEs because of superior performance. Third, compared with SOEs, private enterprises are more likely to switch the issuance system from approval system to registration system; this change makes it easier for them to obtain IPO approval, indicating that private enterprise owners perceive the registration channel to be fairer. Fourth, the effect of RSR on IPO ownership preference mainly occurs in companies in three major urban agglomerations in China—the Pearl River Delta, the Yangtze River Delta, and the Beijing–Tianjin–Hebei region—and in technology-intensive industries. Collectively, our findings reveal that RSR cultivates a fairer IPO approval process.

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1. Introduction

Registration system reform (RSR) in China's capital market has long been advocated, but it has only recently been implemented.[1] An important reason for this delay is the significant controversy surrounding how people view the reform. Some scholars argue that there is no qualitative difference between the registration system and the approval system, and even if the registration system were introduced, this would involve only a change of form, not of content. This view is based on the coexistence of the two systems in global capital markets for an extended period, which implies that there is no distinction between them, with each system having its own advantages and drawbacks (Ren, 2021). Guo Shuqing, former Chairman of the China Securities Regulatory Commission (CSRC), also believes that whether to implement the former or the latter is not the key issue.[2]

Theoretically, the main difference between the registration system and the approval system is that the former emphasizes the market-oriented mechanism and the latter emphasizes administrative intervention for stock issuance. At the end of 2019, to facilitate the market-oriented mechanism under the registration system and make the IPO screening process fairer, China enacted amendments to its Securities Law. The revised Securities Law abolished the Issuance Examination Committee (IEC) of the CSRC, which previously determined a company's eligibility for IPO approval. However, the inspection process under the registration system has not been abolished, although power has been delegated from the IEC of the CSRC to the Listing Committee of the Securities Exchange.[3] One concern is that the Listing Committee may become another form of the IEC, such that RSR creates a mere replica of the approval system.[4] In other words, there may be as much administrative intervention in the IPO process under the registration system as there is under the approval system, such that implementing the registration system would not effectively solve the problems caused by intervention under the approval system. This remains a crucial yet unresolved issue. In this study, we explore how RSR affects administrative intervention from the perspective of discrimination against private enterprises in IPO activities, aiming to answer the crucial question of whether regulators genuinely delegate their power post-RSR.

In addition to achieving specific economic goals, state-owned enterprises (SOEs) undertake various social functions (e.g., addressing public issues and stabilizing employment), and they serve as primary executors of the government (Zhang et al., 2021). The natural and close relationship between the government and SOEs means that the government is likely to treat SOEs preferentially in the allocation of public resources. Thus, the persistence of government power over public resource allocation poses a considerable challenge to resolving the issue of unfair resource allocation for private enterprises. Similarly, as long as securities regulatory authorities hold decision-making power over IPO approval, it will be difficult to address the discrimination against private enterprises. In the absence of government intervention, there should not be a significant difference in IPO approval rates between SOEs and private enterprises. Conversely, if the IPO approval rate of private enterprises remains significantly lower than that of SOEs for a long time, it indicates an intrinsic and close relationship between the government and SOEs. It is precisely because of such a naturally close relationship that the government would inevitably favor SOEs in public resource allocation, leading to ownership preference in determining IPO approval, which reflects the problem of administrative intervention. That is, the more discrimination private enterprises encounter in the IPO process, the more significant the government intervention in resource allocation is. Therefore, the extent of discrimination against private enterprises in the IPO process reflects the intensity of administrative intervention. Based on this, we attempt to examine how RSR affects administrative intervention from the perspective of ownership preference (i.e., whether securities regulators genuinely delegate their power after RSR) to address the concern that RSR brings about only a change in form, not a change in content.

[1] For details on the process of registration system reform in China, please refer to the next section "Background and literature review".
[2] See https://www.bjnews.com.cn/finance/2012/03/02/185805.html.
[3] Please refer to the Administrative Measures for the Listing Committee of the Science and Technology Innovation Board of the Shanghai Stock Exchange, the Examination and Approval Rules of the Science and Technology Innovation Board of the Shanghai Stock Exchange, and the Listing Rules of the Science and Technology Innovation Board of the Shanghai Stock Exchange.
[4] *New Beijing News* article from March 29, 2019 (https://baijiahao.baidu.com/s?id=1629348597890743743).

Our findings indicate that RSR significantly mitigates IPO ownership discrimination under the approval system, particularly for non-politically connected private enterprises. In addition, the post-IPO market performance of SOEs is inferior to that of private enterprises under the approval system, while there is no significant difference under the registration system. Consequently, the assertion that SOEs prioritize approval because of their superior performance under the approval system can be excluded. Under the double-track system, which includes both the approval system and the registration system, we further examine cases of "alternative IPO application" and find that none of the companies that encounter IPO rejections under the registration system opt for reapplication under the approval system. Among the 39 companies transitioning from the approval system to the registration system for IPO reapplication, 38 are private enterprises (with only one being an SOE), and it is easier for them to succeed after switching to the registration system. To the extent that these entrepreneurs perceive IPO approval to be more accessible under the registration system, this finding supports our conjecture that the registration system alleviates IPO ownership discrimination. Finally, heterogeneous analysis reveals that this alleviating effect mainly exists in China's three major urban agglomerations (i.e., the Pearl River Delta, the Yangtze River Delta, and the Beijing–Tianjin–Hebei region) and in technology-intensive industries. Collectively, these results suggest that RSR in China's capital market has led to the decentralization of securities regulators and caused a shift in the market-oriented direction.

The main contribution of this study is our analyses of RSR effectiveness and potential issues (i.e., whether RSR weaken administrative intervention and strengthen the market-oriented mechanism). We conduct the first examination of whether RSR, as an exogenous shock, can alleviate administrative intervention from the perspective of IPO ownership preference, to address the question of whether such a reform ultimately represents a change in form but not in content. The findings demonstrate that the registration system does reduce discrimination against private enterprises in the IPO process and that securities regulators do delegate power, thus establishing a relatively fair environment for IPO activities.

2. Background and literature review

2.1. Background

The registration system originated in the United Kingdom and matured in the United States, and it has since been consistently introduced into various market economy countries (Wang et al., 2019). Despite its widespread implementation, many countries remain cautious about adopting the registration system. For example, developed countries such as France, Switzerland, and Germany have not followed in the United States' footsteps, but have instead continued to uphold the approval system. Emerging market countries in Southeast Asia, such as South Korea and the Philippines, also adhere to the approval system. Thus, global capital markets present a situation in which both the registration system and the approval system coexist.

In China, the decision to promote RSR was made as early as the Third Plenary Session of the 18th Central Committee of the Communist Party on November 15, 2013. However, it was not until November 5, 2018, when President Xi Jinping announced the establishment of the Science and Technology Innovation Board (Sci-Tech Innovation Board) on the Shanghai Stock Exchange and the pilot implementation of the registration system, that RSR was accelerated. In January 2019, the detailed rules of the registration system were introduced; on June 13 of the same year, the Sci-Tech Innovation Board was officially launched, marking the beginning of the practical phase of the registration system. On December 28, 2019, the Securities Law was revised to state that the main institutional arrangements for RSR on the Sci-Tech Innovation Board had withstood market tests and had a practical foundation. It was decided that the registration system would be gradually extended to other boards starting from March 1, 2020. Subsequently, on August 24, 2020, the first batch of companies implementing the registration system in the Growth Enterprise Market (GEM) were officially listed. China's capital market utilizes a double-track system that entails both the approval system and the registration system.

The mechanism for reviewing stock issuance differs significantly between the approval system and the registration system. First, the two systems have different theoretical orientations. The approval system emphasizes government regulation, whereas the registration system advocates marketization. According to Article 22 of the original Securities Law (2014 version), securities regulators shall set up the IEC to review stock

issuance, thus reflecting government regulation under the approval system. In contrast, the registration system emphasizes marketization. For example, the Implementation Opinions of the Registration System on the Science and Technology Innovation Board of the Shanghai Stock Exchange (hereafter "the Implementation Opinions"), issued by the CSRC in January 2019, emphasizes that the registration system should be market-oriented, strengthen market constraints, and establish a new stock issuance system dominated by market mechanisms. Second, there are substantial differences in the practical application of the two systems. Under the approval system, a key part of IPO approval lies in the review conducted by the IEC, which involves strong administrative intervention. To facilitate RSR, the revised Securities Law abolished the IEC and delegated authority to the Listing Committees of the Securities Exchange. After IPO approval by the Securities Exchange, opinions on the IPO review are submitted to the CSRC for further review. If the CSRC disagrees, it can ask the Securities Exchange to re-examine the disputed issues until the CSRC is satisfied. If a company fails to pass the review by the Securities Exchange, its IPO application is terminated (i.e., the IPO is rejected).[5]

2.2. Literature review

Extensive empirical evidence has shown that under the approval system, the phenomenon of "invisible power manipulation" arises in the IPO process in China. For instance, Chen et al. (2014) discovered that private enterprises can increase their likelihood of IPO approval by leveraging the social relationships between intermediary agencies and the IEC. Likewise, Huang and Xie (2016) observed that underwriters can increase the probability of a company's IPO approval by establishing indirect relationships between other IPO audit clients and members of the IEC. Liu et al. (2021) found that the involvement of politically connected venture capital firms increased private companies' likelihood of IPO approval. Wang and Wu (2020) reported similar findings, demonstrating the increased likelihood of politically connected companies obtaining IPO approval. Such evidence shows that there is a clear issue of administrative intervention in the IPO process under the approval system.

The existence of invisible power manipulation is also reflected in the fact that private enterprises suffer unfair treatment during the financing process in the Chinese capital market. Analyzing the allotment behavior of A-share listed companies from 1999 to 2003, Su and Yang (2009) found that the IPO approval rate for SOEs was 38 % higher than that for private enterprises. Interestingly, compared with SOEs, private enterprises approved for rights issues exhibited faster future investment growth and were less likely to change the purpose of raised funds, demonstrating greater efficiency in resource allocation. Claessens and Perotti (2007) highlighted that financing inequality can affect a company's development and may further reinforce such inequality. Wang and Xin (2009) revealed that in the early stages of China's stock market development, SOEs enjoyed substantial privileges in IPO activities. Huang and Li (2016) found that private companies' IPO applications were easily rejected when they conducted earnings management, whereas SOEs' applications were not. Similarly, Zhu and Lu (2011) found that the proportion of private companies issuing equity refinancing plans and implementing equity refinancing was lower than that of SOEs, and that the securities regulatory department prioritized SOEs in the approval process. Li et al. (2019) showed that private enterprises subject to policy regulation and government intervention need to rely on sponsors with strong reputations and rich project experience to avoid IPO failure.

Weakening administrative intervention and emphasizing the market-oriented mechanism are two goals of RSR. Research has examined the economic consequences of market-oriented RSR from various perspectives, such as IPO underpricing (Lai et al., 2022; Wu and Zhang, 2022), IPO inquiry (Xue and Wang, 2022; Yu et al., 2022), and spillover effects (Liu and Li, 2022; Wu et al., 2022). For instance, Xue and Wang (2022) found that the quality of response letters from issuers was negatively correlated with IPO underpricing. Focusing on companies listed on the Sci-Tech Innovation Board, Lai et al. (2022) discovered that RSR significantly reduced IPO underpricing, thereby enhancing the pricing efficiency of the capital market. However, when Wu and Zhang (2022) extended the sample to companies on the GEM, they found that the IPO underpricing rate was higher for companies under the registration system, leading to a decrease in pricing efficiency.

[5] The appendix lists the distinctions between the approval system and the registration system in detail.

Furthermore, certain studies have indicated that the information disclosure environment under the registration system can exert spillover effects on other listed companies in the same industry, reducing stock price synchronicity (Wu et al., 2022) and increasing investment in research and development by companies within the same industry (Liu and Li, 2022).

As mentioned above, the approval system involves administrative intervention in the IPO process. Can the registration system play a market-oriented role to alleviate such intervention? Despite extensive theoretical debate and predictions, corresponding empirical evidence remains scarce. From the perspective of IPO ownership preference, we explore the impact of RSR and assess whether such reform reduces administrative intervention.

3. Hypothesis development

Whether government regulation or the marketization mechanism is better has long been debated in China (Zhu and Lu, 2011), further contributing to the theoretical disagreements surrounding RSR. Keynesianism and public interest theory contend that unregulated markets are susceptible to various failures and that government regulation can address these market failures, ultimately enhancing social welfare (Pigou, 1933). A large amount of empirical evidence has since been provided that administrative regulation, as an effective external governance mechanism, can ensure the stable development of the stock market (Pistor and Xu, 2005). The approval system adheres to the idea that the right to issue stocks is granted by the government and must be substantively reviewed by the securities regulatory authority, which essentially relies on administrative power to determine and control stock issuance. In contrast, neoliberalism and public choice theory argue that strict regulation raises barriers to market entry, impedes market competition, and adversely affects the social welfare of market participants (Stigler, 1971). Building on Stigler's logic, some scholars have contended that government intervention can distort the efficiency of resource allocation, which can lead to the problem of unfair IPO resource allocation (Porta et al., 1998; Djankov et al., 2002; Tian, 2011).

In China's capital market, the problem of ownership preference is prominent, because the stock market was, in its early stages, developed mainly to realize the reform of SOEs. Particularly under the approval system, private enterprises may encounter discrimination during their IPO activities due to government intervention, which can result in an unfair securities issuance market (Zhang, 2017). SOEs, as the principal enforcers of the government, undertake various social functions, such as addressing public issues and stabilizing employment. The inherent relationship between the government and SOEs means that the government has a natural inclination to favor SOEs in the allocation of public resources. SOEs, backed by the government, are more likely to obtain their IPO approval. In this institutional arrangement, numerous private enterprises opt to compensate for their inherent disadvantages in property rights by hiring officials with political backgrounds or politically connected intermediaries to increase their likelihood of IPO approval.

Because administrative intervention under the approval system has brought many drawbacks, there have been calls for RSR to optimize resource allocation through a market-oriented operating mechanism. Specifically, although the registration system does away with the IEC's role in the IPO review process, the right of administrative review remains, but it is delegated to the Listing Committee of the Securities Exchange. It is unclear whether as much administrative intervention occurs during the IPO process under the registration system as under the approval system, such that this intervention cannot be substantially reduced under the registration system. On this matter, there are two opposing theoretical expectations. First, as mentioned above, whether under the approval system or the registration system, SOEs in China still bear considerable social responsibilities. The intrinsic relationship between SOEs and the government is unlikely to disappear due to RSR. Therefore, under the registration system, the relationship between them implies that the government inevitably favors SOEs in the allocation of public resources. As long as the securities regulators retain decision-making power over IPO approval, it will be difficult to fundamentally solve the problem of discrimination against private enterprises in the IPO process.

Second, RSR emphasizes the market-oriented mechanism, which can alleviate ownership discrimination to some extent. For instance, the fundamental principles of the Implementation Opinions emphasize that the registration system must adhere to marketization, strengthen market constraints, and establish a new stock issuance system. One of the characteristics of the market-oriented mechanism is its emphasis on the fairness of

competition. Forced intervention leading to unfair competition would thus violate the principles of the market-oriented mechanism. Therefore, under the market-oriented registration system, administrative intervention in the IPO process may be weakened. Theoretically, companies could apply for IPOs under the current registration system provided they meet the listing standards and the listing conditions set by the Securities Exchange, which would weaken the advantageous position of SOEs. The concept of fair market competition and its corresponding mechanism design under the registration system may give private enterprises and SOEs relatively equal listing opportunities and resources, and may thus to some extent reduce the discrimination against private enterprises during the IPO process. Based on the above analysis, the following hypothesis is proposed:

H1. Compared with the approval system, the registration system alleviates IPO ownership discrimination in the IPO approval process.

4. Research design

4.1. Data collection

The most recent IPO suspensions in the primary securities market occurred in July 2015 and resumed in early 2016 (Wang, 2021). To minimize potential interference from uncertainties during the IPO resumption process and given the relatively short duration of RSR, the primary selection sample includes IPO applications with an acceptance date between January 1, 2017, and June 30, 2021. We exclude financial companies, ST/ST* companies, and companies with missing IPO prospectus or other missing data. Finally, we obtain 1,680 eligible applications from 1,596 companies.[6] Data related to accounting firms are taken from the website of the Chinese Institute of Certified Public Accountants. All financial data are taken from the China Stock Market and Accounting Research database and the WIND database.

4.2. Empirical model

Following Xiong et al. (2020) and Xiong and Zhao (2021), we construct the following regression model to test H1:

$$PASS = \beta_0 + \beta_1 NSOE + \beta_2 RSI \times NSOE + \beta_3 SIZE + \beta_4 LEV + \beta_5 ROE + \beta_6 ACRECTURN + \beta_7 GROWTH + \beta_8 FSHR + \beta_9 BIGUNDR + \beta_{10} BIG10 + BOARD + YEAR + IND + \varepsilon \quad (1)$$

The dependent variable *PASS* is a dummy variable that equals 1 if the firm's IPO application is approved by the IEC or the Listing Committee, and 0 otherwise. The independent variable *NSOE* is a dummy variable that equals 1 if the IPO company's controlling shareholders, largest shareholder, or actual controller is an individual, and 0 otherwise. The independent variable *RSI* indicates the IPO system adopted by companies, equaling 1 for the registration system and 0 for the approval system. If the registration system alleviates IPO ownership discrimination, as predicted by H1, the coefficient β_2 on the interaction term $RSI \times NSOE$ should be positive and statistically significant.

Following Huang and Xie (2016) and Xiong and Zhao (2021), we define the following control variables: (1) company characteristic variables, including *SIZE*, *LEV*, *ROE*, *ACRECTURN*, *GROWTH*, and *FSHR*, and (2) other control variables, including *BIGUNDR*, *BIG10*, *BOARD*, *INDUSTRY*, and *YEAR*. Detailed definitions of all of the variables are reported in Table 1. Winsorize truncation is applied to all continuous variables at the 1 % level.

[6] The number of IPO applications is greater than the number of companies because a company can undergo multiple application rounds before obtaining IPO approval.

Table 1
Variable definitions.

Variables	Definitions
PASS	1 if the firm's IPO application is approved, and 0 otherwise
NSOE	1 if the controlling shareholders, the largest shareholder, or the actual controller of the company that submits the IPO application is an individual, and 0 otherwise
RSI	1 if the application is under the registration system, and 0 if it is under the approval system
SIZE	ln(total assets), the average value of the 3 years preceding the IPO application
LEV	total liabilities/total assets, the average value of the 3 years preceding the IPO application
ROE	net income/shareholders' equity, the average value of the 3 years preceding the IPO application
ACRECTURN	accounts receivables/sales, the average value of the 3 years preceding the IPO application
GROWTH	profit/sales, the average value of the 3 years preceding the IPO application
FSHR	shareholding ratio of the largest shareholder in the year prior to the IPO application
*BIGUND*R	1 if the company's underwriter ranks in the top 10 underwriters according to the market share from WIND, and 0 otherwise
BIG10	1 if the company's auditor ranks in the top 10 auditing/ accounting firms according to the Chinese Institute of Certified Public Accountants
BOARD	1 for the Main Board, 2 for the GEM, and 3 for the Sci-Tech Innovation Board

5. Results

5.1. Descriptive statistics

Table 2 reports the descriptive statistics of our main variables. The mean value of *PASS* is 0.868, with a standard deviation of 0.339 and a minimum value of 0, indicating that approximately 86.8 % of the total IPO applications in the full sample are approved across the two systems. The mean value of *NSOE* is 0.921, indicating that the majority of IPO companies in our sample are private enterprises. The mean value of *RSI* is 0.398, implying that within the sample, approximately 40 % of the companies choose to go public

Table 2
Descriptive statistics.

Variables	Obs.	Mean	Standard deviation	Min.	Median	Max.
PASS	1,680	0.868	0.339	0	1	1
NSOE	1,680	0.921	0.270	0	1	1
RSI	1,680	0.398	0.490	0	0	1
SIZE	1,680	8.890	0.418	8.160	8.820	10.500
LEV	1,680	41.700	16.700	9.810	40.800	81.600
ROE	1,680	23.700	12.800	−6.010	21.300	72.100
GROWTH	1,680	0.528	1.140	−3.570	0.316	7.670
FSHR	1,680	45.200	18.700	12.300	42.400	94.300
ACRECTURN	1,680	17.200	56	1.190	4.770	461
BIGUNDR	1,680	0.442	0.497	0	0	1
BIG10	1,680	0.680	0.466	0	1	1

Table 3
IPO approval statistics.

Year	2017 (January to December)			2018 (January to December)			2019 (January to December)		
	IPO success	IPO failure	IPO failure rate	IPO success	IPO failure	IPO failure rate	IPO success	IPO failure	IPO failure rate
Private enterprises	341	86	20.14 %	89	67	42.95 %	208	27	11.49 %
SOEs	31	5	13.89 %	9	4	30.77 %	19	1	5.00 %
Total	372	91	19.65 %	98	71	42.01 %	227	28	10.98 %
Year	2020 (January to December)			2021 (January to December)			January 2017 to June 2021		
	IPO success	IPO failure	IPO failure rate	IPO success	IPO failure	IPO failure rate	IPO success	IPO failure	IPO failure rate
Private enterprises	537	14	2.54 %	160	18	10.11 %	1,335	212	13.70 %
SOEs	43	0	0	21	0	0	123	10	7.52 %
Total	580	14	2.36 %	181	18	9.05 %	1,458	222	13.21 %

Source: WIND.

through the registration system channel, whereas the remaining 60 % opt for the approval system for their IPO activities.

5.2. IPO approval statistics

Table 3 reports the sample distribution. Among the 1,680 IPO application samples, 1,458 are approved and 222 are rejected, yielding an IPO failure rate of 13.21 %. Specifically, the IPO failure rate for private enterprises is 13.7 % and that for SOEs is 7.52 %. The results in the table indicate that for both the annual sample and the total sample, the IPO failure rate of private enterprises is higher than that of SOEs. This indicates that IPO ownership preference exists throughout our sample period.[7]

Panel A of Table 4 presents the differences in rates of failure of IPO applications between private enterprises and SOEs under the approval system and registration system, respectively. For the full sample, the IPO failure rate of private enterprises under the approval system is 20.28 % and that of SOEs is 10.71 %, representing a difference of 9.57 %. This result indicates an evident ownership preference in the approval-based IPO system. However, under the registration system, the IPO failure rate of private enterprises is reduced to 3.87 %; that of SOEs is reduced to 2.04 %; and the difference is reduced to 1.83 %. Hence, the disparity in approval rates between SOEs and private enterprises under the registration system is smaller than that under the approval system. Therefore, RSR does to a certain extent mitigate the extent of IPO ownership discrimination. In the GEM sample, the IPO failure rate of private enterprises under the approval system is 29.13 % and that of SOEs is only 11.11 %, representing a difference of 18.02 %. After implementing the registration system, the IPO failure rate of private enterprises is reduced to 3.33 % and that of SOEs is 0. This indicates that under the registration system, the phenomenon of preferential approval for SOEs is significantly alleviated, providing preliminary support for H1.

According to previous research, certain private enterprises strategically seek to improve their resource allocation by establishing political connections (Xu et al., 2018). We categorize private enterprises into two distinct types based on their relationship with political connections. Specifically, if the executives or directors of a company have served as National People's Congress deputies or as members of the Chinese People's Political Consultative Conference or if they have held positions in government departments, the company is categorized as a politically connected private enterprise. In contrast, if the executives or directors of a company lack such political roles or positions, the company is classified as a non-politically connected private enterprise. We also categorize SOEs as either local government connected SOEs or central government

[7] This section also makes use of IPO applications in our sample interval (i.e., January 1, 2017 to June 30, 2021).

Table 4
IPO approval statistics for different issuance systems.

Panel A

Issuing system	Companies	Full sample		GEM		Sci-Tech Innovation Board	
		IPO failure rate	Difference	IPO failure rate	Difference	IPO failure rate	Difference
Approval system	Private enterprises	20.28 %	9.57 %	29.13 %	18.02 %	—	—
	SOEs	10.71 %		11.11 %		—	
Registration system	Private enterprises	3.87 %	1.83 %	3.33 %	3.33 %	4.29 %	1.06 %
	SOEs	2.04 %		0		3.23 %	

Panel B

Issuing system	Companies	Distinct types	IPO failure rate	Difference
Approval system	Private enterprises	Non-politically connected	25.97 %	17.18 %
		Politically connected	8.79 %	
	SOEs	Local government connected	13.79 %	9.94 %
		Central government connected	3.85 %	
Registration system	Private enterprises	Non-politically connected	3.43 %	−2.22 %
		Politically connected	5.65 %	
	SOEs	Local government connected	0	−4.76 %
		Central government connected	4.76 %	

Source: WIND.

connected SOEs, as shown in Panel B of Table 4. The results indicate that under the approval system, the IPO failure rate is highest for the non-politically connected private enterprises, followed by the local government connected SOEs. Politically connected private enterprises experience the third highest failure rate and central government connected SOEs have the lowest. Specifically, under the approval system, the IPO failure rate of non-politically connected private enterprises (25.97 %) is significantly higher than that of politically connected private enterprises (8.79 %), with a difference of 17.18 %. The IPO failure rate of local government connected SOEs (13.79 %) is also significantly higher than that of central government connected SOEs (3.85 %), with a difference of 9.94 %. These findings indicate that under the approval system, characterized by government regulation, SOEs with government backgrounds, particularly central government connected SOEs, experience lower IPO failure rates. Furthermore, private enterprises can enhance their IPO approval rate by leveraging political connections. However, under the registration system, the IPO failure rate of non-politically connected private enterprises (3.43 %) is lower than that of politically connected private enterprises (5.65 %), and the IPO failure rate of local government connected SOEs is also lower than that of central government connected SOEs. These results indicate that RSR emphasizes fair financing, curbing the IPO ownership discrimination that is evident under the approval system, thus supporting H1.

5.3. Regression results

The purpose of this study is to test whether RSR alleviates IPO ownership discrimination, but our main test is likely to be affected by endogeneity. As shown in Table 5, there are obvious differences between the basic characteristics of private enterprises and SOEs. If there is a difference in the IPO approval rates between the two types of companies, it is not necessarily caused by differences in ownership. Therefore, it is necessary to use technical means to eliminate some differences between the treatment group ($NSOE = 1$) and the control group ($NSOE = 0$) to overcome possible endogeneity. Following Hainmueller (2012) and Dambra et al. (2020), we use an entropy balancing (EB) regression model to address this potential endogeneity. Table 5 shows our results before and after the matching. The mean, variance, and skewness are lower after EB. Accordingly, we use EB matching weights in the subsequent regressions.

Table 6 reports the regression results after EB matching. In columns (1) and (2), the coefficients of *NSOE* are negative and significant at the 1 % level. Overall, the table indicates that the IPO approval rate for private enterprises is significantly lower than that of SOEs, suggesting a pronounced IPO ownership preference. In columns (3) and (4), the coefficients of *NSOE* are also negative and significant at the 1 % level, suggesting that

Table 5
Entropy balancing results.

Before matching	*NSOE* = 1 (1,547)			*NSOE* = 0 (133)		
	Mean	Variance	Skewness	Mean	Variance	Skewness
SIZE	8.847	0.142	1.045	9.331	0.339	0.417
LEV	40.820	270	0.232	51.350	298.700	−0.220
ROE	24.120	164.300	1.171	18.440	139.400	1.710
GROWTH	0.551	1.342	3.040	0.262	0.740	−0.245
FSHR	44.330	338	0.555	55.060	367.200	0.249
ACRECTURN	17.040	3,151	6.576	19.470	3,022	5.825
After matching	Mean	Variance	Skewness	Mean	Variance	Skewness
SIZE	8.847	0.142	1.045	8.847	0.165	0.947
LEV	40.820	270	0.232	40.820	311.500	0.332
ROE	24.120	164.300	1.171	24.120	270.400	1.481
GROWTH	0.551	1.342	3.040	0.551	1.078	2.846
FSHR	44.330	338	0.555	44.330	248.700	0.643
ACRECTURN	17.040	3,151	6.576	17.040	2,810	7.094

Table 6
Impact of the registration system on IPO approval rates across ownership structures.

Variables	LOGIT (1)	PROBIT (2)	LOGIT (3)	PROBIT (4)	LOGIT (5)	PROBIT (6)
NSOE	−1.613***	−0.923***	−1.897***	−1.072***		
	(-5.247)	(-5.487)	(-5.466)	(-5.983)		
RSI × *NSOE*			1.350**	0.730*		
			(1.967)	(1.943)		
PCNSOE					−0.742*	−0.442**
					(−1.845)	(−2.104)
PCNSOE × *RSI*					−0.731	−0.365
					(-1.081)	(-1.110)
NonPCNSOE					−2.269***	−1.269***
					(−6.490)	(−7.027)
NonPCNSOE × *RSI*					1.759***	0.890***
					(3.122)	(3.135)
SIZE	3.153***	1.537***	2.899***	1.424***	2.894***	1.423***
	(4.728)	(4.280)	(5.140)	(4.579)	(5.157)	(4.593)
LEV	−0.040***	−0.021***	−0.037***	−0.020***	−0.038***	−0.020***
	(−4.468)	(−4.192)	(−4.425)	(−4.232)	(−4.649)	(−4.422)
ROE	0.057***	0.028***	0.053***	0.026***	0.054***	0.027***
	(4.088)	(3.580)	(4.293)	(3.706)	(4.448)	(3.840)
GROWTH	0.069	0.037	0.080	0.044	0.090	0.048
	(0.859)	(0.868)	(0.959)	(0.996)	(1.089)	(1.090)
BIGUNDR	0.144	0.094	0.201	0.125	0.227	0.145
	(0.645)	(0.802)	(0.879)	(1.050)	(0.984)	(1.205)
BIG10	−0.617**	−0.309**	−0.604**	−0.301**	−0.588**	−0.290**
	(-2.462)	(-2.296)	(-2.403)	(-2.237)	(-2.288)	(-2.111)
FSHR	−0.004	−0.003	−0.004	−0.004	−0.005	−0.004
	(-0.695)	(-1.085)	(-0.708)	(-1.124)	(-0.735)	(-1.117)
ACRECTURN	−0.001	−0.001	−0.001	−0.001	−0.001	−0.000
	(-0.532)	(-0.436)	(-0.408)	(-0.361)	(-0.389)	(-0.332)
CONSTANT	−24.708***	−11.740***	–22.279***	−10.625***	–23.055***	−11.059***
	(−4.173)	(−3.707)	(−4.449)	(−3.899)	(−4.631)	(−4.056)
BOARD/IND/YEAR	YES	YES	YES	YES	YES	YES
N	1,680	1,680	1,680	1,680	1,680	1,680
Pseudo R^2	0.3510	0.3453	0.3566	0.3513	0.3792	0.3738

Z-statistics in parentheses. ***p <.01, **p <.05, *p <.1.

there is an obvious IPO ownership preference under the approval system: the IPO approval rate of private enterprises is lower than that of SOEs, which validates previous research conclusions (i.e., Chen et al., 2014; Huang and Xie, 2016). Furthermore, the interaction coefficients of $RSI \times NSOE$ are 1.350 and 0.730 and are significant at the 5 % and 10 % levels, respectively, indicating that the difference between the IPO approval rates of private companies and SOEs is smaller under the registration system than under the approval system. Therefore, IPO ownership discrimination is significantly alleviated, which verifies H1.

We further categorize private enterprises into two groups: those with political connections (*PCNSOE*) and those without political connections (*NonPCNSOE*).[8] Under the approval system characterized by administrative intervention, private enterprises can improve their IPO approval rates and protect themselves from unfair treatment by establishing political connections. However, as administrative intervention does not play a role post-RSR, political connections may not enhance the IPO approval rates for private enterprises. The regression results in columns (5) and (6) show that the coefficients of *PCNSOE* are negative and significant at the 10 % and 5 % levels, respectively, and the coefficients of *NonPCNSOE* are negative and significant at the 1 % level. This suggests that under the approval system, both politically connected and non-politically connected private enterprises have significantly lower IPO approval rates than do SOEs. The coefficients for *PCNSOE* (-0.742, −0.442) are greater than the coefficients for *NonPCNSOE* (-2.269, −1.269). This implies that under the approval system, politically connected private enterprises have higher IPO approval rates than do non-politically connected private enterprises, indicating that private enterprises can alleviate their unfair treatment during the IPO process by establishing political connections. The coefficients of the interaction term $PCNSOE \times RSI$ are not significant, indicating that RSR does not substantially affect the IPO approval rates of politically connected private enterprises. However, the coefficients for the interaction term $NonPCNSOE \times RSI$ are positive and significant at the 1 % level, suggesting that RSR does effectively curb discrimination against non-politically connected private enterprises. In summary, RSR significantly alleviates discrimination against private enterprises in IPO activities under the approval system. This mitigation effect is mainly observed in non-politically connected private enterprises, indicating that RSR indeed reduces government intervention.

5.4. Robustness tests

5.4.1. Entropy balancing–difference-in-difference-in-differences method

Differing from the registration system adopted by the Sci-Tech Innovation Board, the GEM has transitioned from the approval system to the registration system, which serves as a favorable setting in which to conduct an entropy balancing–difference-in-difference-in-differences (EB–DDD) test. Following Brogaard et al. (2019) and Wu and Zhang (2022), we construct an EB–DDD model using observations for IPO applications to the Main Board and the GEM from January 2017 to June 2021[9]:

$$PASS = \beta_0 + \beta_1 NSOE + \beta_2 POST + \beta_3 NSOE \times POST + \sum Controls + \varepsilon \quad (2)$$

where *POST* represents the starting point of RSR for the GEM, with a value of 1 after June 22, 2020,[10] and a value of 0 before June 22, 2020. We use the IPO samples on the Main Board, which are unaffected by RSR, as

[8] After categorization, our sample is divided into three types: SOEs, politically connected private enterprises (*PCNSOE*), and non-politically connected private enterprises (*NonPCNSOE*). Using SOEs as the baseline, we characterize these three types of enterprises through the introduction of two dummy variables, namely *PCNSOE* and *NonPCNSOE*. *PCNSOE* equals 1 when the IPO company is a private enterprise and its executives or directors have served as National People's Congress deputies or as members of the Chinese People's Political Consultative Conference or if they have held positions in government departments, and 0 otherwise. *NonPCNSOE* equals 1 if the IPO company is a non-politically affiliated private enterprise, and 0 otherwise.

[9] As the Sci-Tech Innovation Board adopted the registration system from the beginning, which is unsuitable for the DDD model, we exclude the Sci-Tech Innovation Board samples. Consequently, the sample in Table 7 is smaller than the overall sample.

[10] Although the first batch of companies under the registration system in China was officially listed on the GEM on August 24, 2020, the companies had to obtain IPO approval in this context before going public. In this study, the dependent variable indicates whether the IPO is approved or not (*PASS*), known as the IPO acceptance date. According to the WIND database, the IPO acceptance date for the first batch of GEM companies under the registration system was June 22, 2020. Thus, the cutoff point for defining *Post* is the IPO acceptance date for the first batch of GEM companies under the registration system, which was June 22, 2020.

Table 7
EB–DDD method.

Variables	LOGIT		PROBIT	
	GEM	Main Board	GEM	Main Board
	(1)	(2)	(3)	(4)
NSOE × *POST*	−8.842***	−12.536***	−2.005***	−4.575***
	(−5.461)	(−9.637)	(−3.018)	(−7.154)
Test of difference in *NSOE* × *POST*		3.694**		2.570***
POST	11.210***	11.643***	3.283***	4.147***
	(7.448)	(10.001)	(5.271)	(7.533)
NSOE	−1.989	−0.145	−0.949*	−0.109
	(−1.550)	(−0.283)	(−1.814)	(−0.371)
CONSTANT	−9.894	−21.060***	−5.331	−10.575***
	(−1.173)	(−3.158)	(−1.235)	(−3.286)
CONTROLS	YES	YES	YES	YES
IND/*YEAR*	YES	YES	YES	YES
N	609	664	609	664
Pseudo R^2	0.3222	0.2160	0.3267	0.2077

the control group and those on the GEM, which are affected by RSR, as the experimental group. The coefficient β_3 on the interaction term *NSOE* × *POST* measures the effect of the registration system on the difference in IPO approval rates of private enterprises and SOEs. We regress separately for the GEM (experimental group) and the Main Board (control group).

The results are presented in Table 7. Columns (1) and (3) present the regression results for the treatment group, and columns (2) and (4) present the regression results for the control group. The coefficients β_3 of the interaction term *NSOE* × *POST* are negative and statistically significant at the 1 % level for both the treatment group and the control group, but the treatment group coefficients are larger than the control group coefficients. The differences in β_3 between the two groups are 3.694 and 2.570 and are significant at the 5 % and 1 % levels, respectively, which demonstrates that RSR reduces IPO ownership discrimination to a large extent. That is, under the registration system, the difference in IPO approval rates between private companies and SOEs is smaller in the treatment group than in the control group. These results illustrate that the registration system considerably alleviates the impact of ownership type on IPO approval, and so our main conclusions are robust.

5.4.2. Exclusion of companies that obtain IPO approval but are not successfully listed

A small number of companies obtain IPO approval but are still unable to go public.[11] To avoid such companies interfering with our results, we exclude them from our sample and rerun the regression. The results in Table 8 show that an IPO ownership preference still exists after excluding companies that have obtained IPO approval but have not been successfully listed (see the coefficients of *NSOE* in columns (1) and (2)). Furthermore, IPO ownership discrimination under the approval system is more severe (see the coefficients of *NSOE* in columns (3) and (4)), but RSR significantly reduces this discrimination (see the coefficients of *RSI* × *NSOE* in columns (3) and (4)). These regression results still support our main findings.

5.5. Alternative interpretations

5.5.1. Preferential issuance

Our hypothesis which RSR alleviates IPO ownership discrimination is grounded in the premise that there is no disparity in the quality of private companies and SOEs. We define IPO ownership preference as the

[11] For example, the Listing Committee of the GEM approved the IPO application of a company named Qiande Electronics on January 28, 2021, but Qiande Electronics later submitted a request to withdraw its IPO application to the Shenzhen Stock Exchange on April 26, 2021.

Table 8
Exclusion of companies that obtain IPO approval but are not successfully listed.

Variables	LOGIT	PROBIT	LOGIT	PROBIT
	(1)	(2)	(3)	(4)
NSOE	−1.628***	−0.931***	−1.923***	−1.086***
	(−5.241)	(−5.490)	(−5.560)	(−6.074)
RSI × *NSOE*			1.308**	0.655**
			(2.357)	(2.345)
CONSTANT	−24.835***	−11.925***	–22.543***	−10.902***
	(−4.230)	(−3.756)	(−4.569)	(−4.014)
CONTROLS	YES	YES	YES	YES
BOARD/IND/YEAR	YES	YES	YES	YES
N	1,603	1,603	1,603	1,603
Pseudo R^2	0.3526	0.3473	0.3588	0.3538

preferential IPO approval of SOEs as demonstrated by their increased IPO approval rates relative to private enterprises. However, if SOEs are inherently superior to private enterprises, then their higher IPO approval rates are understandable, and thus an ownership preference may not exist. Therefore, to verify the IPO ownership preference, it is necessary to examine the differences in post-IPO performance between SOEs and private enterprises. We thus compare the market performance of SOEs and private enterprises after listing, and we use the results to assess whether preferential issuance does indeed play a role. If the overall post-IPO performance of SOEs is superior to that of private enterprises, the differences in their approval rates are likely to be driven by optimization rather than IPO ownership preference. Conversely, if listed private enterprises outperform listed SOEs, administrative intervention is likely to result in IPO ownership preference under the approval system.

Following Song and Xin (2017), we construct the following model to examine whether the priority of IPO approval for SOEs is a result of preferential issuance:

$$Performance = \beta_0 + \beta_1 NSOE + \sum Controls + \varepsilon \tag{3}$$

The dependent variable *Performance* represents post-IPO market performance, specifically using the IPO companies' buy-and-hold excess returns for 10 months after listing (*BH_E_10MONTH* and *BH_V_10MONTH*). *BH_E_10MONTH* represents the return of individual stocks minus the market return calculated by the equal weighted average method, and *BH_V_10MONTH* represents the return of individual stocks minus the market return calculated by the float market capitalization weighted average method.

The results are shown in Table 9. Columns (1) and (3) show the regression results for the approval system, and columns (2) and (4) show the regression results for the registration system. The coefficients of *NSOE* in columns (1) and (3) are positive and significant at the 1 % level, and they indicate that private enterprises have

Table 9
Preferential issuance.

Variables	*BH_E_10MONTH*		*BH_V_10MONTH*	
	Approval system	Registration system	Approval system	Registration system
	(1)	(2)	(3)	(4)
NSOE	0.060***	−0.020	0.070***	−0.016
	(3.337)	(−1.144)	(3.141)	(−0.772)
CONSTANT	−0.442***	0.298	−0.476***	0.214
	(−3.036)	(1.080)	(−2.910)	(0.720)
CONTROLS	YES	YES	YES	YES
BOARD/IND/YEAR	YES	YES	YES	YES
N	698	242	698	242
Adj. R^2	0.1430	0.1170	0.1921	0.0867

Table 10
Effect of a strict committee.

Variables	LOGIT	PROBIT	LOGIT	PROBIT
	(1)	(2)	(3)	(4)
NSOE	−1.836***	−0.982***	−2.547***	−1.339***
	(−4.958)	(−4.935)	(−5.623)	(−6.112)
RSI × *NSOE*			1.815***	0.915***
			(3.440)	(3.616)
CONSTANT	–32.761***	−14.507***	−29.080***	−12.841***
	(−4.106)	(−3.443)	(−4.099)	(−3.411)
CONTROLS	YES	YES	YES	YES
BOARD/IND/YEAR	YES	YES	YES	YES
N	1,401	1,401	1,401	1,401
Pseudo R^2	0.3167	0.3078	0.3326	0.3253

better post-IPO market performance than SOEs under the approval system. These results reject the notion that the higher SOE approval rates are a result of their superior performance. In other words, the dominance of administrative power under the approval system gives the "green light" to SOEs whose post-IPO performance is poorer than that of private enterprises. This reflects that the preferential approval given to SOEs under the approval system is not the result of optimal selection but rather a consequence of administrative intervention. The coefficients of *NSOE* in columns (2) and (4) are not significant, indicating that there is no significant difference in the performance of private enterprises and SOEs under the registration system. To some extent, these results support the view that RSR fosters a fairer financing environment for private enterprises.

5.5.2. Effect of a strict committee

Examinations by the IEC of the CSRC were extremely strict between October 2017 and January 2019, because there were a large number of IPO applications and the IPO approval rate hit a record low during this period (Pi, 2017). Therefore, the lower IPO approval rate for private enterprises than SOEs during this period may be attributable to strict IEC examination rather than to the inherent nature of the issuance system. To mitigate the impact of these stringent examinations, we exclude IPO applications filed within this period from our sample and rerun the regression analysis. The results are shown in Table 10. Columns (1) and (2) show that the coefficients of *NSOE* are negative and statistically significant at the 1 % level, indicating that IPO ownership preference still exists in the revised sample. The coefficients of *RSI* × *NSOE* in columns (3) and (4) are positive and significant at the 1 % level, indicating that RSR greatly reduces IPO ownership discrimination. The initial study findings are thus robust.[12]

6. Further analysis

6.1. RSR and alternative IPO application

Indeed, in the IPO market, numerous private enterprises exhibit remarkable perseverance by reattempting the listing process after initial rejection under the approval system. Some enterprises even undergo multiple

[12] To exclude the alternative explanation raised by the expert reviewers regarding the influence of "pre-communication channels" on the IPO approval rates of SOEs and private enterprises, we offer the following discussion. Theoretically, the difference in pre-communication channels between SOEs and private enterprises should remain constant under the approval system or the registration system. We assume that under the approval system SOEs have 50 pre-communication channels while private enterprises have 20, resulting in a disparity of 30 pre-communication channels. According to the expert reviewers, it is this 30-channel difference that leads to variations in IPO approval rates between SOEs and private enterprises. However, the crux of the matter is that even under the approval system, the difference in pre-communication channels is 30, and the registration system theoretically does not alter the 30-channel difference. If the pre-communication channel perspective is valid, there should be no significant differences between the IPO approval rates of SOEs and private enterprises before and after RSR (both should be a 30-channel difference). However, our findings demonstrate that the gap in IPO approval rates between them narrows considerably after RSR, effectively refuting the alternative explanation of pre-communication channels.

application rounds. One example is afforded by Longlide (300883.SZ), which faced rejections in 2018 and 2019 under the approval system but achieved listing on its third attempt under the registration system in 2020. We refer to such a scenario, in which a company seeks listing through an alternative route following an unsuccessful IPO attempt, as "alternative IPO application."

Alternative IPO application arises in two scenarios: (1) when an approval system application shifts to the registration system and (2) when a registration system application shifts to the approval system. Theoretically, if there is no difference in the IPO approval rates between private enterprises and SOEs under the approval system and the registration system, the approval probabilities of private enterprises should be similar in both of these scenarios. Conversely, if private enterprises are more likely than SOEs to switch the issuance system they use from the approval system to the registration system, this suggests that it is more difficult to pass the IPO review under the approval system than under the registration system. Consequently, private enterprises prefer to alter their route and reapply for IPO under the registration system.

Based on our statistical results, neither private enterprises nor SOEs opt for the approval system when reapplying for an IPO. All instances of alternative IPO application involve companies that initially failed under the approval system and subsequently reapplied under the registration system. This indicates that obtaining IPO approval is indeed more difficult under the approval system, leading an increasing number of companies to seek IPO approval to raise funds through the registration system.

In Table 11, we present descriptive statistics for the alternative IPO application scenario in which an approval system application shifts to the registration system. The results reveal that among the 39 companies with alternative IPO applications, 38 are private enterprises and only 1 is an SOE. This implies that private company owners are aware that the registration system is fairer than the approval system. Consequently, when facing obstacles in the IPO process under the approval system, they tend to switch to the registration system. The results in Table 11 also demonstrate that after private enterprises choose the registration system, the IPO success rate increases from 79.72 % (i.e., under the approval system) to 97.37 %. This indicates that the registration system is more favorable to private enterprises than the approval system.

6.2. Impact of RSR on IPO difficulty

Different from situations in which a company successfully passes the review after a single IPO application, the scenario in which IPO approval takes multiple application rounds to a certain extent reflects the resistance encountered by IPO companies during the financing process. In light of this, we use the number of IPO applications to measure the challenges encountered by IPO companies. The model is shown in Eq. (4):

$$APPNUM = \beta_0 + \beta_1 NSOE + \beta_2 RSI \times NSOE + \sum Controls + \varepsilon \tag{4}$$

The independent variable $APPNUM$ represents the number of IPO applications submitted by listed companies whose applications are ultimately successful; the values range from 1 to 3, as the maximum number of IPO applications for the companies in the sample is 3. For the companies that have been successfully approved

Table 11
Alternative IPO application (from the approval system to the registration system).

	No. of companies	No. of companies engaged in alternative IPO application	Proportion	IPO success	IPO success rate after changing	IPO success rate before changing
Private enterprises	1,465	38	2.59 %	37	97.37 %	79.72 %
SOEs	131	1	0.76 %	1	100 %	89.29 %
Total	1,596	39	2.44 %	38		

Source: WIND.

Table 12
Impact of RSR on IPO difficulty.

Variables	Ordinary least squares (1)	Negative binomial (2)	Ordinary least squares (3)	Negative binomial (4)
NSOE	0.051***	0.050***		
	(4.590)	(4.704)		
RSI × *NSOE*	−0.057***	−0.056***		
	(−4.630)	(−4.761)		
PCNSOE			0.033***	0.032***
			(2.666)	(2.718)
PCNSOE × *RSI*			−0.035**	−0.034**
			(−2.413)	(−2.440)
NonPCNSOE			0.062***	0.060***
			(4.535)	(4.678)
NonPCNSOE × *RSI*			−0.069***	−0.067***
			(−4.553)	(−4.702)
CONSTANT	1.182***	1.189***	0.171	0.178
	(8.016)	(7.998)	(1.305)	(1.347)
CONTROLS	YES	YES	YES	YES
BOARD/IND/YEAR	YES	YES	YES	YES
N[1]	1,458	1,458	1,458	1,458
Adj. R^2/*Pseudo* R^2	0.0390	0.0004	0.0410	0.0005

[1] From the initial sample of 1,680, 222 samples that did not pass the approval process are excluded, leaving a total of 1,458 samples that successfully obtained approval.

and are preparing for listing, a higher number of IPO applications indicates a more challenging IPO process. A negative and significant regression coefficient on *RSI* × *NSOE* would indicate that private enterprises can obtain financing more easily under the registration system than under the approval system.

In the Table 12, the coefficients of *NSOE* in columns (1) and (2) are positive and significant at the 1 % level, indicating that the number of IPO applications for private enterprises under the approval system is significantly higher than that for SOEs. This implies that private enterprises face greater difficulties in financing. The coefficients of *RSI* × *NSOE* are negative and significant at the 1 % level, showing that the number of IPO applications of private enterprises is significantly lower under the registration system than under the approval system. This implies that private enterprises encounter less difficulty in obtaining IPO approval under the registration system than under the approval system. We further categorize the samples into three categories: politically connected private enterprises (*PCNSOE*), non-politically connected private enterprises (*NonPCNSOE*), and SOEs (used as a benchmark for comparison). The coefficients for *PCNSOE* and *NonPCNSOE* are both positive and significant at the 1 % level, indicating that under the approval system, both non-politically connected and politically connected private enterprises have significantly higher numbers of IPO applications than do SOEs. This implies that private enterprises face greater challenges than SOEs in applying for IPOs. The coefficients for the interaction terms *PCNSOE* × *RSI* and *NonPCNSOE* × *RSI* are negative and significant at the 5 % and 1 % levels, respectively, suggesting that after RSR, both politically connected and non-politically connected private enterprises experience significant reductions in IPO application difficulty compared with SOEs. The regression results indicate that the registration system does indeed foster a fairer financing environment.

6.3. Heterogeneity analysis

The above analysis shows that after RSR, the difference between the IPO approval rates of private enterprises and SOEs decreases significantly and IPO ownership discrimination is greatly reduced. Next, we analyze the specific areas where reductions in discrimination against private companies during the IPO process are more pronounced after RSR.

6.3.1. Regional heterogeneity

China's three major urban agglomerations—the Pearl River Delta, the Yangtze River Delta, and the Beijing–Tianjin–Hebei region, with the key cities of Guangzhou and Shenzhen, Shanghai, and Beijing, respectively, at their cores—have emerged as focal points for national economic development. The abundant economic resources in these agglomerations provide a solid foundation for the high-quality development of local private enterprises. Their geographical advantage further enables these enterprises to comprehend listing rules and collaborate with underwriters, lawyers, and accountants, enhancing their chances of listing on the Securities Exchange. Additionally, regulators, such as the CSRC and the Stock Exchange, situated in the three major urban agglomerations possess a greater familiarity with the local private enterprises' state of operations and financial performance, which can effectively mitigate information asymmetry. Consequently, RSR may alleviate IPO ownership discrimination to a particularly great extent in these three major urban agglomerations, driven by the market-oriented mechanism. Private enterprises often encounter more hurdles in economically underdeveloped regions, while SOEs tend to contribute significantly to local economic development. Thus, despite implementing RSR, regulators may continue to favor SOEs during the IPO process in less developed regions. The role of the registration system in reducing IPO ownership discrimination is therefore expected to be more pronounced in the three major urban agglomerations than in other regions.

Table 13 examines the effect of RSR on IPO ownership discrimination in different regions (i.e., the three major urban agglomerations vs. other regions). The coefficients of the interaction term $RSI \times NSOE$ for the three major urban agglomerations are positive and statistically significant at the 1 % level, but they are not statistically significant for other regions. These results indicate that RSR does reduce IPO ownership discrimination in the three major urban agglomerations, but it does not substantially reduce such discrimination in regions outside these agglomerations. The results of a Chow test show that the differences in the coefficients between the two groups are significant at the 1 % level, indicating that RSR does play a greater role in reducing IPO discrimination for private enterprises located in the three major urban agglomerations.

6.3.2. Industry-based heterogeneity

In the early stages of their development, prominent high-tech companies, such as Apple and Microsoft in the United States, had mediocre financial performance and teetered on the brink of bankruptcy multiple times. However, upon obtaining stock market listing in the US, these companies secured crucial development funds from the market, experienced rapid growth, and evolved into globally renowned high-tech enterprises. Likewise, the Chinese registration system intends to establish a multi-level capital market mechanism with the objective of providing a capital platform for enterprises that possess core technologies, thus facilitating their accelerated growth. The Administrative Measures for the Registration System of Initial Public Offerings on

Table 13
Regional heterogeneity.

Variables	LOGIT		PROBIT	
	Three major urban agglomerations	Other regions	Three major urban agglomerations	Other regions
	(1)	(2)	(3)	(4)
NSOE	−2.251***	−1.800***	−1.272***	−1.014***
	(−5.393)	(−2.804)	(−6.166)	(−3.227)
RSI × NSOE	2.041***	−0.689	1.057***	−0.213
	(3.018)	(−0.864)	(3.121)	(−0.605)
Test of difference in *RSI × NSOE*		2.730***		1.270***
CONSTANT	–32.448***	−7.498	−14.943***	−3.440
	(−4.884)	(−1.352)	(−4.398)	(−1.235)
CONTROLS	YES	YES	YES	YES
BOARD/IND/YEAR	YES	YES	YES	YES
N	1,079	601	1,079	601
Pseudo R^2	0.4490	0.3470	0.4401	0.3450

Table 14
Industry-based heterogeneity.

Variables	Labor-intensive industries		Capital-intensive industries		Technology-intensive industries	
	LOGIT	PROBIT	LOGIT	PROBIT	LOGIT	PROBIT
	(1)	(2)	(3)	(4)	(5)	(6)
NSOE	0.273	0.058	0.410	0.099	−4.101***	−2.007***
	(0.519)	(0.197)	(0.477)	(0.212)	(−7.696)	(−9.856)
RSI × NSOE	−0.593	−0.183	0.640	0.168	3.674***	1.574***
	(−0.588)	(−0.365)	(0.684)	(0.367)	(3.797)	(4.057)
CONSTANT	−17.727**	−8.093**	−28.912***	−13.955***	−25.882***	−12.819***
	(−2.370)	(−2.124)	(−2.903)	(−2.780)	(−3.791)	(−3.570)
CONTROLS	YES	YES	YES	YES	YES	YES
BOARD/YEAR	YES	YES	YES	YES	YES	YES
N	281	281	354	354	1,045	1,045
Pseudo R^2	0.3129	0.2970	0.4100	0.4021	0.3962	0.3887

the Sci-Tech Innovation Board outline specific criteria for a company's IPO application in accordance with the Sci-Tech Innovation Board's positioning. Specifically, the Sci-Tech Innovation Board is designed for companies with core technologies and exceptional technological innovation capabilities. Additionally, the Administrative Measures for the Registration System of Initial Public Offerings on the GEM emphasize that the GEM primarily caters to innovative and entrepreneurial enterprises. Consequently, regulators are expected to show a preference for high-tech companies post-RSR, contributing to a reduction in IPO ownership discrimination against private companies.

Following Li and Ye (2007) and Lu and Dang (2014), we divide industries into three categories: labor-intensive, capital-intensive, and technology-intensive. Specifically, labor-intensive industries include agriculture, forestry, animal husbandry and fishery, electricity, heat, gas and water production and supply, mining, food manufacturing, textiles, clothing, toys, leather, furniture manufacturing, construction, and wholesale and retail. Capital-intensive industries include printing, papermaking, chemical raw materials and chemical product manufacturing, water conservation, environmental protection and public facilities management, non-metallic mineral products, metal products, automobile manufacturing, real estate, coal, rubber and plastic products, and culture, sports, and entertainment. Technology-intensive industries mainly include biological pharmaceuticals, special equipment manufacturing, information transmission, computer software and hardware technology, education, scientific research and technical services, instrument manufacturing, and other manufacturing industries.

The results are shown in Table 14. The coefficients on *NSOE* are negative and significant at the 1 % level in technology-intensive industries, indicating that technology-intensive private enterprises have a significantly lower IPO approval rate than SOEs under the approval system. The coefficients of the interaction term *RSI × NSOE* are positive and significant at the 1 % level, indicating that RSR does reduce IPO ownership discrimination. Thus, in technology-intensive industries, the gap between the IPO approval rates of private enterprises and SOEs is narrowing.

7. Conclusion

The effectiveness of RSR has become a focus in China's capital market. One of the goals of RSR is to weaken administrative intervention and strengthen the market-oriented mechanism. Is IPO ownership discrimination likely to be alleviated under the registration system? Empirical research has paid insufficient attention to this issue, which is directly related to whether RSR promotes the decentralization of regulators and promotes a market orientation. From the perspective of IPO ownership preference, we find that RSR does help alleviate the discrimination against private enterprises in the IPO process, especially for non-politically connected private enterprises, which indicates that RSR can substantially weaken administrative intervention. In addition, we reveal that the post-IPO market performance of SOEs is not significantly superior to that of

private enterprises after RSR, which rejects the explanation that the preferential IPO approval of SOEs is the result of their superior performance. Under the double-track system, we also find that none of the companies choose to reapply for IPO under the approval system after IPO failure. Among the 39 companies with alternative IPO applications, 38 are private enterprises and only 1 is an SOE. To the extent that more and more private enterprises are willing to seek IPO approval under the registration system, this finding supports our inference that RSR is indeed conductive to reducing IPO ownership discrimination. Furthermore, heterogeneous analysis indicates that this effect mainly occurs in China's three major urban agglomerations, namely the Pearl River Delta, the Yangtze River Delta, and the Beijing–Tianjin–Hebei region, and in technology-intensive industries.

Our findings show that China's IPO registration system has shifted from government intervention to the market-oriented mechanism, which has important implications for optimizing the allocation of capital market resources. First, compared with the approval system, the registration system significantly mitigates IPO ownership discrimination, which shows that RSR is effective and should continue to be implemented. Second, based on the initial RSR results, we believe that the comprehensive implementation of RSR should be accelerated to promote marketization. Finally, the strength of the discrimination-alleviating effect of RSR implementation varies according to a company's industry and geographical location. It is thus necessary to focus on the IPOs of enterprises in labor-intensive and capital-intensive industries, as well as those of private enterprises in relatively remote areas, to broaden these enterprises' financing channels and solve their unique financing problems.

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. Summary of the differences between the approval and registration systems

First, the theoretical orientations of the two systems are fundamentally different. The approval system follows a philosophy of government regulation, as evidenced in Article 22 of China's original Securities Law (2014 version), which required the regulatory authority to establish the Issuance Examination Committee (IEC) to scrutinize stock issuance. In contrast, the registration system advocates a market orientation. It underscores that once all information is accurately disclosed, the registration for issuance and listing can proceed. The decision regarding whether to buy the stock is then entrusted to investors based on the information disclosed by the company. In alignment with the market orientation, the new Securities Law abolished the IEC. In January 2019, the China Securities Regulatory Commission issued the Implementation Opinions of the Registration System on the Science and Technology Innovation Board of the Shanghai Stock Exchange (hereafter "the Implementation Opinions"). These opinions underscore that the registration system should be market oriented, strengthen market constraints, and establish a new stock issuance system dominated by market mechanisms.

Second, regulatory agencies operate according to different reviewing principles under the approval and registration systems. Under the approval system, regulatory agencies are tasked with making substantive judgments regarding the applicant's business performance, development prospects, and overall company value. An illustrative example is Article 13 of the original Securities Law, which mandated that regulatory agencies scrutinize criteria such as sustained profitability and financial condition. In contrast, under the registration

system, regulatory agencies only conduct formal scrutiny of the registration materials provided by the applicant. For instance, Article 10 of the Examination and Approval Rules of the Science and Technology Innovation Board of the Shanghai Stock Exchange (hereafter "the Examination and Approval Rules") explicitly states that an opinion on initial public offering (IPO) approval by the Securities Exchange does not imply a guarantee of the truthfulness, accuracy, or completeness of the application documents and disclosed information. Furthermore, it does not represent a substantive assurance of the investment value of the stock or the returns for investors.

Third, the distinct information disclosure requirements differ between the two systems. The registration system is an issuance review system centered on comprehensive information disclosure. Beyond fulfilling fundamental issuance conditions, issuers must comply with stringent information disclosure standards. Notably, Article 13 of the Implementation Opinions explicitly emphasizes a regulatory framework centered on information disclosure and strict enforcement of the information disclosure system. Chapter 4 of the Examination and Approval Rules and Chapters 5 to 9 of the Listing Rules of the Science and Technology Innovation Board of the Shanghai Stock Exchange (hereafter the "Listing Rules") specifically regulate the information disclosure practices of listed companies. This highlights that compared with the approval system, the registration system imposes more rigorous requirements for information disclosure.

Fourth, the registration system emphasizes the due diligence and verification obligations of intermediary institutions, making them responsible for conducting substantive examinations. Under the approval system, intermediary institutions typically assist regulatory authorities in conducting substantive examinations, with ultimate decision-making power resting with the authorities. Meanwhile, the responsibilities of intermediary institutions are significantly strengthened under the registration system. For instance, Article 18 of the Implementation Opinions underscores the need to reinforce the responsibilities of intermediary institutions. Sponsors are required to thoroughly comprehend the applicant's operational conditions and risks, conducting a comprehensive verification of application documents and information disclosure materials. Additionally, Article 31 of the Examination and Approval Rules requires accounting firms, law firms, and other securities services institutions to ensure the truthfulness, accuracy, and completeness of content pertaining to their professional responsibilities in the prospectus and other issued documents. These provisions underscore that under the registration system, intermediary institutions bear the obligation of substantive review. Furthermore, Article 18 of the Implementation Opinions stipulates that in cases of false records, misleading statements, or significant omissions by the issuers, penalties of sponsors, accounting firms, law firms, and asset appraisal institutions will be increased. Specific distinctions are outlined in Table 15.

Table 15. Differences between the registration system and the approval system.

	IPO system	
difference	Approval system	Registration system
Theoretical orientations	Government regulation, the dominant role of administrative power in the IPO process	Promote marketization mechanism, weaken the role of administrative power in the IPO process
Regulatory authority	The IEC	The Securities Exchange and market participants (abolition of the IEC)
Examination principles	Substantive reviews of operating performance, development prospects, and company qualifications	Formal reviews of materials without making substantive judgments
Requirements for information disclosure	_____	Information disclosure as the core, establishing a comprehensive and strict information disclosure system
Requirements for intermediary institutions	A supporting role in substantive reviews, with regulatory authorities making the final decisions	Responsible for substantive reviews, strengthening the due diligence obligations of intermediary institutions

Source: The new and old versions of the Securities Law, Implementation Opinions of the Registration System on the Science and Technology Innovation Board of the Shanghai Stock Exchange, Examination and Approval Rules of the Science and Technology Innovation Board of the Shanghai Stock Exchange, and Listing Rules of the Science and Technology Innovation Board of the Shanghai Stock Exchange.

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Can the improvement of competitive adequacy and fairness reduce discriminatory M&A behavior? Evidence from the market access negative list pilot in China

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ABSTRACT

Corporate mergers and acquisitions (M&As) are subject to skewed logic due to excessive government regulation. China is progressively adopting the Market Access Negative List (MANL) pilot to transfer the power of resource allocation from the government to the market. Using the DID method, we examine the impact of relaxing market access regulation on firms' M&A behavior against China's institutional background and the M&A events of listed companies from 2012 to 2019. The MANL significantly increases firms' M&A tendency and amount and strengthens the competitive adequacy and fairness of market-oriented M&A decisions. Post-M&A financial performance does not increase, but human capital productivity, innovation effectiveness and total factor productivity do, demonstrating the dynamic balance of profit and efficiency in M&As.

1. Introduction

Mergers and acquisitions (M&As) can serve as important tools for companies to innovate internal structures and processes and make strategic modifications (Jie et al., 2021). The efficiency of resource allocation in a nation is significantly affected by M&As because they cause considerable resource reallocation among

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firms (Jiang, 2021). Research demonstrates that throughout economic transitions, the government retains some control over companies' investment possibilities and financial resources. Companies must seek government support to access a variety of market resources, such as bank loans (Li et al., 2008), corporate diversification licenses (Chen and Huang, 2007; Zhang and Huang, 2009) and M&A resources (Fang, 2008). According to Firth et al. (2009) and Chen et al. (2011), the government also has the authority to approve a company's entry into the capital market and to award land use rights. Government regulation and intervention, however, may skew the M&A behavior driven by competitiveness and efficiency improvement under market mechanisms, as they do not promote healthy competition between companies in the market (Fang, 2008).

China is a typical transitional economy and rising market. China's M&As are frequently influenced by external, non-market-oriented variables. The Chinese M&A market has been occupied by government-led M&As rather than market-driven M&As (Li et al., 2005; Chen and Huang, 2007; Gao and Huang, 2017). Thus, it exhibits M&A characteristics that are distinct from those of mature market countries. In addition, since the 18th National Congress of the Communist Party of China (CPC), the Chinese government has made significant changes to the relationship between the government and the market, shifting the dominant power of resource allocation from the government to the market and introducing a number of deregulation reform measures represented by the MANL. It enables regulation and deregulation to take place virtually concurrently in a nation, hence reducing any endogeneity issues that may arise when analyzing the economic effects of deregulation (Winston, 1993). Based on this, China's distinct institutional setting offers an opportunity to investigate whether loosening government regulation and giving the market more authority might correct the distortion caused by government involvement in M&A incentive and whether it might influence corporate M&A behavior.

Local governments in China have the authority to approve M&A resources and the associated supporting resources (Zhang et al., 2013). They encourage "forced-marriage style" M&As or obstruct "market-driven" M&As to accomplish particular political aims, which lowers M&A performance (Zhang, 2003; Li et al., 2004; Chen and Huang, 2007; Fang, 2008; Pan et al., 2008). As a result, it is difficult for M&As to have the desired favorable effects on resource allocation. Local governments might act as a "helping hand" by giving state-owned enterprises (SOEs), local companies and companies with political ties additional M&A funding (Li et al., 2005; Li and Zhu, 2006; Luo and Liu, 2009; Zhang and Huang, 2009; Li et al., 2021). However, they could also act as a "plundering hand," putting pressure on M&A firms to take on greater social or political duties (Chen and Huang, 2007; Pan et al., 2008; Pan and Yu, 2011; Wang and Gao, 2012). The unsatisfactory market response to Chinese enterprise M&As (Chen and Zhang, 1999; Li and Chen, 2002), financial performance rising (or plateauing) first and then falling (Feng and Wu, 2001; Li and Li, 2003) and other manifestations suggest that this may distort the resource allocation effect of the market competition mechanism.

A unified negative list system for market access was proposed at the 18th CPC National Congress in 2013. It incorporated the "negative list" approach into domestic economic governance, which was originally used to manage foreign investment. The "Opinions on Implementing the Market Access Negative List System" were published in 2015 by the State Council of China, formally endorsing the MANL pilot. It signaled a change in the way the government managed market access, moving away from a "positive list" approach toward the negative list approach. Additionally, it implied a loosening of market access restrictions. According to the positive list approach, the government can positively specify which markets can be accessed while also having discretion over the areas that are not clearly specified, thus creating an important area for government action. According to the negative list approach, the government outlines in unambiguous terms which areas of market access are barred or constrained. Additionally, market entities adhere to the "no prohibition by law" rule, which limits the scope for government involvement. As a result, the government's management of market access has evolved from stringent control to general relaxation as it has shifted from the positive list approach to the negative list approach. This involves reducing government involvement in corporate investment affairs, defining the dominant role of corporate investment and shifting the decision-making power of enterprises entering investment from government dominance to market dominance.

One of the easiest way for firms to expand into new markets and change the size of incumbent companies in those sectors is through M&As. The MANL can restrict the government's ability to allocate resources, increase the autonomy of market entities and encourage corporate M&A behavior to follow a market-

oriented logic. This modification aids in correcting the government intervention-related distortion of resource allocation, which would ultimately result in corresponding changes to the M&A performance and M&A tendency of companies. Fig. 1 depicts the evolution of Chinese listed companies' M&A tendency and size before and after MANL implementation. Before 2015, the M&A transactions of listed companies exhibited a steady growth pattern. Between 2015 and 2016, the number of M&A transactions increased significantly, with the average transaction value topping 1,700 billion yuan. The quantity and value of M&A deals somewhat dropped after 2016. As the first batch of the MANL pilot was implemented in 2015 and 2016, there was a dramatic increase in M&A transactions, showing that this pilot may improve the M&A tendency and scale of Chinese listed businesses.

In this study, we use the MANL pilot as a natural experimental scenario to test how the market access deregulation reform affects the M&A behavior and performance of listed companies. The study is based on the M&A events of A-share listed companies in China's Shanghai and Shenzhen stock markets from 2012 to 2019. We observe the changes in M&A behavior and performance during the transition from government-led to market-led M&As. Next, we investigate whether deregulation may correct the logical distortions in M&As induced by government interference and optimize M&A behavior. Additionally, we offer more general policy advice for developing nations' economies in transition on how to address the ineffective resource allocation caused by governmental regulation and to successfully implement a market-oriented transformation.

Through this study, we make the following contributions. First, we add to the literature on the economic effects of deregulation. Regulation and deregulation cannot take place in a nation concurrently, which presents a fundamental challenge for researchers examining the economic effects of deregulation, as their findings are frequently troubled by endogeneity issues (Winston, 1993). Whereas Chinese studies are primarily based on government-led environments, Western research is primarily based on free market conditions and particular industries. The influence of local adjustments in government regulation on corporate conduct is minimal in the context of market dominance or government domination. This study is mainly based on the institutional framework in which the Chinese government's role in resource allocation has changed from being dominant to being macro-economically regulating, while the market's role has changed from being fundamental to decisive. This radical shift in governmental regulation is expected to have a bigger effect on how businesses behave economically and can also prevent endogeneity problems. As a result, we are better able to assess the economic effects of deregulation in this study.

Second, we contribute to the knowledge of institutional environmental determinants in M&As. Deregulation sparked a surge of M&As (Mitchell and Mulherin, 1996; Andrade and Mitchell, 2001), although few literatures explore the process of deregulation or its effects on M&A performance. In this study, we investigate the impact of market access deregulation on companies' M&A behavior, and we expect the improvement of competition fairness and adequacy to be its mechanism. In addition, Chen and Ma (2017) discover that relax-

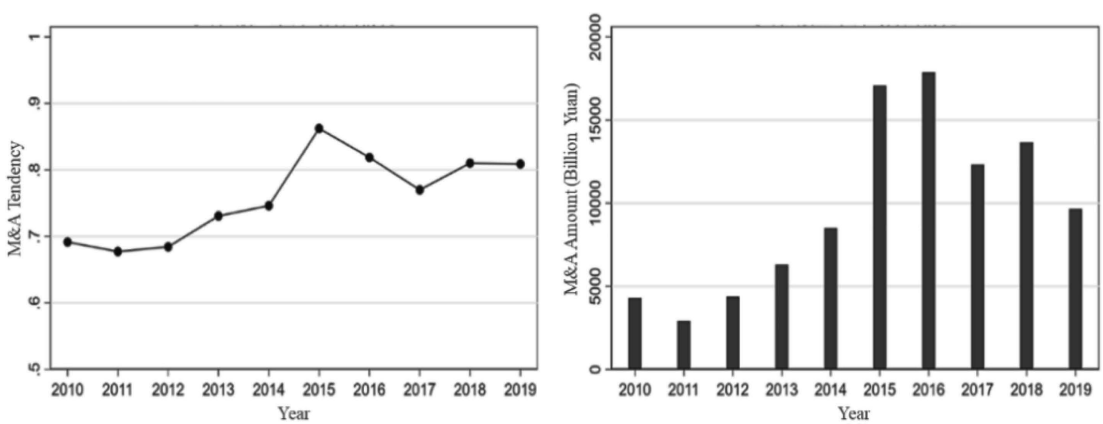

Fig. 1. M&A Tendency and Amount of Listed Companies.

ing short-selling regulations enhances M&A performance. However, the real economy is most affected by the relaxation of market access regulations, and the capital market is primarily affected by the relaxation of short-selling regulations. Whereas our study is founded on the idea that institutional environmental factors play a role in M&As, that of Chen and Ma (2017) is based on the agency theory of M&As. This study is thus highly innovative, as it investigates the mechanism by which deregulation affects M&A performance based on the theory of institutional environmental factors.

Third, from a competitive standpoint, we contribute to the literature on the relationship between competition and corporate investment. The literature on corporate investment and competition discusses the reverse causation problem (Wang and Jiang, 2020). To successfully address this issue, we use the difference-in-differences (DID) model. Additionally, we discover that by fostering more competition, loosening market access regulation encourages effective M&A investment. This enhances Wang and Jiang's (2020) research findings regarding how lowering administrative monopolies and raising competitive fairness may reduce companies' inefficient investments.

2. Institutional background and research hypotheses

2.1. Institutional background

2.1.1. Institutional background of China's M&As

The distinctiveness of Chinese enterprise M&As is demonstrated by the unique institutional background of government intervention. Local governments in China have the power to approve M&A resources and the associated supporting resources (Zhang et al., 2013). This has the potential to significantly influence companies' M&A decisions. Nevertheless, the government frequently disregards M&A performance and efficiency as main deciding factors (Li and He, 2007), which may distort the logic of corporate M&As led by market mechanisms (Fang, 2008). Local governments may act as a helping hand by giving M&A companies various incentives and favors. However, they may also act as a plundering hand by putting pressure on M&A-related companies to take on additional political or social obligations. The discrimination and unfairness arising from local governments' helping or plundering of M&As depend on their personal preferences. These are the main causes of unequal resource distribution (Wang et al., 2017; Jiang and Li, 2018). In companies' M&A activities, discriminatory behavior typically takes three forms, as detailed below.

First, ownership discrimination in M&As. When the government has significant control over scarce resources, it tends to allocate more resources, such as financial subsidies, to state-owned enterprises (Allen et al., 2005; Kong et al., 2013; Xiao and Wang, 2014). Opportunity for market access is also a kind of resource. Through regulatory regimes, the government expands the access options available to SOEs to maintain their economies of scale and competitive advantages. To prevent non-SOEs from entering the market and engaging in fair competition with SOEs, higher or covert access standards are often put in place (Luo and Liu, 2009; Jin et al., 2015; Chen, 2019). Local governments tend to lead more M&As of state-owned enterprises under their direct control (Chen and Huang, 2007). The probability of local state-owned enterprises engaging in cross regional M&As is significantly lower than that of non-state-owned enterprises (Pan and Yu, 2011).

Second, political relational discrimination in M&As. Politically connected companies are more likely to be biased by government regulation and are more likely to get through administrative entry barriers. Non-SOEs have a higher likelihood of forming political ties and overcoming entry barriers created by governmental regulations (Luo and Liu, 2009). Corruption acts as a "lubricant" in the process of market entry in economies with higher levels of regulation (Dreher and Gassebner, 2013). In circumstances of low integrity in the government, non-SOEs with political ties frequently merge (Xiao et al., 2018). Politically connected companies engage in M&As, particularly diversified M&As, yet their M&A performance is generally underwhelming (Li and Zhu, 2006; Zhang and Huang, 2009). Furthermore, SOEs are more likely to experience this occurrence (Zhang et al., 2013).

Third, non-local discrimination in M&As. Most local governments protect the interests of local businesses due to the pressure of performance evaluation of local government officials and concerns about non-local capturing market share and squeezing local firm interests. Many M&A firms in other regions have difficulties (Bai and Wei, 2017). As a result, Chinese listed companies clearly favor local deals when making M&As (Li et al.,

2005; Dong and Yu, 2021). The likelihood of forced-marriage style or ineffective local M&As and diversified M&As occurring in companies controlled by local governments is higher (Fang, 2008). Local SOEs are much less likely to engage in cross-regional M&As than non-SOEs are, and the market responds less favorably to such deals (Pan and Yu, 2011).

2.1.2. Institutional background of the MANL

The 18th CPC National Congress made the decision to "implement a unified market access system" in 2013. The "Several Opinions on Promoting Fair Competition in the Market and Maintaining Normal Market Order" issued by the State Council in 2014 mandated that "the market access negative list, clearly listing industries, fields, businesses, etc. that are prohibited or restricted from investment and operation in a list format" be developed. According to the law, any kind of market entity outside of the list is permitted to enter the market. The MANL is a practice that extends the concept of negative list management from "external" to "internal." The introduction of the negative list model into the area of market access can both mitigate the risks that could result from "market failure" and lessen the likelihood that such government intervention will result in "government failure" (Chen et al., 2020). The precise mechanism of action is outlined below.

First, the MANL integrates market access restrictions that have previously been dispersed among other laws and regulations. This makes the "traffic light" for market entities very apparent and the market access mechanism more transparent and equitable. It also clearly specifies the "red line" for market access, which limits the government's latitude and rent-seeking space.

Second, the MANL is a uniform national standard developed and released by the State Council. It is also a single market access rule at the level of geographic scope, local and international markets, ownership type and other levels. This unity facilitates the removal of hidden obstacles, discriminatory practices and unjustified limitations. This may allow market entities more autonomy and room for action. Furthermore, it can identify government services that do not follow the rules of fairness and transparency and define their direction so that they can function more effectively.

2.2. Research hypotheses

2.2.1. How the MANL affects firms' M&A behavior

The MANL will unavoidably have an impact on M&A transactions, one of the primary market access restrictions for businesses' outward investment behavior. Before the government's implementation of the MANL, corporate M&As were primarily governed by laws and regulations, such as the "Measures for the Administration of Listed Company Acquisitions" and "Measures for the Administration of Major Asset Restructuring of Listed Companies" The administrative management of M&A generally follows the positive list thinking, with detailed regulations on what should be done and how it should be done during the M&A process. The government has complete "residual decision-making power" over the undetermined portions and is free to choose how to allocate M&A resources and approve M&A admissions. After the government implemented the MANL in 2015, different economic entities could freely and equally participate through investment and merger operations in accordance with the law, without the requirement for government approval, with the exception of areas that are expressly forbidden or restricted. Government discretion and intervention in M&As have been severely constrained. The MANL makes corporate entry decisions in investment and M&As market-oriented. They are no longer influenced by the disparate M&A costs created by administrative permission and favorable policies. This could significantly alter corporate M&A performance and tendency.

First, the literature attributes the low tendency of corporate M&As to government-led entry barriers, discriminatory policies and the high transaction costs formed by the "toll" mechanism. It also explains the lack of effective synergy in Chinese business M&As by pointing out that government-led M&As diverge from economic goals in favor of social or political objectives. Notably, the institutional framework, where the government holds a strong position in resource distribution, is the major foundation for such research. In the process of the dominant power of corporate M&As from the government to the market, the vitality of corporate M&As will be released because of the removal of entry barriers and discriminatory policies, and the willingness to carry out corporate M&As will increase because of their role in achieving economic goals.

Second, both neoclassical growth theory and endogenous growth theory contend that scale adjustments among incumbent firms, which result in static resource allocation, encourage economic growth. The new Schumpeter growth model contends that market entry-driven dynamic resource allocation fosters economic growth (Dunne et al., 2009). M&A is a crucial tool for incumbent firms to quickly change their scale and join industries that have been deregulated. Deregulation may result in a surge of M&As (Mitchell and Mulherin, 1996; Andrade and Mitchell, 2001). Strict entry regulations in the past have limited companies' entry into other industries through M&As. The MANL gives Chinese companies greater resources and M&A prospects by streamlining the M&A approval procedure and limiting the extent of government involvement. It ultimately increases the motivation and willingness to carry out corporate M&As by giving company management more opportunity to improve resource allocation through M&As.

Finally, M&As do not produce equal returns and may result in potential costs, as they are a high-risk investment activity for company management (Amihud and Lev, 1981). In other words, management cannot fully gain from M&A projects but instead must endure the potential damages to their personal and professional reputations should their M&A endeavors fail (Wang and Dong, 2020). To reduce risks, risk-averse management may abandon high-risk but profitable M&A projects (Holmstrom and Weisis, 1985; Smith and Stulz, 1985). The MANL draws more and different kinds of market entities, which intensifies competition between incumbent firms. Market competition can serve as a powerful external governance mechanism and act as both a supervisor and a restraint. As a result of higher operational risks and industry benchmark competition, management will be forced to pick up the slack and work more, thus suppressing opportunistic behavior (Xu et al., 2015). Corporate management frequently merges as a result of increased market competition pressure to acquire high-quality assets, expand into new markets and find new opportunities for profit growth. Based on this, we propose the following main hypothesis:

Hypothesis 1: The MANL can significantly improve firms' M&A tendency and amount.

2.2.2. Does the MANL strengthen the marketization logic of firms' M&A behavior?

The MANL assists in alleviating policy discrimination and removing implicit barriers imposed by entry regulation, delegating the entry choice to the market and promoting the continual entry of effective new entities. Not only does it expand market participation and enhance productivity, but it also increases market competitiveness. Consequently, low-productivity entities are forced to leave the market (Klette and Kortum, 2004; Acemoglu et al., 2012; Li and Jiang, 2015). In turn, the resource allocation function of the market competition mechanism improves. Market competition is a key mechanism for the market to carry out its functions of resource allocation and a key illustration of market-oriented thinking. Based on the aforementioned analysis, we investigate the strengthening impact of the MANL on two dimensions of market-oriented M&A: competitive logic and fair logic.

(1) Competitive logic of corporate M&A behavior. M&As constitute a more practical strategy for companies to enter new markets and deal with the heightened competitive environment following deregulation than newly established companies. They provide incumbent companies with a way to increase their scale to counter the threats of new competitors. M&A transactions can help incumbent companies maintain economies of scale and core competitiveness while fending off threats from future competitors. Businesses outside the sector can effectively change their business strategies and operational parameters through M&As, entering the deregulated market quickly to create monopoly profits (Chen et al., 2015; Liu and Lv, 2018). In China, M&As can enhance firms' market power (Jiang, 2021). Firms with fierce industry competition have a stronger motivation to expand market power through corporate M&As to strengthen their own development and to seek to become industry leaders (Xu et al., 2015). It follows that the management of companies with fierce industry competition has a strong motivation to obtain better investment opportunities and competitive advantages. They are more likely to expand their scale and market power through M&As. The management of companies with lower levels of industry competition faces less operational risks and competitive threats, so the motivation to adopt M&As to cope with competition is weak. The logic of marketization clearly dictates that increased market competitiveness pushes companies to make more M&A decisions to fend off entry threats. Therefore, we propose the following hypothesis:

Hypothesis 2: Compared with firms with lower levels of competition, the MANL has a more significant positive effect on the M&A tendency and amount of firms with higher levels of competition.

(2) Fairness logic of corporate M&A behavior. In a previous analysis, unfair phenomena such as ownership discrimination, political connection discrimination and non-local discrimination in corporate M&As are found to be caused by government interference (Klette and Kortum, 2004; Acemoglu et al., 2012; Li and Jiang, 2015). Since implementing the MANL, the market has gradually gained influence in corporate M&As, instead of the government. Market-driven M&As must adhere to the rules of fair competition in the marketplace and reduce or even get rid of discriminatory practices. It follows that the M&A activities of companies that experience less discrimination have been slightly suppressed, and the liberalization of market access has had a limited effect on their M&A choices. The M&A activities of companies that experience more discrimination have been severely suppressed. Furthermore, their M&A vitality has been boosted by loosening market access regulation and reducing M&A discrimination, thus increasing their M&A motivation and willingness. Based on this, we propose the following hypothesis:

Hypothesis 3: Compared with firms with lower levels of discrimination in competition, the MANL has a more significant positive effect on the M&A tendency and amount of firms with higher levels of discrimination in competition.

3. Data and research design

3.1. Data sources and sample selection

To test the main hypothesis, we use the MANL pilot as an exogenous event. The "Opinions on Implementing the Market Access Negative List" document, published by the State Council in 2015, states, "We will promote the reform of the market access negative list for based on the principle of first trial and gradual implementation." The "Market Access Negative List Draft (Pilot Version)" was released in 2016 by the National Development and Reform Commission and the Ministry of Commerce, which also took the initiative to pilot it in four provinces and municipalities, including Tianjin, Shanghai, Fujian and Guangdong. In 2007, the pilot's purview was enlarged to 11 provinces and cities, including Liaoning, Jilin, Heilongjiang, Zhejiang, Henan, Hubei, Hunan, Chongqing, Sichuan, Guizhou and Shaanxi. On 25 December 2018, the National Development and Reform Commission and the Ministry of Commerce published the "Negative Market Access List" and implemented it nationwide.

Following Harford et al. (2011), Wu et al. (2008), Cai and Chen (2020) and Li et al. (2020), we use 2012 to 2019 as the sample period and choose M&A samples that match the following criteria to form the initial sample: (1) a listed company's trading status is "buyer," (2) the target company's equity is included in the M&A subject matter and (3) there is a change in control after the M&A. These criteria eliminate 372 failed M&A transactions and 78 M&A events with the transaction types "financial investment" and "backdoor listing" from the sample. The final sample consists of 6,055 M&A events from 2,180 listed firms.

In this study, we combine M&A data with financial data of listed companies, and we exclude (1) observations from ST and PT listed companies, (2) observations from listed companies in the financial industry, (3) observed values of asset liability ratio ≥ 1 or ≤ 0 and (4) observations with missing primary variables. Ultimately, we obtain 18,893 annual observations from 3,184 A-share listed companies.

The data in this study are collected from multiple sources. The M&A data are taken from the WIND database, and the financial data are taken from the China Stock Market & Accounting Research (CSMAR) database and the China Research Data Service Platform (CNRDS). To avoid the impact of extreme values on the empirical results, we winsorize all of the continuous variables at the 1 % level.

3.2. Variables and models

We begin our investigation of the relation between market access deregulation and firms' M&A behavior by estimating the staggered DID regression model as follows. Based on Hypothesis 1, the regression coefficient β_1 is expected to be positive and significant.

$$MA_{it} = \beta_0 + \beta_1 OPEN_{it} + \beta_k CONTROLS_{it-1} + YEARFE + FIRMFE + \epsilon \quad (1)$$

where the dependent variable MA_{it} reflects the M&A behavior of company i in year t. According to Jarrad (1999), Jiang et al. (2009), Chen et al. (2015), Cai and Chen (2020) and Li et al. (2020), we measure firms' M&A behavior using the indicator variable (MA_DUM_{it}) and the continuous variable (MA_AMT_{it}). If firm i undergoes M&As in year t, MA_DUM_{it} equals 1, and 0 otherwise. MA_AMT_{it} is measured by adding 1 to firm i's M&A amount and taking the natural logarithm.

The independent variable $OPEN_{it}$ reflects whether company i is affected by the MANL pilot in year t. If the province or municipality in which firm i is located implements the pilot in the first half of year t, $OPEN_{it}$ equals 1 for the current year and subsequent years, and 0 otherwise. If the province or municipality in which firm i is located implements the pilot in the second half of year t, $OPEN_{it}$ equals 1 for the following year and subsequent years, and 0 otherwise.

Following Cai and Chen (2020) and Liu et al. (2016), we control a wide array of firm-, industry- and region-level characteristics, including firm size (*SIZE*), the asset liability ratio (*LEV*), return on total assets (*ROA*), firm growth (*GROWTH*), the cash holding ratio (*CASH*), top equity concentration (*TOP*), top equity balance (*TOP2_5/TOP1*), executive compensation (*PAY*), board size (*BSIZE*), board meeting (*MEET*), the marketization index (*MARKET*) and the regional gross domestic product (*GDP*). We delay all control variables by one period to alleviate the endogeneity problem that may arise from reverse causality. In addition, we control for year and firm fixed effects in all of these regressions, and we use White's robust standard errors clustered at the company level. The definitions of and calculation methods used for all of the variables in this study are detailed in Table 1.

4. Empirical results

4.1. Descriptive statistics

Table 2 presents the descriptive statistics of the main variables. The average of *MA_DUM* is 0.17, indicating that 17 % of the listed companies underwent M&A activities during the sample period. The mean value

Table 1
Variable definitions.

Variable	Definition
MA_DUM	Indicator variable that equals 1if the firm *i* undergoes M&As in the year *t*, and 0 otherwise
MA_AMT	The natural logarithm of the acquiring firm's M&A amount
OPEN	Indicator variable that equals 1 when the province or municipality where the firm is located implements the pilot in the first half of the year, 0 otherwise. Or the indicator variable that equals 1 when the province or municipality where the firm is located implements the pilot in the second half of the year, 0 otherwise.
SIZE	The natural logarithm of the total assets
LEV	The ratio between the acquiring firm's debts and its total assets
ROA	The acquiring firm's earnings scaled by total assets
GROWTH	Annual growth rate of operating revenue
CASH	The ratio between the acquiring firm's cash and cash equivalents, and its total assets
TOP	Shareholding ratio of the largest shareholder
TOP2_5/TOP1	Shareholding ratio of the second to fifth largest shareholders, divided by shareholding ratio of the largest shareholder
PAY	The natural logarithm of the total salary of the top three executives
BSIZE	The natural logarithm of board directors' number
MEET	The natural logarithm of the number of board meetings
MARKET	Marketization Index compiled by Fan and Wang (2016)
GDP	Gross Domestic Product Index of the provincial district in which the firm *i* is located for the year *t*

Table 2
Descriptive statistics.

Variables	Observations	Mean	SD	Min	P50	Max
MA_DUM	18,893	0.17	0.37	0.00	0.00	1.00
MA_AMT	18,893	3.05	6.91	0.00	0.00	21.14
OPEN	18,893	0.32	0.47	0.00	0.00	1.00
SIZE	18,893	22.16	1.29	19.78	21.98	26.10
LEV	18,893	0.42	0.21	0.05	0.42	0.88
ROA	18,893	0.04	0.05	−0.17	0.04	0.19
GROWTH	18,893	0.20	0.48	−0.53	0.12	3.26
CASH	18,893	0.16	0.13	0.01	0.13	0.62
TOP	18,893	0.35	0.15	0.09	0.33	0.75
TOP2_5/TOP1	18,893	0.71	0.60	0.03	0.54	2.83
PAY	18,893	14.31	0.68	12.69	14.29	16.23
MARKET	18,893	2.25	0.18	1.79	2.30	2.77
BSIZE	18,893	2.33	0.35	1.61	2.30	3.22
MEET	18,893	8.74	2.04	2.98	8.89	12.24
GDP	18,893	108.25	1.79	103.60	107.80	113.80

and standard deviation of *MA_AMT* are 3.05 and 6.91, respectively, indicating that the M&A expenditures of different firms have significant volatility, and there are significant differences in the value of M&A subject matter. The mean value of *OPEN* is 0.32, indicating that 32 % of the observations during the sample period are affected by the MANL pilot. The sample distribution in the control and treatment groups is reasonable.

4.2. Market access deregulation and firms' M&A behavior

Table 3 reports the main study results. Columns (1) and (2) show the association between MANL implementation and M&A tendency, as measured by Eq. (1). Column (1) presents the results of the tests in which we control for year and firm fixed effects only. Column (2) presents results that further include a set of covariates to control for firm and regional characteristics. The *OPEN* coefficients are all positive and significant at the 1 % level in both columns, implying a significant increase in the tendency of corporate M&A after the MANL pilot. Following Beschwitz and Foos (2018), Srinivasan (2020) and Li et al. (2020), we use a conditional logit model with individual companies as groups to estimate the magnitude of firms' M&A tendency before and after the pilot Implementation. The corresponding results are presented in Columns (3) and (4). The results show that the coefficients of *OPEN* in the univariate and multivariate regressions are 0.245 and 0.298, respectively; both are significant at the 1 % level, suggesting a 24 %–30 % increase in the tendency of M&A activities after the pilot. Columns (5) and (6) show the results of the Eq. (1) regression, in which the dependent variable is *MA_AMT* and the independent variable is *OPEN*. The results also show that the MANL has a significant effect on M&A activities of companies whether or not control variables are added, indicating a significant increase in the scale of corporate M&A after the pilot. These results suggest that the market access deregulation significantly promotes corporate M&A activities, increases the tendency and amount of firms' M&A activities and preliminarily verifies Hypothesis 1.

In terms of controlling variables, firms with a higher asset liability ratio (*LEV*) engage in fewer M&A activities, suggesting that such firms may be constrained by more investment risks and financing constraints when making M&A investments. The firms with stronger profitability (*ROA*) and better growth potential (*GROWTH*) are more likely to engage in M&A activities, and also to pay higher M&A transaction costs. The cash holding level (*CASH*) is positively and significantly at the 5 % level correlated with firms' M&A behavior, which is consistent with the concept of "free cash flow." In addition, the likelihood of a corporation engaging in M&As increases with the size of the top shareholder's shareholding ratio (*TOP*) and the level of management compensation (*PAY*). These findings are consistent with the conclusions in the literature.

Table 3
The effects of market access deregulation on firms' M&A behavior.

Variable	*MA_DUM*				*MA_AMT*	
	Fixed Effect Model		*Logit Model*		*Fixed Effect Model*	
	(1)	(2)	(3)	(4)	(5)	(6)
OPEN	0.034***	0.034***	0.245***	0.298***	0.616***	0.615***
	(3.137)	(3.127)	(2.878)	(3.342)	(3.077)	(3.092)
SIZE		0.003		0.003		0.053
		(0.321)		(0.033)		(0.319)
LEV		−0.194***		−1.905***		−3.714***
		(−6.077)		(−6.100)		(−6.226)
ROA		0.334***		3.260***		6.008***
		(4.678)		(4.157)		(4.536)
GROWTH		0.016**		0.144***		0.285**
		(2.512)		(2.702)		(2.348)
CASH		0.071**		1.128***		1.476**
		(2.058)		(3.540)		(2.305)
TOP		0.159***		1.787***		2.978***
		(2.794)		(3.552)		(2.763)
TOP2_5/TOP1		−0.003		−0.018		−0.044
		(−0.290)		(−0.184)		(−0.223)
PAY		0.020**		0.199**		0.343*
		(2.031)		(2.282)		(1.851)
BSIZE		0.045		0.423		0.819
		(1.496)		(1.451)		(1.448)
MEET		0.191***		1.605***		3.635***
		(16.566)		(15.022)		(16.928)
MARKET		−0.007		−0.084		−0.111
		(−1.099)		(−1.176)		(−0.998)
GDP		0.001		−0.028		0.011
		(0.452)		(−0.817)		(0.219)
Constant	0.052***	−0.931**			0.947***	−15.894**
	(9.506)	(−2.524)			(9.314)	(−2.295)
Company FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Observations	18,893	18,893	11,141	11,141	18,893	18,893
Adjusted/Pseudo R^2	0.038	0.063	0.081	0.130	0.038	0.065
F / Chi^2	85.32	49.28	683.66	1092.73	84.00	48.54

Note: The t-statistics are in parentheses. ***, ** and * denote significance at the 0.01, 0.05 and 0.10 levels, respectively. Additionally, the intercept term of the conditional Logit model does not affect the selection probability, therefore the result does not include the intercept term.
The decrease in sample size in Columns (3) and (4) of Table 3 is due to the deletion of observations without intra-group variation in the logit model during regression, as well as the panel negative binomial regression in the following text.

4.3. Market access deregulation and the marketization logic of firms' M&A behavior

4.3.1. Competitive adequacy perspective

The government has loosened various market access regulations as a result of MANL implementation. Economic entities can freely enter the market according to market rules, and an increase in economic entities will ultimately lead to more adequate competition. The previous analysis suggests that businesses have a stronger desire and inclination to implement M&A strategies in industries with more intense market rivalry to fend off the threat of entry.

We take the Herfindahl index of main business income (*HHI*) to capture the degree of competition. We use the median of *HHI* to divide the collective sample into acquiring firms with low industry competition and those with high industry competition. Subsample regressions are then run for both of these groups. Table 4 tabulates the regression findings. The results show that the MANL pilot is significantly and positively corre-

Table 4
Market access deregulation, and marketization logic of firms' M&As: the perspective of competitive adequacy.

Variable	*MA_DUM*		*MA_AMT*	
	Low competitive	High competitive	Low competitive	High competitive
	(1)	(2)	(3)	(4)
OPEN	0.019	0.046***	0.410	0.792***
	(1.239)	(3.132)	(1.400)	(2.928)
SIZE	0.016	−0.014	0.308	−0.260
	(1.311)	(−1.101)	(1.310)	(−1.160)
LEV	−0.214***	−0.168***	−4.003***	−3.330***
	(−4.743)	(−3.768)	(−4.690)	(−4.054)
ROA	0.333***	0.334***	6.070***	5.953***
	(3.033)	(3.605)	(2.968)	(3.470)
GROWTH	0.019**	0.012	0.339**	0.210
	(2.219)	(1.286)	(2.085)	(1.171)
CASH	0.089*	0.060	1.858**	1.217
	(1.850)	(1.220)	(2.034)	(1.349)
TOP	0.106	0.197***	2.197	3.487***
	(1.256)	(2.645)	(1.335)	(2.592)
TOP2_5/TOP1	−0.018	0.010	−0.340	0.207
	(−1.184)	(0.615)	(−1.207)	(0.742)
PAY	0.034**	0.005	0.567**	0.103
	(2.327)	(0.371)	(2.029)	(0.427)
BSIZE	0.035	0.058	0.738	0.971
	(0.809)	(1.402)	(0.888)	(1.264)
MEET	0.168***	0.211***	3.258***	3.954***
	(10.125)	(13.124)	(10.404)	(13.396)
MARKET	0.000	−0.013	0.003	−0.219
	(0.013)	(−1.607)	(0.016)	(−1.485)
GDP	−0.004	0.006	−0.095	0.104
	(−1.151)	(1.522)	(−1.381)	(1.464)
Constant	−0.765	−0.939*	−12.156	−16.835*
	(−1.464)	(−1.801)	(−1.223)	(−1.744)
Company FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Observations	8,752	10,141	8,752	10,141
Adjusted R^2	0.064	0.063	0.066	0.064
F	24.34	27.05	24.07	26.26
Chow Test	*P-value* = 0.006***		*P-value* = 0.003***	

Note: The t-statistics are in parentheses. ***, ** and * denote significance at the 0.01, 0.05 and 0.10 levels, respectively.

lated with M&A tendency and amount in firms with high industry competition, whereas no significant correlation is observed in firms with low industry competition. This indicates that the MANL pilot strengthens market-driven M&A activities, manifested as the policy effect of the MANL having a more significant effect in a group with more intense industry competition. Thus, Hypothesis 2 is validated.

4.3.2. Competitive fairness perspective

All sorts of market entities have the right to decide whether to enter the market through M&As according to the logic of fair competition in the market. The vitality of competitive and discriminated firms in M&As can be increased by relaxing market access regulation and eliminating discriminatory conduct, which can also increase their motivation and propensity for M&As.

First, we take the nature of property rights and the level of government subsidies to measure ownership discrimination, and we use the relationship between the government and enterprises to measure political relational discrimination. Based on this, subsample regressions are performed. Panel A of Table 5 reports the subsample regressions for the firms with below-median and above-median government subsidies or with state-owned property and non-state-owned property. The coefficients of *OPEN* on *MA_DUM* or *MA_AMT* are

both positive and significant at least at the 5 % level for the firms with non-state-owned property or lower government subsidies. In contrast, the coefficients of *OPEN* are not significant for the firms with state-owned property or higher government subsidies. Furthermore, the *OPEN* regression coefficients for firms with state-owned property (or higher government subsidies) and with non-state-owned property (lower government subsidies) pass the inter-group coefficient difference test.

Panel B of Table 5 reports the subsample regressions for the firms with and without political relationships. The *OPEN* coefficients on both *MA_DUM* and *MA_AMT* are positive and significant for both of these groups. However, the regression coefficients of *OPEN* and their significance in the groups without political relationships are greater than those in the groups with political relationships.

Second, because of non-local discrimination in Chinese M&A activities and according to Rossi and Volpin (2004), we examine the performance of non-local companies entering the pilot area through M&As from the perspective of the acquired companies after the implementation of the MANL. We construct three variables[1]: *MA_TARGET*, the sum of the number of M&A targets in each province in the current year; *MA_LOCAL*, the number of local M&As by listed companies in this province using local companies as the target party; and *MA_CROSS*, the number of non-local M&As by listed companies in other provinces using local companies as the target party. We also define an indicator variable *OPEN_TARGET*, which equals 1 if the province in which the M&A target party is located has conducted the MANL pilot that year and 0 otherwise.

Panel C of Table 5 presents the regression results. As shown in Columns (1) to (3), we find that the *OPEN_TARGET* regression coefficient on *MA_TARGET* is 8.275 (and significant at the 5 % level), the *OPEN_TARGET* regression coefficient on *MA_LOCAL* is 3.332 (and significant at the 10 % level) and the *OPEN_TARGET* regression coefficient on *MA_CROSS* is 4.944 (and significant at the 5 % level). The coefficient of *OPEN_TARGET* on *MA_CROSS* is approximately 1.5 times that on *MA_LOCAL*. These results indicate that there has been a significant increase in M&As in the pilot areas since the MANL pilot. Furthermore, this increase is mainly due to more non-local firms engaging in M&A investments. In other words, the MANL has eliminated non-local discrimination in M&As and promoted more cross-regional M&As. Thus, Hypothesis 3 is supported.

The findings above show that the promotion effect of the MANL implementation on firms' M&A behavior is mainly reflected in the firms with high industry competition. This indicates that the MANL pilot strengthens the market logic of corporate adopting M&A decisions to respond to an increase in market competition. The findings also suggest that the promotion effect of the MANL implementation on firms' M&A behavior is mainly reflected in the non-SOE group, low government subsidy group, non-political relationship group and non-local M&A group. This indicates that the MANL strengthens the market logic of fair competition in corporate M&A behavior and further unleashes the M&A potential of firms that experience discrimination in the marketplace. In conclusion, MANL implementation promotes the shift of corporate M&A domination toward the market and encourages corporate M&A decisions to adhere to the operational rules of the market competition mechanism.

5. Further analysis

Government interference affects the market logic of corporate M&A behavior, altering the function of M&As in the market's resource allocation. The empirical findings in the preceding section show that the MANL encourages M&A activities to proceed in the direction of market domination. Firms' M&A activities follow market logic, meaning that M&A performance is the most crucial component to take into account. Therefore, we further test whether the MANL can improve M&A performance and whether the MANL can correct the distorted effect of government intervention on market resource allocation.

[1] By consulting the M&A announcement published on the CNINFO website and the Tianyancha website, we manually collect data on the province in which the M&A target is located. Then, observation data for the ''year- acquiring firm-target firm'' are aggregated according to the pilot areas.

Table 5
Market access deregulation, and marketization logic of firms' M&As: the perspective of competitive fairness.

Panel A Firm level: Property rights

Variable	*MA_DUM*		*MA_AMT*		*MA_DUM*		*MA_AMT*	
	SOEs	Non-SOEs	SOEs	Non-SOEs	High subsidies	Low subsidies	High subsidies	Low subsidies
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
OPEN	0.021	0.040***	0.310	0.779***	0.016	0.042***	0.373	0.651**
	(1.392)	(2.726)	(1.135)	(2.848)	(0.944)	(2.640)	(1.170)	(2.241)
SIZE	0.007	0.004	0.120	0.095	0.033**	−0.003	0.616**	−0.027
	(0.586)	(0.341)	(0.580)	(0.395)	(2.135)	(−0.235)	(2.065)	(−0.126)
LEV	−0.066	−0.251***	−1.304	−4.764***	−0.188***	−0.186***	−3.927***	−3.608***
	(−1.460)	(−5.753)	(−1.560)	(−5.828)	(−2.891)	(−4.637)	(−3.180)	(−4.880)
ROA	0.218**	0.332***	4.110**	5.811***	0.213	0.391***	3.249	7.283***
	(2.453)	(3.332)	(2.520)	(3.129)	(1.610)	(4.284)	(1.315)	(4.287)
GROWTH	0.012	0.017*	0.176	0.307*	0.026**	0.007	0.503**	0.114
	(1.472)	(1.847)	(1.180)	(1.802)	(2.278)	(0.868)	(2.342)	(0.736)
CASH	0.081	0.080*	1.285	1.756**	0.193***	0.025	3.923***	0.480
	(1.451)	(1.846)	(1.235)	(2.159)	(2.748)	(0.570)	(3.002)	(0.585)
TOP	0.062	0.191**	1.171	3.481**	0.083	0.188**	1.464	3.688**
	(0.763)	(2.301)	(0.777)	(2.202)	(0.793)	(2.450)	(0.723)	(2.542)
TOP2_5/TOP1	0.009	−0.003	0.234	−0.066	0.003	−0.013	0.087	−0.204
	(0.510)	(−0.190)	(0.715)	(−0.259)	(0.136)	(−0.834)	(0.234)	(−0.740)
PAY	0.011	0.027*	0.142	0.487*	0.051***	−0.015	1.017***	−0.359
	(0.807)	(1.873)	(0.572)	(1.809)	(3.094)	(−1.144)	(3.239)	(−1.457)
BSIZE	0.025	0.057	0.491	1.025	0.020	0.039	0.374	0.661
	(0.649)	(1.245)	(0.670)	(1.203)	(0.388)	(0.929)	(0.381)	(0.845)
MEET	0.099***	0.235***	1.930***	4.439***	0.197***	0.188***	3.855***	3.500***
	(6.357)	(14.553)	(6.520)	(14.872)	(10.010)	(11.435)	(10.382)	(11.563)
MARKET	0.005	−0.016*	0.114	−0.295*	−0.009	−0.005	−0.150	−0.097
	(0.759)	(−1.693)	(0.867)	(−1.655)	(−0.855)	(−0.596)	(−0.770)	(−0.618)
GDP	−0.000	0.001	−0.003	−0.003	0.006	0.005	0.109	0.096
	(−0.086)	(0.237)	(−0.044)	(−0.034)	(1.399)	(1.401)	(1.307)	(1.380)
Constant	−0.585	−1.093*	−10.576	−18.164	−2.530***	−0.766	−47.668***	−13.300
	(−1.232)	(−1.832)	(−1.199)	(−1.615)	(−4.130)	(−1.464)	(−4.103)	(−1.366)
Company FE	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES
Observations	7,288	11,605	7,288	11,605	8,727	10,166	8,727	10,166
Adjusted R^2	0.028	0.085	0.029	0.087	0.069	0.058	0.072	0.059
F	11.16	40.79	10.92	40.42	22.00	22.24	22.17	21.70
Chow Test	*P-value* = 0.000***		*P-value* = 0.000***		*P-value* = 0.003**		*P-value* = 0.001***	

Panel B Firm level: Political connection

Variable	*MA_DUM*		*MA_AMT*	
	Political connection	Non-political connection	Political connection	Non-political connection
	(1)	(2)	(3)	(4)
OPEN	0.039**	0.049***	0.646**	0.929***
	(2.227)	(3.057)	(2.014)	(3.098)
SIZE	0.018	0.006	0.357	0.100
	(1.227)	(0.456)	(1.335)	(0.390)
LEV	−0.223***	−0.191***	−4.376***	−3.720***
	(−3.902)	(−4.099)	(−4.117)	(−4.268)
ROA	0.164	0.343***	2.915	6.148***
	(1.296)	(3.537)	(1.247)	(3.395)
GROWTH	0.014	0.011	0.199	0.193
	(1.205)	(1.272)	(0.944)	(1.168)
CASH	0.068	0.029	1.200	0.747
	(1.071)	(0.616)	(1.039)	(0.831)

(*continued on next page*)

Table 5 (*continued*)

Panel B Firm level: Political connection								
Variable	*MA_DUM*		*MA_AMT*		*MA_DUM*		*MA_AMT*	
	SOEs	Non-SOEs	SOEs	Non-SOEs	High subsidies	Low subsidies	High subsidies	Low subsidies
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
TOP		0.150		0.211**		2.730		3.731**
		(1.625)		(2.406)		(1.611)		(2.262)
TOP2_5/TOP1		−0.006		0.003		−0.057		0.054
		(−0.363)		(0.165)		(−0.186)		(0.186)
PAY		0.024		0.023		0.439		0.427
		(1.484)		(1.560)		(1.478)		(1.542)
BSIZE		0.073		0.029		1.372		0.550
		(1.488)		(0.617)		(1.496)		(0.618)
MEET		0.152***		0.206***		2.974***		3.943***
		(8.072)		(12.458)		(8.499)		(12.905)
MARKET		−0.002		−0.018*		−0.060		−0.279
		(−0.158)		(−1.714)		(−0.307)		(−1.451)
GDP		−0.001		0.005		−0.026		0.076
		(−0.231)		(1.198)		(−0.311)		(1.010)
Constant		−1.056*		−1.364**		−19.561*		−24.197**
		(−1.722)		(−2.463)		(−1.726)		(−2.303)
Company FE	YES		YES		YES		YES	
Year FE	YES		YES		YES		YES	
Observations		7,881		10,639		7,881		10,639
Adjusted R^2		0.059		0.061		0.061		0.063
F		19.52		26.25		19.41		26.15
Chow Test	*P-value* = 0.000***				*P-value* = 0.000***			

Panel C Regional level				
Variable	*MA_TARGET*	*MA_LOCAL*	*MA_CROSS*	
	(1)	(2)	(3)	
OPEN_TARGET	8.275**	3.332*	4.944**	
	(2.171)	(1.768)	(2.002)	
NONSTATE	−4.457**	−1.936**	−2.521**	
	(−2.126)	(−2.035)	(−2.041)	
GDP	−14.736*	−6.503*	−8.233	
	(−1.706)	(−1.807)	(−1.401)	
STRUCTURE	−1.372**	−0.403	−0.970**	
	(−2.263)	(−1.561)	(−2.377)	
INFRA	4.563**	2.163**	2.400**	
	(2.563)	(2.569)	(2.189)	
UNEMPOLY	−24.403***	−10.455***	−13.948**	
	(−2.895)	(−3.062)	(−2.458)	
FISCAL	−4.888	0.141	−5.029	
	(−0.827)	(0.070)	(−1.204)	
CREDIT	−2.932	−1.680*	−1.252	
	(−1.534)	(−1.892)	(−0.985)	
Constant	652.203***	215.091***	437.111***	
	(3.393)	(2.840)	(3.295)	
Region FE	YES	YES	YES	
Year FE	YES	YES	YES	
Observations	248	248	248	
Adjusted R^2	0.795	0.781	0.768	
F	13.77	11.76	13.14	

Note: The t-statistics are in parentheses. ***, ** and * denote significance at the 0.01, 0.05 and 0.10 levels, respectively.

Table 6
Market access deregulation and market response to firms' M&A behavior.

Variable	BHAR calculated by market combination		BHAR calculated by corresponding combination	
	12 months	24 months	12 months	24 months
	$BHAR\_MARKET_{12}$	$BHAR\_MARKET_{24}$	$BHAR\_PORT_{12}$	$BHAR\_PORT_{24}$
	(1)	(2)	(3)	(4)
OPEN	0.082*	0.106**	0.045	0.102**
	(1.959)	(2.169)	(1.160)	(2.373)
SIZE	−0.347***	−0.379***	−0.282***	−0.239***
	(−6.228)	(−5.106)	(−5.525)	(−3.838)
LEV	0.401**	0.173	0.263	0.035
	(1.993)	(0.697)	(1.446)	(0.165)
ROA	−0.822*	−2.121***	−1.043**	−2.170***
	(−1.685)	(−3.458)	(−2.366)	(−3.501)
GROWTH	0.009	0.006	−0.002	−0.025
	(0.395)	(0.231)	(−0.109)	(−1.095)
CASH	0.002	0.178	−0.015	−0.093
	(0.013)	(0.731)	(−0.103)	(−0.434)
TOP	0.258	0.821**	0.627**	0.793**
	(0.826)	(2.313)	(2.023)	(2.482)
TOP2_5/TOP1	−0.066	0.017	−0.064*	−0.038
	(−1.411)	(0.268)	(−1.771)	(−0.710)
PAY	0.002	−0.072	0.027	−0.003
	(0.039)	(−1.175)	(0.770)	(−0.066)
BSIZE	−0.268*	−0.274	−0.204	−0.355**
	(−1.703)	(−1.389)	(−1.614)	(−2.051)
MEET	−0.144***	−0.103	−0.135***	−0.131**
	(−2.790)	(−1.398)	(−3.028)	(−2.065)
MARKET	0.047	0.053	0.009	−0.032
	(1.015)	(0.948)	(0.226)	(−0.650)
GDP	−0.042**	−0.086***	−0.033**	−0.077***
	(−2.411)	(−3.631)	(−2.282)	(−3.559)
MTB	−0.099***	−0.129***	−0.074***	−0.082***
	(−6.526)	(−7.176)	(−5.543)	(−5.386)
RETURN	−0.110***	−0.183***	−0.088***	−0.118***
	(−3.575)	(−5.696)	(−3.336)	(−4.068)
WC	0.341**	0.198	0.219	0.176
	(2.280)	(1.071)	(1.629)	(1.034)
LABOR	0.028	0.024	−0.003	−0.027
	(0.641)	(0.452)	(−0.077)	(−0.597)
DUAL	−0.021	0.001	−0.036	0.054
	(−0.544)	(0.011)	(−1.051)	(1.099)
VOL	0.320	−0.046	0.037	−0.166
	(1.546)	(−0.189)	(0.206)	(−0.762)
Constant	12.559***	19.264***	10.018***	15.234***
	(5.413)	(6.137)	(5.030)	(5.596)
Company FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Observations	4,006	4,006	4,006	4,006
Adjusted R^2	0.175	0.271	0.112	0.130
F	13.21	17.35	7.982	8.312

Note: The t-statistics are in parentheses. ***, ** and * denote significance at the 0.01, 0.05 and 0.10 levels, respectively.

5.1. Variables and models

In this study, we explore the relationship between market access deregulation and M&A performance from the perspectives of long-term market value, total factor productivity (TFP), human resource quality, innovation level and financial performance.

First, based on Gregory (1997), Li and Zhu (2006) and Chen et al. (2013), we establish Eq. (2) and use the held-to-maturity return indicator (BHAR) to estimate the impact of market access deregulation on the long-term response of the M&A market. The regression coefficient β_1 is expected to be positive and significant.

$$BHAR_{it} = \beta_0 + \beta_1 OPEN_{it} + \beta_k CONTROLS_{it} + YEARFE + FIRMFE + \epsilon_{it} \tag{2}$$

where we use two measures to capture the BHAR: *BHAR_MARKET*, which is the held-to-maturity yield calculated based on market combinations, and *BHAR_PORT*, which is the held-to-maturity yield calculated by corresponding combination. The BHAR for purchasing in the month of M&A announcement and holding the shares of the acquiring firms i for t months is calculated according to Eq. (3):

$$BHAR_{it} = \Pi(1 + R_{it}) - \Pi(1 + R_{p(m)t}) \tag{3}$$

where R_{it} is the stock return considering reinvestment of cash dividends of the acquiring company i in month t. R_{mt} represents the monthly returns of the market portfolio. R_{pt} represents the monthly returns of the corresponding portfolios. For these two variables, t is set to 0–12 or 0–24. R_{pt} is calculated using the cross-grouping method (Li and Zhu, 2006) in three steps. First, the listed company's circulating market value in June of year t is isolated and divided into five groups. Second, the five groups are ranked from small to large based on the ratio of the company's book earnings to market value in December of year t-1 (i.e., earnings per share/year-end closing price), and then each is divided into another five groups. Finally, the equal monthly return on 25 investment portfolios in any year is calculated to obtain R_{pt}.

Second, we estimate Eq. (4) to investigate the impact of market access deregulation on M&A synergies (Schweizer et al., 2004; Liu et al., 2018; Srinivasan, 2020). We expect the regression coefficient of the interaction term β_3 to be positive and significant.

$$\begin{aligned} EFFECT_{it+1(2)} = {} & \beta_0 + \beta_1 OPEN_{it} + \beta_2 MA_{it} + \beta_3 OPEN_{it} \times MA_{it} + \beta_k CONTROLS_{it} \\ & + YEARFE + FIRMFE + \epsilon \end{aligned} \tag{4}$$

where $EFFECT_{it}$ captures the synergistic effects of M&As, including production efficiency synergy, financial synergy, human resource synergy and innovation capability synergy. We use the total factor productivity (*TFP*) of the acquiring party as calculated using the Levinsohn–Petrin (LP) method to measure production efficiency synergy (Giannetti et al., 2015). We use the per-capita labor productivity (*LPR*) of the acquiring party (i.e., sales revenue divided by the number of employees) to measure the synergy effect of human resources (Liu et al., 2020). We use the logarithmic value of the number of invention patents authorized by the acquiring party (*PATENT*) to measure innovation synergy (Li, 2013; Luong et al., 2017). We also use the return on equity (*PROFIT*) to measure financial performance of M&As.

The control variables of Eqs. (2) and (4) not only include all of the control variables of Eq. (1) but also the following (Chen and Ma, 2017; Li et al., 2020): the market-to-account ratio (*MTB*), which is the ratio of the market value to the book value of the acquiring party; the stock return rate (*RETURN*), which is the annual return rate calculated based on individual stock returns over the past 12 months; working capital (*WC*), which is the ratio of working capital to total assets; the number of employees (*LABOR*), which is the natural logarithm of the number of registered employees; duality (*DUAL*), which equals 1 if the chairman concurrently serves as the CEO, and 0 otherwise; and M&A expenditure (*VOL*), which is the ratio of the M&A expenditure amount of the acquiring party in the current year to the total assets at the beginning of the year. We delay all of the control variables by one period to alleviate the endogeneity problem that may arise from reverse causality.

5.2. Effects of market access deregulation on firms' M&A performance

Table 6 reports the regression results of the market response to firms' M&As after the market access deregulation from the perspective of holding to maturity returns. In Columns (1) to (4), we find that the *OPEN* coefficients on $BHAR\_MARKET_{12}$, $BHAR\_MARKET_{24}$ and $BHAR\_PORT_{24}$ are positive and statistically significant at a level of at least 10 %. Furthermore, *BHAR* as calculated by market combination is greater than that calculated by corresponding combination, and *BHAR* with a maturity yield of 24 months is greater than that with a maturity yield of 12 months. The results imply that the relaxation of market access regulations

Table 7
Market access deregulation and synergistic effect of firms' M&A behavior (TFP).

Variable	$TFP\text{-}LP_{t+1}$		$TFP\text{-}LP_{t+2}$	
	(1)	(2)	(3)	(4)
MA_DUM × OPEN	0.040**		0.082***	
	(2.138)		(2.714)	
MA_AMT × OPEN		0.002*		0.004**
		(1.787)		(2.525)
MA_DUM	0.014*		0.021**	
	(1.743)		(2.103)	
MA_AMT		0.001**		0.001***
		(1.984)		(2.652)
OPEN	−0.015	−0.014	−0.036*	−0.036*
	(−1.117)	(−1.031)	(−1.890)	(−1.859)
SIZE	0.409***	0.409***	0.249***	0.249***
	(19.221)	(19.217)	(10.940)	(10.925)
LEV	0.563***	0.563***	0.203**	0.202**
	(7.548)	(7.544)	(2.304)	(2.295)
ROA	0.704***	0.703***	0.040	0.039
	(6.735)	(6.729)	(0.294)	(0.287)
GROWTH	0.154***	0.154***	0.102***	0.102***
	(13.984)	(13.982)	(10.048)	(10.053)
CASH	−0.202***	−0.203***	−0.091	−0.091
	(−3.410)	(−3.413)	(−1.316)	(−1.322)
TOP	0.031	0.031	0.068	0.068
	(0.347)	(0.346)	(0.699)	(0.699)
TOP2_5/TOP1	0.064***	0.064***	0.068***	0.068***
	(3.363)	(3.365)	(3.172)	(3.178)
PAY	0.050***	0.050***	0.012	0.012
	(3.635)	(3.637)	(0.726)	(0.723)
BSIZE	0.098**	0.098**	0.088*	0.088*
	(2.143)	(2.139)	(1.686)	(1.676)
MEET	0.089***	0.089***	0.144***	0.143***
	(6.341)	(6.335)	(8.648)	(8.620)
MARKET	0.023**	0.023**	0.028*	0.028*
	(1.997)	(1.999)	(1.718)	(1.709)
GDP	0.003	0.003	−0.002	−0.002
	(0.608)	(0.608)	(−0.430)	(−0.429)
MTB	0.029***	0.029***	0.030***	0.030***
	(6.559)	(6.561)	(5.484)	(5.483)
RETURN	0.017**	0.017**	0.012	0.012
	(2.036)	(2.026)	(1.344)	(1.324)
WC	0.302***	0.302***	0.106*	0.107*
	(5.452)	(5.453)	(1.709)	(1.723)
LABOR	0.039**	0.039**	0.032**	0.032**
	(2.469)	(2.473)	(2.152)	(2.155)
DUAL	−0.004	−0.004	0.001	0.001
	(−0.280)	(−0.292)	(0.084)	(0.064)
VOL	0.039	0.041	0.631***	0.638***
	(0.525)	(0.546)	(6.799)	(6.848)
Constant	5.082***	5.082***	9.847***	9.858***
	(8.399)	(8.397)	(14.977)	(14.991)
Company FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Observations	18,631	18,631	15,509	15,509
Adjusted R^2	0.503	0.503	0.340	0.341
F	163.6	163.4	93.19	93.13

Note: The t-statistics are in parentheses. ***, ** and * denote significance at the 0.01, 0.05 and 0.10 levels, respectively.

Table 8
Market access deregulation and synergistic effect of firms' M&A behavior (Human resource efficiency).

Variable	LPR_{t+1}		LPR_{t+2}	
	(1)	(2)	(3)	(4)
MA_DUM × OPEN	0.038**		0.073**	
	(1.980)		(2.423)	
MA_AMT × OPEN		0.002*		0.004**
		(1.723)		(2.382)
MA_DUM	−0.011		−0.001	
	(−1.273)		(−0.061)	
MA_AMT		−0.001		0.000
		(−1.451)		(0.114)
OPEN	−0.018	−0.018	−0.029	−0.029
	(−1.308)	(−1.246)	(−1.444)	(−1.443)
SIZE	0.351***	0.351***	0.166***	0.166***
	(16.782)	(16.787)	(7.939)	(7.934)
LEV	0.451***	0.451***	0.202**	0.202**
	(5.612)	(5.611)	(2.371)	(2.366)
ROA	0.401***	0.402***	−0.278**	−0.278**
	(3.457)	(3.462)	(−2.057)	(−2.059)
GROWTH	0.139***	0.139***	0.095***	0.095***
	(12.480)	(12.478)	(8.731)	(8.732)
CASH	−0.211***	−0.211***	−0.059	−0.059
	(−3.138)	(−3.137)	(−0.731)	(−0.735)
TOP	−0.033	−0.032	0.039	0.039
	(−0.365)	(−0.361)	(0.398)	(0.399)
TOP2_5/TOP1	0.018	0.018	0.046**	0.046**
	(0.937)	(0.936)	(2.221)	(2.224)
PAY	0.040***	0.040***	0.006	0.006
	(2.590)	(2.592)	(0.387)	(0.386)
BSIZE	0.014	0.014	−0.021	−0.021
	(0.284)	(0.285)	(−0.390)	(−0.395)
MEET	0.040***	0.041***	0.076***	0.076***
	(2.759)	(2.772)	(4.714)	(4.699)
MARKET	0.004	0.004	0.006	0.006
	(0.328)	(0.330)	(0.410)	(0.404)
GDP	0.003	0.003	−0.005	−0.005
	(0.539)	(0.539)	(−0.929)	(−0.927)
MTB	0.015***	0.015***	0.013**	0.013**
	(2.776)	(2.781)	(2.310)	(2.311)
RETURN	0.008	0.008	0.005	0.005
	(0.857)	(0.857)	(0.579)	(0.572)
WC	0.211***	0.211***	0.072	0.072
	(3.532)	(3.523)	(1.094)	(1.099)
LABOR	−0.339***	−0.339***	−0.160***	−0.160***
	(−17.642)	(−17.641)	(−8.594)	(−8.591)
DUAL	−0.020	−0.020	−0.022	−0.022
	(−1.473)	(−1.472)	(−1.356)	(−1.366)
VOL	−0.165*	−0.167*	0.146	0.149
	(−1.901)	(−1.927)	(1.527)	(1.548)
Constant	7.256***	7.250***	11.388***	11.391***
	(10.838)	(10.828)	(16.242)	(16.257)
Company FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Observations	18,631	18,631	15,509	15,509
Adjusted R^2	0.301	0.301	0.192	0.192
F	77.91	77.89	44.42	44.35

Note: The t-statistics are in parentheses. ***, ** and * denote significance at the 0.01, 0.05 and 0.10 levels, respectively.

Table 9
Market access deregulation and synergistic effect of firms' M&A behavior (innovation output).

Variable	$PATENT_{t+1}$		$PATENT_{t+2}$	
	(1)	(2)	(3)	(4)
MA_DUM × OPEN	0.022		0.114**	0.006**
	(0.543)		(2.355)	(2.345)
MA_AMT × OPEN		0.001		
		(0.541)		
MA_DUM	0.002		0.003	
	(0.136)		(0.179)	
MA_AMT		−0.000		0.001
		(−0.092)		(0.510)
OPEN	−0.018	−0.017	0.011	0.011
	(−0.716)	(−0.709)	(0.383)	(0.386)
SIZE	0.179***	0.179***	0.162***	0.162***
	(6.597)	(6.603)	(5.952)	(5.936)
LEV	−0.040	−0.040	0.003	0.002
	(−0.411)	(−0.412)	(0.028)	(0.019)
ROA	−0.272*	−0.270*	0.019	0.018
	(−1.726)	(−1.718)	(0.106)	(0.102)
GROWTH	−0.012	−0.012	−0.029**	−0.029**
	(−1.030)	(−1.032)	(−2.486)	(−2.483)
CASH	−0.023	−0.023	0.010	0.009
	(−0.263)	(−0.264)	(0.105)	(0.099)
TOP	0.024	0.024	0.061	0.061
	(0.157)	(0.161)	(0.417)	(0.418)
TOP2_5/TOP1	0.014	0.014	−0.002	−0.002
	(0.551)	(0.549)	(−0.073)	(−0.068)
PAY	0.019	0.019	0.009	0.009
	(0.845)	(0.847)	(0.383)	(0.380)
BSIZE	0.191**	0.191**	0.112	0.111
	(2.347)	(2.347)	(1.425)	(1.418)
MEET	0.017	0.018	0.022	0.022
	(0.755)	(0.769)	(0.890)	(0.866)
MARKET	−0.005	−0.005	0.001	0.001
	(−0.270)	(−0.269)	(0.034)	(0.025)
GDP	0.025***	0.025***	0.026***	0.026***
	(3.431)	(3.433)	(3.374)	(3.376)
MTB	0.002	0.002	−0.002	−0.002
	(0.248)	(0.254)	(−0.262)	(−0.266)
RETURN	0.003	0.003	0.025*	0.025*
	(0.213)	(0.215)	(1.840)	(1.828)
WC	−0.077	−0.077	−0.090	−0.089
	(−1.017)	(−1.023)	(−1.145)	(−1.131)
LABOR	0.094***	0.094***	0.052**	0.052**
	(4.601)	(4.600)	(2.277)	(2.278)
DUAL	−0.023	−0.023	0.007	0.007
	(−0.955)	(−0.954)	(0.275)	(0.263)
VOL	0.126	0.123	0.029	0.037
	(0.776)	(0.759)	(0.171)	(0.216)
Constant	−7.137***	−7.143***	−6.351***	−6.338***
	(−6.851)	(−6.857)	(−5.853)	(−5.842)
Company FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Observations	18,631	18,631	15,509	15,509
Adjusted R^2	0.124	0.124	0.106	0.106
F	28.98	29.00	25.67	25.71

Note: The t-statistics are in parentheses. ***, ** and * denote significance at the 0.01, 0.05 and 0.10 levels, respectively.

Table 10
Market access deregulation and synergistic effect of firms' M&A behavior (financial performance).

Variable	$PROFIT_{t+1}$		$PROFIT_{t+2}$	
	(1)	(2)	(3)	(4)
MA_DUM × OPEN	−0.003		−0.005	
	(−0.908)		(−0.833)	
MA_AMT × OPEN		−0.000		−0.000
		(−1.303)		(−1.014)
MA_DUM	0.001		0.002	
	(1.033)		(1.358)	
MA_AMT		0.000		0.000
		(1.308)		(1.498)
OPEN	−0.002	−0.002	−0.005*	−0.005*
	(−1.148)	(−1.030)	(−1.923)	(−1.860)
SIZE	−0.016***	−0.016***	−0.025***	−0.025***
	(−8.068)	(−8.061)	(−9.464)	(−9.468)
LEV	0.016**	0.016**	0.022**	0.022**
	(2.223)	(2.229)	(2.339)	(2.341)
ROA	0.110***	0.110***	−0.073***	−0.073***
	(6.747)	(6.740)	(−3.829)	(−3.834)
GROWTH	0.010***	0.010***	0.009***	0.009***
	(8.795)	(8.791)	(7.752)	(7.751)
CASH	0.050***	0.050***	0.044***	0.044***
	(8.445)	(8.451)	(6.069)	(6.074)
TOP	0.035***	0.035***	0.047***	0.047***
	(4.027)	(4.022)	(3.813)	(3.811)
TOP2_5/TOP1	0.004**	0.004**	0.006**	0.006**
	(1.962)	(1.966)	(2.538)	(2.540)
PAY	0.005***	0.005***	0.001	0.001
	(3.428)	(3.437)	(0.340)	(0.341)
BSIZE	0.011**	0.011**	−0.004	−0.004
	(2.106)	(2.110)	(−0.701)	(−0.701)
MEET	0.002	0.002	0.001	0.001
	(1.445)	(1.449)	(0.771)	(0.771)
MARKET	−0.001	−0.001	0.000	0.000
	(−1.123)	(−1.117)	(0.336)	(0.338)
GDP	−0.001**	−0.001**	−0.002***	−0.002***
	(−1.965)	(−1.972)	(−2.763)	(−2.769)
MTB	0.003***	0.003***	−0.000	−0.000
	(6.178)	(6.174)	(−0.238)	(−0.242)
RETURN	0.008***	0.008***	0.008***	0.008***
	(7.961)	(7.952)	(6.035)	(6.030)
WC	0.012**	0.012**	0.020***	0.020***
	(2.300)	(2.293)	(2.993)	(2.994)
LABOR	0.001	0.001	−0.003	−0.003
	(0.831)	(0.838)	(−1.289)	(−1.288)
DUAL	0.000	0.000	0.001	0.001
	(0.141)	(0.143)	(0.419)	(0.419)
VOL	0.039***	0.038***	0.021	0.021
	(3.481)	(3.455)	(1.415)	(1.415)
Constant	0.319***	0.319***	0.728***	0.729***
	(5.596)	(5.590)	(9.104)	(9.108)
Company FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Observations	18,631	18,631	15,509	15,509
Adjusted R^2	0.097	0.097	0.072	0.072
F	31.92	31.94	16.15	16.15

Note: The t-statistics are in parentheses. ***, ** and * denote significance at the 0.01, 0.05 and 0.10 levels, respectively.

increases the long-term value of companies through M&As. Firms do not engage in value-reducing M&A investments in the face of a fair and adequate market competition environment, and investors also respond more positively to such M&A behavior, resulting in an increase in long-term stock holding returns. This contradicts the conclusion in the M&A literature that government intervention in corporate M&As cannot generate long-term market value.

Table 7 reports the regression results of the synergistic effect of firms' M&As after the relaxation of market access regulations from the perspective of TFP. In Columns (1) to (4), whether the independent variable is the TFP in the first year ($TFP\text{-}LP_{t+1}$) or in the second year ($TFP\text{-}LP_{t+2}$) of an M&A, the $OPEN \times MA\_DUM$ and $OPEN \times MA\_AMT$ coefficients are both positive and statistically significant at a level of at least 10 %. The regression coefficient and significance of the interaction terms on $TFP\text{-}LP_{t+2}$ are greater than those on $TFP\text{-}LP_{t+1}$. These results indicate that since MANL implementation, M&As have significantly improved companies' TFP. After market access deregulation, companies face a more comprehensive and fair competitive environment, can free themselves from the constraints of government intervention and can conduct more efficient M&As, leading to stronger M&A synergies.

Table 8 reports the regression results of the synergistic effect of firms' M&As after market access deregulation from the perspective of human resource efficiency. In Columns (1) to (4), whether the independent variable is the human resource efficiency in the first year (LPR_{t+1}) or in the second year (LPR_{t+2}) of an M&A, the $OPEN \times MA\_DUM$ and $OPEN \times MA\_AMT$ coefficients are both positive and statistically significant at a level of at least 10 %. The regression coefficient and significance of the interaction terms on LPR_{t+2} are greater than those on LPR_{t+1}. These results imply that after market access deregulation, firms obtain more high-quality labor through effective M&A activities, optimize the labor structure, promote the upgrading of their human resource quality and improve their overall labor productivity. Additionally, this effect demonstrates an increasing trend over time.

Table 9 displays the regression results of the synergistic effect of firms' M&As after market access deregulation from the perspective of innovation output. Both the $OPEN \times MA\_DUM$ and $OPEN \times MA\_AMT$ coefficients are positive and statistically significant at the 5 % level when the independent variable is the innovation output efficiency in the second year of an M&A ($PATENT_{t+2}$), but the interaction terms are not significant when the independent variable is the innovation output efficiency in the first year of an M&A ($PATENT_{t+1}$). These results suggest that after market access deregulation, the number of invention patent authorizations obtained by firms within 2 years post-M&A increases significantly, and M&A activities promote the improvement of the acquiring firms' R&D and innovation capabilities, resulting in significant innovation synergies.

Table 10 shows the regression results of the profit synergistic effect of firms' M&As after market access deregulation from the perspective of financial performance. In Columns (1) to (4), whether the independent variable is the financial performance in the first year ($PROFIT_{t+1}$) or in the second year ($PROFIT_{t+2}$) after an M&A, the $OPEN \times MA\_DUM$ and $OPEN \times MA\_AMT$ coefficients are both negative but not significant. These results suggest that M&A activities after market access deregulation decrease financial performance slightly in the short term and do not yet improve profitability. However, based on the previous evidence, despite the slight decrease in financial performance post-M&A, MANL implementation significantly improves production efficiency and innovation efficiency. That is, there is a two-way dynamic balance between profitability and production efficiency when companies make M&A decisions. Companies tend to sacrifice financial performance for efficiency improvement in the short term, which is consistent with the conclusion of Liu (2018). Furthermore, the increase in long-term market value indicates that the efficiency gains after M&As exceed the performance losses.

In conclusion, firms' value has improved dramatically since the MANL pilot because of the capital market's more favorable long-term response. Firms' financial performance post-M&A has decreased since the relaxation of the market access regulation, but their TFP, human capital efficiency and innovation efficiency have significantly improved, creating an "efficiency synergy" impact. These findings show that during the early stages of deregulation, companies engage in the practice of "trading profits for efficiency" in their M&A decisions. This involves forgoing short-term financial performance in favor of a more comprehensive improvement in corporate efficiency. The overall increase in market value shows that efficiency gains outweigh financial losses. This result conflicts with research that shows poorly synergistic effects of government-led corporate

Table 11
Robustness tests: Parallel trend test.

Variable	*MA_DUM*	*MA_AMT*
	(1)	(2)
BEFORE4-7	0.000	−0.002
	(0.030)	(−0.007)
BEFORE3	−0.007	−0.169
	(−0.509)	(−0.625)
BEFORE2	0.001	0.016
	(0.098)	(0.083)
CURRENT	0.032**	0.574**
	(2.543)	(2.496)
AFTER1	0.030*	0.647*
	(1.663)	(1.933)
AFTER2	0.031	0.649
	(1.383)	(1.580)
AFTER3-4	0.013	0.315
	(0.450)	(0.604)
SIZE	0.003	0.051
	(0.321)	(0.311)
LEV	−0.193***	−3.707***
	(−6.045)	(−6.211)
ROA	0.332***	5.983***
	(4.660)	(4.519)
GROWTH	0.016**	0.286**
	(2.515)	(2.356)
CASH	0.071**	1.475**
	(2.064)	(2.304)
TOP	0.159***	2.978***
	(2.794)	(2.765)
TOP2_5/TOP1	−0.003	−0.044
	(−0.286)	(−0.223)
PAY	0.020**	0.343*
	(2.028)	(1.846)
BSIZE	0.045	0.816
	(1.487)	(1.442)
MEET	0.191***	3.638***
	(16.569)	(16.936)
MARKET	−0.006	−0.100
	(−0.935)	(−0.875)
GDP	0.001	0.013
	(0.532)	(0.251)
Constant	−0.960**	−16.069**
	(−2.567)	(−2.289)
Company FE	YES	YES
Year FE	YES	YES
Observations	18,893	18,893
Adjusted R^2	0.063	0.065
F	37.98	37.41

Note: The t-statistics are in parentheses. ***, ** and * denote significance at the 0.01, 0.05 and 0.10 levels, respectively.

M&As. The primary reason is that the MANL pilot has caused a shift in firms' M&A behavior from being driven by the government to being driven by the market, in addition to the fact that market-based corporate M&As can produce stronger synergistic effects. The major thesis of this study is that the MANL may enhance M&A performance and correct the distorting effect of government intervention on resource allocation. These conclusions verify our main argument.

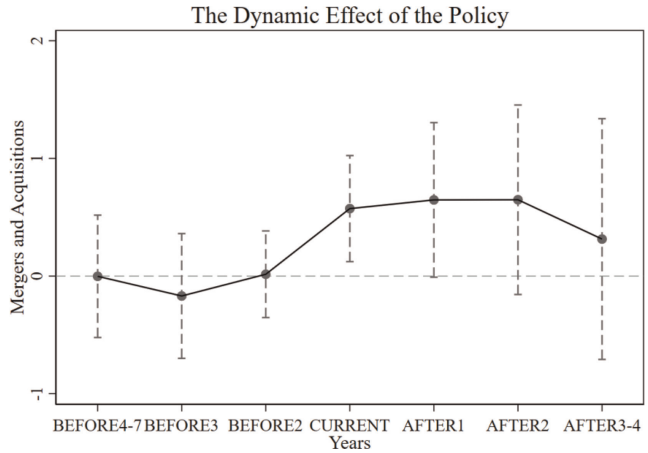

Fig. 2. Dynamic effect of the MANL pilot.

Table 12
Balance test.

Variable	*Mean*		*Mean Diff*	*p-value*
	Treat	*Control*		
SIZE	22.075	22.123	−0.047	0.268
LEV	0.393	0.403	−0.009	0.175
ROA	0.045	0.044	0	0.872
GROWTH	0.24	0.266	−0.026	0.155
CASH	0.15	0.156	−0.006	0.130
TOP	0.34	0.34	0	0.932
TOP2_5/TOP1	0.785	0.794	−0.009	0.669
PAY	14.426	14.42	0.006	0.786
BSIZE	2.229	2.229	0	0.990
MEET	2.367	2.384	−0.017	0.174
MARKET	9.551	9.532	0.019	0.727
GDP	107.531	107.686	−0.156***	0.000

6. Robustness tests

In this section, we report the results of additional tests performed to confirm the robustness of our findings.

6.1. Test of parallel trend assumption and dynamic effect analysis

The most important premise of the DID model is that the control group and the treatment group should satisfy a common trend; that is, they should demonstrate the same trend of change before the exogenous shock occurs. We construct four pre-event indicator variables, *BEFORE4-7*, *BEFORE3*, *BEFORE2* and *BEFORE1*, to correspond to 7–4 years, 3 years, 2 years and 1 year before the MANL pilot, respectively (Serfling, 2016; Chen and Ma, 2017). During the corresponding period, the indicator variable equals 1, and 0 otherwise. We construct post-event indicator variables, *CURRENT*, *AFTER1*, *AFTER2* and *AFTER3-4*, to correspond to 1 year, 2 years and 3–4 years after the pilot, respectively. Based on the year before the event (i.e., *BEFORE1* = 1), the regression results in Columns (1) and (2) of Table 11 show that the regression coefficients of *BEFORE2*, *BEFORE3* and *BEFORE4-7* are not significant, indicating that there is no significant difference in M&A behavior between the control group and the treatment group before the pilot. This is consistent with the parallel trend hypothesis. After the MANL pilot, the regression coefficients of *CURRENT* and *AFTER1* are positive and significant at a level of at least 10 %. Fig. 2 illustrates the changes in corporate M&A behavior

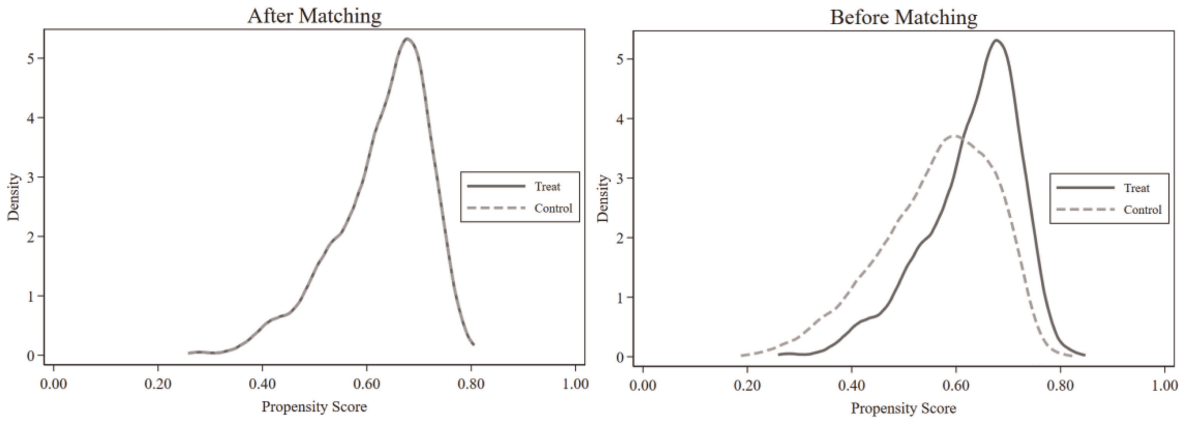

Fig. 3. Probability density function plot.

before and after the MANL pilot, which more intuitively demonstrates the dynamic effects of the pilot. It shows that the year of and the years following the pilot see a significant increase in firms' M&A activities, with a significant difference from 0 at least within the 90 % confidence interval. These results strongly suggest that the relaxation of market access regulation promotes M&A activities.

6.2. Propensity score matching

The pilot areas of the MANL are often characterized by high levels of economic development and marketization. The local companies themselves are large in scale, are highly profitable and have abundant free cash flow, making them more likely to become the acquiring parties in M&A activities. These inherent differences in characteristics may interfere with the causal inference of our conclusions because of sample selection problems. We use the propensity score matching (PSM) method to mitigate the potential impact of differences in company characteristics between the control group and the treatment group. The procedure is as follows. All of the control variables in Eq. (1) are used as covariates, and the logit model is used to regress those covariates on the indicator variable *OPEN*. The propensity score is then calculated. Based on the propensity score, a 1:1 nearest neighbor matching with a caliper radius of 0.01 is performed year by year, resulting in 15,796 annual firm observations. The results of the balance test in Table 12 show that after matching, except for GDP, the mean deviation of each covariate in the control and treatment groups is less than 10 %, and the differences between the covariates are eliminated, passing the balance test. The results of the common support test in Fig. 3 display a significant difference in the probability density function maps of the propensity score between the control group and the treatment group before matching. After matching, the probability density function maps of the two groups almost overlap, suggesting that the matching process corrects the overall differences between the two sample groups and thus passes the common support test. We re-estimate Eq. (1) using the matched sample, and the regression results of PSM-DID are reported in Columns (1) and (2) of Table 13. The results show that the regression coefficients of *OPEN* on *MA_DUM* and *MA_AMT* are both positive and significant at a level of at least 10 %, confirming the robustness of Hypothesis 1.

To test the robustness of Hypotheses 2 and 3, we follow the previous approach and use the main business income Herfindahl Index (*HHI*) to measure industry competition and property rights to measure competition discrimination. Based on whether the Herfindahl Index is above the median and whether the firm is an SOE, we divide the matched sample into two groups. We then perform subsample regressions for each of these two groups. The regression results are shown in Columns (3) to (6) of Table 13. The regression results show that the MANL pilot is positively and significantly correlated with M&A tendency and amount in firms with high industry competition and with non-state-owned property, whereas there is no significant correlation in firms with low industry competition or with state-owned property. The between-group coefficient difference tests show that the difference of the *OPEN* coefficients between the high and low industry competition groups is

Table 13
Robustness tests: PSM-DID.

Variable	Hypothesis 1		Hypothesis 2		Hypothesis 3	
	MA_DUM	*MA_AMT*	*MA_DUM*		*MA_DUM*	
			Low competitive	High competitive	SOEs	Non-SOEs
	(1)	(2)	(3)	(4)	(5)	(6)
OPEN	0.028*	0.607**	0.007	0.050**	0.000	0.043**
	(1.915)	(2.232)	(0.317)	(2.369)	(0.024)	(2.070)
SIZE	0.008	0.126	0.032*	−0.027	0.015	0.011
	(0.571)	(0.477)	(1.846)	(−1.160)	(0.787)	(0.571)
LEV	−0.159***	−3.222***	−0.163**	−0.139*	−0.035	−0.218***
	(−2.757)	(−2.908)	(−2.118)	(−1.661)	(−0.399)	(−2.934)
ROA	0.498***	8.560***	0.539***	0.462***	0.263*	0.581***
	(4.066)	(3.774)	(3.079)	(2.806)	(1.829)	(3.358)
GROWTH	0.024**	0.346*	0.023*	0.025	0.013	0.027**
	(2.419)	(1.899)	(1.944)	(1.466)	(1.104)	(2.067)
CASH	0.089*	1.946*	0.078	0.113	−0.029	0.133**
	(1.657)	(1.932)	(1.184)	(1.395)	(−0.358)	(1.990)
TOP	0.133	2.556	0.107	0.120	0.167	0.096
	(1.410)	(1.414)	(0.839)	(0.884)	(1.150)	(0.782)
TOP2_5/TOP1	−0.005	−0.122	−0.019	0.008	0.023	−0.021
	(−0.285)	(−0.348)	(−0.713)	(0.307)	(0.805)	(−0.891)
PAY	−0.000	−0.075	0.009	−0.011	0.023	−0.008
	(−0.023)	(−0.237)	(0.371)	(−0.530)	(0.952)	(−0.384)
BSIZE	0.051	0.847	0.006	0.121*	−0.003	0.094
	(1.085)	(0.974)	(0.087)	(1.847)	(−0.047)	(1.319)
MEET	0.225***	4.292***	0.196***	0.250***	0.106***	0.283***
	(12.742)	(12.816)	(7.958)	(9.867)	(4.375)	(11.646)
MARKET	−0.011	−0.206	0.011	−0.028	0.009	−0.026
	(−0.896)	(−0.867)	(0.738)	(−1.578)	(0.709)	(−1.287)
GDP	0.003	0.040	−0.000	0.006	0.004	−0.000
	(0.826)	(0.515)	(−0.089)	(0.976)	(0.865)	(−0.048)
Constant	−1.084*	−15.959	−1.289	−0.560	−1.456**	−0.712
	(−1.823)	(−1.451)	(−1.592)	(−0.637)	(−1.992)	(−0.759)
Company FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Observations	15,787	15,787	7,446	8,341	5,847	9,940
Adjusted R^2	0.066	0.068	0.068	0.067	0.033	0.089
F	27.34	25.82	16.41	13.26	7.401	23.60
Chow Test			*P-value* = 0.000***		*P-value* = 0.000***	

Note: The t-statistics are in parentheses. ***, ** and * denote significance at the 0.01, 0.05 and 0.10 levels, respectively.

statistically significant at the 1 % level, as well as between the SOE and non-SOE groups. Therefore, the robustness of Hypotheses 2 and 3 is confirmed.[2]

6.3. Placebo test

Some unobservable factors, such as economic growth and other macroeconomic policies, may be associated with both deregulation and corporate M&A behavior, resulting in a "pseudo regression." This means that the positive correlation between market access deregulation and M&A behavior may only be an accidental phenomenon rather than a causal relationship. We use a placebo test to exclude this possibility. Table 14 tabulates the results. In Panel A, the pilot period of the MANL is pushed forward by 2 years and *OPEN* is redefined. In Columns (1) and (2), the results show that the regression coefficient *OPEN* is not statistically significant

[2] The group regression results using *MA_AMT* as the dependent variable are also robust, but they are not reported because of space limitations.

Table 14
Robustness tests: Placebo test.

Panel A Two years ahead of the pilot.

Variable	Hypothesis 1		Hypothesis 2		Hypothesis 3	
	MA_DUM	*MA_AMT*	*MA_DUM*		*MA_DUM*	
			Low competitive	High competitive	SOEs	Non-SOEs
	(1)	(2)	(1)	(2)	(3)	(4)
OPEN	0.133	0.009	0.003	0.015	−0.001	0.009
	(0.633)	(0.814)	(0.171)	(1.011)	(−0.088)	(0.565)
SIZE	0.055	0.003	0.016	−0.013	0.007	0.004
	(0.336)	(0.343)	(1.321)	(−1.093)	(0.583)	(0.341)
LEV	−3.685***	−0.192***	−0.214***	−0.165***	−0.065	−0.249***
	(−6.175)	(−6.025)	(−4.720)	(−3.723)	(−1.424)	(−5.713)
ROA	6.090***	0.338***	0.337***	0.337***	0.221**	0.336***
	(4.591)	(4.734)	(3.063)	(3.625)	(2.501)	(3.361)
GROWTH	0.289**	0.016**	0.019**	0.012	0.012	0.017*
	(2.378)	(2.539)	(2.245)	(1.257)	(1.476)	(1.898)
CASH	1.493**	0.072**	0.091*	0.059	0.083	0.080*
	(2.331)	(2.085)	(1.880)	(1.197)	(1.503)	(1.849)
TOP	2.948***	0.157***	0.103	0.198***	0.062	0.188**
	(2.735)	(2.763)	(1.228)	(2.649)	(0.765)	(2.256)
TOP2_5/TOP1	−0.036	−0.003	−0.018	0.010	0.009	−0.002
	(−0.184)	(−0.252)	(−1.167)	(0.658)	(0.535)	(−0.157)
PAY	0.342*	0.020**	0.034**	0.005	0.011	0.027*
	(1.840)	(2.021)	(2.325)	(0.362)	(0.787)	(1.880)
BSIZE	0.796	0.044	0.035	0.057	0.024	0.056
	(1.412)	(1.456)	(0.796)	(1.369)	(0.626)	(1.232)
MEET	3.636***	0.191***	0.168***	0.212***	0.099***	0.235***
	(16.931)	(16.571)	(10.107)	(13.179)	(6.338)	(14.577)
MARKET	−0.069	−0.004	0.001	−0.010	0.006	−0.013
	(−0.620)	(−0.715)	(0.155)	(−1.190)	(0.927)	(−1.355)
GDP	0.037	0.003	−0.003	0.008**	0.000	0.003
	(0.747)	(0.988)	(−0.937)	(2.043)	(0.136)	(0.715)
Constant	−19.099***	−1.106***	−0.861	−1.186**	−0.666	−1.353**
	(−2.755)	(−2.994)	(−1.643)	(−2.275)	(−1.406)	(−2.265)
Company FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Observations	18,893	18,893	8,752	10,141	7,288	11,605
Adjusted R2	0.064	0.063	0.064	0.062	0.028	0.084
F	48.44	49.15	24.35	26.81	11.10	40.69

Panel B Randomly select treatment groups.

Variable	Hypothesis 1		Hypothesis 2		Hypothesis 3	
	MA_DUM	MA_AMT	MA_DUM		MA_DUM	
			Low competitive	High competitive	SOEs	Non-SOEs
	(1)	(2)	(3)	(4)	(5)	(6)
OPEN	0.007	0.112	0.003	0.007	−0.001	0.009
	(1.198)	(1.041)	(0.171)	(0.466)	(−0.088)	(0.565)
SIZE	0.003	0.054	0.016	0.031***	0.007	0.004
	(0.331)	(0.327)	(1.321)	(2.889)	(0.583)	(0.341)
LEV	−0.193***	−3.696***	−0.214***	−0.232***	−0.065	−0.249***
	(−6.045)	(−6.192)	(−4.720)	(−5.854)	(−1.424)	(−5.713)
ROA	0.338***	6.097***	0.337***	0.209**	0.221**	0.336***
	(4.738)	(4.594)	(3.063)	(2.346)	(2.501)	(3.361)
GROWTH	0.017**	0.291**	0.019**	0.023***	0.012	0.017*
	(2.558)	(2.392)	(2.245)	(2.895)	(1.476)	(1.898)

Table 14 (*continued*)

Panel B Randomly select treatment groups.						
Variable	Hypothesis 1		Hypothesis 2		Hypothesis 3	
	MA_DUM	***MA_AMT***	***MA_DUM***		***MA_DUM***	
			Low competitive	High competitive	SOEs	Non-SOEs
	(1)	(2)	(1)	(2)	(3)	(4)
CASH	0.071**	1.487**	0.091*	0.013	0.083	0.080*
	(2.074)	(2.321)	(1.880)	(0.310)	(1.503)	(1.849)
TOP	0.158***	2.955***	0.103	0.112	0.062	0.188**
	(2.772)	(2.742)	(1.228)	(1.560)	(0.765)	(2.256)
TOP2_5/TOP1	−0.003	−0.035	−0.018	−0.020	0.009	−0.002
	(−0.241)	(−0.174)	(−1.167)	(−1.502)	(0.535)	(−0.157)
PAY	0.020**	0.344*	0.034**	0.012	0.011	0.027*
	(2.031)	(1.849)	(2.325)	(0.910)	(0.787)	(1.880)
BSIZE	0.044	0.799	0.035	0.097***	0.024	0.056
	(1.465)	(1.418)	(0.796)	(2.588)	(0.626)	(1.232)
MEET	0.191***	3.637***	0.168***	0.168***	0.099***	0.235***
	(16.572)	(16.933)	(10.107)	(11.538)	(6.338)	(14.577)
MARKET	−0.004	−0.069	0.001	−0.000	0.006	−0.013
	(−0.714)	(−0.621)	(0.155)	(−0.040)	(0.927)	(−1.355)
GDP	0.003	0.037	−0.003	−0.002	0.000	0.003
	(0.998)	(0.755)	(−0.937)	(−0.535)	(0.136)	(0.715)
Constant	−1.111***	−19.180***	0.003	0.007	−0.666	−1.353**
	(−3.010)	(−2.768)	(0.171)	(0.466)	(−1.406)	(−2.265)
Company FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Observations	18,893	18,893	8,752	10,141	7,288	11,605
Adjusted R2	0.063	0.064	0.064	0.054	0.028	0.084
F	49.10	48.39	24.35	24.21	11.10	40.69

Note: The t-statistics are in parentheses. ***, ** and * denote significance at the 0.01, 0.05 and 0.10 levels, respectively.

regardless of whether the dependent variable is *MA_DUM* or *MA_AMT*. This further confirms the robustness of Hypothesis 1. To verify the robustness of Hypotheses 2 and 3, we follow the previous approach and conduct subsample regressions based on industry competition and property rights. Again, Panel A of Table 14 reports the regression results. In Columns (3) to (6), the results show that the regression coefficient *OPEN* is also not statistically significant in either the high or low industry competition groups or in the SOE or non-SOE groups.

We randomly select the treatment and control groups for each year while ensuring that the number of individuals affected by the policy remains unchanged. In Columns (1) and (2), the results still show that the regression coefficient *OPEN* is not statistically significant, regardless of whether the dependent variable is *MA_DUM* or *MA_AMT*. We also conduct subsample regressions based on industry competition and property rights. Panel B of Table 14 reports the regression results. In Columns (3) to (6), the results show that the *OPEN* regression coefficients are also not statistically significant in either the high or low industry competition groups or in the SOE or non-SOE groups. These results solidly demonstrate a positive correlation between market access deregulation and firms' M&A behavior. Therefore, the conclusion that this positive correlation is concentrated in groups with high levels of competition discrimination and sufficiency is not an accidental phenomenon.

6.4. Sample selection bias

The *WIND* database does not necessarily include all of the M&A data of listed companies. We use the "Merger and Reorganization Database of Listed Companies" of the CSMAR as the source of M&A data

Table 15
Robustness: tests: Alternative data source and sample selection.

变量	Hypothesis 1		Hypothesis 2		Hypothesis 3	
	MA_DUM	*MA_AMT*	*MA_DUM*		*MA_DUM*	
			Low competitive	High competitive	SOEs	Non-SOEs
	(1)	(2)	(3)	(4)	(5)	(6)
OPEN	0.022**	0.442**	0.012	0.031**	0.021	0.027*
	(2.151)	(2.231)	(0.762)	(2.146)	(1.189)	(1.887)
SIZE	−0.013	−0.253	−0.001	−0.027**	−0.000	−0.029**
	(−1.308)	(−1.339)	(−0.072)	(−2.121)	(−0.024)	(−2.138)
LEV	−0.176***	−3.324***	−0.176***	−0.172***	−0.155***	−0.177***
	(−5.070)	(−5.093)	(−3.505)	(−3.671)	(−2.954)	(−3.602)
ROA	0.174**	3.166**	0.162	0.186*	0.068	0.131
	(2.338)	(2.241)	(1.508)	(1.805)	(0.542)	(1.286)
GROWTH	0.009	0.149	0.013*	0.000	0.011	0.007
	(1.455)	(1.313)	(1.722)	(0.002)	(1.427)	(0.699)
CASH	0.138***	2.673***	0.189***	0.097*	0.083	0.189***
	(3.819)	(3.919)	(3.687)	(1.908)	(1.453)	(3.658)
TOP	0.225***	4.488***	0.206**	0.241***	0.290***	0.069
	(3.954)	(4.060)	(2.323)	(3.457)	(3.428)	(0.802)
TOP2_5/TOP1	0.005	0.103	0.007	0.003	0.010	0.004
	(0.405)	(0.466)	(0.445)	(0.176)	(0.509)	(0.252)
PAY	0.018*	0.335*	0.034**	0.000	0.030*	0.003
	(1.811)	(1.738)	(2.398)	(0.022)	(1.896)	(0.187)
BSIZE	0.023	0.519	0.010	0.039	0.023	0.027
	(0.721)	(0.850)	(0.221)	(0.881)	(0.459)	(0.577)
MEET	0.194***	3.758***	0.169***	0.218***	0.182***	0.207***
	(16.674)	(17.001)	(10.118)	(13.378)	(9.778)	(12.876)
MARKET	−0.001	0.013	0.006	−0.008	0.017**	−0.014
	(−0.159)	(0.104)	(0.671)	(−0.898)	(2.018)	(−1.276)
GDP	0.003	0.044	−0.002	0.007*	0.002	0.005
	(0.892)	(0.834)	(−0.408)	(1.735)	(0.459)	(1.225)
Constant	−0.683*	−12.773*	0.012	0.031**	−1.178*	−0.286
	(−1.746)	(−1.725)	(0.762)	(2.146)	(−1.906)	(−0.510)
Company FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Observations	17,774	17,774	8,236	9,538	7,173	10,601
Adjusted R^2	0.036	0.039	0.034	0.040	0.029	0.042
F	24.69	25.63	11.04	15.05	7.962	15.93
Chow Test			*P-value* = 0.044**		*P-value* = 0.000***	

Note: The t-statistics are in parentheses. ***, ** and * denote significance at the 0.01, 0.05 and 0.10 levels, respectively.

to alleviate the possible impact of data omissions on the accuracy of the regression results. We also exclude samples of M&As that are classified as asset divestment, asset replacement, debt restructuring, share repurchase and equity transfer to eliminate the potential impact of sample selection bias in M&A (Lai et al., 2017; Brooks et al., 2018; Liu et al., 2018). The regression results reported in Columns (1) and (2) of Table 15 show that even after changing the data source and sample selection method, the *OPEN* regression coefficient remains positive and significant at the 5 % level, confirming the robustness of Hypothesis 1. Furthermore, we conduct subsample regressions based on the level of industry competition and whether the firm is an SOE, as previously discussed. Columns (3) to (6) of Table 15 report the regression results. They show that the carrying out of the MANL pilot is positively and significantly correlated with M&A tendency and amount in firms of high industry competition and of non-state-owned property, whereas no significant correlation is observed in firms of low industry competition or of state-owned property. The between-group coefficient difference tests show that the difference in the *OPEN* coefficients is statistically significant at at a level of at least 5 % between those two types of groups, thus supporting the robustness of Hypotheses 2 and 3.

Table 16
Robustness: Alternative measures of firm's M&A behavior.

Variable	Hypothesis 1		Hypothesis 2		Hypothesis 3	
	MA_COUNT		*MA_COUNT*		*MA_COUNT*	
	Fixed Effect Model	Negative Binomial Model	Low competitive	High competitive	SOEs	Non-SOEs
	(1)	(2)	(3)	(4)	(5)	(6)
OPEN	0.062***	0.252***	0.011	0.050**	0.013	0.090***
	(2.994)	(3.721)	(0.307)	(2.235)	(0.531)	(3.039)
SIZE	0.017	−0.004	−0.036	−0.022	0.023	0.024
	(0.951)	(−0.072)	(−1.302)	(−1.041)	(1.141)	(0.882)
LEV	−0.343***	−1.718***	−0.251**	−0.310***	−0.123*	−0.434***
	(−6.177)	(−7.182)	(−2.570)	(−4.355)	(−1.804)	(−5.588)
ROA	0.443***	2.397***	0.534***	0.398***	0.359***	0.372**
	(3.822)	(3.728)	(2.640)	(3.035)	(2.874)	(2.225)
GROWTH	0.016	0.090**	−0.011	0.013	0.011	0.012
	(1.520)	(2.255)	(−0.582)	(0.833)	(0.886)	(0.828)
CASH	0.127**	1.038***	0.169*	0.050	0.088	0.162**
	(2.268)	(4.192)	(1.817)	(0.739)	(1.109)	(2.187)
TOP	0.280**	1.555***	0.059	0.366***	−0.005	0.365*
	(2.111)	(4.345)	(0.430)	(3.109)	(−0.040)	(1.779)
TOP2_5/TOP1	−0.006	0.062	0.002	0.019	−0.011	0.000
	(−0.313)	(0.849)	(0.050)	(0.756)	(−0.316)	(0.015)
PAY	0.023	0.171**	0.042	0.002	0.008	0.034
	(1.230)	(2.572)	(1.287)	(0.084)	(0.363)	(1.232)
BSIZE	0.101**	0.505**	0.013	0.120**	0.035	0.160**
	(1.991)	(2.272)	(0.158)	(1.983)	(0.503)	(2.179)
MEET	0.327***	1.301***	0.329***	0.330***	0.168***	0.397***
	(14.351)	(15.915)	(9.132)	(12.638)	(4.868)	(13.101)
MARKET	−0.013	0.022	−0.026	−0.020	−0.006	−0.019
	(−1.455)	(0.487)	(−1.440)	(−1.590)	(−0.596)	(−1.344)
GDP	−0.000	−0.022	0.012*	0.005	−0.002	−0.002
	(−0.083)	(−0.819)	(1.776)	(0.810)	(−0.378)	(−0.311)
Constant	−1.502**	−5.579*	−1.743*	−0.953	−0.768	−1.832*
	(−2.465)	(−1.685)	(−1.675)	(−1.268)	(−0.887)	(−1.866)
Company FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Observations	18,893	11,177	8,752	10,141	7,288	11,605
Adjusted R^2	0.059		0.059	0.064	0.026	0.079
F/ Chi^2	32.13	1032.34	11.78	21.22	8.188	26.88
Chow Test			*P-value* = 0.000***		*P-value* = 0.000***	

Note: The t-statistics are in parentheses. ***, ** and * denote significance at the 0.01, 0.05 and 0.10 levels, respectively.

6.5. Alternative measures of firms' M&A behavior

We use the number of M&A activities in the current period (*MA_COUNT*) to capture the firms' M&A behavior (Schweizer et al., 2004; Li et al., 2020). Column (1) of Table 16 reports the regression results. The coefficient of *OPEN* on *MA_COUNT* is 0.252 and is positive and significant at the 1 % confidence level. This implies that the number of M&A activities increases by 25.2 % after the MANL pilot, thus verifying the robustness of Hypothesis 1. Additionally, we adopt the subsample regressions based on the nature of property rights and the degree of industry competition, as previously discussed. Columns (3) to (6) of Table 16 report the regression results. The coefficient of *OPEN* on *MA_COUNT* is positive and significant only in the high-level industry competition group and the non-SOE group. We also conduct between-group coefficient difference tests. The *OPEN* coefficients between the high and low industry competition groups as well as between the SOE and non-SOE groups are significantly different. Therefore, the robustness of Hypotheses 2 and 3 is confirmed.

Table 17
Robustness test: Alternative window selection.

Variable	Hypothesis 1		Hypothesis 2		Hypothesis 3	
	MA_DUM	*MA_AMT*	*MA_DUM*		*MA_DUM*	
			Low competitive	High competitive	SOEs	Non-SOEs
	(1)	(2)	(3)	(4)	(5)	(6)
OPEN	0.032***	0.586***	0.021	0.041**	0.019	0.040**
	(2.599)	(2.623)	(1.220)	(2.451)	(1.133)	(2.351)
SIZE	−0.003	−0.076	0.014	−0.022	−0.008	0.005
	(−0.239)	(−0.347)	(0.886)	(−1.298)	(−0.464)	(0.317)
LEV	−0.191***	−3.855***	−0.255***	−0.119**	−0.055	−0.241***
	(−4.560)	(−4.899)	(−4.319)	(−1.995)	(−0.859)	(−4.310)
ROA	0.350***	5.914***	0.262*	0.436***	0.244**	0.372***
	(3.739)	(3.389)	(1.876)	(3.439)	(2.312)	(2.695)
GROWTH	0.022***	0.383***	0.027***	0.012	0.017	0.022**
	(2.775)	(2.589)	(2.615)	(0.995)	(1.551)	(2.033)
CASH	0.122***	2.477***	0.148**	0.108*	0.120*	0.126**
	(2.731)	(2.957)	(2.274)	(1.757)	(1.673)	(2.251)
TOP	0.241***	4.469***	0.210*	0.267***	0.180	0.251**
	(3.231)	(3.137)	(1.919)	(2.648)	(1.500)	(2.501)
TOP2_5/TOP1	0.005	0.043	−0.005	0.014	−0.012	0.011
	(0.333)	(0.167)	(−0.276)	(0.727)	(−0.479)	(0.614)
PAY	0.021	0.380	0.027	0.013	0.030*	0.016
	(1.621)	(1.554)	(1.447)	(0.757)	(1.744)	(0.870)
BSIZE	0.064*	1.259*	0.086	0.042	0.045	0.082
	(1.692)	(1.786)	(1.598)	(0.789)	(0.926)	(1.438)
MEET	0.216***	4.109***	0.179***	0.247***	0.100***	0.279***
	(15.316)	(15.640)	(8.832)	(12.545)	(5.150)	(14.250)
MARKET	−0.003	−0.066	0.010	−0.018	0.007	−0.007
	(−0.396)	(−0.384)	(0.876)	(−1.390)	(0.615)	(−0.559)
GDP	0.000	−0.016	−0.005	0.004	−0.001	−0.001
	(0.037)	(−0.229)	(−0.887)	(0.793)	(−0.328)	(−0.173)
Constant	−0.794	−12.366	−0.728	−0.642	−0.471	−0.892
	(−1.580)	(−1.309)	(−0.991)	(−0.931)	(−0.729)	(−1.089)
Company FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Observations	13,964	13,964	6,509	7,455	5,435	8,529
Adjusted R^2	0.050	0.052	0.048	0.053	0.019	0.070
F	33.35	33.75	15.24	19.71	5.985	29.80
Chow Test			*P-value* = 0.006**		*P-value* = 0.000***	

Note: The t-statistics are in parentheses. ***, ** and * denote significance at the 0.01, 0.05 and 0.10 levels, respectively.

6.6. Window selection bias

We repeat the main Eq. (1) regression for the period from 2013 to 2018. Columns (1) and (2) of Table 17 report the regression results. The regression coefficients of *OPEN* on *MA_DUM* and *MA_AMT* are both positive and significant at the 1 % level. The robustness of Hypothesis 1 is thus confirmed. We then conduct subsample regressions based on the nature of property rights and the degree of industry competition, again using the period from 2013 to 2018. Columns (3) to (6) report the regression results. The coefficient of *OPEN* on *MA_DUM* is positive and significant only in the high-level industry competition group and the non-SOE group. Furthermore, we perform between-group coefficient difference tests and find that the *OPEN* coefficients between those two types of groups are significantly different. Therefore, the robustness of Hypotheses 2 and 3 is verified (See Table 17).

Table 18
Robustness test: Control the effects of similar policies.

Panel A Free trade zones.

Variable	Hypothesis 1		Hypothesis 2		Hypothesis 3	
	MA_DUM	*MA_AMT*	*MA_DUM*	*MA_AMT*	*MA_DUM*	*MA_AMT*
			Low competitive	High competitive	SOEs	Non-SOEs
	(1)	(2)	(3)	(4)	(5)	(6)
OPEN	0.029***	0.530**	0.012	0.045***	0.013	0.040***
	(2.589)	(2.546)	(0.726)	(2.902)	(0.834)	(2.611)
FTZ	0.014	0.277	0.023	0.004	0.022	0.000
	(1.268)	(1.341)	(1.408)	(0.264)	(1.462)	(0.000)
SIZE	0.003	0.050	0.016	−0.014	0.006	0.004
	(0.305)	(0.302)	(1.301)	(−1.103)	(0.541)	(0.341)
LEV	−0.195***	−3.733***	−0.217***	−0.168***	−0.067	−0.251***
	(−6.110)	(−6.263)	(−4.795)	(−3.773)	(−1.471)	(−5.757)
ROA	0.333***	6.007***	0.328***	0.335***	0.219**	0.332***
	(4.680)	(4.537)	(2.984)	(3.613)	(2.463)	(3.332)
GROWTH	0.016**	0.285**	0.019**	0.012	0.012	0.017*
	(2.512)	(2.349)	(2.236)	(1.282)	(1.477)	(1.847)
CASH	0.071**	1.482**	0.089*	0.060	0.081	0.080*
	(2.066)	(2.314)	(1.837)	(1.226)	(1.458)	(1.845)
TOP	0.158***	2.961***	0.103	0.197***	0.061	0.191**
	(2.780)	(2.749)	(1.221)	(2.645)	(0.750)	(2.301)
TOP2_5/TOP1	−0.003	−0.043	−0.018	0.010	0.009	−0.003
	(−0.284)	(−0.216)	(−1.183)	(0.619)	(0.501)	(−0.190)
PAY	0.020**	0.342*	0.034**	0.005	0.011	0.027*
	(2.026)	(1.847)	(2.292)	(0.376)	(0.819)	(1.874)
BSIZE	0.045	0.809	0.034	0.058	0.023	0.057
	(1.479)	(1.431)	(0.785)	(1.399)	(0.595)	(1.245)
MEET	0.191***	3.623***	0.167***	0.211***	0.099***	0.235***
	(16.498)	(16.862)	(10.055)	(13.094)	(6.335)	(14.517)
MARKET	−0.007	−0.120	−0.001	−0.013	0.005	−0.016*
	(−1.167)	(−1.070)	(−0.080)	(−1.616)	(0.650)	(−1.689)
GDP	0.002	0.017	−0.004	0.006	0.000	0.001
	(0.572)	(0.345)	(−0.995)	(1.546)	(0.031)	(0.237)
Constant	−0.957***	−16.393**	−0.803	−0.948*	−0.607	−1.093*
	(−2.595)	(−2.368)	(−1.537)	(−1.821)	(−1.281)	(−1.830)
Company FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Observations	18,793	18,793	8,717	10,076	7,282	11,511
Adjusted R^2	0.0634	0.0649	0.0640	0.0633	0.0286	0.0845
F	46.97	46.26	23.18	25.77	10.70	38.86
Chow Test			*P-value* = 0.020**		*P-value* = 0.000***	

Panel B Special economic zones.

Variable	Hypothesis 1		Hypothesis 2		Hypothesis 3	
	MA_DUM	*MA_AMT*	*MA_DUM*	*MA_DUM*	*MA_AMT*	是否并购（*MA_DUM*）
			Low competitive	High competitive	SOEs	Non-SOEs
	(1)	(2)	(3)	(4)	(5)	(6)
OPEN	0.033***	0.611***	0.019	0.046***	0.021	0.040***
	(3.101)	(3.063)	(1.216)	(3.134)	(1.393)	(2.686)
SEA	0.044	0.981	0.108	−0.026	−0.068***	0.069
	(0.564)	(0.690)	(1.057)	(−0.235)	(−4.276)	(0.767)
SIZE	0.003	0.054	0.016	−0.014	0.007	0.005
	(0.329)	(0.328)	(1.299)	(−1.106)	(0.585)	(0.365)
LEV	−0.194***	−3.711***	−0.215***	−0.168***	−0.066	−0.250***
	(−6.074)	(−6.223)	(−4.749)	(−3.778)	(−1.461)	(−5.742)

(*continued on next page*)

Table 18 (*continued*)

Panel B Special economic zones.						
Variable	Hypothesis 1		Hypothesis 2		Hypothesis 3	
	MA_DUM	*MA_AMT*	*MA_DUM*	*MA_AMT*	*MA_DUM*	*MA_AMT*
			Low competitive	High competitive	SOEs	Non-SOEs
	(1)	(2)	(3)	(4)	(5)	(6)
ROA	0.333***	6.003***	0.330***	0.334***	0.218**	0.331***
	(4.670)	(4.527)	(2.993)	(3.601)	(2.452)	(3.317)
GROWTH	0.016**	0.286**	0.019**	0.012	0.012	0.017*
	(2.518)	(2.356)	(2.246)	(1.288)	(1.473)	(1.865)
CASH	0.070**	1.472**	0.090*	0.060	0.081	0.080*
	(2.051)	(2.298)	(1.866)	(1.224)	(1.451)	(1.839)
TOP	0.158***	2.966***	0.107	0.198***	0.062	0.190**
	(2.789)	(2.756)	(1.273)	(2.678)	(0.763)	(2.290)
TOP2_5/TOP1	−0.003	−0.042	−0.018	0.009	0.009	−0.003
	(−0.280)	(−0.211)	(−1.173)	(0.609)	(0.509)	(−0.180)
PAY	0.020**	0.341*	0.034**	0.005	0.011	0.026*
	(2.021)	(1.840)	(2.329)	(0.377)	(0.806)	(1.857)
BSIZE	0.045	0.811	0.033	0.058	0.025	0.055
	(1.484)	(1.433)	(0.763)	(1.401)	(0.650)	(1.214)
MEET	0.191***	3.630***	0.167***	0.211***	0.099***	0.234***
	(16.538)	(16.896)	(10.050)	(13.123)	(6.352)	(14.492)
MARKET	−0.007	−0.117	−0.000	−0.013	0.005	−0.017*
	(−1.143)	(−1.051)	(−0.045)	(−1.582)	(0.759)	(−1.775)
GDP	0.001	0.012	−0.004	0.006	−0.000	0.001
	(0.468)	(0.238)	(−1.152)	(1.511)	(−0.090)	(0.263)
Constant	−0.938**	−16.046**	−0.765	−0.931*	−0.578	−1.108*
	(−2.543)	(−2.318)	(−1.467)	(−1.780)	(−1.216)	(−1.860)
Company FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Observations	18,793	18,793	8,717	10,076	7,282	11,511
Adjusted R^2	0.0633	0.0649	0.0640	0.0633	0.0283	0.0846
F	46.99	46.28	23.31	25.76	9.49	38.91
Chow Test			*P-value* = 0.000***		*P-value* = 0.000***	

Note: The t-statistics are in parentheses. ***, ** and * denote significance at the 0.01, 0.05 and 0.10 levels, respectively.

6.7. Controlling for the effects of similar policies

The time span, implementation location and policy efficacy of free trade zones, special economic zones and the MANL pilot share some similarities. It is thus important to distinguish between the MANL pilot, special economic zones and free trade zones in terms of policy effectiveness. We construct two indicator variables, namely *FTZ* and *SEA*. If the province or municipality in which a firm is located is a free trade area (or special economic zone) in the current year, the variable *FTA* (or *SEA*) equals 1, and 0 otherwise. *FTZ* and *SEA* are controlled in Eq. (1). Table 18 tabulates the results.

In Columns (1) and (2) of Panel A of Table 18, the regression results (controlling for the indicator variable *FTZ*) show that the *FTZ* coefficients are positive but not significant, and the *OPEN* coefficients are positive and significant at the 1 % level. The absolute value of the *OPEN* coefficient is lower than that in Table 3. This implies that although free trade areas have a promoting effect on corporate M&As, our conclusion regarding Hypothesis 1 is not affected. In addition, we conduct subsample regressions based on the degree of industry competition and the nature of property rights. Columns (3) to (6) of Panel A report the regression results. The coefficients of *OPEN* on *MA_COUNT* and *MA_DUM* are both positive and significant in the high-level industry competition and non-SOE groups. In addition, we conduct between-group coefficient difference tests and find that the *OPEN* coefficients between these two types of groups are significantly different. Therefore, our conclusions regarding Hypotheses 2 and 3 are not affected by free trade zones.

In Columns (1) and (2) of Panel B, the regression results (controlling for the indicator variable *SEA*) show that the *SEA* coefficients are positive but not significant, whereas the *OPEN* regression coefficients are positive and significant at the 1 % level. In addition, we conduct subsample regressions based on the degree of industry competition and the nature of property rights. Columns (3) to (6) of Panel B report the regression results. The *OPEN* coefficients on *MA_COUNT* and *MA_DUM* are both positive and significant in the high-level industry competition and non-SOE groups. Additionally, the between-group coefficient difference tests show that the *OPEN* coefficients between those two types of groups are significantly different. Therefore, our conclusions regarding Hypotheses 2 and 3 are not affected by special economic zones.

The above results solidly indicate that the MANL pilot has significantly boosted the tendency and amount of firms' M&A behavior. M&As enable companies to enter the new market more conveniently and to scale up more rapidly than other types of investment. Market access deregulation offers opportunities for growth and enhances market competition mechanisms. Through M&As, firms can easily enter the deregulated market and quickly develop a large-scale operation to cope with the new competition pattern arising as a result of market access deregulation. These conclusions validate Hypotheses 1, 2 and 3, namely that the MANL pilot increases corporate M&A behavior and strengthens the market-oriented M&A logic of competitive response and fair competition.

7. Conclusions and insights

MANL implementation has shifted the government's management thinking on market access from the positive list to the negative list approach, which promotes the shift of firms' M&As from being led by the government to being led by the market. This change may boost the M&A market's vibrancy. The empirical evidence presented in this study indicates that firms' M&A activities have significantly expanded since the MANL pilot in terms of both likelihood and amount. It also suggests that the MANL pilot strengthens the market-oriented logic of M&As. Under the competitive logic, the MANL encourages enterprises to adopt more M&A strategies to contend with highly competitive industries. Under the logic of fairness, the MANL further reinforces the M&A incentive and propensity of firms that face discrimination in the marketplace. Additionally, we find that the MANL pilot enhances M&A performance, suggesting that it is helpful in reversing the resource allocation distortion caused by government interference. Furthermore, the financial performance of M&As has not improved, but the human capital efficiency, innovation efficiency and total factor productivity of M&As have significantly improved, indicating that there is a dynamic balance between profit and efficiency in M&As.

With China serving as the institutional backdrop, we offer empirical evidence on the policy effects of market access deregulation from the standpoint of firms' M&A activity. The MANL serves as an institutional design for China to encourage significant changes in the government's function. It is also clear that the government's dominant position over resource distribution to the market is advantageous for fostering the robust economic growth and high-quality of development of transition economies, such as China. The government has allowed the market to take the lead in resource allocation. The negative effects of government dominance have since vanished, and the beneficial effects of market dominance are starting to materialize. The mechanism analysis presented in our study, however, places a greater emphasis on the former, namely that the MANL pilot may boost the vitality of corporate M&A activity by decreasing government interference and eliminating M&A discrimination. Little information about how the development of certain market mechanisms affects corporate M&A behavior is available. Furthermore, it is challenging to match the MANL with the business scope of firms to determine whether a firm has entered the field of relaxed regulation through diversified M&A or whether a firm in the field of relaxed regulation has made a large-scale horizontal M&A due to the detailed and complex nature of the MANL. Consequently, there remains room for growth in both our research and design.

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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Do investors care about auditor assignments? Evidence from last-minute changes to signing auditors

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ABSTRACT

Against the background of China's strengthening of finance and accounting supervision, this study examines the practice among listed companies of changing signing auditors at the last minute and explores whether Chinese investors can capture this information in a timely manner. We find that China's capital market responds significantly negatively to these last-minute changes, implying that investors perceive a potential negative impact of this behavior. Cross-sectional analyses suggest that the characteristics of the change event, recent corporate events, and accounting firm capability significantly affect the stock price response. Furthermore, in terms of the individual characteristics of signing auditors, external investors appear to comprehensively consider busyness level, industry experience, and the timing of the change to determine the causes and effects of the auditor change and make different market reactions accordingly. In addition, consistent with investor perceptions, we find that last-minute changes significantly impair the quality of financial statements, indicating that external investors' judgments based on information about changes in signing auditors are rational and effective.

1. Introduction

In February 2023, the General Office of the Central Committee of the Communist Party of China (CPC) and the General Office of the State Council issued the "Opinions on Further Strengthening the Supervision of Finance and Accounting," which emphasized that the scrutiny function of accounting firms is an important part of China's financial and accounting supervision system. In this process, as the link between an accounting

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firm and a listed company, the assignment of a signing auditor directly impacts the supervision effect, i.e., the audit quality (Gul et al., 2013; Chen et al., 2016; Li et al., 2017). Therefore, the choice of signing auditors should be an essential factor in stakeholders' assessments. Accordingly, the disclosure requirements on signing auditor appointment have been gradually improved in China.

In February 2020, the Shanghai Stock Exchange (SHSE) and the Shenzhen Stock Exchange (SZSE) issued specific guidelines on the content and format of daily information disclosure. Listed companies are required to not only disclose the final signing auditors' information in the annual report, but also announce the identities of auditors to be appointed when renewing or switching accounting firms. Thanks to these disclosure requirements, we are able to collect data on a considerable number of inconsistencies between the signing auditor information disclosed in companies' announcements of the renewal or switching of accounting firms and the names disclosed in annual reports. This phenomenon indicates that many accounting firms make the interim change to their signing auditors during the audit process. However, only some of the listed companies publicly issue announcements on changes in signing auditors.[1] By reflecting the staffing arrangements of the accounting firm after undertaking the engagement, this phenomenon can be regarded as an intuitive manifestation of the changes in auditor. At the same time, as these are interim changes in signing auditors, we call this phenomenon "changing the signing auditor at the last minute" (hereafter referred to as "last-minute changes").

Compared with ordinary changes in signing auditors, which generally occur between fiscal years, the "interim" characteristic is obviously an important feature of these last-minute changes and a major concern for external stakeholders. Last-minute changes could even be regarded as abnormal redeployments of key practitioners during the annual report audit. On April 14, 2023, YanAn Bicon Listed Company received a letter of concern from the SZSE on the same day that the company announced a change of auditors. The SZSE asked the accounting firm to explain the reason for the change in auditor, whether the remaining time was sufficient to complete the audit work, and whether audit quality could be fully assured. It can be seen that regulators have already taken the lead in expressing concerns about audit quality in response to serious last-minute changes, as in the YanAn Bicon Co. event. Given the increasing policy guidance, it is unclear whether investors can effectively capture the abnormal phenomenon of auditor change and make rational investment decisions based on this information. The related stock price fluctuations in the securities market are also unknown. These important issues are considered in this study. Using the Chinese scenario of last-minute changes in signing auditors, we explore the ability of investors to capture information about the reassignment of signing auditors and their response to these changes.

We manually collect data on the last-minute changes in signing auditors of A-share listed companies on the SHSE and SZHE since 2020 and use the event study method to investigate the market responses to 680 announcements of signing auditor changes during the 2020–2022 period. The empirical results show that these last-minute changes have a significant negative effect on stock prices. The characteristics of the change event, recent corporate events, and the capability of accounting firms affect the sensitivity of investors' responses to these change announcements. Investors become doubtful of the quality of future financial statements when there are last-minute changes to auditors and respond more negatively if the change occurs late in the audit process, if the number of auditors changed is large, if the company has recently changed its key executives or was exposed for committing violations, or if the new accounting firm is undertaking the auditee's engagement for the first time. In contrast, when the accounting conservatism of the company is high or the accounting firm has appropriate industry expertise, the negative stock price response is alleviated. In addition, external investors take account of the busyness and experience of the auditors together with the timing of the change, and comprehensively judge the causes and effects of specific last-minute changes. Accordingly, investors' market

[1] A typical example is the "Announcement on the Change of Engagement Partner, Signing Certified Public Accountants and Engagement Quality Reviewer of Accounting Firm" issued by North Electro-Optic Co., Ltd. (Stock code: 600184) on January 11, 2022. The announcement clearly states that "Ms. Cai Xiaoli was originally assigned as the engagement partner, Mr. An Xing as the signing auditor, and Mr. Zhang Fan as the engagement quality reviewer to provide auditing services for the company. Due to the work arrangement adjustment of the accounting firm, Mr. An Xing is now assigned as the engagement partner, and Mr. Xiong Yu as the signing auditor." Other basic information on Mr. An Xing and Mr. Xiong Yu is also disclosed in the change announcement.

feedback has variable intensity. Consistent with investor perceptions, we find that last-minute changes do impair the quality of financial statements, indicating that investors' negative reactions to information about changes in the signing auditors' appointment are rational and effective investment decisions.

Our study contributes to the literature in several ways. First, we explore a new research scenario, i.e., last-minute changes to the signing auditors. By comparing the signing auditor information disclosed in announcements of the renewal or switching of accounting firms with the names disclosed in annual reports, we are able to collect data on last-minute changes to signing auditors. The data provide a window for observing interim adjustments in signing auditors in the audit process of accounting firms. Moreover, adopting the perspective of external investors, we explore the impacts of these last-minute changes on the capital market and open a new topic in research on auditor change.

Second, by examining market responses to auditor change announcements, we test the effectiveness of China's system for disclosing information on signing auditors. At the same time, the magnitude of the stock price effect shows that the intensity of investors' reaction is not high, indicating that the content, timeliness, and regulation of the disclosure of auditor changes need to be improved.

Third, as of now, there is no consensus on whether the capital market responds significantly to auditor information. The Public Company Accounting Oversight Board (PCAOB) mandated the disclosure of auditors in 2017, and Doxey et al. (2021) find that the U.S. capital market has no significant response to the information of who conducts annual report audits. In contrast, our conclusion that Chinese investors capture auditor reassignment information in a timely manner not only enriches the literature on the link between auditors and the capital market but also provides empirical evidence of the difference between Chinese and foreign settings. We expand research on institutional environmental differences and their consequences.

Fourth, adopting the perspective of investors, we discuss the externality impact of last-minute changes, guiding market participants' attention to this phenomenon and helping them to make reasonable investment decisions based on specific conditions. Moreover, our study provides new ideas for regulators seeking to supervise the assignment of signing auditors, monitor the dynamics of audit and capital markets and provides insights into policies for the development and improvement of the regulatory system.

The rest of this paper is organized as follows. After reviewing the literature in Section 2, we outline the background of disclosure regulations in Section 3. An analysis of the market response to last-minute changes in signing auditors is presented in Section 4. Section 5 describes the research design of the study. Sections 6 and 7 discuss the empirical results and further analyses, respectively. Robustness tests are reported in Section 8. Finally, Section 9 presents our conclusions.

2. Literature review

2.1. Consequences of changing accounting firms or signing auditors

As an important contractual behavior in the capital market, changes to accounting firms or signing auditors are highly scrutinized by securities regulators and the media. The consequences of such changes are an important topic in academic research. In this section, we briefly summarize research on the consequences of these changes for the market and audit quality.

In terms of market consequences, as listed companies in many countries are only required to disclose changes in accounting firms, research on market reactions to these changes is generally conducted at the accounting firm level. Some studies show that investors tend to have negative views of accounting firm changes, leading to negative market responses around the announcement date (Fried and Schiff, 1981; Smith, 1988; Dunn et al., 1999). For companies with high litigation risk or late changes, the investor reactions are even more negative than for their counterparts (Shu, 2000; Alhaija, 2017). Furthermore, some firms selectively hide key information about the change (Xie and Yan, 2013b), and frequent switches further increase the risk of a stock price crash (Yao et al., 2017). In a study of the reasons for such changes, Hackenbrack and Hogan (2002) find that the earnings response coefficient is lower when listed companies switch accounting firms for disagreement-related or fee-related reasons, and higher for companies that change due to audit ser-

vices. If the reasons disclosed by the dismissed and newly appointed accounting firms are inconsistent, investors become more anxious about audit quality and tend to sell more shares (Zhang and Zhang, 2019). In contrast to the above findings, Zhang et al. (2012) document that although changing an accounting firm reduces the credibility of the financial earnings of listed companies, the change event still receives a positive market reaction.

In terms of audit quality, studies show that listed companies can improve their financial statement audit opinions and internal control audit opinions by changing their accounting firm or signing auditors (Wu et al., 2013; Chen et al., 2016; Zhang, 2018; Fang et al., 2020). However, a new accounting firm can lead to problems such as a decline in the auditor's independence or a lack of client-specific knowledge, which in turn results in a higher level of earnings management and a greater possibility of financial restatements (Liu and Liu, 2007; Stanley and DeZoort, 2007). For companies that make these changes late in the fiscal year, the justifications for the changes are often unreasonable. Their annual reports are disclosed late and have low audit quality (Schwartz and Soo, 1996; Wu and Shu, 2006; Cassell et al., 2017). Fitzgerald et al. (2018) show that changing the signing auditors does not improve the quality of internal control reports because new auditors do not have sufficient knowledge of their clients. In the case of simultaneous changes in the accounting firm and signing auditors, or changes in the accounting firm but not signing auditors, the initial audit fees discount and the motivation to return the "favor" may lead to a deterioration in earnings quality, indicating that the audit quality is impaired (Xie and Yan, 2013a; Zhang et al., 2018). However, Kwon et al. (2014) provide a different viewpoint. They document that reputation effects and peer evaluation pressure incentivize new accounting firms to provide higher quality audit services in the first year after the change.

2.2. Market consequences of changing the signing auditor

The requirement for listed companies to disclose auditor identity has existed for more than two decades in China; thus, there is sufficient data for academic research on signing auditors. Some studies find that the characteristics of auditors, such as educational background and work experience, have a significant impact on audit quality (Gul et al., 2013), while auditors with impaired reputations are associated with high debt financing costs in firms (Jiang and Jiang, 2017). Aobdia et al. (2015) document that when Taiwanese companies adopt high-quality partners in place of low-quality partners, the market responds positively. In addition, although auditor reappointment after mandatory rotation results in worse audit quality, the earnings response coefficients do not show any significant difference (Jiang and Tao, 2016).

In 2017, the PCAOB mandated the disclosure of auditors. Based on this new rule, using trading volume, absolute abnormal returns, and bid–ask spreads, Doxey et al. (2021) find that U.S. investors do not have a significant response to the disclosure of the auditor's identity, and the market response is not significantly affected by whether the auditor is associated with restatement or has relevant industry experience or a large workload. It has been suggested that most investors focus their attention on the type of audit opinion and respond negatively to going concern opinions (Menon and Williams, 2010), but fail to derive incremental information from the explanatory statements in audit reports (Gutierrez et al., 2018; Czerney et al., 2019). In contrast, Lambert et al. (2018) show that with the help of auditor disclosure, investors are less likely to invest in firms audited by signing auditors with restatement experience.

First, although there are many studies of changes in accounting firms and signing auditors, most focus on the changes between fiscal years. Few studies pay attention to changes in signing auditors during the audit process. Second, most of the literature explores the consequences of accounting firm changes, and few studies consider changes in signing auditors or their impact on securities markets. Third, after the PCAOB mandated the disclosure of auditors' identity, research on signing auditors in the U.S. context has gradually increased, and some scholars document that investors do not pay attention to who conducts an audit (Doxey et al., 2021). However, whether investors can capture useful information from the related announcements in China, a market environment where the auditor disclosure system is relatively mature, is a research topic worthy of attention, given the different disclosure environments of the two countries. Therefore, this study focuses on the market consequences of last-minute changes. While enriching relevant theoretical research, our findings also help investors to make reasonable judgments and assist the authorities to regulate the assignment of auditors.

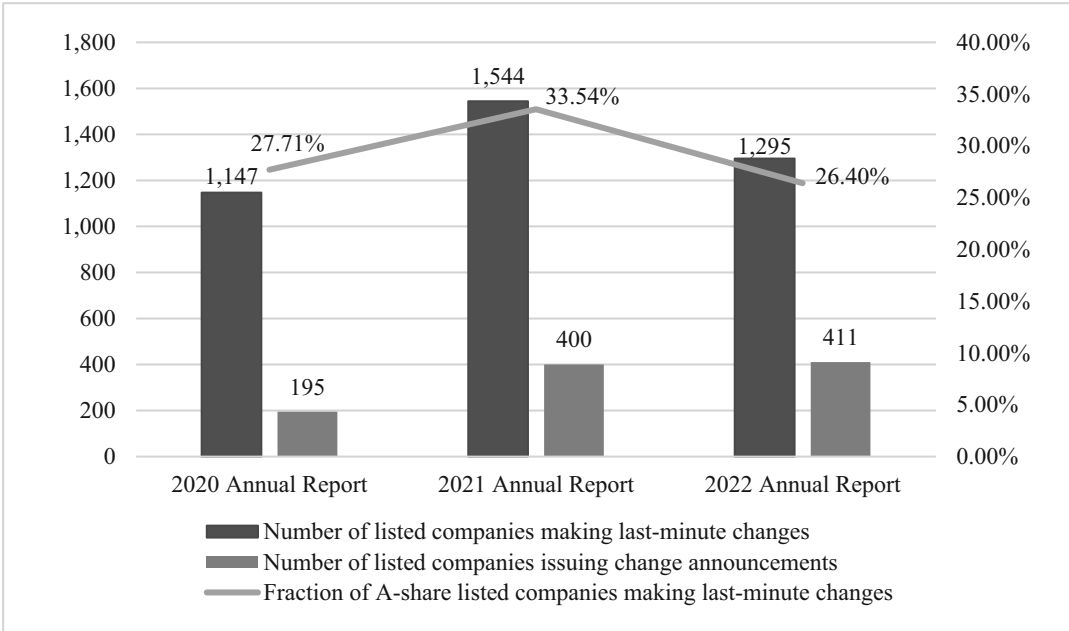

Fig. 1. Last-minute changes to signing auditors.

3. Institutional background

Since the establishment of the SHSE and SZSE, China has promulgated a series of regulations relating to information disclosure, which have been continuously improved through revisions and now form the disclosure system. As early as 2000, the China Securities Regulatory Commission (CSRC) had formulated rules for the information disclosure of listed companies, which mandated companies to disclose the names of signing auditors in their annual reports. In addition, the hiring and dismissal of accounting firms are regarded as important matters that need to be announced in a timely manner. This shows that China's regulators attach importance to major events such as hiring an accounting firm, external audits, and relevant information disclosure.

In recent years, Chinese regulators have gradually tightened the disclosure requirements of listed companies and accounting firms, and the relevant provisions have been increasingly refined. In February 2020, the SHSE and SZSE, respectively, issued guidelines on the format of information disclosure announcements and revised the guidelines for the content of the announcements on the renewal or reassignment of accounting firms by listed companies. The above regulations mandate the disclosure of the signing auditors to be appointed at the time the accounting firm is hired. Accordingly, if an accounting firm reassigns an auditor to take over an engagement during the audit period, the company should issue an announcement of the change in signing auditor to inform stakeholders of the event.

However, according to the data we collect, not all companies engaged in last-minute changes issue a change announcement. Many firms do not make any statement. Fig. 1 shows the number of listed companies who according to their annual reports made last-minute changes during the 2020–2022 period and the number of companies that made change announcements in the same period. Taking 2021 as an example, 1,544 companies changed their auditors at the last minute, but only 400 disclosed this behavior. Some companies even changed the appointment twice in a one year.[2] It can be seen that last-minute changes have the characteristics

[2] In the case of Landai Technology Group Corp., Ltd. (Stock code: 002765), the company issued two change announcements for the 2022 annual report on December 6 and December 15, 2022, respectively.

of frequent occurrence and concealment and are important events that deserve attention from academics and practitioners.

Most academics and investors focus on changes in accounting firms and the personal characteristics of the signing auditors, but do not notice potential personnel deployment problems in the audit process and the consequences that they may trigger. Thanks to the public disclosure of the relevant information, we can collect data on last-minute changes in signing auditors, which provides a unique setting for observing the attitudes and responses of external investors to this phenomenon. In summary, under the new rules formulated by Chinese stock exchanges, it is necessary, feasible, and of great practical significance to explore the market response to last-minute changes.

4. Theoretical analysis

Capital markets are essentially information markets. Investors who are at an information disadvantage enhance their knowledge of firm value by searching for more information (Chen et al., 2022). However, investor expectations adjust to external information shocks, and their emotional reactions are also reflected in their investment strategies and ultimately affect the securities market (Zhang and Wang, 2013). Therefore, theoretically, market participants' attention to the auditor information disclosed by listed companies and their reactions could be reflected in share price fluctuations.

From the perspective of external investors, last-minute changes are first characterized by the basic fact of the change. As the key contributors to annual report audits, signing auditors are obviously closely related to the final audit quality and accounting information quality (Nelson and Tan, 2005; Nelson, 2009). However, in China's audit market, the extent of unification within the accounting firms is relatively low, and the weak quality control system makes it difficult to ensure homogeneous audit services across engagements. Even within the same accounting firm, the variation in audit quality among auditors is affected by individual characteristics, such as gender, professional knowledge, risk perception, and ethical standards (Gold et al., 2009; Gul et al., 2013). Accordingly, when signing auditors are reassigned, differences in risk perception, practice standards, and work style between auditors may hinder the work handover and the follow-up audit work of the succeeding auditors. Therefore, for external stakeholders, a change event increases uncertainty about audit quality. If investors become doubtful of the audit quality and the company's financial statement quality, the capital market will show a relatively negative stock price response.

Furthermore, unlike a general change in signing auditors, the ad hoc characteristic is obviously an important feature of last-minute changes. When audit work that is already scheduled or even partially completed is suddenly interrupted, the unexpected nature of this event makes it more likely to attract investors' attention and to affect their decision-making (Rosa and Durand, 2008). Moreover, as people are usually more sensitive to negative information (Cianci and Falsetta, 2008), in the case of last-minute changes, external investors will not only attach importance to this unexpected information but also have a corresponding sense of crisis, which will aggravate their doubts about the quality of future financial statements and elicit a negative market response.

In addition to the fact that unexpected events are more likely to trigger pessimistic investor sentiment, last-minute changes may have a substantive negative impact on audit efficiency and financial statement quality. According to Chinese auditing standards and their application guidelines, the engagement partners and other key members should participate in the audit work from the planned audit work and maintain attention to the auditee's environment, risks and other issues. However, in the context of a last-minute change, the auditor's knowledge accumulation is interrupted. At the time of the handover, the newly appointed auditors may be unfamiliar with the auditee's environment and risks and may even have missed a large amount of audit evidence collection work. In general, successors lacking client-specific knowledge will have difficulty detecting errors in financial statements, which leads to lower audit quality and even increases the risk of audit failure (AICPA, 1992; Chi and Huang, 2005; Wu and Zheng, 2015). All of these effects are detrimental to investors' interests. Furthermore, due to their lack of auditee-specific experience and knowledge, new auditors not only have start-up costs (DeAngelo, 1981) but they also need to implement more substantive procedures (AICPA, 1978; Petty and Cuganesan, 1996), which means that they need to invest more time, human, and material resources in the audit. However, last-minute changes are often accompanied by tight deadlines. In such cases,

insufficient time and the urgency due to the interim appointment will increase the pressure on the new auditors. Accordingly, it will be hard to guarantee the audit quality. In summary, last-minute changes are likely to result in substantial damage to the quality of the audit work, and even impair the quality of financial statements. Under such circumstances, external investors may give negative market feedback.

Currently, China's audit market remains fragmented, with fierce competition among accounting firms (Wu et al., 2018), and clients tend to occupy a dominant position in contractual relationships. Therefore, if the auditee and the signing auditors disagree on key audit matters and audit adjustments, the accounting firm may make certain concessions to retain the client such as reassigning signing auditors whose views are more "consistent" with those of the client to continue to fulfill the engagement (PCAOB, 2011; Chen et al., 2016). Based on this potential reality, when external investors observe last-minute changes, they could interpret this event as the accounting firm making compromises, and thus doubt the independence of the new auditors. As a result, out of concern for the quality of the audit and financial statements, as well as a rational response to this danger signal, investors could sell their shares, thus eliciting a negative market response.

In summary, the above theoretical analysis shows that last-minute changes contain important information and affect external investors' perceptions of financial statement quality. However, there are no studies testing this relationship. Therefore, using change announcement data and the event study method, we empirically test and systematically analyze whether external investors perceive the potential impact of last-minute changes in auditors in a timely manner and give reasonable feedback.

5. Sample and research design

5.1. Sample construction

The data on last-minute changes used in this study is from the CNINFO website (https://www.cninfo.com.cn/new/index). We collect the announcements of changes in signing auditors issued by A-share listed companies on the SHSE and SZSE and extract the basic information on the event, such as the stock code, the announcement time, and the names of the original signing auditors and their successors. We begin the sample of change announcements in October 2020 (the first announcement) and end in December 2022. We drop observations with missing values for the main variables and observations with less than 120 trading days. Our final sample includes 680 events.

Other financial data and stock price information of listed companies are mainly taken from the China Stock Market and Accounting Research database and Wind database. All of the continuous variables are winsorized at the 1st and 99th percentiles.

5.2. Event study method

This study uses the event study method to examine the impact of last-minute changes on stock prices, and then analyzes the heterogeneity of the stock price effect based on the different characteristics of the event, the audited firm, and the accounting firm.

We use the cumulative abnormal return (CAR) around the date of the signing auditor change announcement ($t = 0$) to measure the market response to last-minute changes. Following Wu and Zhang (2014), the market model is used to calculate CAR. Specifically, we take the announcement date as the event date, and select the period from 260 trading days to 11 trading days prior to the event date as the window for estimating the firm's normal stock return. We calculate the CAR for five windows, namely [0, +1], [0, +2], [0, +3], [−1, +1], and [−1, +2]. When CAR is less than 0, a smaller value indicates a more negative effect of last-minute changes on stock prices. The specific calculation steps are as follows.

First, we calculate the expected normal returns based on the following market model:

$$R_{i,t} = \alpha_i + \beta_i R_{m,t} + \varepsilon \tag{1}$$

where i represents the listed company's stock, t represents the trading day, $R_{i,t}$ is the stock return considering reinvestment of cash dividends, $R_{m,t}$ is the market return considering reinvestment of cash dividends, and α_i and β_i are the regression coefficients of the corresponding stocks.

Then, we calculate the abnormal return $AR_{i,t}$ for stock i on trading day t as follows:

$$AR_{i,t} = R_{i,t} - \left(\widehat{\alpha_i} + \widehat{\beta_i} R_{m,t}\right) \tag{2}$$

The CAR of stock i during the window period t_1 to t_2 is

$$CAR_{[t_1,t_2]} = \sum\nolimits_{t_1}^{t_2} AR_t \tag{3}$$

In this study, we examine whether CAR deviates from 0 under each event window to determine whether last-minute changes elicit significant market responses.

5.3. Research design

In Section 6, we analyze the heterogeneity of the effect on stock prices due to different characteristics of the events, audited firms, and accounting firms. Following Wu and Zhang (2014) and Chen et al. (2018), we construct the following regression model:

$$CAR_{i,[0,+1]} = \alpha_0 + \alpha_1 NCPA_i + \alpha_2 Time_i + \theta Control_{i,t-1} + \varepsilon \tag{4}$$

$$CAR_{i,[0,+1]} = \beta_0 + \beta_1 Manchange_i + \beta_2 Violate_i + \beta_3 ACC_{i,t-1} + \beta_4 Complexity_{i,t-1} + \beta_5 DA_{i,t-1} + \beta_6 Risk_{i,t-1} + \theta Control_{i,t-1} + \varepsilon \tag{5}$$

$$CAR_{i,[0,+1]} = \gamma_0 + \gamma_1 AFfirst_{i,t} + \gamma_2 AFspec_{i,t-1} + \gamma_3 AFpunish_i + \theta Control_{i,t-1} + \varepsilon \tag{6}$$

where the dependent variable is the market response to the last-minute change, i.e., CAR around the change announcement date. Model (4) corresponds to the heterogeneity analysis at the event level, and the independent variables include the number of signing auditors changed ($NCPA$) and the time of change ($Time$). Models (5) and (6) examine the market response under different company characteristics and different accounting firm characteristics, respectively.

In terms of control variables, as factors such as company characteristics and market characteristics may have an impact on market responses, we follow Chen et al. (2018) and He et al. (2022) and control for a series of variables, including firm size ($Size$), financial leverage (Lev), and stock volatility ($Stdret$). We also include year and listing sector fixed effects in the regression. Moreover, following Wu and Zhang (2014) and Chen et al. (2018), as the sample is small and more than half of the companies are in the manufacturing sector, a manufacturing dummy variable ($Manuf$) is set to control the difference between manufacturing companies and companies in other industries. The variable definitions are provided in Table 1.

6. Empirical results

6.1. Descriptive statistics

As shown in Table 2, the mean value of $CAR_{[0,+1]}$ is −0.40 %, indicating that the CAR around the change announcement date is less than 0, which provides preliminary evidence that external investors respond negatively to last-minute changes. The mean value of $Time$ is 0.88, indicating that most last-minute changes occur in December or later, and that relatively late changes may hold hidden dangers that impair financial statement quality.

6.2. Market response to the announcement of a change in signing auditors

We calculate CAR for the [−4, +4] window surrounding the change announcement. As shown in Fig. 2., CAR for [−4, −1] trading days before the announcement is positive and the overall trend is relatively flat. However, during the [−1, +2] window, CAR falls sharply, indicating that external investors identify the information contained in the change announcement and perceive that last-minute changes may have a negative

Table 1
Variable definitions.

Variable	Definition
CAR	Cumulative abnormal stock returns around the signing auditor change announcements. The market model is used in the calculation.
NCPA	The number of signing auditors changed.
Time	Taking December 1 of the financial year of the focal annual report as the cut-off date, if the announcement date is earlier than December 1 (i.e., May 1 to November 30 of that year), auditors are changed relatively early in the process, and *Time* equals 0. If the announcement date is between December 1 of the current year and April 30 of the next year, *Time* equals 1, indicating that the change in auditors is relatively late.
Manchange	Equals 1 if the company changes its CEO or chairman of the board in the 30 days before the announcement date, and 0 otherwise.
Violate	Equals 1 if a company violation event is announced in the 30 days before the change announcement date, and 0 otherwise.
ACC	Following Mei and Gao (2016), accounting conservatism is calculated with the ACF model.
Complexity	(Account receivables + inventories)/total assets.
DA	Earnings management level in the company financial statements, measured as the absolute residuals from the modified Jones model (Dechow et al., 1995).
Risk	The volatility of the return on assets calculated over the period from year *t*-2 to year *t*.
AFfirst	Equals 1 if the accounting firm is conducting the annual report audit of the company for the first time, and 0 otherwise.
AFspec	Following Zhou et al. (2020), the market share of audit fees is calculated annually by industry. If the market share of the accounting firm in a specific industry in that year exceeds 10 %, the accounting firm is recognized as having industry expertise and *AFspec* equals 1, and 0 otherwise.
AFpunish	Equals 1 if the accounting firm is relatively severely punished by regulators (in the form of fines, confiscation of illegal income, cancellation of business license, or market entry ban) in the 30 days before the change announcement, and 0 otherwise.
Size	The natural logarithm of the company's total assets at the end of the year.
Lev	The ratio of debt to total assets at the end of the year.
ROA	The ratio of earnings to total assets at the end of the year.
Ins	The shareholding ratio of institutional investors.
Top1	The shareholding ratio of the largest shareholder.
Agelist	The natural logarithm of the number of years since a company's IPO.
Stdret	Stock return volatility for the 240 trading days before the announcement date.
State	Equals 1 if the company is state-owned, and 0 otherwise.
Dual	Equals 1 if the CEO is also the chairman of the board, and 0 otherwise.
Big4	Equals 1 if the accounting firm is a Big4 firm, and 0 otherwise.
Manuf	Equals 1 if company is in the manufacturing industry, and 0 otherwise.

impact on their interests. Thus, investors make a degree of reverse correction to original positive expectations. It is not until the third trading day after the announcement that *CAR* rebounds.

In addition, we conduct a *t*-test to examine whether *CAR* is different from 0. As shown in Table 3, in five windows, namely [0, +1], [0, +2], [0, +3], [−1, +1], [−1, +2], the values of *CAR* are all less than 0, and the *t*-test results show that all of the values are significant and negative. This indicates that external investors have significant negative reactions to last-minute changes, which elicit a negative stock price effect. However, the value of *CAR* for each window is maintained between −0.40 % and −0.64 %. In this respect, we posit that as the stock exchanges' disclosure guidelines have been implemented relatively recently, company disclosure and regulation of last-minute changes is still insufficient. Accordingly, although investors respond to announcements of such changes negatively, the overall market response is weak, and investors' understanding of and attention to this behavior needs to be enhanced.

6.3. Market responses to last-minute changes under different situational characteristics

The above results show that capital markets generally respond negatively to last-minute changes. At the same time, whether different characteristics affect external investors' perceptions of last-minute changes is an important issue. Therefore, we examine the heterogeneity of market responses due to different event, company, accounting firm, and individual signing auditor characteristics.

Table 2
Descriptive statistics.

Variable	N	Mean	SD	P25	Median	P75
$CAR_{[0,+1]}$	680	−0.004	0.036	−0.025	−0.004	0.014
NCPA	680	1.216	0.443	1.000	1.000	1.000
Time	680	0.882	0.322	1.000	1.000	1.000
Manchange	680	0.026	0.161	0.000	0.000	0.000
Violate	680	0.031	0.173	0.000	0.000	0.000
ACC	578	−0.463	2.373	−1.128	−0.625	−0.081
Complexity	657	0.261	0.149	0.146	0.251	0.346
DA	601	0.065	0.069	0.020	0.043	0.084
Risk	680	0.046	0.074	0.009	0.019	0.049
AFfirst	680	0.082	0.275	0.000	0.000	0.000
AFspec	680	0.346	0.476	0.000	0.000	1.000
AFpunish	680	0.050	0.218	0.000	0.000	0.000
Size	680	22.157	1.310	21.199	21.973	22.882
Lev	680	0.411	0.204	0.247	0.404	0.554
ROA	680	0.033	0.095	0.016	0.039	0.074
Ins	680	41.627	25.818	18.255	42.731	61.659
Top1	680	32.841	14.736	21.780	30.675	41.695
Agelist	680	1.969	1.025	1.386	2.197	2.890
Stdret	680	0.030	0.008	0.024	0.029	0.035
State	680	0.271	0.445	0.000	0.000	1.000
Dual	680	0.354	0.479	0.000	0.000	1.000
Big4	680	0.076	0.266	0.000	0.000	0.000
Manuf	680	0.718	0.451	0.000	1.000	1.000

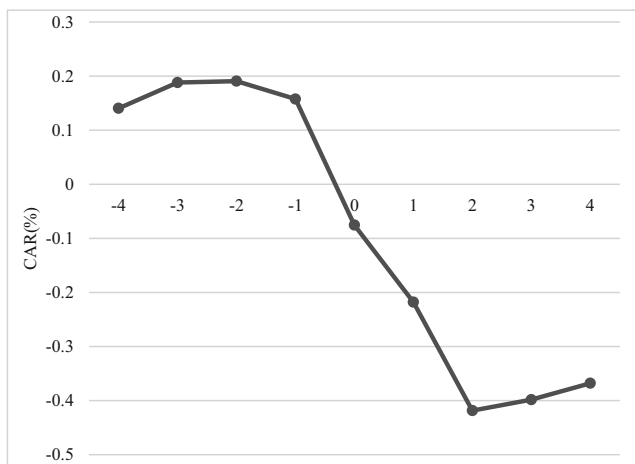

Fig. 2. Cumulative abnormal returns (CAR) for the [−4, +4] window.
Note: The graph presents *CAR* for the [−4, +4] window surrounding the change announcement. The y-axis represents the value of *CAR*, and the x-axis represents the number of days around the change announcement.

6.3.1. Event characteristics

Both the number of auditors changed and the time of the change are disclosed in change announcements, so these change characteristics can be directly observed by external investors. A change in auditor may indicate problems such as impaired auditor independence and a decline in earnings quality (Chen et al., 2016). Especially in the case of last-minute changes, new signing auditors could be unfamiliar with the engagement, and their independence may be doubted by stakeholders. Accordingly, a mass withdrawal of the original team, for example, if both the engagement partner and engagement manager are replaced or the original two engage-

Table 3
Market responses to last-minute changes: Baseline results.

Window	*CAR*(%)	T-test	N
[0, +1]	−0.40***	−2.84	680
[0, +2]	−0.63***	−3.64	680
[0, +3]	−0.62***	−2.88	680
[−1, +1]	−0.42**	−2.34	680
[−1, +2]	−0.64***	−3.13	680

Note: Statistical significance is indicated as follows: ***p < 0.01, **p < 0.05, and *p < 0.1.

ment managers are changed at the same time, may aggravate external investors' doubts about audit quality and final financial statement quality, and thus elicits a strong negative market response.

Similarly, if the change occurs late in the fiscal year, the interim appointment of a new auditor appears hasty. Both the new auditor's unfamiliarity with the auditees' risk environment and the tension created by limited follow-up time could weaken audit quality. Furthermore, a late change may imply that the company's reasons for making the change are not justified, and may delay the disclosure of the annual report, leading to a significant impairment in audit quality (Wu and Shu, 2006; Schwartz and Soo, 1996), and eventually damage to financial statement quality. To capture the variations in market responses due to different change times more intuitively, we set the following conditions. In general, an audit team enters the company at the beginning of December. Therefore, December 1 is set as the cut-off date defining last-minute changes. If the auditor change occurs before December (May 1 to November 30 of the fiscal year), it is considered an early change, and we expect its negative impact to be relatively small. Changes between December 1 and April 30 of the following year create greater time pressure and are considered late changes. The late appointment of new auditors will make external investors more anxious and elicits a more negative market response than an early change.

To test the above conjecture, we estimate the regression specified in Model (4). The results reported in Table 4 show that the coefficients on the number of auditors changed (*NCPA*) and the time of the change (*Time*) are significant and negative, suggesting that changing more than one auditor and changing auditors late in the audit process both aggravate external investors' doubts about the quality of financial statements, and thus result in a negative stock price effect.

6.3.2. Company characteristics

At the company level, we consider six factors: changes in key executives (chairman and CEO), corporate violations, accounting conservatism, engagement complexity, financial statement quality, and operational risk. Specifically, companies with higher accounting conservatism reflect bad news in accounting information more quickly, helping to reduce information asymmetry, protect shareholder interests, and increase firm value (LaFond and Watts, 2008). As external investors recognize the value of accounting conservatism, if such firms change their signing auditors, external investors may still trust the quality of the firm's future financial statements, alleviating the negative effect of last-minute changes on investors' attitudes. In contrast, if a firm has poor financial statement quality, investors may perceive the likelihood of manipulation as high and may be more sensitive to an auditor change, resulting in a more negative response to last-minute changes.

In addition, higher operational risks and engagement complexity tend to create greater risks and difficulties for auditors (Bedard and Johnstone, 2004; Zhao and Zhou, 2013). New signing auditors appointed at the last minute could find it difficult to fully grasp client-specific knowledge and to implement sufficient audit procedures in a timely manner. In this situation, external investors may predict a decline in financial statement quality and decide to withdraw from the investment.

Apart from these inherent characteristics, we also consider whether negative news such as being recently found guilty of violations or a change in key executives exacerbates the negative sentiment of external investors toward last-minute changes. Moreover, the appointment of new executives is often accompanied by earnings management activities (Lin et al., 2013), and corporate violations also include numerous situations that directly harm shareholder interests, such as fictitious profits, false records, and insider trading. In this case,

Table 4
Effects of event characteristics on market responses to last-minute changes.

	Dep. Var. = $CAR_{[0,+1]}$
NCPA	−0.005*
	(−1.68)
Time	−0.009*
	(−1.95)
Size	0.003**
	(2.10)
Lev	−0.010
	(−1.08)
ROA	0.050***
	(2.89)
Ins	−0.000***
	(−2.78)
Top1	0.000
	(1.27)
Agelist	0.004**
	(2.30)
Stdret	−0.193
	(−0.86)
State	0.005
	(1.48)
Dual	0.007**
	(2.09)
Big4	−0.006
	(−1.37)
Manuf	0.001
	(0.17)
Constant	−0.053*
	(−1.66)
Year FE	Yes
Listing sector FE	Yes
Observations	680
R-squared	0.067

Note: The t-statistics of robust standard errors clustered at the company level are reported in parentheses. Statistical significance is indicated as follows: ***p < 0.01, **p < 0.05, and *p < 0.1.

external investors may associate an auditor change with negative news, and even evaluate the auditor change as further evidence that current executives are manipulating financial statements or hiding bad news, which will exacerbate the negative market response to the change event.

To test the above conjecture, we run the regression specified in Model (5). Table 5 reports the results. The coefficients on recent corporate violations (*Violate*), key executive changes (*Manchange*), and accounting conservatism (*ACC*) all pass the significance test. The results suggest that if a listed company has high accounting conservatism, external investors may be more tolerant due to their long-term trust in the company, which alleviates the negative response to last-minute changes. In contrast, for companies that have recently been found guilty of violations or that have changed key executives, the accumulation of negative news could aggregate market participants' doubts about the future quality of firm information, thus eliciting a more negative response to last-minute changes.

In addition, the coefficients on the remaining three independent variables, namely engagement complexity (*Complexity*), financial statement quality (*DA*), and operational risk (*Risk*), are not significant, but the signs of the coefficients are consistent with our expectations. These results may indicate that information on changes in key executives, corporate violations, and accounting policy choices is more easily available to external stakeholders, and the capital market can quickly obtain and incorporate such information into judgments about the change event. In contrast, operational risk and financial statement manipulation in the form of earnings management may be difficult for investors to observe directly, leading to a lack of knowledge about such characteristics and nonsignificant cross-sectional differences.

Table 5
Effects of company characteristics on market responses to last-minute changes.

	Dep. Var. = $CAR_{[0,+1]}$
Manchange	−0.016**
	(−2.02)
Violate	−0.013*
	(−1.68)
ACC	0.001*
	(1.86)
Complexity	−0.014
	(−1.27)
DA	−0.003
	(−0.13)
Risk	−0.030
	(−0.97)
Size	0.002
	(1.26)
Lev	−0.004
	(−0.41)
ROA	0.021
	(0.92)
Ins	−0.000**
	(−2.29)
Top1	0.000
	(0.85)
Agelist	−0.001
	(−0.37)
Stdret	−0.233
	(−0.94)
State	0.008**
	(2.00)
Dual	0.002
	(0.44)
Big4	−0.004
	(−0.77)
Manuf	0.003
	(0.90)
Constant	−0.032
	(−0.89)
Year FE	Yes
Listing sector FE	Yes
Observations	556
R-squared	0.062

Note: The t-statistics of robust standard errors clustered at the company level are reported in parentheses. Statistical significance is indicated as follows: ***p < 0.01, **p < 0.05, and *p < 0.1.

6.3.3. Accounting firm characteristics

At the accounting firm level, we consider three characteristics: industry specialization, recent punishment, and length of relationship with the company. In general, industry specialization indicates that the accounting firm produces higher quality audits within a specific industry (Liu et al., 2010; Reichelt and Wang, 2010), which enhances disclosure (Dunn and Mayhew, 2004) and provides more reliable financial statement information. Therefore, if listed companies employ accounting firms with industry expertise in a given year, external investors may believe that an audit team appointed at the last minute can still obtain support in the form of resources and industry experience from their accounting firms, which will provide a certain level of assurance of audit quality and financial statement quality. In this case, investors may be less concerned about last-minute changes due to their trust in the accounting firm, and the negative market response to the change announcement will be mitigated.

In contrast, if an accounting firm is auditing a company for the first time, both the signing auditors and the audit team may not have sufficient specific knowledge about the auditee, due to high information asymmetry (DeAngelo, 1981; Wang et al., 2016a). In this scenario, the interim replacement of signing auditors would further hinder or even disrupt the connection and cooperation established between the original signing auditors and the auditees. The audit quality could be difficult to guarantee. When investors perceive that the quality of a firm's future financial statements may be impaired, their negative response will be shown in the capital market.

In addition, if the accounting firm has recently been subject to a serious punishment from regulators (such as fines, confiscation of illegal income, revocation of business licenses, or market bans), the signal effect of the punishment may not only damage the accounting firm's reputation but may even reduce market participants' trust in the accounting firm. In this case, investors' doubts about the accounting firm will be transferred to the listed company, which will increase their suspicions about the reasons for last-minute changes and trigger a negative stock price response.

Based on the above analysis, we estimate Model (6), and the regression results are reported in Table 6. We find that the coefficient on first-time audit (*AFfirst*) is significant and negative, and the coefficient on industry

Table 6
Effects of accounting firm characteristics on market responses to last-minute changes.

	Dep. Var. = $CAR_{[0,+1]}$
AFfirst	−0.009*
	(−1.81)
AFspec	0.006**
	(1.97)
AFpunish	−0.007
	(−0.87)
Size	0.003*
	(1.75)
Lev	−0.008
	(−0.88)
ROA	0.045***
	(2.60)
Ins	−0.000***
	(−2.74)
Top1	0.000
	(1.17)
Agelist	0.004**
	(2.45)
Stdret	−0.195
	(−0.89)
State	0.006*
	(1.67)
Dual	0.006**
	(2.02)
Big4	−0.002
	(−0.60)
Manuf	0.000
	(0.02)
Constant	−0.058*
	(−1.84)
Year FE	Yes
Listing sector FE	Yes
Observations	680
R-squared	0.070

Note: The t-statistics of robust standard errors clustered at the company level are reported in parentheses. Statistical significance is indicated as follows: ***p < 0.01, **p < 0.05, and *p < 0.1.

expertise (*AFspec*) is significant and positive, which is consistent with the above analysis. The results imply that the market response is more negative if the accounting firm is auditing the auditee for the first time than if the relationship is established, while auditors' industry expertise alleviates the negative attitude of investors toward last-minute changes. In addition, although *AFpunish* fails the significance test, the sign of its corresponding coefficient is still negative, which is consistent with our expectation.

6.3.4. Signing auditor characteristics

After a change announcement, external investors can form preliminary judgments about the last-minute change based on the characteristics of the event, the audited company, and the accounting firm. However, external investors' assessments of the event are obviously not limited to this information. The motivation for a sudden change in signing auditor is also related to the quality of the firm's future financial statements. In general, accounting firms need to consider the signing auditors' personal characteristics when adjusting personnel arrangements. Therefore, external investors may be able to use information about the original and succeeding auditors to make a more in-depth analysis of the context and reasons for the change event, with corresponding variability in market feedback. Extending this line of thought, we comprehensively consider investors' perspectives of the potential motivations for last-minute changes and the market responses to these different motivations.

(1) Effects of signing auditors' busyness on market responses

For investors, workload is obviously a relevant characteristic of a signing auditor, and it is also an important factor in the work arrangements of accounting firms. If the original signing auditors are initially assigned too much audit engagement work, the heavy workload reduces the prudence of audit decisions and may even result in low audit quality (Zhang and Pan, 2018; Yan et al., 2020). In such cases, to ensure audit efficiency, accounting firms may adjust the original work arrangements to appropriately reduce the workload of busy auditors by assigning auditors with less work to some of the busy auditors' engagements, resulting in last-minute changes.

Thus, when external investors observe a change from a busy signing auditor to one with a lighter workload, the investors may presume that the succeeding auditor has more time and will make more effort to ensure audit quality. Accordingly, the original negative attitude of external investors toward the change could be alleviated. In contrast, if the original signing auditors are replaced by busier auditors, the workload pressure of the succeeding auditors will increase, and investors may become more anxious about the auditee's financial statement quality, resulting in increased negative market feedback.

To verify the above conjecture, we use the signing auditor data disclosed in the renewal or switching announcements for each company in each year to calculate the total assets of all the audit engagements that each auditor is originally scheduled to complete, which is used to measure the original workload of each signing auditor. Next, we calculate the average workload of all the original signing auditors of the company and the average workload of all the succeeding signing auditors. If the average workload of the succeeding auditor in a change event is lower than the average workload of original signing auditor, the event will be classified in the "Busyness of signing auditors decreases" subsample, otherwise it will be classified in the "Busyness of signing auditors increases or remains constant" subsample.[3] We conduct t-tests on the *CAR* of the two subsamples. The results in columns 1 and 2 of Table 7 show that only a small number of the events are cases in which low workload auditors are replaced by busier auditors, and the corresponding market response to these changes is −0.94 %, which is significantly lower than 0. In contrast, the *CAR* of the reduced busyness subsam-

[3] For example, if the signing auditors of company *i* change from A and B to C and D. The total assets of companies that auditor A is originally scheduled to audit is 500, i.e., the original workload of A is 500. And the original workload of B, C, and D is 300, 200, and 100 respectively. Then, the average workload of the original signing auditors (A and B) is 400 ((500+300)/2), and the average workload of the succeeding signing auditors (C and D) is 150 ((200+100)/2). Obviously, the workload of the original signing auditors is higher (4 0 0>150), so this change event of company *i* should be included in the "Busyness of signing auditors decreases" subsample.

Table 7
Market responses to changes in signing auditors' busyness.

	Busyness of signing auditors increases or remains constant	Busyness of signing auditors decreases	Busyness of signing auditors decreases and late change time
	(1)	(2)	(3)
$CAR_{[0,\ +1]}$ (%)	−0.94***	−0.25	−0.30*
T-test	−3.15	−1.60	−1.77
N	143	537	479

Note: Statistical significance is indicated as follows: ***p < 0.01, **p < 0.05, and *p < 0.1.

ple, shown in column 2, is only −0.25 % and fails the significance test. This suggests that although external investors still have negative attitudes toward last-minute changes, these are partially alleviated if the change means that less busy auditors are assigned, which can help to guarantee audit quality.

Admittedly, the sample sizes in the analyses presented in columns 1 and 2 show that, in most cases, accounting firms reassign auditors with lower workloads to take over engagements at the last minute, but this does not mean that the negative impact of last-minute changes can be completely mitigated. Moreover, a change event is not assessed by a single characteristic, and investors' judgements may change when they simultaneously observe multiple characteristics from different perspectives. Among the observable characteristics of last-minute changes, the time of the change is always a key feature, and late changes can be a significant threat to financial statement quality. Therefore, considering the auditors' workload in conjunction with the time of the change, we posit that even if the succeeding auditors face low workload pressure, if the remaining audit time is limited, the time constraint still has a direct and negative impact on the work. Accordingly, if the time is insufficient, the stock price may still decline.

To test the above conjecture, we create a subsample of events in which the change time is late ($Time = 1$) and the original auditors are replaced by auditors with lighter workloads and conduct a *t*-test on the *CAR* of this subsample. Column 3 in Table 7 shows that the market response is −0.30 %, which is not only lower than the *CAR* of the "Busyness of signing auditors decreases" subsample in column 2 but also significantly different from 0. This suggests that although signing auditors with lighter workloads are able to gain the trust of investors by virtue of their abundant work time, a late change is still perceived as a threat to financial statement quality, as shown in the lower and significantly negative market reactions in column 3.

(2) Effects of signing auditors' industry experience on market responses

In addition to workload, the professional competence of the signing auditors is an important factor in accounting firms' work arrangements. If the original auditors leave or retire for personal reasons during the audit period, or the engagement is so difficult that the auditors voluntarily resign, the accounting firm needs to reassign another auditor for the auditee. In this case, if the accounting firm dispatches an auditor with more industry experience than the departing auditor, the new experienced auditor can effectively inhibit earnings management activities and provide better assurance of financial statement quality than the auditor with less industry experience (Wang et al., 2016b); thus, investors may have greater confidence in a successor with industry experience and the negative market response to the last-minute change will be moderated. In contrast, if investors observe that the original signing auditors are replaced by auditors with less industry experience, they could be more anxious about financial statement quality, and their negative response would be stronger.

To verify the above conjecture, following Yan et al. (2019), we measure the industry experience of an auditor as the total assets of all the listed companies audited by the auditor in a certain industry before the focal year. Then, we calculate the average industry experience of all the original auditors of the company and the average industry experience of the succeeding auditors. If the average experience of the succeeding auditors is higher than the original auditors, the event is categorized into the "Industry experience of signing auditors increases" subsample, otherwise it is classified into the "Industry experience of signing auditors decreases

or remains constant" subsample.[4] We conduct a *t*-test to compare the market responses of the two subsamples, and the results are shown in columns 1 and 2 of Table 8. In all 680 change events, most succeeding auditors have less industry experience than the original auditors, and the market response is −0.40 %, which is significantly lower than 0. In contrast, in only 152 change events are the original auditors replaced by auditors with more industry experience, and the corresponding *CAR* is −0.39 %, which fails to pass the significance test. In summary, the comparison of columns 1 and 2 suggests that investors can extract information about the relative experience of the signing auditors, and then produce a reasonable market response.

At the same time, as in the analysis of busyness, the time of the change is an important factor affecting the work quality of the succeeding signing auditors. Although an auditor's industry experience could enhance investors' confidence in audit quality, it is difficult to guarantee financial statement quality if the succeeding auditors have limited time. In this case, the external investors' judgments may comprehensively weigh the benefits and risks of both industry experience and time of change, and the market feedback will have varying intensity depending on the relative weights.

To test the above conjecture, we identify the events in which the change time is late (*Time* = 1) and the original auditors are replaced by auditors with more industry experience and conduct a *t*-test on the *CAR* of this subsample. The results in column 3 show that the market response is −0.41 % when the auditors' industry experience increases but the change time is late. Although it does not pass the significance test, the value is lower than the results in column 2, suggesting that while experienced auditors can win some "favors" from investors, late changes undoubtedly make investors anxious about audit quality, which in turn elicits a more negative market response.

(3) Market response to the "abnormal" assignment of signing auditors

As discussed above, if an accounting firm decides to change auditors because the original signing auditors have heavy workloads or insufficient professional experience, the accounting firm should prioritize guaranteeing work efficiency and safeguarding audit quality when reassigning successors by appointing auditors with lighter workloads or more industry experience. Then, investors may adopt a positive attitude toward the change event, believing that the accounting firm has reasonable motives for changing auditors at the last minute.

In contrast, if external investors observe that the successors have higher workloads or less industry experience than the original auditors, they may believe that the accounting firm has not made sufficient effort in personnel arrangements. In this case, the last-minute change may even be interpreted as abnormal behavior and linked to the purchase of an audit opinion by the auditee. Such speculation could aggregate investors' doubts about financial statement quality, and thus elicits a more negative market response.

To test the above conjecture, we identify the abnormal events in which the original auditors are replaced by auditors with heavier workloads and less industry experience and rerun the test on this subsample. The results in Table 9 show that *CAR* is −1.08 %, which is lower than the *CAR* values of all of the subsamples in Tables 7 and 8. This suggests that external investors make judgments based on the characteristics of the auditor reassignment.

7. Further analyses

Based on the results of the above analyses, last-minute changes may indicate problems in the audit process such as a lack of specific knowledge about the auditee, insufficient remaining audit time, and questionable audit independence. Accordingly, investors may have concerns about financial statement quality, which may be reflected in a negative market response. Thus, a new question naturally arises: Is the quality of com-

[4] For example, if the signing auditors of company *i* change from A and B to C and D. The industry experience of A, B, C, and D is 200, 100, 500, and 300 respectively. Then, the average industry experience of the original signing auditors (A and B) is 150 ((200+100)/2), and the average industry experience of the subsequent signing auditors (C and D) is 400 ((500+300)/2). Obviously, the succeeding signing auditors are more experienced in the industry, so this change event of company *i* should be included in the "Industry experience of signing auditors increases" subsample.

Table 8
Market responses to changes in signing auditors' industry experience.

	Industry experience of signing auditors decreases or remains constant	Industry experience of signing auditors increases	Industry experience of signing auditors increases and late change time
	(1)	(2)	(3)
$CAR_{[0,\ +1]}$(%)	−0.40**	−0.39	−0.41
T-test	−2.49	−1.35	−1.28
N	528	152	131

Note: Statistical significance is indicated as follows: ***p < 0.01, **p < 0.05, and *p < 0.1.

panies' financial statements significantly damaged by last-minute changes? Testing this question is not only a further validation of the logic of the above analyses but also an aid in determining whether the negative market feedback given by external investors is reasonable.

In the case of last-minute changes, the newly appointed signing auditors do not fully know the environment and risks of the auditees and have missed much of the audit evidence collection work. Due to their lack of specific knowledge about the client, the succeeding auditors have start-up costs (DeAngelo, 1981), and need to implement substantive procedures (AICPA, 1978; Petty and Cuganesan, 1996), which require time, staff, and resources. In this situation, if the new auditors fail to implement sufficient and effective audit procedures due to time constraints or inadequate preparation, it may be difficult for them to find and correct errors in the financial statements in a timely manner, ultimately impairing the quality of the audited financial statements.

We also make the following hypothesis. If the motivation for a last-minute change is to improve audit quality, the accounting firm will fully consider factors such as engagement complexity, auditors' industry experience and workload, and the need to coordinate audit resources and work arrangements. Then it will reassign suitable auditors for the engagement. Under these conditions, audit quality and financial statement quality would be guaranteed or even improved. Based on the above conjectures, we empirically test the impact of last-minute changes on financial statement quality.

Unlike the previous tests of market responses, we explore the quality of the financial statements of companies with last-minute changes in signing auditors in this section. First, we need to collect data on final annual reports to measure and compare the quality of companies' financial statements. We collect financial statement data from A-share listed firms on the SHSE and SZSE for the 2020–2022 period. After dropping firms in the financial industry, firms with abnormal listing status (ST, *ST and PT), and firms lacking necessary data, our final sample consists of 11,216 firm-year observations.[5] All of the continuous variables are winsorized at the 1st and 99th percentiles. We estimate the effect of last-minute changes using the following regression:

$$DA_{i,t} = \alpha_0 + \alpha_1 LZHS_{i,t} + \gamma ControlDA_{i,t} + \varepsilon \tag{7}$$

where *DA* is the quality of financial statements, measured as the absolute magnitude of abnormal accruals, following Dechow et al. (1995). *LZHS* is an indicator variable for last-minute changes. Specifically, if the signing auditor information disclosed in the renewal or switching announcement is inconsistent with that disclosed in the annual report, indicating that the auditor(s) has been changed at the last minute, *LZHS* equals 1, and 0 otherwise. *ControlDA* represents a vector of control variables, including firm size (*Size*), revenue growth rate

[5] As the test of market responses requires specific observable events, the change announcement data are used in the estimation in the previous analyses. As the test of financial statement quality requires final annual report data, the sample used here consists of annual report data. The financial statement quality of all firms with last-minute changes (including the firms that issued change announcements and those that did not issue change announcements) is compared with that of the other firms. Meanwhile, in an untabulated test, we compare the subsample of firms that made last-minute changes and issued change announcements with the subsample of firms that made last-minute changes and did not issue change announcements. We find that there are no significant differences in the key characteristics of firms in the two subsamples. Therefore, both the change announcement sample and the annual reports sample can be used to explore the effects of last-minute changes. The change in sample does not affect the reliability of our conclusions.

Table 9
Market responses to abnormal reassignments of signing auditors.

	Industry experience of signing auditors decreases and busyness level increases
$CAR_{[0,\ +1]}$(%)	−1.08**
T-test	−2.24
N	71

Note: Statistical significance is indicated as follows: ***p < 0.01, **p < 0.05, and *p < 0.1.

(*Growth*), current ratio (*Liq*), ratio of net cash flow from operating activities to total assets (*OCF*), audit opinion type (*Opinion*), accounting firm type (*Big10*), and profit position (*Loss*). Table 10 presents the results.

The coefficient on *LZHS* is significant and positive, implying that last-minute changes indeed impair financial statement quality. This further supports the above findings that investors make rational decisions based on information about the reassignment of the signing auditors.

8. Robustness checks

8.1. Sample data screening

To reduce the potential interference of unusual events, we drop change announcement events that occur within a [-2, +2] window of other major announcements.[6] We then conduct a *t*-test on the *CAR* of the new sample. Table 11 shows that the remaining change announcements still have a significant negative stock price effect, which is consistent with the baseline results.

8.2. Replacement of the stock return estimation model

Following Bian et al. (2021), we calculate the abnormal return and *CAR* around the change announcement using the Fama–French three-factor model. Compared with the market model, the Fama–French three-factor model adjusts the stock returns and market returns with risk-free returns and considers firm size and book-to-market equity ratio in the estimation. The results presented in Table 12 show that the market responses to last-minute changes calculated using the Fama–French three-factor model are still significant and negative. Our findings remain robust.

8.3. Time placebo test

Following Chen et al. (2022), to test whether the negative stock price effect identified in the baseline regression could be caused by factors such as time trends, we advance the time of the announcement by 20 and 30 days and recalculate the corresponding *CAR*. Table 13 presents the results. The *CAR*s for 20 days ahead are not overall significantly different from 0, and the *CAR*s for 30 days ahead are greater than 0 or significant and positive, contrary to the baseline results in Table 3. These findings suggest that the stock price decline shown in the baseline results is indeed due to the change announcement. Our findings remain robust.

8.4. PSM-OLS

To ensure the robustness of the conclusions in Section 7, we test the impact of last-minute changes on financial statement quality using the propensity score matching (PSM) scheme. Specifically, we match each firm

[6] Following Lu and Jiang (2023), major events are events such as issuance of regular reports, stock repurchase and private placement, right issue, convertible bond financing, mergers and acquisitions, litigation judgments, violations, donations, and equity pledge, etc.

Table 10
Effects of last-minute changes on financial statement quality.

	Dep. Var. = *DA*
LZHS	0.003**
	(1.99)
Size	−0.005***
	(−6.36)
Lev	0.011*
	(1.83)
ROA	−0.260***
	(−10.16)
Complexity	0.029***
	(4.70)
Growth	0.036***
	(11.82)
Agelist	−0.001
	(−1.32)
OCF	0.098***
	(4.82)
Liq	0.001***
	(2.84)
State	−0.006***
	(−3.70)
Big10	−0.004**
	(−2.32)
Opinion	−0.014***
	(−2.74)
Dual	−0.002
	(−1.46)
Loss	0.014***
	(5.63)
Constant	0.164***
	(9.34)
Year FE	Yes
Industry FE	Yes
Observations	11,216
R-squared	0.226

Note: The t-statistics of robust standard errors clustered at the company level are reported in parentheses. Statistical significance is indicated as follows: ***p < 0.01, **p < 0.05, and *p < 0.1.

Table 11
Market responses to last-minute changes: Excluding potentially confounding announcements.

Window	*CAR*(%)	T-test	N
[0, +1]	−0.38***	−2.62	594
[0, +2]	−0.54***	−2.97	594
[0, +3]	−0.51**	−2.28	594
[−1, +1]	−0.38**	−2.03	594
[−1, +2]	−0.54**	−2.49	594

Note: Statistical significance is indicated as follows: ***p < 0.01, **p < 0.05, and *p < 0.1.

that made a last-minute change with a control firm by adopting nearest neighbor matching, kernel matching, and Mahalanobis metric matching. The propensity score for each sample is estimated using the control variables in Model (7). The results in Table 14 show that after eliminating the differences in firm characteristics, the negative impact of last-minute changes on financial statement quality still exists. Our findings remain robust.

Table 12
Market responses to last-minute changes: Fama–French three-factor model.

Window	*CAR*(%)	T-test	N
[0, +1]	−0.30**	−2.24	680
[0, +2]	−0.42**	−2.65	680
[0, +3]	−0.37*	−1.87	680
[−1, +1]	−0.30*	−1.79	680
[−1, +2]	−0.41**	−2.17	680

Note: Statistical significance is indicated as follows: ***p < 0.01, **p < 0.05, and *p < 0.1.

Table 13
Market responses to last-minute changes: Placebo test.

Window	20 days advanced			30 days advanced		
	CAR(%)	T-test	N	*CAR*(%)	T-test	N
[0, +1]	0.04	0.26	680	0.24	1.53	680
[0, +2]	−0.02	−0.09	680	0.33	1.62	680
[0, +3]	0.14	0.66	680	0.43*	1.86	680
[−1, +1]	−0.11	−0.63	680	0.36*	1.84	680
[−1, +2]	−0.15	−0.73	680	0.43*	1.85	680

Note: Statistical significance is indicated as follows: ***p < 0.01, **p < 0.05, and *p < 0.1.

Table 14
Effects of last-minute changes on financial statement quality: PSM regression results.

	Dep. Var. = *DA*		
	Nearest neighbor matching	Kernel matching	Mahalanobis metric matching
	(1)	(2)	(3)
LZHS	0.003*	0.003*	0.005***
	(1.75)	(1.95)	(3.74)
Size	−0.004***	−0.005***	−0.005***
	(−3.85)	(−6.32)	(−6.02)
Lev	0.009	0.010*	0.016**
	(1.20)	(1.70)	(2.44)
ROA	−0.202***	−0.261***	−0.268***
	(−5.51)	(−10.19)	(−9.18)
Complexity	0.036***	0.029***	0.022***
	(4.31)	(4.79)	(3.42)
Growth	0.037***	0.036***	0.037***
	(8.83)	(11.86)	(10.81)
Agelist	−0.003*	−0.001	−0.002*
	(−1.96)	(−1.31)	(−1.90)
OCF	0.057**	0.099***	0.088***
	(2.03)	(4.84)	(3.92)
Liq	0.001**	0.001***	0.001**
	(2.09)	(2.82)	(2.26)
State	−0.006***	−0.006***	−0.006***
	(−3.03)	(−3.71)	(−3.52)
Big10	−0.005**	−0.004**	−0.005***
	(−2.09)	(−2.34)	(−2.85)
Opinion	−0.008	−0.013**	−0.012**
	(−1.14)	(−2.55)	(−2.29)

(*continued on next page*)

Table 14 (*continued*)

	Dep. Var. = *DA*		
	Nearest neighbor matching	Kernel matching	Mahalanobis metric matching
	(1)	(2)	(3)
Dual	−0.004**	−0.002	−0.002
	(−1.97)	(−1.42)	(−1.47)
Loss	0.020***	0.015***	0.012***
	(5.53)	(5.65)	(4.41)
Constant	0.137***	0.162***	0.176***
	(6.33)	(9.24)	(8.71)
Year FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
Observations	5,365	11,209	9,491
R-squared	0.216	0.226	0.238

Note: The t-statistics of robust standard errors clustered at the company level are reported in parentheses. Statistical significance is indicated as follows: ***p < 0.01, **p < 0.05, and *p < 0.1.

9. Conclusions and implications

Annual report auditing is a key activity for listed companies and accounting firms seeking to obtain public trust and protect the interests of investors. It is obvious that changes in the assignment of signing auditors have a direct impact on external stakeholders' perceptions of the quality of the audit and financial statements. In the context of new disclosure requirements of signing auditors in 2020 in China, we discover a new research scenario, namely last-minute changes in signing auditors. Based on this, we explore whether market investors perceive the potential impact of changes in signing auditor deployment and give corresponding reasonable market feedback.

Our findings show that last-minute changes have a significant negative stock price effect, and the characteristics of the change event, of corporate recent events, and of accounting firm capability significantly affect the stock price response. When the number of auditors changed is large, the change time is late, the firm has recently changed key executives or its violations are exposed, and the accounting firm is working for the auditee for the first time, the market responds more negatively than if these conditions are not met. In contrast, if the accounting conservatism of the firm is high or the accounting firm has relevant industry expertise, the negative effect on stock prices is alleviated to a certain extent. In addition, investors may comprehensively consider the auditors' workloads, industry experience, and the change time to further assess the potential motivation for the change and its specific impact on financial statement quality. Accordingly, market responses vary in intensity. Finally, we find that, consistent with investor perceptions, last-minute changes indeed adversely affect the quality of the final financial statements, suggesting that investors make rational and effective investment decisions based on information about the reassignment of the signing auditors.

Our findings have the following implications. First, although the revisions to the regulations on the disclosure of signing auditors' identities are recent, Chinese investors are able to effectively capture information on the reassignment of auditors from the announcements, accurately perceive its potential impact on the quality of financial statements, and give reasonable market feedback. Thus, the announcement of change in signing auditors has important information value. Regulators should strengthen the maintenance and regulation of auditor information disclosure to provide external stakeholders with useful decision-making information.

Second, the results of the market response test show that although change announcements cause a negative and significant stock price effect, the absolute value of the overall CAR is relatively small, indicating that external investors may not fully realize the negative impact of last-minute changes in signing auditors on the quality of financial statements. Regulators could guide investors to be more concerned about such events. Stakeholders should be appropriately skeptical of the information quality of such firms.

Third, our conclusions show that investors can make a comprehensive judgment of the specific impact of a last-minute change based on the individual characteristics of the auditors and information such as the change time. Therefore, at the early stage of an engagement, accounting firms should fully plan for the signing auditor appointment to minimize the possibility of future adjustments to work arrangements. If auditors must be changed at the last minute, accounting firms need to comprehensively consider the auditors' workload, professional abilities, and the time of the change. Reserving enough audit time and sufficient supporting resources for the succeeding auditors will help to minimize audit quality impairment.

Finally, according to our current data, it seems that many listed companies do not pay enough attention to issue change announcements, so that many firms change their signing auditors "in silence". In this respect, regulatory authorities should strengthen their supervision of the disclosure of signing auditors. External stakeholders need to be vigilant about the motivations for such changes and to be appropriately skeptical of the quality of financial statements of firms that change signing auditors at the last minute.

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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