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Heterogeneous Shareholders' Participation, COVID-19 Impact, and Innovation Decisions of State-Owned Firms: Evidence from China

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Abstract: Innovation ability has become an important factor affecting the global competitiveness and sustainable development of state-owned enterprises (SOEs) in China, particularly during the COVID-19 period. This study examined the association between heterogeneous shareholders and SOE innovation, in addition to the moderating impact of corporate governance characteristics and the COVID-19 pandemic on this association. Using data from Chinese A-share listed mixed ownership enterprises (MOEs), we found that the mixed ownership reform of SOEs positively affected firm innovation compared to other MOEs by reducing agency costs, indicating that the manager view channel was proven. We also found that heterogeneous shareholders resulted in more innovation output in state-owned holding mixed ownership enterprises (SHMOEs) with affiliated managers, in those audited by lower reputation accounting firms or that had a lower external marketization, or during the COVID-19 period. The implications of this study are of importance for improving heterogeneous shareholders' active participation in the mixed ownership reform of SOEs.

Keywords: heterogeneous shareholders; COVID-19; corporate governance characteristics; state-owned holding mixed ownership enterprises

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1. Introduction

The ability to innovate is not only the decisive factor for sustainable competitive advantage in a firm, but is also the driving force of sustainable economic growth for a country [1,2]. A firm's innovation willingness and innovation performance are crucial for improving the overall innovation level of a nation. Therefore, research on which factors affect or restrict firm innovation is of significant concern in academia.

The existing research has mainly studied the factors from the perspectives of innovation ability and innovation willingness. From the aspect of innovation ability, most studies focus on the channels, such as obtaining government R&D funding [3] and using the smoothing function of a working capital [4], to improve the ability of a firm's resource obtainment, so as to promote firm innovation. From the aspect of innovation willingness, the existing literature mainly analyzes the influence of internal and external corporate governance mechanisms on a firm's innovation, from the perspective of an agency problem, such as ownership concentration [5], board of directors [6], management compensation incentives [7], institutional investors [8], security analysts [9], legal environment [10], and product market competition [11]. However, the relevant literature does not pay enough attention to the influence of heterogeneous major shareholders on a firm's innovation activities.

The firm ownership structure determines a series of governance structure issues, such as the distribution of control rights and the cooperative relationship between owners and

managers [12]. Additionally, different governance structures ultimately affect the firm's financial behavior and business performance [13]. In emerging markets, such as China, the ownership nature distinguished by the type of the ultimate controlling shareholder is a highly important firm feature, which significantly impacts the firm's innovation decisions. Based on Chinese listed firms, a large portion of the literature finds that state-owned equity discourages R&D investment, patent applications, and innovation efficiency [14–16]. Since 2013, the Chinese government has implemented abundant policies to support the development of the mixed ownership economy, hoping to enhance the core competitiveness of SOEs, particularly in innovation through property rights reform.

At the micro level, the mixed ownership reform of SOEs refers to the fact that SOEs allow private capital, foreign capital, and other heterogeneous shareholders to participate in shares, thus forming a cross-shareholding equity structure. In this study, the term "heterogeneous shareholders" refers to the shareholders in a non-controlling position in the SOEs. The situation in which heterogeneous shareholders hold more than 10% in SOEs is referred to as state-owned holding mixed ownership enterprises (SHMOEs) in this study. By fully utilizing the advantages of various ownership shareholders, this kind of ownership structure in SOEs can form a corporate governance mechanism that is compatible with effective supervision and incentives and optimizes corporate decision making. The mixed ownership structure, which is a special type of multiple major shareholder structure, shows strong characteristics of the transformation economy. In practice, the ownership structure of multiple major shareholders coexists in both Western developed countries [17] and in developing countries [18].

Most studies have found that mutual supervision among major shareholders could restrain the controlling shareholders from encroaching on the interests of minority shareholders through capital occupation [19], excess dividend payment [20], earnings management [21], and information manipulation [22]. Furthermore, multiple major shareholders can also reduce information asymmetry between shareholders and managers [23]. However, based on the "collusion effect", some scholars find that multiple major shareholders might conspire with each other for personal gains to worsen the agency problem [24]. Based on the "coordination costs", another study states that the coordination friction among several major shareholders reduces the supervision efficiency [25]. Furthermore, Megginson et al. [26] and Bortolotti et al. [27] documented that partial privatization could improve the performance of SOEs. To our knowledge, most studies ignore the heterogeneous characteristics of major shareholders, and the research focus on the impact of heterogeneous shareholders on SOE's innovation is even scarcer. In particular, the COVID-19 epidemic has a huge impact on a firm's sustainable development, which provides a new perspective for this study.

To fill this research gap, we explored the relationship between the heterogeneous shareholders' ratio of SHMOEs listed in China and their firm innovation decisions, from 2003 to 2020. The empirical results for whole samples indicated that the mixed ownership reform of SOEs positively affected firm innovation decisions compared to other mixed ownership enterprises (MOEs). Then, we focused on the SHMOE sample. The results showed that the increasing ratio of heterogeneous shareholders positively promoted SOE innovation activities. Moreover, compared to other types of SHMOEs, there was a significant difference in the effect of heterogeneous shareholders on innovation in SOEs; this difference was apparent in those SOEs with affiliated managers, audited by the lower reputation accounting firms, and with a lower extent of external marketization. Additionally, we took 2020 as the dividing point and divided the sample period into two sub-periods. We observed that the relationship between heterogeneous shareholders and innovation behaviors in SHMOEs became more significantly positive during the COVID-19 pandemic. Furthermore, we found that mixed ownership reform promoted innovation by strengthening the market-based operation mechanism of SHMOEs, which indicated that the manager view channel was confirmed.

This paper contributes to the literature about the impact of heterogeneous shareholders on firm innovation in several ways. First, compared with previous literature, the data in this paper rigorously address the problem of the "shareholder relationship". We combine the shareholdings of the top ten shareholders, consistent with a relationship of acting in concert, kinship, and a controlling relationship, to obtain the shareholdings of "shareholder groups". Thus, we were able to measure the ownership structure more accurately than with the traditional index of degree of equity balance. Second, in this study we selected innovation behavior to represent the sustainable development ability and competitiveness of SHMOEs, which enriches the research on the economic consequences of mixed ownership reform in SOEs. Little research has been conducted about the relationship between heterogeneous shareholders and firm innovation behavior. We found that heterogeneous shareholders can promote SOE innovation by optimizing corporate governance and reducing agency costs. Finally, in contrast to prior literature that focuses on the macro field to analyze epidemic problems, using micro quarterly data we found that the high operational flexibility and sensitive market influence of heterogeneous shareholders can better promote SOEs' innovation during the COVID-19 pandemic, which contributes to the microeconomics literature on the impact of public health events.

The remainder of this paper is structured as follows. Section 2 presents a review of related literature and the research hypotheses. Section 3 describes the data and introduces the variable and model information. Section 4 provides the empirical results. Section 5 concludes our study.

2. Literature Review and Hypothesis

2.1. Literature Review

2.1.1. SOEs and Innovation Decision Making

Research int the impact of state-owned controlling shareholders on firm innovation decision making mainly comprises analysis basis on the principal–agent and government intervention theories. Most of the literature suggests that state-owned equity discourages firm innovation.

According to the principal–agent theory, Jensen and Meckling [12] noted that because ownership and management are separated, professional managers may seek personal gains and damage the interests of the principal by using their own management authority and company internal information. Cuervo-Cazurra [28] stated that, although the principal of SOEs is nominally owned by all citizens, an ordinary citizen has no actual ability and motivation to supervise the managers of SOEs. Shleifer [29] showed that the absence of owners in SOEs leads to the lack of an effective incentive and supervision mechanism for managers, which increases agency costs and reduces innovation efficiency. Hirshleifer et al. [30] documented that innovation activities are different from productive activities, which are characterized by a long cycle, high risk, and high investment. John et al. [31] reported that SOE managers are more likely to reduce investment in high-risk innovation projects for self-interested motives.

Based on the government intervention theory, Shleifer and Vishny [32] found that the policy burden undertaken by SOEs, such as over-employment, over-investment, and local economic contribution, are not conducive to the development of more innovative activities, based on value maximization. However, other research presents a different view. Chang et al. [33] claimed that the policy burden of SOEs can balance the deviation between social benefits and the enterprises' profit-seeking nature. Wang et al. [34] indicated that the policy burden can alleviate the tendency of SOEs to avoid the risk of innovation.

2.1.2. Non-Controlling Shareholders and Firm Behaviors

In academia, the problem of non-controlling shareholders is also called the corporate governance issue of multiple large shareholders. Laeven and Levine [17] found that nearly one-third of companies in Western European have non-controlling shareholders who hold more than 10% shares, and this kind of shareholder can improve firm performance. Further

research documented that non-controlling shareholders not only help reduce the cost of equity, but also increase the cash value of the business [35]. However, other research suggests that shareholders will have a negative impact on firm performance, and indicates that the nature of shareholders is an important factor that determines the effect of corporate governance [36]. Maury and Pajuste [37] indicated that family shareholders are more likely to conspire with controlling shareholders to damage the interests of other minority shareholders. Cheng et al. [38] noted that, when the non-controlling shareholders have a property relationship or personal connection with the controlling shareholder, firm value is reduced.

These research conclusions are inconsistent for two reasons. First, some studies stated that multiple major shareholders play a positive supervisory role. Bennedsen and Wolfenzon [39] claimed that supervision of other major shareholders can cause both managers and controlling shareholders to lower their encroachment on the interests of other shareholders. Attig et al. [36] noted that other major shareholders will alleviate the controlling shareholders' behavior of seizing control of private income via related transactions and fund embezzlement. Second, a portion of the literature suggests that conflicts of interest or value divergence among major shareholders may lead to efficiency losses. Zwiebel [40] showed that major shareholders may form a controlling alliance to infringe on the interests of minority shareholders. Cai et al. [41] noted that, when the shareholding ratio among major shareholders is close, the interest embezzlement caused by their collusion is more obvious. However, Jiang et al. [42] stated that the difference in ownership structure is a main cause of the disputes over governance effects of multiple major shareholders. However, the role played by heterogeneous shareholders in a non-controlling position is less examined in the literature.

In reality, the mixed ownership structure of private or foreign shareholders as non-controlling shareholders in SOEs is a strong characteristic of a transformation economy such as China. Koppell [43] noted that American SOEs are a kind of hybrid organization which substitute for government agencies and are not in competition with private firms. In contrast, Chinese SOEs compete with private companies in the same industry and their revenues are the main source of government finance. Thus, the equity structure of SHMOEs in China remains relatively underexplored. Megginson et al. [26] found that partial privatization can improve SOE performance. Maw [44] found that state-owned shareholders maintain equity in the process of privatization due to the multi-objective characteristics of SOE reform, which has an influence on corporate governance. Innovation decisions require higher tolerance of failure and greater decision-making space [45]. Chen et al. [46] claimed that MOEs have more diverse innovation strategies than pure SOEs and pure non-state-owned enterprises (NSOEs) operating under the mixed oligopoly model. However, few studies have paid attention to the relationship between equity structure and the firm innovation behavior of SHMOEs using empirical methods.

2.1.3. Public Health Events and Economic Consequences

A growing body of literature in economics and finance has begun to study the impact of public health events on the economy. The related papers have mainly analyzed the impact of epidemic diseases, such as cholera in 1854, flu in 1918, H2N2 flu in 1957, SARS in 2003, H1N1 in 2009, MERS in 2015, and COVID-19 in 2019, on real estate prices, gross national product, and other macroeconomics variables [47–55].

Hanna and Huang [56] noted that, in 2003, to prevent and control infection from the SARS virus, the movement of people was automatically or passively restricted, which reduced service demand, interrupted production, export and investment, increased unemployment, and worsened the fiscal and financial environment. Following the global spread of the COVID-19 virus in 2020, recent macroeconomic research has analyzed the connection between COVID-19 and stock market returns [57–60], crude oil prices [61], and exchange rates [62]. However, relatively few studies have investigated the microeconomic consequences of COVID-19, such as the negative impact of the COVID-19 pandemic on

firms' performance [63], outward foreign direct investment [64], and cash holding [65]. Specifically, Shen et al. [63] showed that the COVID-19 pandemic has had a negative impact on firm performance, which was more significant in firms with smaller investment and sales revenues, or in regions and industries that were most significantly impacted. Francis et al. [66] noted that the COVID-19 pandemic has an uneven impact on firms with distinct characteristics. Due to the lag in micro data disclosure, scholars often use the case study and investigation study methods to compare the changes in macroeconomic situation before and after public health events [67]. Overall, few studies have used empirical methods to directly examine the impact of epidemic diseases on the specific behaviors of a company, such as the influence of COVID-19 on the decision making of firm innovation.

2.2. Research Hypothesis

2.2.1. Heterogeneous Shareholders' Participation and SOEs' Innovation

In theory, the political view and manager view are the two main channels for analyzing the inefficiency of SOEs. The political view holds that an SOE's inefficiency mainly results from the government's intervention in firm business activities [68]. According to the manager view, SOE inefficiency is mostly due to the lack of effective supervision and incentive mechanisms for executives [69,70]. Based on these two theories, most of the literature has argued that SOEs have no incentive to invest in innovation [31,32]. Through mixed ownership reform, the government transfers part of the ownership of SOEs it controls to private or foreign shareholders, which reduces the proportion of state-owned shares.

Under the mixed ownership structure, heterogeneous major shareholders, such as private or foreign shareholders, usually take an active part in corporate governance for the following three reasons. First, heterogeneous major shareholders have the motivation to supervise the controlling shareholders of SOEs. When the controlling shareholder pursues opportunities, heterogeneous shareholders with relatively high shareholding lose a larger amount, which leads them with greater motivation to become active supervisors. Furthermore, heterogeneous major shareholders have the ability to monitor controlling shareholders. Heterogeneous major shareholders holding more than 10% can generally assign at least one director to the listed company, thus having an impact on the company's operation and decision making. Finally, the mixed ownership reform of SOEs provides conditions for heterogeneous major shareholders to play a governance role. In SHMOEs, state-owned and heterogeneous shareholders develop on the basis of different operating systems and behavioral cognition frameworks. As a result, when SOEs implement mixed ownership reform, heterogeneous shareholders and controlling shareholders are less likely to collude.

Specifically, there are two explanations for the impact of heterogeneous shareholders on SOEs' innovation activities. Under the political view, heterogeneous shareholders with relatively high shareholding provide the benefit of reducing government intervention in firm investment decision making, which can lower the occupation of firm innovation resources. Local governments in China undertake public management objectives, such as promoting economic development, improving public services, and maintaining social stability. In this situation, local governments have an incentive to shift the policy burden to SOEs, and make them invest more in fixed assets, employ more staff, and pay higher taxes. These will crowd out the resources available to SOEs for innovation. Following the mixed ownership reform of SOEs, the rising proportion of heterogeneous shareholders led to an increase in the costs of government intervention [68]. Therefore, a higher shareholding ratio of heterogeneous shareholders can reduce the political burden imposed by the government on SOEs, which helps SOEs to carry out more innovative activities, based on the business goal of value maximization.

Under the manager view, a higher heterogeneous shareholding ratio is conducive for SOEs to improve corporate governance and alleviate agency problems. To maintain a comfortable professional position, improve their professional reputation, or obtain more private benefits, CEOs usually choose robust investment strategies when effective supervi-

sion and incentive mechanisms are lacking, which leads to fewer innovative investment projects in SOEs [31]. In addition, the compensation regulation of SOEs in China will reduce the strength of the relationship between compensation and performance, thus decreasing the willingness of the CEO to carry out innovative activities. Providers of private capital, foreign capital, and other heterogeneous investors to a SOE, have the motivation and ability to improve the SOE's supervision and incentive mechanisms, and urge the CEO to reduce opportunistic or moral hazard behaviors, so as to actively undertake innovation risks. Based on these arguments, we formulate the first hypothesis:

Hypothesis 1. *Heterogeneous shareholders have a positive impact on SOEs' innovation.*

2.2.2. Moderating Effect of Corporate Governance Characteristics

Affiliated managers, which refers to managers who are both the CEO and a controlling shareholder, are widespread in China's SOEs because the existence of affiliated managers enables controlling shareholders to directly intervene in the execution of firm decisions. Therefore, this type of manager increases the opportunistic behavior of controlling shareholders. Furthermore, affiliated managers expand the information advantage of controlling shareholders and conceal their tunneling behaviors. This raises the question of whether the affiliated status of managers may have a moderating effect. On the one hand, the combination of ownership and management rights will lead heterogeneous shareholders to actively participate in firm decision-making, which will significantly weaken the power of control of controlling shareholders. On the other hand, in companies with affiliated managers, heterogeneous shareholders will be more active in obtaining internal information to alleviate the information asymmetry between them and controlling shareholders, thus better promoting SOE innovation.

When the efficiency of internal governance is low, effective external governance is an inevitable choice to protect the rights and interests of non-controlling investors [71]. First, the external auditor is an important part of the external governance. The level of audit quality is highly correlated with the heterogeneity of the firm behavior. When SOEs are audited by large accounting companies with a strong reputation, the controlling shareholder's opportunistic behavior can be better restrained. Higher quality accounting information disclosure helps reduce the information asymmetry between heterogeneous shareholders and controlling shareholders, which may lead to free-riding by heterogeneous shareholders. Conversely, when SOEs are audited by small accounting companies with a poor reputation, heterogeneous shareholders have a strong desire to monitor the controlling shareholder and promote more valuable innovation opportunities for the SOE.

In addition, the marketization degree is another significant factor of external governance. A higher degree of marketization can not only reduce the government's administrative intervention in SOEs' investment decisions, but also protect the interests of heterogeneous shareholders through a better legal system and external supervision to avoid the tunneling behavior of controlling shareholders. The higher degree of marketization has a substitute effect on the supervisory role of heterogeneous shareholders, and the promoting effect of the heterogeneous shareholders on the innovation of SOEs is limited. Therefore, we propose the following hypotheses:

Hypothesis 2. *Corporate governance characteristics have a moderating effect on the relationship between the heterogeneous shareholding ratio and SOEs' innovation.*

More specifically, we have:

Hypothesis 2a. *When the managers are affiliated, the heterogeneous shareholding ratio has a greater promoting effect on SOEs' innovation than otherwise.*

Hypothesis 2b. *When the companies are not audited by one of the four largest accounting firms, the heterogeneous shareholding ratio has a greater promoting effect on SOEs' innovation than others.*

Hypothesis 2c. *When the companies have a lower extent of external marketization, the heterogeneous shareholding ratio has a greater promoting effect on SOEs' innovation than otherwise.*

2.2.3. Moderating Effect of COVID-19 Impact

At the beginning of 2020, the COVID-19 pandemic began, significantly impacting global economic and social development. According to official data released by China's National Bureau of Statistics, China's gross domestic product of 2020 reached CNY 101,598.6 billion, which was an increase of 2.3% compared to 2019. Examining this economic indicator quarter-by-quarter shows that it fell 6.8% from a year earlier in the first quarter, before successively increasing 3.2%, 4.9%, and 6.5% in the following quarters. This indicates that China's economy is continuing to recover, and raises the question of how China was able to achieve a rapid economic recovery in a relatively short period of time?

When an epidemic causes a shortage in labor and increases the price of balanced supply, innovation factors play a more important role in economic growth. In response to the impact of the COVID-19 pandemic, and due to the demand of non-clustered economic activities undertaken to fight the epidemic, China adopted more digital and intelligent technologies in a number of areas. First, the COVID-19 pandemic rapidly increased the demand for remote collaborative business offices; thus, cloud service firms accelerated the promotion of online office services. Second, to strengthen social isolation control and access to personal health information, artificial intelligence technology has been widely used in community governance. Furthermore, during the COVID-19 pandemic, the Internet was deeply integrated into productive services such as education, medical care, finance, and transportation, resulting in a large number of online service platforms. Finally, industrial Internet, cloud manufacturing platforms, industrial robots, and other forms of intelligent manufacturing were widely applied during the COVID-19 pandemic.

These innovative technologies involved the application of a large number of private or foreign enterprise products, such as Tencent conference, Dingding office, WeChat health code, Huawei intelligent factory, Jingdong intelligent warehouse, Ali cloud, and Tesla intelligent workshop. NSOEs have the advantages of high operational flexibility and sensitive market influences, which are crucial to the success of innovation. In the process of SOE mixed-ownership reform, heterogeneous shareholders can compensate for the problems of inefficient management and an insufficient marketization level of SOEs by promoting them to quickly capture the market demand for high quality products under COVID-19, thus enhance the SOEs' ability to find more valuable opportunities for technological innovation. Therefore, we propose hypothesis 3 as follows.

Hypothesis 3. *When the COVID-19 period, the heterogeneous shareholding ratio has a greater promoting effect on SOE innovation than another periods.*

3. Data and Methodology

3.1. Data Source

Since the establishment of the State-Owned Assets Supervision and Administration Commission in 2003, cross-shareholding among SOEs has become common in China. In addition, the ultimate controller information disclosure of listed companies in China has been continuously improved since 2003. Therefore, for this study we used 2003–2020 data of A-share listed mixed ownership enterprises from the China Stock Market & Accounting Research (CSMAR) Database, which provides equity, innovation, financial, and corporate governance data. The equity structure information in this study was mainly obtained by manually determining the nature, association relationship, and shareholding ratio of the top ten shareholders on websites such as Sky Search and Baidu Search. Annual financial reports, which have been used in prior accounting research, were not disclosed until 2019. In contrast, quarterly financial reports are able to reflect timely equity and innovation data during the COVID-19 pandemic of 2020. Thus, we used both annual data (Years: 2003–2019) and quarterly data (Quarter 1: 2003 to Quarter 3: 2020).

In this study, we focused on the SHMOEs, which is a form of SOE. Referring to the research of Laeven and Levine [17], we choose 10% as the separation threshold. If the sum of private-owned and foreign-owned shares in an SOE exceeded 10%, it was classified as a state-owned holding mixed ownership enterprise. SOE refers to enterprises in which actual control is held by government department, the SOE legal person, or the four state-owned asset management companies. To accurately identify the SHMOEs, we defined the nature and shareholding ratio of the top ten shareholders as follows: (1) Based on the equity information disclosed in the annual and quarterly reports of listed companies, we manually analyzed data from periodic reports and official websites of each company to judge the equity nature and shareholding ratio of the top ten shareholders. (2) The top ten shareholders of listed companies were divided into four types: state-owned shareholders, private shareholders, foreign shareholders, and unknown shareholders. (3) We combined the shareholdings of the top ten shareholders based on the relationship of acting in concert, kinship, and the controlling relationship, to obtain the shareholdings of "shareholder groups", who have a stronger incentive to conspire with each other. In particular, the use of "shareholder groups" differs from previous research, which has generally used the ratio of "the sum of the shares held by the second to tenth shareholders" divided by the ratio of "the shares held by the largest shareholder" to measure the degree of equity balance, which can provide more accurate information about the ownership structure. The term "shareholders" hereinafter means "shareholder groups" regarding its association.

Referring to the research methods in the previous literature, the initial samples were processed as follows: (1) Due to the particularity of financial indicators in the finance and insurance industry, we excluded these kinds of companies. (2) We excluded Special Treatment (ST) and *Special Treatment (*ST) companies, who had been warned of the risk of delisting by the China Securities Regulatory Commission mainly due to suffering losses for two or three consecutive years. (3) We excluded companies with missing data for vital variables. (4) If the proportion of private-owned and foreign-owned shares (or stated-owned shares) in the top ten shareholders of a SOE (or non-state-owned enterprises) exceeded 10%, it was deemed a mixed-ownership enterprise. Finally, the total sample of MOEs consisted of 12,636 firm-year observations and 39,510 firm-quarter observations. From the total sample, we identified the SHMOE sample, which was the main sample of this study. It contained 4907 firm-year observations and 9750 firm-quarter observations of the SHMOEs. The distribution of SHMOEs by year is shown in Table A1 of the Appendix A. To avoid the influence of extreme values, all continuous variables were winsorized at the top 1% and bottom 1%.

3.2. Measurement of Variables

3.2.1. Independent Variables

The independent variable in our model is NSOE, which is measured by the sum of the total heterogeneous shareholding ratio in the state-owned holding mixed ownership enterprises. We also construct two dummy variables, ANSOE and MNSOE. If NSOE is larger than the average, ANSOE equals 1, and 0 otherwise. If NSOE is larger than the median, MNSOE equals 1, and 0 otherwise. In addition, we also constructed another independent variable, SHMOE, which equals 1 if the sum of the non-state-owned shares in the state-owned holding company exceeds 10%, and 0 in other MOEs.

3.2.2. Dependent Variables

The dependent variable is firm innovation, which is usually measured by the R&D investment or the number of patents. The former tends to measure innovation input, whereas the latter focuses on measuring innovation output. In this study, we aimed to use the data of 2020 to compare and analyze the COVID-19 impact on the core hypothesis. However, the data of R&D investment and patents of listed companies in 2020 has yet not been disclosed. Considering that patent and non-patented technology are the most important components of the intangible assets, to measure firm innovation output we mainly used

the intangible assets (IA) from accounting statements, which currently have been disclosed for the first three quarters of 2020. Therefore, we constructed the dependent variables Ln_IA and Ratio_IA, which were calculated using the logarithm of intangible assets and the proportion of intangible assets in total assets, respectively. In the robustness test, we also examined the influence of heterogeneous shareholders based on R&D personnel, R&D spending, and future innovation output.

3.2.3. Moderating Variables

According to Hypotheses 2 and 3, four moderating variables were established: AM represents affiliated managers, which equals 1 if the manager in an SHMOE is both CEO and controlling shareholder, and 0 otherwise; AQ is defined as audit quality, which equals 1 if the audit opinion of SHMOEs comes from the "Big Four" accounting firms, namely, PwC, Deloitte, KPMG, and EY, and 0 otherwise; MD represents the extent of external marketization, which equals 1 if an SHMOE is registered in the eastern part of China and 0 otherwise; NC is a dummy variable for the impact of COVID-19, which takes a value of 1 if the sample period is Quarter 1: 2020 to Quarter 3: 2020, and 0 for the same quarters in 2019.

3.2.4. Mediating Variables

Under the political view (PV), we used the number of employees and wage expenditure to measure the policy burden of SHMOEs. EMP represents the number of employees, which is measured by the total number of employees divided by the total assets. WE is defined as the wage expenditure, which is calculated by the payable salary divided by the prime operating revenue.

Under the manager view (MV), we used the operating expense ratio and asset turnover ratio to measure the agency costs of SHMOEs. OE represents the operating expense ratio, which is measured by the sum of the management and sales expenses divided by the prime operating revenue. AT is defined as the asset turnover ratio, which is calculated by the prime operating revenue divided by the total assets.

3.2.5. Control Variables

As in prior firm innovation research, control variables were included as the other factors affecting firm innovation decisions, such as tangible assets (TA), cash holding (CH), liquid assets (LA), and return on assets (ROA). In addition, year, quarter, and industry were controlled in the model. The main variables and descriptions are shown in Table A2 of the Appendix A.

3.3. Model Specification

Based on theoretical analysis and the hypotheses, we estimated the following five panel data models. Models 1–2 were used to test the impact of heterogeneous shareholders on firm innovation. In addition, we tested the moderating effect of corporate governance factors in Hypothesis 1 through the grouped regression of Model 2, such as affiliated managers, audit quality, and marketization degree. Models 3–4 were used to test the role of the COVID-19 pandemic on the impact of heterogeneous shareholders on firm innovation. Models 5–6 were used to test whether heterogeneous shareholders influence firm innovation through the political view or the manager view. In addition, we tested the following models using both quarterly and annual data. We only regressed model (1) using the MOE sample, and the other models using the SHMOE sample.

In order to verify Hypotheses 1–2, the models were constructed as:

$$IA_{i,t} = \beta_0 + \beta_1 SHMOE_{i,t} + \beta_2 Controls_{i,t} + \varepsilon_{i,t} \quad (1)$$

$$IA_{i,t} = \beta_0 + \beta_1 NSOE_{i,t} + \beta_2 Controls_{i,t} + \varepsilon_{i,t} \quad (2)$$

In order to verify Hypothesis 3, the models are constructed as:

$$IA_{i,t} = \beta_0 + \beta_1 ANSOE_{i,t} + \beta_2 NC_{i,t} + \beta_3 ANSOE_{i,t} \times NC_{i,t} + \beta_4 Controls_{i,t} + \varepsilon_{i,t} \quad (3)$$

$$IA_{i,t} = \beta_0 + \beta_1 MNSOE_{i,t} + \beta_2 NC_{i,t} + \beta_3 MNSOE_{i,t} \times NC_{i,t} + \beta_4 Controls_{i,t} + \varepsilon_{i,t} \quad (4)$$

To test the mediating effect, the models were constructed as:

$$PV_{i,t}\ (MV_{i,t}) = \beta_0 + \beta_1\ NSOE_{i,t} + \beta_2 Controls_{i,t} + \varepsilon_{i,t} \quad (5)$$

$$IA_{i,t} = \beta_0 + \beta_1 NSOE_{i,t} + \beta_2 PV_{i,t}\ (MV_{i,t}) + \beta_3 Controls_{i,t} + \varepsilon_{i,t} \quad (6)$$

where β_0 is the constant term, and β_i represent coefficients of the independent variables, the cross-terms, and control variables in the models. IA is the intangible assets, SHMOE is state-owned holding mixed ownership enterprises, NSOE is non-state-owned shareholding ratio, ANSOE is the non-state-owned shareholding ratio larger than the average, MNSOE is the non-state-owned shareholding ratio larger than the median, PV is the political view, MV is the manager view, Controls includes TA, CH, ROA, LA, YEAR, QUARTER, INDUSTRY. Variable subscript i represents the company. Variable subscript t represents year or quarter. ε is the random error term.

In particular, we used Models 5 and 6 to examine the mediation effect by following two steps taken from prior literature: First, if the regression coefficients of β_1 in Model 5 and β_2 in Model 6 are both significant, it indicates that the mediating effect is significant. Second, on this basis, if the regression coefficient β_1 in Model 6 is significant (not significant), it indicates that a partial (complete) mediating effect exists.

4. Empirical Results and Discussion

4.1. Descriptive Statistics and Pearson's Correlation

Table 1 outlines the descriptive statistics of the variables employed at the firm–quarter level. The descriptive statistics at the firm–year level are similar. In Table 1, Panel A, the average NSOE is 51.0712 with a standard deviation of 22.0905. The minimum value and maximum value of NSOE are 1.38 and 80.84, respectively, which indicate that the non-stated-owned shareholding ratio of Chinese MOEs is significantly different. The average SHMOE is 0.2468, indicating that SHMOEs account for 24.68% of the MOEs. The average Ln_IA is 17.0987 with a standard deviation of 1.9453. The minimum value and maximum value of Ln_IA are 11.5408 and 22.8772, respectively, which indicate that the differences in the intangible assets between MOEs are large. The average Ratio_IA is 0.0406, indicating that the proportion of intangible assets in the total assets of Chinese MOEs is relatively low. Regarding control variables, the mean (median) values for TA, CH, LA, and ROA are 0.2292 (0.1734), 0.1717 (0.1369), 0.558 (0.2154), and 0.5471 (114.7698), respectively. In particular, the descriptive statistics of ROA indicate that the differences in the financial performance of Chinese MOEs are significant.

Table 1. Descriptive statistics.

Panel A: MOEs' Sample of Firm Quarter Level						
Variables	**N**	**Mean**	**STD**	**Mix**	**Median**	**Max**
Ln_IA	39,510	17.0987	1.9453	11.5408	17.1933	22.8772
Ratio_IA	39,510	0.0406	0.0521	0.0001	0.0231	0.3111
NSOE	39,510	51.0712	22.0905	1.3800	54.7500	80.8400
SHMOE	39,510	0.2468	0.2702	0	0	1
TA	39,510	0.2292	0.1734	0.0017	0.1943	0.7307
CH	39,510	0.1717	0.1369	0.0023	0.1331	0.6773
LA	39,510	0.5580	0.2154	0.0655	0.5719	0.9665
ROA	39,510	0.5471	114.7698	−214.4124	0.0344	235.1573
Panel B: SHMOEs' Sample of Firm Quarter Level						
Variables	**N**	**Mean**	**STD**	**Mix**	**Median**	**Max**
Ln_IA	9750	18.4370	2.0602	11.5406	18.4588	22.8772
Ratio_IA	9750	0.0438	0.0544	0.0012	0.0273	0.3110
NSOE	9750	23.8598	11.8878	10	20.59	78.78
SHMOE	9750	1	0	1	1	1
TA	9750	0.2753	0.1954	0.0017	0.2412	0.7307
CH	9750	0.1636	0.1255	0.0023	0.1327	0.6773
LA	9750	0.5167	0.2311	0.0655	0.5219	0.9665
ROA	9750	0.0342	0.1878	−1.006	0.0309	8.4414

In Table 1, Panel B, the average NSOE is 23.8598 with a standard deviation of 11.8878. The minimum value and maximum values of NSOE are 10 and 78.78, respectively, which suggest that non-state-owned shareholders have a certain degree of influence in SHMOEs. The average Ln_IA and Ratio_IA values are 18.4370 and 0.0438, respectively, which are obviously higher than the same variables in Panel A. These results likely indicate that SHMOEs have a higher innovation investment than other MOEs. The mean (median) values for control variables TA, CH, LA, and ROA are 0.2753 (0.1954), 0.1636 (0.1255), 0.5167 (0.2311), and 0.0342 (0.1878), respectively.

Table 2 presents the Pearson's correlation coefficients among the main variables of the total sample at the firm–quarter level. The correlation coefficients at the firm–year level are similar. There are significant negative correlations between NSOE and the dependent variables Ln_IA and Ratio_IA. Significant negative correlations are also found between SHMOE and two dependent variables, Ln_IA and Ratio_IA. These results are consistent with Hypothesis 1. Variance inflation factors were computed and do not surpass the critical value of 10, which indicates that no multicollinearity problems are present.

Table 2. Correlation coefficients between variables.

Variables	Ln_IA	Ratio_IA	NSOE	SHMOE	TA	CH	LA	ROA
Ln_IA	1							
Ratio_IA	0.476 ***	1						
NSOE	0.077 ***	0.026 ***	1					
SHMOE	0.041 ***	0.002 ***	0.072 ***	1				
TA	0.141 ***	0.082 ***	−0.161 ***	−0.184 ***	1			
CH	−0.176 ***	−0.137 ***	0.138 ***	0.032 ***	−0.314 ***	1		
LA	−0.312 ***	−0.308 ***	0.146 ***	0.108 ***	−0.672 ***	0.448 ***	1	
ROA	0.028 ***	0.063 ***	0.164 ***	0.013 ***	−0.079 ***	0.251 ***	0.120 ***	1

Note: *** denotes statistical significance at the 1% level.

4.2. Regression Results

Table 3 shows the regressions results of Models 1–2, to test the impact of heterogeneous shareholders on SOEs' innovation decision. The empirical results are highly similar whether we use quarterly or annual data for regression. When the dependent variable is Ln_IA, the coefficients of SHMOE are significantly positive in columns (1) and (2), which indicates that SHMOEs have higher innovation output than other type of MOEs. Furthermore, the coefficients of NSOE are also significantly positive in columns (3) and (4). This suggests that the high proportion of non-state-owned shareholders can provide more innovation output to SHMOEs. When the dependent variable is Ratio_IA, the coefficients of SHMOE are significantly positive in columns (5) and (6), which indicates that innovation output accounts for a greater proportion of total assets in SHMOEs than other types of MOEs. In addition, the coefficients of NSOE are also significantly positive in columns (7) and (8). This suggests that the higher the proportion of non-state-owned shareholders, the greater the proportion of innovation output in total assets of SHMOEs. Hypothesis 1 is supported. This means that heterogeneous shareholders have a positive impact on SOEs' innovation decisions.

Ln_IA and Ratio_IA are significant correlated with the control variables in Table 3. Regardless of whether innovation output is measured by Ln_IA or Ratio_IA, the control variables TA, CH, and LA have negative correlations with innovation output, whereas ROA is negatively correlated. These results remained consistent with the following regression results.

This study applied the grouped regression method using the SHMOE sample to test the moderating effect of corporate governance characteristics. First, the results of the role of affiliated managers in the impact of heterogeneous shareholders on SOEs' innovation are presented in Table 4, which shows that a small fraction of SHMOEs has affiliated managers. As shown in columns (1)–(4), when the CEO is also the controlling shareholder, the regression coefficients of NSOE are positive and significant. This demonstrates that when the control power of the state-owned controlling shareholder is relatively high, the heterogeneous shareholders will effectively restrict the state-owned controlling shareholder by actively participating in the corporate governance and alleviate the information asymmetry, thus promoting SOEs' innovation. It should be noted that, when AM equals 0, as

shown in columns (5)–(8), the regression coefficients of NSOE are negative and fail to pass the significance test. This indicates that, when the CEO is not the controlling shareholder, heterogeneous shareholders have no significant promoting effect on SOEs' innovation output. Therefore, Hypothesis 2a is supported.

Table 3. Influence of heterogeneous shareholders on SOEs' innovation decisions.

Variables	Ln_IA				Ratio_IA			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
SHMOE	0.485 *** (5.70)	1.877 *** (37.25)			0.005 * (1.70)	0.010 *** (6.13)		
NSOE			0.581 *** (6.74)	1.890 *** (37.28)			0.005 * (1.65)	0.011 *** (6.39)
TA	−174.713 *** (−12.70)	−219.381 *** (−27.33)	−181.035 *** (−12.89)	−219.315 *** (−27.02)	−18.083 *** (−38.71)	−17.879 *** (−67.57)	−18.283 *** (−37.85)	−18.104 *** (−66.80)
CH	−106.398 *** (−6.75)	−100.732 *** (−10.71)	−109.968 *** (−6.59)	−108.448 *** (−11.09)	−2.299 *** (−4.35)	−2.298 *** (−7.50)	−2.211 *** (−3.92)	−2.191 *** (−6.80)
LA	−292.773 *** (−23.56)	−294.413 *** (−41.55)	−292.545 *** (−22.92)	−288.295 *** (−40.13)	−17.737 *** (−42.21)	−17.449 *** (−74.78)	−17.770 *** (−40.60)	−17.450 *** (−72.76)
ROA	19.192 *** (2.68)	36.836 *** (5.14)	58.433 *** (3.63)	96.414 *** (6.47)	1.225 *** (7.45)	1.051 *** (7.58)	0.875 *** (2.83)	1.234 *** (4.50)
Intercept	1941.390 *** (100.30)	2074.070 *** (157.63)	1945.108 *** (96.70)	2134.702 *** (113.56)	21.783 *** (32.85)	20.656 *** (53.00)	22.067 *** (31.69)	20.749 *** (44.59)
YEAR	Yes		Yes		Yes		Yes	
QUARTER		Yes		Yes		Yes		Yes
INDUSTRY	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	12,636	39,510	4907	9750	12,636	39,510	4907	9750
Adj R^2	0.360	0.308	0.356	0.308	0.352	0.361	0.358	0.366

Note: * and *** represent significance levels of 10% and 1%, respectively; T value is shown in brackets in the table.

Table 4. Grouped regression based on affiliated managers.

Variables	AM = 1				AM = 0			
	Ln_IA		Ratio_IA		Ln_IA		Ratio_IA	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
NSOE	0.572 *** (6.40)	0.953 *** (5.62)	0.006 * (1.82)	0.009 ** (1.96)	−0.346 (−1.25)	−0.030 (−0.04)	−0.005 (−0.69)	−0.010 (−1.50)
TA	−173.544 *** (−12.04)	−198.708 *** (−7.31)	−18.573 *** (−37.27)	−10.576 *** (−14.85)	−178.452 *** (−3.85)	−221.586 *** (−26.41)	−11.826 *** (−9.12)	−18.538 *** (−65.64)
CH	−125.184 *** (−7.44)	−80.226 *** (−2.89)	−1.942 *** (−3.36)	−1.875 *** (−2.74)	−67.492 (−1.51)	−119.806 *** (−12.01)	−2.459 ** (−2.06)	−2.136 *** (−6.38)
LA	−276.857 *** (−21.15)	−393.821 *** (−16.36)	−17.962 *** (−39.82)	−14.734 *** (−23.57)	−405.224 *** (−10.02)	−282.190 *** (−38.02)	−14.801 *** (−13.24)	−17.678 *** (−70.78)
ROA	22.787 *** (3.01)	6.285 *** (4.30)	2.422 *** (9.60)	0.124 *** (5.94)	14.360 (0.68)	41.198 *** (5.45)	0.197 (1.11)	2.640 *** (10.83)
Intercept	1929.183 *** (96.22)	2145.201 *** (45.70)	22.362 *** (31.86)	13.614 *** (12.77)	2047.068 *** (27.98)	2069.743 *** (151.47)	14.083 *** (7.08)	19.641 *** (42.89)
YEAR	Yes		Yes		Yes		Yes	
QUARTER		Yes		Yes		Yes		Yes
INDUSTRY	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	448	946	448	946	4459	8804	4459	8804
Adj R^2	0.363	0.377	0.358	0.401	0.445	0.311	0.396	0.365

Note: *, ** and *** represent significance levels of 10%, 5% and 1%, respectively; T value is shown in brackets in the table.

Second, the results of the role of audit quality in the impact of heterogeneous shareholders on SOEs' innovation are presented in Table 5, which shows that a small fraction of the audit opinions of SHMOEs is provided by the "Big Four" accounting firms. Columns (1)–(4) show that, when the company is audited by one of the "Big Four" ac-

counting firms, the regression coefficients of NSOE fail to pass the significance test. This demonstrates that, when accounting firms with a strong reputation conduct the audit, the opportunistic behaviors of state-owned controlling shareholders and the asymmetry degree of accounting information are reduced, which weakens the enthusiasm of heterogeneous shareholders to supervise controlling shareholders and participate in innovation decision-making. Columns (5)–(8) show that, when AQ equals 0, the regression coefficients of NSOE are positive and significant, which indicates that, when accounting firms with a poor reputation conduct the audit, heterogeneous shareholders have a strong motivation to obtain accurate and timely accounting information, which encourages SOEs to find more valuable innovation opportunities. Therefore, Hypothesis 2b is supported.

Table 5. Grouped regression based on audit quality.

Variables	AQ = 1				AQ = 0			
	Ln_IA		Ratio_IA		Ln_IA		Ratio_IA	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
NSOE	−0.065 (−0.74)	0.263 (1.18)	−1.737 (−1.27)	−0.001 (−0.75)	0.683 *** (2.72)	2.440 *** (16.70)	0.042 *** (3.99)	0.055 *** (10.10)
TA	−154.311 *** (−11.09)	−203.096 *** (−24.77)	−15.195 *** (−32.55)	−15.143 *** (−56.95)	−168.577 *** (−3.33)	−190.879 *** (−6.32)	−32.675 *** (−15.66)	−28.091 *** (−25.18)
CH	−89.303 *** (−5.73)	−80.415 *** (−8.53)	−1.645 *** (−3.19)	−1.585 *** (−5.25)	−220.418 *** (−3.26)	−283.354 *** (−7.26)	−9.185 *** (−3.26)	−8.612 *** (−5.91)
LA	−271.312 *** (−21.67)	−280.661 *** (−38.89)	−16.279 *** (−38.95)	−16.140 *** (−69.08)	−279.914 *** (−5.99)	−240.720 *** (−8.86)	−23.146 *** (−11.91)	−20.786 *** (−20.55)
ROA	14.330 ** (2.09)	29.125 *** (4.20)	1.249 *** (8.03)	1.079 *** (8.18)	33.156 *** (3.31)	26.700 *** (5.30)	1.232 *** (3.26)	2.871 *** (4.85)
Intercept	1943.238 *** (103.00)	2082.868 *** (162.14)	20.678 *** (32.34)	19.869 *** (52.97)	2210.103 *** (42.00)	2254.035 *** (23.75)	28.232 *** (12.97)	25.898 *** (7.30)
YEAR	Yes		Yes		Yes		Yes	
QUARTER		Yes		Yes		Yes		Yes
INDUSTRY	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	485	965	485	965	4422	8785	4422	8785
Adj R^2	0.462	0.407	0.392	0.414	0.331	0.331	0.351	0.321

Note: ** and *** represent significance levels of 5% and 1%, respectively; T value is shown in brackets in the table.

Third, the results of the role of marketing degree in the impact of heterogeneous shareholders on SOEs' innovation are presented in Table 6. As shown in columns (1)–(4), when MD equals 1, the regression coefficients of NSOE are positive but fail to pass the significance test. This demonstrates that, when the company is in a region with a high degree of marketization, lower administrative intervention and a good legal system can provide a good external market environment for SOEs, which has a substitute effect on the supervisory role of heterogeneous shareholders. It should be noted that, when MD equals 0, as shown in columns (5)–(8), the regression coefficients of NSOE are positive and significant. This indicates that heterogeneous shareholders will protect their interests by actively participating in innovation decisions. Therefore, Hypothesis 2c is supported.

Based on the above results, it can be seen that corporate governance characteristics have a moderating effect on the relationship between heterogeneous shareholding ratio and SOEs' innovation decisions. Specifically, when SHMOEs have affiliated managers, are audited by accounting firms with poorer reputations, or have a lower extent of external marketization, the heterogeneous shareholders will play an interactive role and promote the SOE's innovation. Therefore, Hypothesis 2 is supported.

Furthermore, the demand for non-clustered economic activities during the COVID-19 pandemic changed the mode of social and economic development. As shown in Table 7, we used Models 3–4 to test the difference in the effect of heterogeneous shareholders on the SOEs' innovation before and after the outbreak of the COVID-19 pandemic. When the dependent variable is Ln_IA, the coefficients of ANSOE and MNSOE are significantly

positive, which indicates that SHMOEs with a high private-owned and foreign-owned shareholding ratio can motivate innovation output. Furthermore, the coefficients of the two cross-terms ANSOE × NC and MNSOE × NC are also positive and significant in columns (1) and (2). This suggests that, after the outbreak of COVID-19, a high proportion of non-state-owned shareholders were able to provide more innovation output to the SHMOEs than in the non-COVID-19 period.

Table 6. Grouped regression based on marketing degree.

Variables	MD = 1				MD = 0			
	Ln_IA		Ratio_IA		Ln_IA		Ratio_IA	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
NSOE	0.116 (0.95)	0.063 (0.30)	0.005 (0.97)	0.001 (0.94)	0.593 *** (5.02)	2.045 *** (29.27)	0.012 *** (3.33)	0.017 *** (8.28)
TA	−178.973 *** (−9.77)	−217.324 *** (−19.92)	−24.284 *** (−33.37)	−23.463 *** (−57.47)	−135.775 *** (−6.51)	−195.498 *** (−16.33)	−13.728 *** (−22.64)	−14.119 *** (−40.73)
CH	−52.590 ** (−2.32)	−32.093 ** (−2.36)	−1.546 * (−1.77)	−1.083 ** (−2.18)	−145.021 *** (−6.63)	−151.315 *** (−11.68)	−1.892 *** (−2.98)	−2.298 *** (−6.12)
LA	−357.099 *** (−19.97)	−353.459 *** (−33.97)	−24.194 *** (−34.21)	−23.291 *** (−59.91)	−236.727 *** (−13.74)	−245.275 *** (−25.28)	−13.473 *** (−26.89)	−13.658 *** (−48.41)
ROA	8.321 (1.18)	20.137 *** (2.80)	2.028 *** (8.19)	2.012 *** (8.91)	85.859 *** (4.17)	117.957 *** (6.16)	0.250 *** (4.19)	0.243 *** (3.46)
Intercept	1988.383 *** (86.61)	2120.830 *** (142.95)	28.486 *** (30.78)	25.822 *** (47.93)	1878.245 *** (54.37)	2076.372 *** (72.85)	13.201 *** (13.23)	13.008 *** (20.95)
YEAR	Yes		Yes		Yes		Yes	
QUARTER		Yes		Yes		Yes		Yes
INDUSTRY	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	2659	5265	2659	5265	2248	4485	2248	4485
Adj R^2	0.382	0.340	0.357	0.368	0.389	0.313	0.402	0.411

Note: *, ** and *** represent significance levels of 10%, 5% and 1%, respectively; T value is shown in brackets in the table.

Table 7. Heterogeneous shareholders, COVID-19 impact, and SOEs' innovation decisions.

Variables	Ln_IA		Ratio_IA	
	(1)	(2)	(3)	(4)
ANSOE	0.051 ** (2.567)		0.021 ** (2.495)	
ANSOE × NC	0.493 *** (6.262)		0.012 *** (3.715)	
MNSOE		0.052 *** (2.639)		0.042 * (1.821)
MNSOE × NC		0.564 *** (7.308)		0.013 ** (2.245)
NC	0.568 *** (7.633)	0.530 *** (7.319)	0.031 ** (2.449)	0.025 * (1.887)
TA	−2.568 *** (−40.661)	−2.569 *** (−40.684)	−0.143 *** (−88.543)	−0.168 *** (−88.556)
CH	−0.916 *** (−14.263)	−0.918 *** (−14.286)	−0.019 *** (−9.967)	−0.023 *** (−9.992)
LA	−3.433 *** (−58.890)	−3.194 *** (−58.911)	−0.169 *** (−100.094)	−0.174 *** (−100.103)
ROA	0.311 *** (6.115)	0.313 *** (6.163)	0.004 *** (6.067)	0.011 *** (6.062)
Intercept	20.953 *** (213.300)	18.459 *** (213.484)	0.156 *** (78.510)	0.219 *** (78.527)
QUARTER	Yes	Yes	Yes	Yes
INDUSTRY	Yes	Yes	Yes	Yes

Table 7. *Cont.*

Variables	Ln_IA		Ratio_IA	
	(1)	(2)	(3)	(4)
N	989	989	989	989
Adj R^2	0.248	0.259	0.308	0.308

Note: In this report, the sample of Quarter 1 to Quarter 3 of 2019 is in the normal period and the sample of Quarter 1 to Quarter 3 of 2020 is in the COVID-19 period. *, ** and *** represent significance levels of 10%, 5% and 1%, respectively; T value is shown in brackets in the table.

In Table 7, when the dependent variable is Ratio_IA, the coefficients of ANSOE and MNSOE are significantly positive. This indicates that innovation output accounts for a greater proportion of total assets in SHMOEs that have a high private-owned and foreign-owned shareholding ratio. In addition, the coefficients of the two cross-terms, ANSOE × NC and MNSOE × NC, are also positive and significant in columns (3) and (4). This suggests that, after the outbreak of COVID-19, the higher the proportion of non-state-owned shareholders, the greater the proportion of innovation output in the total assets of SHMOEs. Hypothesis 3 is supported.

Based on the above results, it can be seen that, during the period of the COVID-19 pandemic, private-owned and foreign-owned shareholders can enhance the SHMOEs to quickly capture the market demand for high-tech products. Therefore, we conclude that the heterogeneous shareholding ratio has a greater promoting effect on SOEs' innovation during the COVID-19 pandemic than during other periods.

4.3. Additional Analysis

As shown in Table 8, we used the mediation effect Models 5–6 to test whether heterogeneous shareholders influence SOE innovation via the political view channel or manager view channel. Under the political view channel, the dependent variables are employee number (EMP) and wage expenditure (WE), and the coefficients of NOSE fail to pass the significance test at the 10% level in columns (1) and (2). This indicates that SHMOEs with a high heterogeneous shareholding ratio do not employ fewer workers or pay lower wages. That is, regardless of whether the shareholding ratio of heterogeneous shareholders in SHMOEs is high or low, there is no difference in the degree of government intervention.

Table 8. Political view and manager view.

Variables	PV Channel		MV Channel			
	EMP	WE	OE	AT	Ln_IA	Ln_IA
	(1)	(2)	(3)	(4)	(5)	(6)
NSOE	−0.042 (−0.52)	−0.066 (−1.42)	−0.264 *** (−6.55)	0.011 *** (5.44)	0.728 (1.41)	0.010 (0.64)
OE					−125.211 *** (−3.92)	
AT						171.770 *** (40.60)
TA	−37.256 *** (−2.86)	68.621 *** (9.24)	−0.827 * (−1.87)	0.511 *** (14.29)	−190.025 *** (−13.56)	−141.466 ** (−2.01)
CH	−13.981 *** (−4.95)	−24.131 *** (−2.87)	−1.349 ** (−2.30)	−0.315 *** (−7.80)	−115.542 *** (−6.94)	−39.262 ** (2.23)
LA	−23.337 *** (−2.96)	23.575 *** (3.53)	0.857 * (1.80)	1.148 *** (35.18)	−301.841 *** (−23.68)	−326.314 *** (−5.74)
ROA	−5.706 *** (−3.14)	−18.947 *** (−7.25)	−1.494 *** (−7.45)	0.095 *** (6.93)	52.382 *** (3.26)	58.242 *** (3.67)
Intercept	21.684 *** (4.17)	145.373 *** (13.76)	0.496 *** (10.67)	−0.305 *** (−6.00)	−1900.025 *** (−13.56)	−1412.466 ** (−2.01)
QUARTER INDUSTRY	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes
N Adj R^2	9750 0.058	9750 0.227	9750 0.119	9750 0.339	9750 0.324	9750 0.357

Note: *, ** and *** represent significance levels of 10%, 5% and 1%, respectively; T value is shown in brackets in the table.

Under the manager view channel, the dependent variables are the operating expense ratio (OE) and asset turnover ratio (AT), and the coefficients of NOSE are both significant at the 1% level in columns (3) and (4). This indicates that SHMOEs with a high heterogeneous shareholding ratio have a lower operating expense ratio and a higher asset turnover ratio. Therefore, heterogeneous shareholders can improve corporate governance and alleviate agency problems, so as to reduce agency costs. Furthermore, in columns (5) and (6), the coefficients of NOSE fail to pass the significance test at the 10% level, but the coefficients of OE and AT are both statistically significant, which means that agency costs had a complete mediating effect.

Based on the above results, it can be seen that heterogeneous shareholders promote SOEs' innovation by strengthening the market-based operation mechanism of SOEs, which indicates that the manager view channel is confirmed.

4.4. Robustness Analysis

To check the robustness of our main findings, some additional regressions were conducted. First, because there are several methods to calculate firm innovation, we retested our main model by employing four different and well-accepted measurements of firm innovation, calculated using the CSMAR database, as the dependent variables. The variable definitions and results are shown in Table A3 of the Appendix A. Similar to our main results reported in Table 3, the estimated coefficient of $NSOE_t$ was again found to positively and significantly related with the other firm innovation measures ($Person_t$, $Spend_t$, Ln_IA_{t+1}, $Ratio\_IA_{t+1}$). That is, a higher ratio of heterogeneous shareholders indicates more R&D personnel, R&D spending, and future innovation output in SHMOEs.

Furthermore, heterogeneous shareholders' participation and SOEs innovation may be subject to the endogeneity problem of reverse causality, which means SOEs with higher levels of innovation are more likely to attract private-owned and foreign-owned shareholders. Referring to Acemoglu et al. [72] and Boubakri et al. [73], as shown in Table A4 of the Appendix A, we took the seasonal average temperature (Climate) of the cities in which the SHMOEs are located as the instrument variable of NSOE. There are two main reasons for selecting the quarterly average temperature as the instrumental variable of the shareholding ratio of heterogeneous shareholders. First, in the previous literature, the average temperature is regarded as an important economic and geographical variable. Second, the average temperature does not directly affect the innovation activities.

As show in Table A4, we used the control variable mentioned above and the instrumental variable, Climate, to perform a regression for NSOE in column (1). The first stage of regression shows that Climate and NSOE are significantly and positively correlated at the 1% level. The robust-f value of the test is 19.54, which indicates that our instrumental variable is effective. In the second stage of regression, we used Model 2 to test the predicted value of NSOE as the independent variable. The results of column (2) show that the coefficient of predicted NSOE is positive and significant, which is consistent with the main results.

In addition, we used the grouped regression method to retest the moderating effect of corporate governance characteristics during the COVID-19 period. As shown in Table A5 of Appendix A, the results are consistent with Hypothesis 2.

5. Conclusions

In this study, we focused on the relationship between heterogeneous shareholders and SOEs' innovation during the pre-COVID-19 and COVID-19 periods. We used manually organized ownership structure data and the financial yearly and quarterly data of mixed ownership enterprises in China from 2003–2020 as the sample. First, we empirically tested the impacts of heterogeneous shareholders on SOEs' innovation. Then, we examined the role of corporate governance characteristics, such as affiliated managers, reputation of accounting firms, and marketization degree, in the impacts of heterogeneous shareholders on SOEs' innovation. Furthermore, we studied the relationship between heterogeneous

shareholders and SOEs' innovation during the COVID-19 pandemic. Finally, we analyzed the influence path of heterogeneous shareholders on SOEs' innovation.

In contrast to the previous claim that SOEs discourage innovation [31,32], we found that SHMOEs, which are a special type of SOEs, more positively affect firm innovation decisions than other kinds of MOEs. Therefore, we then mainly focused on the sample of SHMOEs. In SHMOEs, the high proportion of non-state-owned shareholders can result in more innovation output. This proves that the mixed ownership reform of SOEs can enhance firm core competition. The results were unchanged after retesting the main model by employing four different measurements of firm innovation, or using the 2SLS method to overcome the endogeneity problem. In additional analysis, we used the mediation effect models to test whether heterogeneous shareholders influence SOEs' innovation via the political view channel or manager view channel. We found that the number of employees and wage expenditure are not significantly correlated with the non-state-owned shareholding ratio, which means that the political view channel was not evident. However, the non-state-owned shareholding ratio was significantly negatively correlated with the operating expense ratio, and positively correlated with the asset turnover ratio, which indicates that heterogeneous shareholders can reduce agency costs in SHMOEs. Furthermore, the operating expense ratio and asset turnover ratio are both significantly correlated with innovation output, which confirms the existence of the manager view channel [70,71].

In addition, we found that corporate governance characteristics play a moderating role in the impacts of heterogeneous shareholders on SOEs' innovation. We found that heterogeneous shareholders play a substitute role for internal and external governance factors by grouped regression. In particular, when SHMOEs have affiliated managers, are audited by accounting firms with a poorer reputation, or have a lower degree of external marketization, heterogeneous shareholders will have a strong desire to monitor the controlling shareholder and promote SOEs to find more valuable innovation opportunities. These results were found to be robust when we retested the moderating effect during the COVID-19 period samples.

More importantly, this study reveals why China's economy was quickly able to recover from the COVID-19 pandemic from the perspective of the mixed reform of SOEs. This finding is distinct from previous studies on the microeconomic consequences of COVID-19 from the perspective of the firm's performance, outward foreign direct investment, and cash holding [64–66]. We found that the heterogeneous shareholding ratio had a greater promoting effect on SOE innovation after the outbreak of COVID-19. This phenomenon may be attributed to China's adoption of applications of digital and intelligent technologies. Due to the increase in the demand for non-clustered economic activities, heterogeneous shareholders, such as private-owned or foreign-owned companies, have the advantages of high operational flexibility and sensitive market influences, which improve SOEs' ability to find more valuable opportunities for innovation. Overall, heterogeneous shareholders' active participation in mixed ownership reform can help SOEs to more quickly undergo industrial restructuring.

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Appendix A

Table A1. The distribution of SHMOEs.

Year	Number of Firm-Year	Proportion	Number of Firm-Quarter	Proportion
2003	310	6.32%	605	6.21%
2004	341	6.95%	655	6.72%
2005	348	7.09%	685	7.03%
2006	340	6.93%	669	6.86%
2007	321	6.54%	639	6.55%
2008	311	6.34%	614	6.30%
2009	299	6.09%	597	6.12%
2010	248	5.05%	508	5.21%
2011	226	4.61%	461	4.73%
2012	218	4.44%	441	4.52%
2013	207	4.22%	417	4.28%
2014	216	4.40%	429	4.40%
2015	241	4.91%	458	4.70%
2016	255	5.20%	493	5.06%
2017	276	5.62%	551	5.65%
2018	262	5.34%	539	5.53%
2019	287	5.85%	576	5.91%
2020	201	4.10%	413	4.24%
Total	4907	100%	9750	100%

Table A2. Main variables and descriptions.

Variable			Description
Independent Variables		SHMOE	If enterprise is state-owned holding mixed ownership, it takes 1 and, otherwise, 0
		NSOE	The sum of private-owned and foreign-owned shareholding ratio
		ANSOE	If the sum of private-owned and foreign-owned shareholding ratio larger than the average, it takes 1 and, otherwise, 0
		MNSOE	If the sum of private-owned and foreign-owned shareholding ratio larger than the median, it takes 1 and, otherwise, 0
Dependent Variables	IA	Ln_IA	The logarithm of intangible assets
		Ratio_IA	The proportion of intangible assets in total assets
Moderating Variables		AM	If the manager is both CEO and controlling shareholder, it takes 1 and, otherwise, 0
		AQ	If the audit opinion of the listed company comes from the "Big Four" accounting firms, it takes 1 and, otherwise, 0
		MD	If the company is registered in the eastern of China, it takes 1 and, otherwise, 0
		NC	If the sample period is Quarter 1: 2020 to Quarter 3: 2020, it takes 1 or, otherwise, 0; the same applies for quarters in 2019
Mediating Variables	PV	EMP	The total number of employees divided by the total assets
		WE	The salary payable divided by the prime operating revenue
	MV	OE	The sum of the management and sales expenses divided by the prime operating revenue
		AT	The prime operating revenue divided by the total assets
Control Variables		TA	Net fixed assets divided by the total assets
		CH	Monetary capital divided by the total assets
		LA	Liquid assets divided by total assets
		ROA	Earnings before interest and tax divided by total assets
		YEAR	Dummy variable, used to control the fixed effect of year
		QUARTER	Dummy variable, used to control the fixed effect of quarter
		INDUSTRY	Dummy variable, used to control industry fixed effect

Table A3. Influence of heterogeneous shareholders on SOEs' innovation decisions by alternative variables. Robustness checks.

Variables	$Person_t$	$Spend_t$	Ln_IA_{t+1}	$Ratio\_IA_{t+1}$
	(1)	(2)	(3)	(4)
$NSOE_t$	0.004 ***	0.006 ***	0.003 **	0.012 ***
	(3.03)	(4.85)	(1.98)	(13.75)
TA_t	−0.172 ***	−0.396 *	−130.754 *	−3.121 ***
	(−5.72)	(−1.75)	(−1.85)	(−21.94)

Table A3. *Cont.*

Variables	$Person_t$	$Spend_t$	Ln_IA_{t+1}	$Ratio\_IA_{t+1}$
	(1)	(2)	(3)	(4)
CH_t	−0.483 * (−1.83)	−0.541 ** (−2.34)	−45.257 *** (−3.84)	−0.448 ** (−2.55)
LA_t	−0.020 *** (−3.10)	0.163 *** (4.83)	−318.003 *** (−5.59)	−3.514 *** (−27.87)
ROA_t	1.218 *** (3.19)	0.578 *** (3.18)	4.282 ** (1.97)	1.079 *** (2.69)
Intercept	4.100 *** (8.34)	15.554 *** (43.29)	1949.659 *** (27.24)	20.348 *** (45.17)
QUARTER INDUSTRY	Yes Yes	Yes Yes	Yes Yes	Yes Yes
N Adj R^2	9750 0.319	9750 0.319	9437 0.237	9437 0.216

Note: *, ** and *** represent significance levels of 10%, 5% and 1%, respectively; T value is shown in brackets in the table. $Person_t$ represents the number of t quarter's R&D personnel. $Spend_t$ represents the t quarter's R&D expenditure. Both $Person_t$ and $Spend_t$ are collected from CSMAR database. Ln_IA_{t+1} and $Ratio\_IA_{t+1}$ represent the future firm innovation output. Ln_IA_{t+1} is measured by the t + 1 quarter's logarithm of intangible assets. $Ratio\_IA_{t+1}$ is measured by the t+1 quarter's proportion of intangible assets in total assets.

Table A4. Influence of heterogeneous shareholders on SOEs' innovation decisions by 2SLS. Robustness checks.

Variables	First Stage: NSOE	Second Stage: Ln_IA
	(1)	(2)
Climate	0.004 *** (4.297)	
NSOE		1.886 *** (11.300)
TA	−219.315 *** (−27.023)	−143.881 *** (−3.151)
CH	−108.448 *** (−11.091)	50.377 * (1.820)
LA	−288.295 *** (−40.134)	−329.884 *** (−8.759)
ROA	96.414 *** (6.475)	6.224 *** (4.821)
Intercept	2134.702 *** (113.564)	2006.035 *** (15.510)
QUARTER INDUSTRY	Yes Yes	Yes Yes
N Adj R^2	9750 0.225	9750 0.273

Note: * and *** represent significance levels of 10% and 1%, respectively; T value is shown in brackets in the table.

Table A5. Grouped regression based on corporate governance characteristics during COVID-19. Robustness checks.

Model	Panel A: Dependent Variable Ln_IA					
	AM = 1	AM = 0	AQ = 1	AQ = 0	MD = 1	MD = 0
	(1)	(2)	(3)	(4)	(5)	(6)
NSOE	0.014 *** (3.612)	0.019 (0.747)	0.010 (0.975)	0.029 *** (3.518)	0.007 (0.960)	0.024 *** (10.138)
TA	−0.683 *** (−3.764)	−2.754 *** (−10.356)	−2.036 *** (−7.890)	−3.266 *** (−2.958)	−2.237 *** (−6.694)	−2.799 *** (−7.380)
CH	−1.307 *** (−5.399)	−0.825 ** (−2.445)	−0.387 ** (−2.220)	−4.077 *** (−3.078)	−0.304 ** (−2.158)	−0.907 ** (−2.069)

Table A5. *Cont.*

Model	Panel A: Dependent Variable Ln_IA					
	AM = 1	**AM = 0**	**AQ = 1**	**AQ = 0**	**MD = 1**	**MD = 0**
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
LA	−2.272 *** (−3.031)	−3.458 *** (−14.741)	−3.002 *** (−13.202)	−3.310 *** (−4.445)	−3.507 *** (−10.843)	−3.030 *** (−9.748)
ROA	0.576 *** (3.461)	0.752 (1.532)	0.629 * (1.819)	3.317 ** (1.971)	0.742 ** (2.130)	0.618 *** (3.802)
Intercept	23.069 *** (26.139)	21.483 *** (35.033)	21.366 *** (44.948)	27.150 *** (7.176)	21.989 *** (41.043)	20.532 *** (19.565)
QUARTER INDUSTRY	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes
N Adj R^2	52 0.351	436 0.313	60 0.441	428 0.360	264 0.355	224 0.329
Model	**Panel B: Dependent Variable Ratio_IA**					
	(7)	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**
NSOE	0.021 ***	0.013	0.009	0.001 ***	0.003	0.005 ***
	(5.763)	(1.235)	(0.429)	(4.605)	(0.127)	(4.249)
TA	−0.017 ***	−0.218 ***	−0.183 ***	−0.115 ***	−0.265 ***	−0.161 ***
	(−3.739)	(−22.916)	(−20.072)	(−2.907)	(−19.250)	(−14.264)
CH	−0.031 ***	−0.005 ***	−0.003 ***	−0.032 ***	0.013 ***	−0.009 ***
	(−4.287)	(−6.403)	(−4.298)	(−3.704)	(4.703)	(−6.704)
LA	−0.106 ***	−0.194 ***	−0.179 ***	−0.143 ***	−0.248 ***	−0.149 ***
	(−5.545)	(−23.101)	(−22.265)	(−5.537)	(−18.660)	(−16.089)
ROA	0.142 ***	0.037 **	0.090 ***	0.163 ***	0.081 ***	0.091 ***
	(14.079)	(2.119)	(7.713)	(3.272)	(5.670)	(3.997)
Intercept	0.051 **	0.195 ***	0.133 ***	0.057 ***	0.205 ***	0.042 ***
	(2.276)	(8.883)	(7.879)	(3.437)	(9.276)	(6.361)
QUARTER INDUSTRY	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes	Yes Yes
N Adj R^2	52 0.386	436 0.448	60 0.350	428 0.393	264 0.383	224 0.355

Note: ** and *** represent significance levels of 5% and 1%, respectively; T value is shown in brackets in the table.

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