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Corporate environmental governance scheme and investment efficiency over the course of COVID-19

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ABSTRACT

Taking the COVID-19 outbreak as the exogenous shock, we use quarterly reports of Chinese listed firms to examine whether enhanced environmental governance scheme improves corporate investment efficiency over the course of COVID-19. The results show that after the outbreak, firms with greater environmental governance scheme experience more efficient investments, with this effect being more pronounced in non-state-owned enterprises, firms unlisted as key pollution-monitoring units, and firms with higher financial constraints. The results are robust to a battery of robustness checks. These findings provide new evidence on the importance of environmental governance in reaping economic benefits and resilience during crisis times.

1. Introduction

For decades, many countries have participated in international environmental agreements and committed to stricter environmental regulations (Espinola-Arredondo and Munoz-Garcia, 2012; Tian et al., 2020). Firms start to move beyond environmental compliance and take active environmental governance measures in attempts to protect the environment and achieve a sustainable development path (Hart, 1997; Tang et al., 2012). Especially during crisis times, green recovery has been regarded as an important way of post-crisis economic recoveries. For example, during the 2008-2009 global financial crisis (GFC) period, some G20 countries began to integrate “green” investments in their stimulus plans (Pollin et al., 2008). During the ongoing COVID-19 pandemic, China committed to the goal of a carbon peak by 2030 and a carbon neutrality by 2060 (Tian et al., 2021). Consequently, all arms of the Chinese government have implemented policies to encourage firms to commit to green investment to achieve these goals. Accordingly, governments worldwide are now attaching significant importance to corporate environmental governance practices.

Emerging evidence suggests that high sustainability firms are more resilient during turbulent times (Bae et al., 2021; Broadstock et al., 2021; Garel & Petit-Romec, 2021a,b). Engagement with ESG (environmental, social and governance) issues could reduce downside risk (Hoepner et al., 2019), enhance the performance of a managed portfolio (Broadstock et al., 2021), and increase the value to shareholders (Griffin et al., 2020). Studies on COVID-19 and corporate performance further indicate that under the circumstances of uncertain global capital markets (Liu et al., 2020) and turbulent investment environment (Jiang et al., 2021), firms with responsible strategies on environmental issues experience better stock returns (Rui et al., 2020; Bae et al., 2021; Garel & Petit-Romec, 2021a).

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Some scholars have found that environmentally-friendly firms often pay higher compliance costs (Ghoulet et al., 2018), have lower-than-expected earnings (Palmer and Portney, 1995), experience greater fluctuations in future cash flows (Jung et al., 2018), and have decreased investment capacity (Phan et al., 2021). However, with the increasing emphasis on green recovery and environmental responsibility during the COVID-19 period (Wan et al., 2021), firms with stronger environmental governance scheme may demonstrate better crisis management and greater resilience capacity (Liu et al., 2021). First, environmental governance scheme (EGS) entails a firm’s environmental governance vision, concepts, planning, and implementation (Tang et al., 2012). Resource-based theory (RBT) states that incorporating “green” components into business operations can lead to lower inputs (Gallego-Alvarez et al., 2015), new business opportunities (Flammer et al., 2013), and firms with better environmental governance can improve their competitive advantages and have more effective investments by taking the first-mover advantage (Porter and Linde, 1999; Rodrigue et al., 2013), surpassing previously advantaged competing firms in the long run (Tang et al., 2012). Second, firms with good environmental governance can send a more positive signal to the market, indicating better environmental adaptation and resource utilization, so that favorably meet stakeholders’ green expectations and earn green trust, enhance corporate reputation (Chen et al., 2006; Nidumolu et al., 2009); as a result, they are more likely to reap economic gains through a lower operation cost and higher profitability (Klassen and McLaughlin, 1996; Bruna and Nicolo, 2020). Therefore, these tangible and intangible profits can motivate firms with “green” strengths to improve their investment quality and efficiency.

Accordingly, this study seeks to examine whether firms with greater environmental governance scheme are more resilient and adaptive in adjusting their investments over the course of the pandemic, and provides answers to the following two research questions: during crisis times, 1) whether environmental governance scheme is conducive to improving corporate investment efficiency; and 2) what types of firms are more likely to benefit from the enhanced environmental governance scheme.

To answer the research questions, we construct a comprehensive environmental governance scheme (EGS) evaluation index and employ a quasi-natural experiment framework to test the impact of EGS on investment efficiency during the crisis period. It is found that a higher-quality EGS is able to alleviate under-investment and over-investment inefficiency over the course of the COVID-19 crisis. The Propensity Score Matching (PSM) and Heckman’s two-stage approaches are implemented to verify the robustness of the baseline results. We further demonstrate that the advantageous effect of EGS on efficient investment during the pandemic crisis is more evident in non-state-owned enterprises (non-SOEs), firms not listed as key pollution-monitoring units, and firms with higher financial constraints.

This study makes three main contributions. First, we focus specifically on the environmental governance scheme (EGS) and construct a comprehensive firm-level EGS indicator to reflect a systematic picture of corporate environmental governance from the perspectives of top-level designs, visions and actions, as well as management systems. Second, our findings contribute to the literature on the role of environmental governance plays against unexpected shocks. Prior studies examine the effect of environmental performance and risk on corporate performance such as stock returns (Liu et al., 2021) and the cost of capital (Huynh et al., 2020) during normal times. This study advances the knowledge of the relationship between environmental governance and firm performance by identifying EGS as an important but formerly ignored driver of corporate investment efficiency during crisis times. Third, to date, due to the data availability, few studies have been conducted on the impact of corporate environmental governance on investment efficiency over the course of the ongoing pandemic. Our research enriches research on the impact of COVID-19 and provides practical guidelines for firms’ sustainable development during crisis times.

2. Data and methodology

2.1. Data

Based on the availability and comparability of financial data, fifteen quarters from the first quarter of 2018 to the third quarter of 2021 were selected. We use Chinese A-share firms listed on the Shanghai and Shenzhen stock markets as the sample firms. The key variable of interest is the EGS and its component sub-indicators, the data for which were collected from the China Listed Firms’ Environmental Research Database. Other firm-level data were then matched and merged from the respective financial reports in the China Stock Market & Accounting Research (CSMAR) database.

2.2. Variables

2.2.1. Environmental governance scheme (EGS)

Building on Li et al.’s (2019) green governance index system, we select eight indicators that are closely related to ESG covering areas such as environmental protection concepts, implementation, and environmental management status. The Macromos, Content, and Technique (MCT) Social Responsibility Report Evaluation System by Ranking CSR Ratings (RKS)\(^1\) is employed to develop a structured expert scoring method to classify the eight indicators into three dimensions with corresponding weights. Details are provided in Appendix A.

First, the macrocosm score (M-score) includes a secondary environmental protection concept index to reflect the top-level designs of firms’ environmental governance visions, missions, and culture. If it is disclosed in the financial reports, it is assigned as 1; and

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1. Ranking CSR Ratings (RKS), an authoritative third-party rating agency for corporate social responsibility (CSR) in China.
### Table 1
Descriptive statistics.

| Variable | N   | Mean   | Median | Std Dev | Min   | Max   |
|----------|-----|--------|--------|---------|-------|-------|
| INVEST  | 44848 | 2.793  | 1.403  | 4.618   | 0     | 65.52 |
| Age     | 48403 | 2.334  | 2.398  | 0.740   | 0     | 3.367 |
| Lev     | 48403 | 0.442  | 0.428  | 0.213   | 0.059 | 0.987 |
| OPR     | 48403 | 0.063  | 0.077  | 0.296   | -1.852| 0.799 |
| FCF     | 48403 | -0.148 | -0.044 | 0.822   | -4.727| 2.405 |
| AT      | 48403 | 0.335  | 0.289  | 0.242   | 0.012 | 1.418 |
| Size    | 48403 | 22.41  | 22.21  | 1.449   | 19.77 | 27.31 |
| Maow    | 47494 | 5.561  | 0.047  | 13.51   | -1.011| 70.75 |
| Indratio| 47494 | 37.60  | 37.50  | 13.49   | 0     | 73.80 |
| Compen  | 48323 | 15.64  | 15.58  | 0.71    | 14.04 | 17.71 |

### Table 2
Difference-in-differences regression results.

| VARIABLES | (1) DID INVEST\(_{t-1}\) | (2) Heckman INVEST\(_{t-1}\) |
|-----------|---------------------------|-----------------------------|
| Treat*Post| -0.2797* (0.1491)         | -0.4128** (0.1607)         |
| Post      | 4.5701*** (0.1592)        | 4.5611*** (0.1703)         |
| Treat     | 0.1797 (0.1108)           | 0.0955 (0.8124)            |
| Age       | -0.6626*** (0.0676)       | -0.5825*** (0.0895)        |
| Lev       | 0.1680 (0.2393)           | 0.0678 (0.3176)            |
| OPR       | 0.2990* (0.1526)          | 0.3557* (0.2071)           |
| FCF       | -0.5319*** (0.0571)       | -0.6370*** (0.0856)        |
| AT        | -0.4147* (0.2171)         | -0.7530*** (0.2698)        |
| Size      | -0.1858*** (0.0416)       | -0.1751* (0.0910)          |
| Maow      | 0.0044 (0.0045)           | 0.0093* (0.0051)           |
| Indratio  | 0.0041 (0.0033)           | 0.0066* (0.0039)           |
| Compen    | 0.0648 (0.1025)           | 0.1152 (0.4568)            |
| IMR       | 0.0870 (0.4568)           | 0.0870 (0.4568)            |
| Constant  | 4.8436*** (1.1767)        | 4.3857* (2.5079)           |
| Quarter_FE| Yes                       | Yes                         |
| Industry_FE| Yes                      | Yes                         |
| Observations| 33,899                | 13,221                      |
| R-squared | 0.309                     | 0.259                       |

**Notes:** This table provides the results on relationship between EGS scores of Chinese listed firms and investment efficiency during the COVID-19 period. Column (1) reports the DID results for overall investment efficiency. Columns (2) shows the results for the Heckman’s two-stage approach. All variables are defined in Appendix B, and time and industry fixed effects are also controlled. Robust standard errors are clustered at the firm level and are reported in the parentheses. All continuous variables are winsorized at the 1% and 99% levels, and ***, **, and * indicate significances at the 1%, 5%, and 10% levels.
0 otherwise. The full M-score is 0.4 by the MCT weight. Second, based on four secondary indicators, environmental protection goals, environmental protection education and training, environmental protection special actions, and environmental protection honors or rewards, the content score (C-score) reflects the specific achievements of a firm’s environmental governance. If disclosed, it is assigned as 1; and 0 otherwise. The full C-score is 0.3 by the MCT weight. Third, to reflect the effectiveness of firms’ EGS implementation, the system score (S-score) is calculated based on three secondary indicators, including environmental protection management system, emergent environmental event management mechanism, and the “three simultaneous system”. If disclosed, it is assigned as 1; and 0 otherwise. The full S-score is 0.3 by the MCT weight. Therefore, in total, the full EGS score is 1 (0.4 + 0.3 + 0.3).

Based on the EGS evaluation system, the total EGS scores for the listed firms are calculated at a given year. If the average total EGS score of a firm is higher than the average score of all firms before the pandemic outbreak, the firm is classified as a high-quality EGS firm, and so other firms are labelled as low-quality EGS.

### 2.2.2. Investment efficiency

We follow Richardson (2006) to measure corporate investment efficiency. By establishing an investment regression model with a positive NPV (Net Present Value) for new projects, the residual error obtained using the model is regarded as part of the inefficient investment in the total investment expenditure. The residual measurement model is shown in model (1):

\[
I_i, t = \beta_0 + \beta_1 Q_{i,t-1} + \beta_2 \text{Lev}_{i,t-1} + \beta_3 \text{Age}_{i,t-1} + \beta_4 \text{Cash}_{i,t-1} + \beta_5 \text{AR}_{i,t-1} + \beta_6 \text{Size}_{i,t-1} + \beta_7 I_{i,t-1} + \sum \text{Quarter} + \sum \text{Ind} + \sum \text{Firm} + \epsilon
\]

(1)

where, \(I_i, t\) is the capital investment, which is the change in the net value of “the cash paid for the purchase and construction of fixed assets, intangible assets and other long-term assets in the current quarter” scaled by the total assets in the current quarter; \(Q_{i,t-1}\) is the firm’s investment opportunities, which is measured by the operating income growth rate; \(\text{Lev}_{i,t-1}\) is the liability-asset ratio; \(\text{Age}_{i,t-1}\) refers to the total years the firm has been listed; \(\text{Cash}_{i,t-1}\) is the free cash flow, which is equal to the net cash flow generated by the operating activities scaled by the total assets; \(\text{AR}_{i,t-1}\) is the return on individual stocks, which is measured by adjusting the previous quarter’s basic earnings per share; and \(\text{Size}_{i,t-1}\) is the size of the firm, which is measured by the natural logarithms of the total assets. Time and industry fixed effects are also included.

Regression model (1) is estimated to obtain the residual \(r_i\); if \(r_i > 0\), it indicates excessive investment, the bigger the value, the greater
the degree of over-investment, and if \( r < 0 \), it indicates insufficient investment, which is then multiplied by -1, with the greater the value, the greater the degree of under-investment. We thus calculate the overall investment efficiency (\( \text{INVEST} \)) as the absolute value of \( r \) multiplied by 1,000\(^3\); the larger the value, the lower the overall investment efficiency.

### 2.2.3. Control variables

We refer to previous research on corporate investment efficiency (e.g., Biddle and Gilles, 2006; Verdi, 2009) to select control variables, including the firm-level financial and corporate governance data. Explanations about the variables used in this study and the corresponding correlation coefficient matrix are provided in Appendix B and Appendix C, respectively, and Table 1 shows the descriptive statistics. We also employ the VIF test to test the potential multicollinearity problem. The largest VIF statistic is found to be 4.77, which is less than the critical value of 10, indicating that there is no serious multicollinearity problem in the regressions.

### 3. Empirical results

#### 3.1. Role of EGS in investment efficiency during the COVID-19 crisis

The difference in differences (DID) estimation is employed to investigate the role of EGS in corporate investment efficiency during crisis times. COVID-19 is taken as an exogenous shock to evaluate its impact on corporate investments. We identify the “high-quality EGS firms” as the treatment group (\( \text{Treat} = 1 \)), and the “low-quality EGS firms” (\( \text{Treat} = 0 \)) as the control group. \( \text{Post} \) is a dummy variable that takes a value of 1 when \( t \) is the second quarter of 2020 and after; otherwise, \( \text{Post} = 0 \), which is the first quarter of 2020 and before. Therefore, the DID model is established as follows:

\[
\text{Treat}^*\text{Post} = \beta_0 + \beta_1 \text{Treat} + \beta_2 \text{Post} + \beta_3 \text{Treat}^*\text{Post} + \gamma \text{Control variables} + \epsilon
\]

### Table 3

| VARIABLES | \( \text{PSM-DID} \) \( \text{INVEST}_{t+1} \) | \( \text{PSM-DID} \) \( \text{OVER}_{t+1} \) | \( \text{PSM-DID} \) \( \text{UNDER}_{t+1} \) |
|-----------|---------------------------------|-------------------------------|-------------------------------|
| \( \text{Treat}^*\text{Post} \) | -0.0336*** | -0.0350* | -0.0302** |
| \( \text{Post} \) | 0.1330*** | 0.1040* | 0.1450*** |
| \( \text{Treat} \) | 0.0197 | 0.0914 | -0.0732 |
| \( \text{Age} \) | -0.3300*** | -0.2760*** | -0.3630*** |
| \( \text{Lev} \) | 0.1360 | 0.1390 | 0.1420 |
| \( \text{OPR} \) | 0.0754 | 0.0748 | 0.0704 |
| \( \text{FCF} \) | -0.1650*** | -0.2720*** | -0.0794*** |
| \( \text{AT} \) | -0.1840 | -0.2440 | -0.1390 |
| \( \text{Size} \) | -0.0774*** | -0.1130*** | -0.0750** |
| \( \text{Maow} \) | 0.0013 | 0.0025 | 0.0003 |
| \( \text{Indratio} \) | 0.0014 | 0.0013 | 0.0016 |
| \( \text{Compen} \) | 0.0072 | -0.0298 | 0.0586 |
| \( \text{Constant} \) | 2.3850*** | 3.5660*** | 1.2450* |
| \( \text{Quarter FE} \) | Yes | Yes | Yes |
| \( \text{Industry FE} \) | Yes | Yes | Yes |
| \( \text{Firm FE} \) | No | No | No |
| Observations | 40,517 | 18,633 | 21,884 |
| R-squared | 0.111 | 0.126 | 0.159 |

Notes: This table reflects the impact of corporate EGS on investment efficiency over the course of the COVID-19 crisis. Columns (1)-(3) report the results for the PSM-DID strategy for overall investment efficiency, over- and under-investment efficiency, respectively. All variables are defined in Appendix B, and time and industry fixed effects are also controlled. Robust standard errors are clustered at the firm level and are reported in the parentheses. All continuous variables are winsorized at the 1% and 99% levels, and ***, **, and * indicate significances at the 1%, 5%, and 10% levels.

\[^3\] Because the scale of \( | r | \) is relatively small, we scale it up by 1,000 for easy interpretations while not affecting statistical significance.
Table 4: Heterogeneity results.

| VARIABLES | (1) SOE Invest_{t+1} | (2) Non-SOE Invest_{t+1} | (3) Key Invest_{t+1} | (4) Non-Key Invest_{t+1} | (5) FC Invest_{t+1} | (6) NFC Invest_{t+1} |
|-----------|-----------------|----------------|----------------|----------------|----------------|----------------|
| Treat*Post | -0.0027** | -0.0370*** | 0.0030 | -0.6045*** | -0.8081*** | 0.2278 |
| (0.0121) | (0.0163) | (0.2345) | (0.1946) | (0.2652) | (0.2005) |
| Post | 0.0122 | 0.179*** | 5.0876*** | 4.3192*** | 5.8479*** | 3.7868*** |
| (0.0458) | (0.0454) | (0.2749) | (0.1948) | (0.2825) | (0.2050) |
| Treat | -0.1410 | 0.1550 | 0.0565 | 0.2367 | 0.4069* | 0.0372 |
| (0.1030) | (0.1040) | (0.1674) | (0.1526) | (0.2146) | (0.1410) |
| Age | -0.0741 | -0.382*** | -1.0614*** | -0.5712*** | -0.8537*** | -0.2027 |
| (0.0794) | (0.0501) | (0.1342) | (0.0774) | (0.1409) | (0.1652) |
| Lev | -0.1300 | 0.3990** | 1.2243*** | -0.3106 | 0.4362 | 0.3371 |
| (0.2680) | (0.2030) | (0.4657) | (0.2823) | (0.4756) | (0.3299) |
| OPR | 0.0442 | 0.1390 | 0.8098* | 0.1803 | 0.5944 | 0.531* |
| (0.1650) | (0.1050) | (0.4377) | (0.1573) | (0.4992) | (0.3022) |
| FCF | -0.0735** | -0.2020*** | -0.8394*** | -0.4320*** | -0.6739*** | -0.3644*** |
| (0.0302) | (0.0319) | (0.1233) | (0.0638) | (0.0927) | (0.0882) |
| AT | 0.0039 | -0.3190** | -0.1794 | -0.4096 | 0.0356 | 0.6026** |
| (0.2110) | (0.1600) | (0.3536) | (0.2791) | (0.4116) | (0.2717) |
| Size | -0.1140*** | -0.0449 | -0.2792*** | -0.1626*** | -0.1055 | -0.229*** |
| (0.0352) | (0.0355) | (0.0842) | (0.0477) | (0.0717) | (0.0660) |
| Maow | 0.0010 | 0.0005 | 0.0019 | 0.0058 | 0.0056 | 0.0026 |
| (0.0187) | (0.0021) | (0.0010) | (0.0050) | (0.0060) | (0.0068) |
| Indratio | 0.0001 | 0.0017 | 0.0054 | 0.0081* | 0.0045 | 0.0006 |
| (0.0024) | (0.0018) | (0.0062) | (0.0039) | (0.0054) | (0.0044) |
| Compens | 0.0400 | -0.0132 | 0.2616** | -0.0215 | -0.0304 | 0.1036 |
| (0.0582) | (0.0538) | (0.1242) | (0.0813) | (0.1283) | (0.0925) |
| Constant | 1.8440* | 2.1960*** | 1.5915 | 6.1830*** | 5.2388*** | 2.8888* |
| (1.0600) | (0.8350) | (1.6983) | (1.4040) | (1.8482) | (1.4882) |
| Quarter_FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Industry_FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Firm_FE | No | No | No | No | No | No |
| Observations | 12,499 | 28,018 | 11,209 | 22,690 | 14,348 | 14,753 |
| R-squared | 0.157 | 0.117 | 0.339 | 0.307 | 0.332 | 0.311 |

Notes: This table reflects the heterogeneous effects of state ownership, whether listed as key pollution-monitoring units, and financial constraints on the relationship between firms’ EGS and investment efficiency. Columns (1) and (2) show the results for the SOEs and non-SOEs; Columns (3) and (4) show the results for the key pollution-monitoring and non-key pollution-monitoring companies; Columns (5) and (6) show the results for firms with high and low financial constraints. All variables are defined in Appendix B, and time and industry fixed effects are also controlled. Robust standard errors are clustered at the firm level and are reported in the parentheses. All continuous variables are winsorized at the 1% and 99% levels, and ***, **, and * indicate significances at the 1%, 5%, and 10% levels.

\[
\text{Invest}_{t+1} = \alpha_0 + \alpha_1 \text{Treat}_{it} + \alpha_2 \text{Post}_{it} + \alpha_3 \text{Treat}_{it} \times \text{Post}_{it} + \alpha_4 \text{Controls}_{it} + \epsilon_{it}
\]  

(2)

where \(\text{Invest}_{it}\) is the inefficient investment of listed firm \(i\) in period \(t+1\), and \(\text{Post}_{it} \times \text{Treat}_{it}\) is the interaction term for \(\text{Post}_{it}\) and \(\text{Treat}_{it}\) with the coefficient for \(\text{Treat}_{it}\), reflecting the investment efficiency differences between the treated and control groups over the course of COVID-19. The firm-level control variables are \(\text{Age}\) (firm age), \(\text{Lev}\) (asset-liability ratio), \(\text{OPR}\) (net operating interest rate), \(\text{FCF}\) (free cash flow per share), \(\text{AT}\) (total asset turnover), \(\text{Size}\) (the size of the firm), \(\text{Maow}\) (executive stockholding rate), \(\text{Indratio}\) (proportion of independent directors), \(\text{Compens}\) (executive salary, taking logarithm). To account for the potential time-specific shocks and any unobservable industry shocks, time and industry fixed effects are also included. \(\epsilon_{it}\) is the random error term.

Columns (1) in Table 2 shows the DID regression results for overall investment efficiency (\(\text{Invest}_{t+1}\)). The coefficient on \(\text{Post}\) is positive and statistically significant at the 1% level, indicating that the overall investment inefficiency of firms has increased significantly after the COVID-19 outbreak. In other words, the external adverse pandemic shock has caused significant and negative impacts on corporate investments. However, the coefficient on \(\text{Treat}_{it} \times \text{Post}_{it}\) is negative and statistically significant, suggesting that firms with greater environmental governance scheme have more efficient investment over the course of COVID-19. The results are consistent with the existing literature on the vital role of corporate environmental governance. Compared to non-green firms, those with better pro-environmental practices have stronger resilient capabilities (Li et al., 2019), greater competitiveness (Albuquerque et al., 2020) and so faster rebound speed against unexpected crises (Broadstock et al., 2021).

In addition, because of possible self-selection bias concerns, we also employ the Heckman’s two-stage approach and placebo tests to further examine the robustness of the EGS impact on investment efficiency during the COVID-19 crisis. Column (2) in Table 2 shows the results from the Heckman two-stage estimation and Figure 1 illustrates the results from running the regression for 1,000 times by advancing or delaying the virtual time node for the “policy” implementation (the COVID-19 outbreak). The results further document that our key findings on the advantageous impact of EGS on corporate investment efficiency over the course of the crisis are robust and reliable.

To further mitigate the impact of endogenous problems, a matched group is selected for each high-quality EGS firm using the
Propensity Score Matching (PSM) method, after which the DID test is conducted. Table 3 shows the PSM-DID regression results for overall investment efficiency (INVEST), over-investment (OVER), and under-investment (UNDER), respectively. The PSM-DID results are reported in Column (1) and are consistent with the baseline finding that greater EGS helps mitigate the impact of the pandemic crisis on corporate investment efficiency, and the coefficient for the Treat*Post term in Columns (2) and (3) is significantly negative, indicating that firms with higher-quality EGS have better investment efficiency after the COVID-19 outbreak and that environmental governance is able to effectively curb both over- and under-investment inefficiency. The results give solid evidence that a strong EGS provides a buffering mechanism against external shocks; it significantly enhances a firm’s crisis resistance capabilities, and promotes post-crisis investment activities. Taken together, when faced with an external crisis, good environmental governance is found to play a significant and positive role in enhancing corporate investment efficiency.

3.3. Heterogenous effects

The impact of EGS on investment efficiency during the COVID-19 crisis may vary across firms. This section discusses the relationship between EGS and corporate investment efficiency contingent on firms’ state ownership (SOE/Non-SOE), whether listed as key pollution-monitoring units (Key/Non-Key), and financial constraints (FC/NFC). Specifically, first, we categorize firms into state-owned enterprises (SOE) and non-state-owned (Non-SOE) due to their state ownership. Second, based on the environmental supervision and certification disclosures for the listed firms collected from the China Listed Firm Environmental Research Database, the sample firms are divided into key pollution-monitoring units (Key) and non-key pollution-monitoring firms (Non-Key). Third, to verify the heterogeneous effect of financial constraints on the EGS-investment nexus, the SA (Size-Age) index proposed by Hadlock and Pierce (2010) is utilized to quantitatively measure the degree of firms’ financial constraints, for which the sample is divided into a high financial constraint group (FC) and a low financial constraint group (NFC). Table 4 reports the heterogeneity results.

The results indicate that over the course of COVID-19, the EGS plays a stronger role in improving corporate investment efficiency in non-SOEs, firms not listed as key pollution-monitoring units, and those with high financial constraints. Compared to heavy-polluted firms, firms with inherent advantages in environmental protection could promote their positive image by paying more attention to pro-environmental activities, and their sustainable development modes echo with the green recovery principle worldwide, favoring increasingly prevalent green expectations and needs of stakeholders (Gallego-Alvarez et al., 2015; Phan et al., 2021). Greater environmental governance is the key to obtaining government and public trust; therefore, the benefits reaped from better environmental governance outweigh the costs (Liu et al., 2021). Environmental governance scheme can also effectively mitigate inefficient investment behavior in resource-poor firms such as non-state-owned and firms with financial constraints, which further demonstrates the vital importance of environmental governance to corporate resilience against external shocks (Wan et al., 2021).

4. Conclusion

The outbreak of COVID-19 has generated great uncertainties to corporate investment activities. Focusing on the resistance of environmental governance capacity against external adverse shocks, we construct a comprehensive firm-level environmental governance scheme (EGS) evaluation system to systematically measure corporate environmental governance capacity, and provide evidence that stronger EGS effectively enhances corporate investment efficiency over the course of the pandemic. This study advances the knowledge on the advantageous impact of environmental governance scheme on enhancing corporate resilience and so survival rate when facing with unexpected external shocks. As environmental issues and green recovery are increasingly concerned by the investors, the development and implementation of environmental governance scheme is vital for attracting investor attention and mitigating regulatory compliance costs, and ultimately improving corporate investment efficiency during crisis times. Therefore, corporate decision-makers should incorporate the environmental governance scheme into the corporate strategic development plans. Future research can explore the mechanism channel through which enhanced EGS protects and enhances corporate performance, and/or collect longer-term data to investigate the medium- and long-term benefits of EGS.

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Appendix A. Environmental governance scheme (EGS) evaluation system

| Indicator | Description |
|-----------|-------------|
| **M-Score (macrocosm score)** | Disclosure of the firm’s environmental protection concept and policy, environmental management structure, circular economy development model, green development, etc. |
| Environmental protection concept | |
| Environmental education and training | Disclosure of the firm’s environmental protection related education and training that the firm has participated in |
| **C-score (content score)** | |
| Environmental protection goals | |
| Environmental education and training | |

(continued on next page)
Indicator Description

- Environmental protection special actions: Disclosure of the firm’s participation in environmental protection special actions, environmental protection, and other public welfare activities.
- Environmental honors or awards: Disclosure of environmental protection honors or awards the firm has received.
- S-Score (system score): Disclosure of the environmental management systems, regulations, and responsibilities that have been implemented.
- Emergency management mechanism for environmental events: Disclosure of the firm’s emergency management mechanism for big environmental events, the emergency measures taken, and the treatment of pollutants, etc.
- “Three simultaneous” system: Disclosure of the firm’s implementation of the “three simultaneous” system.

Appendix B. Variable definitions

| Variable | Definition |
|----------|------------|
| **Dependent variables** | |
| INVEST | 1000*|Invest, and |Invest is the absolute value of the residual value of regression model (1); the larger the value, the lower the investment efficiency. |
| OVER | 1000*r if r>0, and r is the residual value of regression model (1), it indicates excessive investment. |
| UNDER | 1000*r if r<0, and r is the residual value of regression model (1), it indicates under-investment. |
| **Independent Variable** | |
| Post | 1 = if period t belongs to the second quarter of 2020 and after; 0 otherwise. |
| Treated | A dummy variable: 1=firm has a better environmental governance scheme (EGS); 0 otherwise. |
| **Independent Variable** | |
| Age | Listing age of firm |
| Lev | Asset liability ratio: ratio of total liabilities divided by total assets. |
| OPR | Operating net interest rate: ratio of net profit to operating income. |
| FCF | Free cash flow per share from operating activities divided by sample mean. |
| AT | Total assets turnover: ratio of the sales (operating) revenue to total assets. |
| Size | Logarithm of market value. |
| Maow | Managerial ownership: the executives share. |
| Indratio | Proportion of independent directors: ratio of independent directors to number of directors. |
| Compen | Logarithm of executive compensation. |

Appendix C. Correlation coefficient matrix

|     | Age    | Lev    | OPR    | FCF    | AT     | Size   | Maow   | Indratio | Compen  |
|-----|--------|--------|--------|--------|--------|--------|--------|----------|---------|
| Lev | 0.282*** |        |        |        |        |        |        |          |         |
| OPR | -0.098*** | -0.216*** |        |        |        |        |        |          |         |
| FCF | 0.140***  | -0.084*** | 0.041*** |        |        |        |        |          |         |
| AT  | -0.037*** | 0.018***  | 0.037*** | 0.009** |        |        |        |          |         |
| Size | 0.187***  | 0.304***  | 0.168*** | -0.013** | 0.216*** |        |        |          |         |
| Maow| -0.290***  | -0.161*** | 0.038*** | -0.049*** | -0.017*** | -0.109*** |        |          |         |
| Indratio | 0.051*** | 0.007 | 0.002 | 0.024*** | -0.023*** | 0.026*** | 0.052*** |          |         |
| Compen | 0.124***  | 0.199***  | 0.186*** | -0.009** | 0.064*** | 0.507*** | -0.061*** | 0.042*** |         |

This table presents the correlations among the variables. All variables are defined in Appendix B. ***, **, and * indicate significances at the 1%, 5%, and 10% levels.

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