

# Can anti-corruption improve the quality of environmental information disclosure?

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## Research Article

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# Abstract

This study takes the anti-corruption campaign of the 18th CPC National Congress in China as an exogenous impact, using the data of heavy polluting enterprises in Shanghai and Shenzhen A-share manufacturing industry over 2008–2018 and the local level data to build a double difference (DID) model, which proves that anti-corruption can increase the quality of enterprise environmental information disclosure significantly. After a series of tests such as parallel trend test and placebo test, the results are still robust. The intermediary effect model results indicate that the anti-corruption increases the violation cost of enterprises and encourages enterprises to carry out innovation activities, and ultimately increase the quality of enterprise environmental information disclosure. Considering that enterprise nature, enterprise size, and the environmental supervision strength will influence the quality of enterprise environmental information disclosure differently. We further construct a group regression model for heterogeneity analysis and finds that non-state-owned enterprises, large enterprises and regions with more substantial environmental supervision will improve the quality of enterprise environmental information disclosure to a greater extent. The findings of paper can help understand the internal mechanism between anti-corruption and corporate environmental information disclosure and provide empirical evidence for the implementation of mandatory environmental information disclosure policy.

## 1. Introduction

As the booming of China's economy, serious environmental pollution has proved to be a key factor restricting society's overall development (Du et al., 2013; Wang and Sun, 2018; Zhang et al., 2018). Chinese government has introduced a series of environmental protection regulations in recent years, trying to solve high environmental costs in the process of economic development. As an essential channel for external stakeholders to obtain corporate environmental performance, environmental information disclosure is an integral part of China's modern environmental regulatory system. The improvement of quality of enterprise environmental disclosure is conducive to public's real understanding of corporate environmental performance, forcing enterprises to carry out environmental governance and improving environmental conditions (Wang et al., 2017).

Up to now, China has issued several regulations to standardize environmental information disclosure (Wang and Zhang, 2019), such as the Environmental information disclosure (trial), the Measures for Environmental Information Disclosure of Enterprises and Institutions, etc. These regulations stipulate heavy polluting enterprises to disclose environmental information about pollutant emissions, the operation of environmental protection facilities, environmental input, etc. More importantly, for enterprises that disclose environmental information illegally, the environmental protection department will pursue the corresponding legal responsibility and impose a fine.

Although above regulations put forward higher requirements on the quantity and quality of environmental information disclosure, existing studies indicate that the quality of enterprise environmental disclosure has not been substantially improved. Enterprises tend to disclose only self-interest information, mainly a qualitative description (Liu and Anbumozhi, 2009). In 2019, China Association of Environmental Journalists and Beijing University of Chemical Technology jointly released the Evaluation Report on Environmental Information Disclosure of Chinese Listed Companies. The report showed that the average score of the environmental information disclosure index of Chinese listed enterprises was only 33.44 points, which was still low. Thus, improving quality of enterprise environmental disclosure is still an urgent matter that needs to be settled.

China's existing environmental regulation system has a serious problem of paper-based, there is a large gap between legislations and enforcement. Enterprises can collude with local environmental protection authorities through rent-seeking and other ways to adopt strategic interaction, so as to escape the constraint of environmental regulation

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be internalized in the production and operation activities of enterprises, and will not promote the quality of enterprise environmental information disclosure. In addition, the emergence of corruption makes enterprises have no incentive to improve the quality of environmental information disclosure (Paunov, 2016). From the perspective of the motivation of political connection, enterprises expect to make advances to the government through rent-seeking and other ways, in order to use limited environmental input to return for tax relief, fiscal subsidies and other greater economic benefits (Cai et al., 2011; Dreher and Gassebner, 2013). For enterprises without political connections, even if the quality of enterprise environmental information disclosure is improved, it is difficult for them to get a fair chance to compete in resource allocation and tax treatment, which makes them have no motivation to carry out environmental governance.

In fact, the anti-corruption campaign has increased the punishment of government officials involved in corruption and irregularities, such as overstepping and abusing their powers, and subjected the government's administrative power to strict supervision and legal authorization. Such strict regulations on the power and behavior of the government greatly increase the probability of rent-seeking behavior being discovered and punished, reducing the opportunities and related interests of enterprise rent-seeking. In order to obtain favorable production resources, enterprises have to pay a higher price to establish more covert political ties with government officials, which will increase the cost of rent-seeking, reduce the benefit of rent-seeking, and decrease the possibility of rent-seeking (Cai et al., 2011). At this time, enterprises have to follow the requirements of environmental information disclosure regulations to disclose true environmental information.

More importantly, anti-corruption explicitly standardizes administrative rules and procedures, limits the discretionary power of the government, and reduces excessive government intervention in the market (Olken, 2007). Therefore, anti-corruption is conducive to building a fair and sound institutional environment, which can effectively safeguard the possibility of enterprises to obtain external resources, promote fair competition among enterprises, and conducive to enterprise development. At this time, considering the limited net income of rent-seeking behavior, the management will reduce the speculative behavior, put more funds into the production field, optimize the production structure of enterprises, improve energy efficiency, save energy consumption and reduce pollutant emissions (Xu and Yano, 2017). Finally, the environmental performance of enterprises can be improved, and enterprises will be more willing to disclose high-quality environmental information. Above all, there is a close relationship between anti-corruption and information disclosure quality, so it is important to explore the causal relationship between them.

However, the existing literature ignores the impact of macro institutional level on enterprise environmental information disclosure, and pays more attention to the impact of internal factors on the quality of environmental information disclosure. Based on the signal transmission theory, Some scholars found that listed companies with large scale, strong profitability and good environmental performance will disclose high-quality environmental information to obtain the recognition of stakeholders and accept social supervision, and reduce the environmental risk of sustainable enterprise operation (Cormier et al., 2005; Hossain and Reaz, 2007; Clarkson et al., 2008; Zhu and Xue, 2009). Based on the principal-agent theory, it also found that internal governance factors such as managers' ability, education level and the number of independent directors will also differentiate corporate environmental information quality (Said et al., 2013; Jizi et al., 2014; Wang et al., 2017; Grigoris et al., 2019). Lewis et al. (2014) used the data of 589 listed American companies over 2002–2008 to show that the environmental actions of companies are more likely to be based on the executives' awareness of environmental problems and subjective willingness to transmit information. These factors are often affected by CEO's age, qualifications, education level and human capital characteristics. Few mathematicians extend the research of influencing factors to outside. Based on the legitimacy theory, through empirical research confirmed that the social pressure generated by public supervision and media reports will affect the quality of enterprise environmental information disclosure (Brammer and Pavelin, 2006; Frost, 2007; Staden and Hooks, 2007; Aerts et al., 2008; Aerts and Cormier, 2009).

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As we know, only two scholars based on stakeholder theory found that the political connection between enterprises and government will influence the quality of environmental information disclosed by enterprises. Charles et al. (2006) used the data of 119 heavily polluting enterprises in the United States to construct the Tobit model and confirmed that there is a significant positive correlation between political expenditure and environmental disclosure. Cheng et al. (2017) used the panel data of European and American enterprises for 3–5 years to construct a fixed-effect model to confirm that political connection represents a certain degree of corruption and inefficiency, which is a means for enterprises to evade environmental investment and environmental regulation. Enterprises tend to use government-enterprise relations to hide negative environmental information and exaggerate useful information, thereby reducing environmental information disclosure quality.

On November 4, 2012, Xi Jinping, the new General Secretary of the CPC Central Committee, declared his determination to crack down on corruption and stressed the necessity of investigating and punishing the corruption which seriously damages the ruling foundation of the CPC. After that, a series of anti-corruption regulations have been implemented, including 'eight policies' and 'six prohibitions', further strengthening the central inspection work, opening up the Internet reporting channels, etc. The national anti-corruption efforts have increased unprecedentedly. A large number of government officials and state-owned enterprises' executives have been investigated and punished for corruption. The corruption of 'collapse mode' in some places has also been exposed. According to statistics, in 2013–2016, the national discipline inspection and supervision organs jointly handled 2,674,000 corruption cases, filed 1,545,000 lawsuits, punished 1,537,000 people, and transferred 58,000 suspected crimes to judicial organs. By contrast, in 2008–2012, 693,000 persons were subject to party discipline, and 27,951 were transferred to the judiciary, accounting for only 4.06%. It can be seen that the anti-corruption campaign of the 18th CPC National Congress is of grand scale and remarkable results, which makes a reality to study the influence of anti-corruption on the quality of environmental information disclosure.

This research's marginal contribution is mainly to further explore the impact of external factors on environmental information disclosure from the perspective of anti-corruption, in order to make up for the lack of such literature. Based on the practice of Pan and Tian, (2017) and Kong et al. (2020), this paper intends to take the anti-corruption campaign of the 18th CPC National Congress in China as an exogenous shock, using the panel data of heavily polluting manufacturing listed companies in Shanghai and Shenzhen A-shares over 2008–2018 to construct the DID model, through a series of robustness tests such as parallel trend test and placebo test, trying to alleviate the endogenous problems in the model, which can reveal the causal relationship between anti-corruption and enterprise environmental information disclosure quality.

The structure of rest of this study is as follows: Sect. 2 reports the practical design, including data sources and variable definitions. Section 3 shows the estimated results of benchmark regression and robustness test. Section 4 is the mechanism test and heterogeneity analysis. Section 5 gives some conclusions and policy suggestions.

## 2. Empirical Strategy

### 2.1 Difference-in-differences model

Considering the different implementation periods of local anti-corruption campaign in each province, this study draws on the idea of Li et al. (2016), setting the progressive double difference (DID) model. The DID model's essence is to place the different time of anti-corruption shocks in each province in the same model, so it can automatically generate the treatment group and the control group. Then, the differences between the treatment group and control group are compared the quality of enterprise environmental disclosure before and after the implementation of the policy, which

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blems such as missing variables and reverse causality in the model, and

reveal the causal relationship between the anti-corruption campaign and the quality of enterprise environmental disclosure. The specific model is constructed as follows:

$$EIDI_{ijt} = \beta_0 + \beta_1 AntiCorr_{ijt} + \sum_{i=1}^j \omega_i Control_{ijt} + \mu_i + \gamma_t + \eta_r \times trend_t + \lambda_s \times trend_t + \varepsilon_{ijt}$$

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where  $i, j$  and  $t$  represent corporates, cities and years, respectively.  $EIDI_{ijt}$  indicates the corporate environmental information disclosure index of corporate  $j$  located in the city  $i$  by year  $t$ .  $AntiCorr_{ijt}$  is a dummy variable for provinces, if a senior government official belongs to province  $i$  is investigated in year  $t$ , the value of  $AntiCorr_{ijt}$  equals one. Otherwise, otherwise it is zero.  $Control_{ijt}$  is a vector of control variables used to control the effect of observable factors on corporate environmental information disclosure and the Anti-corruption campaign.  $\mu_i, \gamma_t, \eta_r$  and  $\lambda_s$  indicates firm fixed effects, time fixed effects, region fixed effects and sector fixed effects, respectively.  $Trend_t$  indicates the time span considered in the equation.  $\varepsilon_{ijt}$  is an error term. In the above equation,  $\beta_1$  is the Anti-corruption campaign effect that we estimate.

In order to alleviate the bias of regression results caused by endogenous problems, the explanatory variables we used in empirical regression all lag one stage in the time dimension.

## 2.2 Sample and data

To evaluate the impact of anti-corruption campaign on the quality of enterprise environmental disclosure, we select heavy polluting listed companies in Shanghai and the Shenzhen A-share manufacturing industry over the 2008–2018. Specifically, The identification of pollution-intensive industry based on the Guidelines for Environmental Information Disclosure of Listed Companies, which was released by the Ministry of Environmental Protection in September 2010, determining steel, cement, coal, petrochemical, thermal power, electrolytic aluminum, metallurgy, building materials, chemical, brewing, papermaking, mining, pharmaceutical, leather, fermentation and textile industries such as 16 kinds of industries for the pollution-intensive industry.

We collect the enterprise Environmental Information Disclosure Index by looking for the *Enterprise Annual Report*. Corporate financial data such as enterprise-scale and asset-liability ratio are from China's Stock Market Accounting Research Database (CSMAR). Annual GDP per capital and foreign investment were collected from *China City Statistical Yearbook* (2009–2019), and the marketization index compiled by Wang et al. (2017). After obtaining the original data, we processed it as follows: First, we match enterprise-level data with municipal-level data according to the enterprise's geographic location. Second, in order to avoid the influence of outliers and extreme values of data, we remove ST and \*ST companies, and perform 1% winsorize processing on the major continuous variables. Finally, a total of 6364 sample data of 914 enterprises were obtained.

## 2.3 Variable measurement

### 2.3.1 Dependent variable: Environmental information disclosure

Following prior literature (Al-Tuwaijri, 2004; Clarkson et al., 2008), we adopt the 'content analysis method' to estimate the quality of enterprise environmental disclosure. Specifically, based on the Measures for Environmental Information Disclosure of Enterprises and Institutions and the Guidelines for Environmental Information Disclosure of Listed Companies, combined with the production process of listed manufacturing companies, this paper determines three

Loading [MathJax]/jax/output/CommonHTML/jax.js's production control' Post-event output governance', and sets up 15

secondary projects according to the sequence of occurrence as the evaluation indicators of environmental information disclosure index (Table 1).

In order to improve the scientificity of measurement results, we refer to and modify the evaluation methods of Wiseman (1982) and Darrell and Schwartz (1997), select two quality dimensions of quantification and significance, and the time dimension is removed. This is because the existing literature believes that the disclosure of past, present, and future environmental information of enterprises can comprehensively increase the quality of enterprise environmental disclosure. But in fact, enterprises prefer to disclose only self-interest environmental information. It is difficult for us to verify the future information, so adding time dimension indicators into the index system will often overestimate the scoring results.

In the process of scoring, we adopt the method of two-person independent scoring. Only when the consistency of reaches 90% in the trial stage can the formal scoring begin. If there is a big difference between the two raters in the formal scoring, it will be coordinated by a third person. Finally, we conducted a credibility test on all scoring results, and the value of cronbach's  $\alpha$  was above 0.9, indicating that the scoring results were more reliable.

## 2.3.2 Independent variable: Anti-corruption

Referring to the practice of existing literatures to measure anti-corruption (Pan and Tian, 2017; Kong et al., 2020), we collect the time of senior government officials were investigated for corruption in 31 provinces from 2012 to 2015. Table 2 presents the distribution and the year of investigated provinces. If a senior government official in a province is investigated by the Central Inspection Team (CIT) after the 18th CPC National Congress, we believe that the anti-corruption intensity of the province has changed significantly, and then the anti-corruption intensity of the province equals one, otherwise it is zero, thus constructing a dummy variable of anti-corruption.

## 3.3.3 Control variable

Control variables are used to mitigate the influence of missing variables on the regression results. In particular, this study selects the enterprise characteristics such as enterprises' size, asset-liability ratio, book-market ratio, etc. as control variables. Besides, Annual GDP per capital, marketization index and foreign investment will be controlled to measure the local economic performance, the intensity of marketization and the degree of opening to the outside world respectively, which not only affect the anti-corruption efforts, and will differentiate the quality of enterprise environmental disclosure by influencing the concept of corporate environmental governance (Zhang, 2019; Zhou, 2020)

The variables descriptive statistics are reported in Table 3.

## 3. Results And Discussions

### 3.1 Anti-corruption campaign and the quality of the quality of environmental disclosure

The estimated results of the anti-corruption campaign on the quality of enterprise environmental disclosure are reported in Table 4. Column 1 of Table 4 shows the impact of  $AntiCorr_{ijt}$  on the quality of enterprise environmental disclosure on the basis of controlling time and firm fixed effects. We also control for industry-by-year fixed effects and city-by-year fixed effects to remove any time-variant shocks at the industry and regional level. The regression coefficient of  $AntiCorr_{ijt}$  is positively significant at the 5% level.

Further, we control the municipal-level characteristics and enterprise-level characteristics in columns 2–3, the impact coefficient of  $AntiCorr_{ijt}$  is significantly reduced, which shows that the endogenous problem caused by missing variables has been alleviated to a certain extent. The third column contains all the control variables and fixed effects, and thus the estimation results are more reliable. It can be found that the coefficient of  $AntiCorr_{ijt}$  is significantly positive in the level  $p < 0.05$ , and the anti-corruption campaign leads to an average increase of 0.49 points in the environmental information disclosure index, accounting for 5.3% of its average level. It can be explained that since the 18th CPC National Congress, China has carried out the most powerful anti-corruption actions, including the introduction of eight policies' and 'six prohibitions', further strengthening the central inspection work, opening up the Internet reporting channels, etc. The high-intensity anti-corruption action has achieved remarkable results, and a large number of senior government officials and enterprise executives have fallen, which has a deterrent impact on other government officials in office, thus effectively curbing the abuse of power, rent-seeking and other corruption, and greatly improving the competition environment. In this case, enterprises not only face a greater risk of punishment, but also have to pay higher rent-seeking costs to establish a close relationship with the government. The rational approach of enterprises is to reduce rent-seeking, and take more innovative behavior such as technology improvement and management optimization as important means of competition, so as to improve the quality of enterprise environmental disclosure.

### 3.2 Parallel trend assumption and dynamic effect analysis

Using the double-difference method needs to satisfy the parallel trend assumption, that is, before implementing the anti-corruption campaign in China, the changing trend of the quality of enterprise environmental disclosure of the treatment and control group is consistent. According to the framework of Li et al. (2016) and Zhang et al. (2019), this study uses the event study analysis to test the parallel trend before the impact of the anti-corruption campaign and further observes the dynamic effect of the anti-corruption campaign on the quality of enterprise environmental disclosure. The specific model is constructed as follows:

$$EIDI_{ijt} = \beta_0 + \sum_{k=1}^k F_k Anticorr_{i,t-k} + \sum_{j=0}^j L_j Anticorr_{i,t+j} + \sum_{i=1}^j \omega_i Control_{ijt} + \mu_i + \gamma_t + \eta_r \times trend_t + \lambda_s \times trend_t + \varepsilon_{ijt}$$

2

$Anticorr_{i,t}$  is a dummy variable in the model (1), representing a senior government official in province  $i$  is investigated in year  $t$ .  $Anticorr_{i,t-k}$  represents the preposition of period  $k$ , which is set to examine whether the enterprises in the treatment group and control group experienced differential trends in enterprise environmental information disclosure before the initial anti-corruption campaign. What we focused on is the coefficient  $F_k$  of the dummy variable  $Anticorr_{i,t-k}$ . The dummy variable can estimate the differences in corporate environmental information disclosure between treatment group and control groups before the initial anti-corruption campaign. If the corresponding  $F_k$  is not significant, it means that there is no systematic difference, and the parallel trend hypothesis can be established. The coefficient  $L_j$  of dummy variable  $Anticorr_{i,t+j}$  allows us to assess the dynamic effect of anti-corruption on the quality of enterprise environmental disclosure.

The estimated results of the parallel trend assumption are reported in Fig. 1. The insignificant coefficients  $F_k$  indicate that treated and control group have a parallel trend before the initial anti-corruption campaign, which shows the parallel trend hypothesis can be verified. Further observing the dummies variables after the anti-corruption policy, the coefficient

$L_j$  decreases year by year from 2.99 ( $L0$ ) to 1.31 ( $L5$ ), and gradually close to significant in level  $p < 0.1$ . This shows that anti-corruption can improve the quality of enterprise environmental disclosure, but the effect is difficult to sustain. The reason may be that the Party Central Committee of China has a 'zero tolerance' attitude towards corruption, which has a deterrent effect on government officials and greatly reduces the non-productive behavior of enterprises such as rent-seeking. Therefore, the phenomenon of corruption will gradually disappear, the intensity of anti-corruption will also decrease, and the effect on the quality of enterprise environmental information disclosure will gradually weaken.

### 3.3 Further treatment of selectivity deviation

Although adding controlling variables in the model can alleviate the self-selection problem to a certain extent. Owing to that OLS requires a priori to give the conditional expectation function form of dependent variables in the treatment group and control group concerning the controlling variable if the conditional expectation function does not conform to the reality or the economic theory, the extrapolation bias caused by the model error will be generated, and the average causal effect cannot be obtained. Therefore, we introduce propensity score matching (PSM) to test further the robustness of the causal relationship between the anti-corruption campaign and the quality of enterprise environmental disclosure.

In particular, the controlling variables in benchmark regression are selected as covariates and EIDI is taken as the dependent variable. The propensity score is calculated through the Logit model. According to the propensity score, the treated and control group are matched, so as to calculate the average treatment effect for the treated. In this paper, the radius matching method is used to verify the robustness of the results, and the absolute value of the standardized deviation of most covariates is less than 10%, which are significantly lower than that before matching, shows that the matching effect is well (Table 5).

After completing the above matching, the model (1) is used for regression again to identify the net effect of the anti-corruption campaign on the quality of enterprise environmental disclosure. The estimation results of PSM-DID are reported in Table 6. After controlling the observable systematic deviation, the anti-corruption campaign has a significant positive impact on the quality of enterprise environmental disclosure in the level  $p < 0.05$ , which is consistent with the baseline regression results.

### 3.4 Placebo test

Although the regression results above control the systematic differences caused by observable variables such as the total number of employees, asset-liability ratio, we are still concerned that the unobservable systemic factors may interfere with the regression results. Therefore, our research intends to construct a series of counterfactual frameworks for placebo test. If the impact of anti-corruption campaign is still positively significant under the counterfactual circumstances, it means that this utility comes from the unobservable systemic factors, not from the implementation of anti-corruption campaign.

We first use bootstrap to randomly allocate the anti-corruption campaign's selection time for each city, and repeat the regression 500 times according to model (1). The estimated results are reported in Fig. 2, which can be found that the  $t$ -value of the coefficient is approximately normally distributed, mostly around 0, rarely around  $\pm 3$  and  $\pm 4$ . It means that in the 500 random experiments conducted, the hypothetical policy implementation will have a small probability that the regression coefficient of  $EIDI$  will be significantly positive and negative. Therefore, the counterfactual treatment effect of the implementation of the anti-corruption campaign does not exist.

What's more, we further assumed that advancing anti-corruption campaign policy 1 year to 6 years, respectively to construct the pseudo-implementing time of the anti-corruption campaign policy. If the coefficient is not significant, the anti-corruption campaign policy indeed increases the corporate environmental information disclosure. Otherwise, basic regression is not robust. The bootstrap results are reported in Table 7. The estimated results indicate that the anti-corruption campaign policy implemented 1 year in advance positively affects the environmental information disclosure in level  $p < 0.05$ . The possible reason is that as early as the early stage of reform and opening up, China has been clear about the road of anti-corruption within the party, the Work plan for establishing a sound system for punishing and preventing corruption issued by the Party Central Committee in 2008 makes specific plans for anti-corruption actions in the future. The coefficient of the anti-corruption campaign policy 2 to 6 years in advance does not significantly influence the quality of enterprise environmental disclosure, which shows the robustness of the basic regression.

## 4. Further Discussion

### 4.1 Influential mechanism

Based on the above theoretical analysis, this study selects two mediating variables of innovation input and violation cost, and uses the stepwise method to test the mediating effect, so as to test whether the anti-corruption campaign will influence the production and management behavior of enterprises, and further differentiate the disclosure of enterprise environmental information. The specific model is constructed as follows:

$$mediation_{it} = \theta_0 + \theta_{med}AntiCorr_{ijt} + \sum_{i=1}^j \omega_i Con_{ijt} + \mu_i + \gamma_t + \eta_r \times trend_t + \lambda_s \times trend_t + \varepsilon_{ijt}$$

3

$$EIDI_{ijt} = \varphi_0 + \varphi_{CR}AntiCorr_{ijt} + \varphi_{med}mediation_{it} + \sum_{i=1}^j \omega_i Con_{ijt} + \mu_i + \gamma_t + \eta_r \times trend_t + \lambda_s \times trend_t + \varepsilon_{ijt}$$

4

In Equations (3) and (4),  $mediation_{it}$  is the mediating variable, including innovation input and violation cost. Among them, innovation input is measured by total R&D investment, which can timely reflect the enterprise innovation investment in the short term; Violation cost is measured by entertainment and travel expenses. When the cost of violation increases, the cost of rent-seeking should be reduced.

The specific test steps of mediating effect are as follows: Step 1 is to confirm that anti-corruption campaign will indeed affect the quality of enterprise environmental disclosure. That is, based on the model (1) coefficient  $\beta_1$  is significant, the coefficient  $\theta_{med}$  in Eq. (3) and the coefficient  $\phi_{med}$  in Eq. (4) are tested in turn. If both are significant, it means that the indirect effect exists and is tested in step 3. If at least one is not significant, the second step test is conducted. Step 2 uses the Sobel method to test the original hypothesis directly:  $\theta_{med} \cdot \phi_{med} = 0$ , if significant, the mediating effect is significant, step 3, otherwise stop the analysis. Step 3 is to test the coefficient  $\phi_{CR}$  in Eq. (4), if not significant, then the direct effect is not significant, indicating that the model only exists mediating effect, if significant, then step 4 test is needed. Step 4 compares the symbols of  $\theta_{med} \cdot \phi_{med}$  and  $\phi_{CR}$  if the symbol is consistent, means that there is a partial mediation effect, and the test results are as follows.

#### 4.1.1 Violation cost effect

Violation cost mechanism test results are reported in table 8. Step 1 (Table 8, column 1) indicates that the dummy variable  $AntiCorr_{ijt}$  has a negative impact on the entertainment and travel expenses, but it is not statistically significant. The results of table 8, column 2, show that entertainment and travel expenses has a negative effect on the quality of enterprise environmental disclosure at the 10% level. Therefore, this study adopts the Sobel method to test Step 2. The results show that the Z statistic value of EIDI is -2.911, which rejects the original hypothesis at the level of 5%, confirming the establishment of violation cost mechanism. The explanation for this is that the strengthening of anti-corruption makes the government's power and behavior subject to strict regulations, which greatly increases the probability of rent-seeking behavior being found and punished, and reduces the opportunity of enterprise rent-seeking. Enterprises need to pay higher rent-seeking costs to maintain a stable relationship with the government in order to avoid environmental regulation. At this time, with the reduction of rent-seeking benefits and the increase of rent-seeking costs, the possibility of enterprises engaging in rent-seeking is reduced, and enterprises get internal incentives to improve the quality of environmental information disclosure.

The results of Step 3 show that (Table 8, column 2), the dummy variable  $AntiCorr_{ijt}$  has a positive influence on the quality of enterprise environmental disclosure in the level  $p < 0.1$ , and is consistent with the symbol of  $\theta_{med}$   $\phi_{med}$  indicating that violation cost has a partial mediating effect.

## 4.1.2 Innovation input effect

Innovation input effect mechanism test results are reported in table 8. Step 1 (Table 8, column 3) indicates that the dummy variable  $AntiCorr_{ijt}$  has a positive impact on the total R&D investment, but it is not statistically significant. The results of table 8, column 4, show that corporate total R&D investment has a positive impact on the quality of enterprise environmental disclosure in the level  $p < 0.1$ . Therefore, this paper adopts Sobel method to test Step 2. The results show that the Z statistic value of EIDI is 3.178, which rejects the original hypothesis at the level of 5%, confirming the establishment of a technological innovation mechanism. This result means that the anti-corruption campaign has greatly increased the rent-seeking cost of enterprises, stimulated enterprises to invest more funds in the production field, developed innovative activities such as technology research and development, and improved enterprises' technological level. The improvement of enterprise technology level can optimize enterprise production structure, improve energy efficiency, save energy consumption, reduce pollutant emissions, and improve enterprise environmental performance. Based on this, enterprises will be more ready to disclose high-quality environmental information to respond the supervision of stakeholders

The estimated results of Step 3 show that (Table 8, column 4), the dummy variable  $AntiCorr_{ijt}$  has a positive effect on the quality of enterprise environmental disclosure in the level  $p < 0.01$ , and is consistent with the symbol of  $\theta_{med}$   $\phi_{med}$  indicating that management optimization has a partial mediating effect.

## 4.2 Heterogeneity tests

The above theoretical analysis and empirical results confirm that the anti-corruption campaign can encourage the improvement of the quality of enterprise environmental disclosure. However, the above analysis is based on the fact that the anti-corruption campaign has the same impact on all listed manufacturing enterprises, ignoring institutional performance differences. In fact, the effect of anti-corruption on the quality of enterprise environmental disclosure is often different for enterprises which have different property rights, enterprise size and regions. Specifically, enterprises with different property rights and sizes often have differences in the degree of association between resources and government, and taking into account the different levels of corruption in different regions, making different types of enterprises subject to different constraints of anti-corruption, thereby affecting the quality of enterprise environmental disclosure. Therefore, we further discuss the relationship between the anti-corruption campaign and the quality of

enterprise environmental disclosure from three aspects: enterprise nature, enterprise size and environmental supervision strength

## 4.2.1 Enterprise nature

This study divides enterprises into state-owned enterprises and non-state-owned enterprises according to different property rights and further verifies the impact of the anti-corruption campaign on enterprise environmental information disclosure under different property rights. The regression results are reported in column 1–2 of Table 9. The estimated results indicate that the dummy variable  $AntiCorr_{ijt}$  has a positive influence on the quality of enterprise environmental disclosure of non-state-owned enterprises in the level  $p < 0.1$ , and the regression coefficient is 0.505, but it has no statistical significance for the environmental information disclosure quality of state-owned enterprises. This means that the anti-corruption campaign has a greater role in promoting the the quality of enterprise environmental disclosure of non-state-owned enterprises.

The estimated results indicate that the anti-corruption campaign has created a fair institutional environment for state-owned enterprises and non-state-owned enterprises, and government power has been effectively supervised and restricted. In this institutional environment, non-state-owned enterprises can rely on the price competition mechanism to obtain more resources in the market, which can further encourage non-state-owned enterprises to carry out technological innovation and management optimization, so as to improve the corporate environmental performance and increase the quality of enterprise environmental disclosure. In addition, non-state-owned enterprises often take profit maximization as their business philosophy and face greater survival pressure. They are looking forward to obtaining competitive advantage by improving the quality of enterprise environmental disclosure, and thus the innovative activities of non-state-owned enterprises are more adventurous. However, the state-owned enterprises draw more attention to stability and efficiency in strategy and tend to adopt a defensive attitude. Their diversified development goals make the technological innovation lack internal motivation, the innovation incentive effect of anti-corruption is smaller so that the quality of environmental information disclosure is difficult to improve (Cull, 2005). Therefore, the anti-corruption campaign has a greater role in increasing the quality of environmental information disclosure of non-state-owned enterprises.

## 4.2.2 Enterprise size

Referring to most literature practices, this paper considers total assets as the classification basis and defines small & medium-sized enterprises as those less than the median of total assets, and large enterprises as those greater than the median. The estimated results are reported in column 3–4 of Table 9. The estimated results indicate that the interaction item positively influences the environmental information disclosure of enterprises of different sizes in the level  $p < 0.1$ , which is consistent with the benchmark regression results. Further observation of the regression coefficient of each group indicates that the regression coefficient of the quality of large enterprise environmental disclosure is greater than that of small & medium-sized enterprises, which indicates that the anti-corruption campaign will improve the quality of enterprise environmental disclosure of different sizes, and the positive effect of the anti-corruption campaign on the environmental information disclosure quality of large enterprises is greater.

This paper argues that small & medium-sized enterprises are less associated with the government and have fewer production resources to obtain. Anti-corruption is conducive to breaking this unfair competitive environment and ensuring the input and income of small & medium-sized enterprises in production and management activities to a greater extent. Their willingness to carry out technological innovation and management optimization will significantly increase, and the quality of enterprise environmental disclosure will also be improved. For large enterprises, anti-

corruption makes it difficult to obtain additional production resources through non-productive activities such as rent-

seeking, which greatly weakens large enterprises' competitive advantage. Therefore, it will force large enterprises to innovate and continuously improve the quality of enterprise environmental disclosure to obtain environmental premium to maintain their competitiveness. However, it is worth noting that compared with small & medium-sized enterprises, large enterprises have the advantages of advanced technology and high-end technical talents, which can innovate at a low cost. Therefore, anti-corruption has a stronger promoting effect on large enterprises to improve the quality of enterprise environmental disclosure.

### 4.2.3 Environmental supervision strength

Referring to the existing literature practice, this research uses the number of environmental administrative punishment cases of each province in 2011 to measure the local environmental supervision strength (Ren et al., 2020). We define the provinces with the number of environmental administrative punishment cases higher than the median as the provinces with higher environmental supervision strength, and vice versa as the provinces with lower environmental supervision strength. The regression results are reported in column 5–6 of table 9. The estimated results indicate that the interaction item has a positive impact on the environmental information disclosure of enterprises in the areas with strong supervision in the level  $p < 0.05$ , and the regression coefficient is 1.353, but it has no statistical significance for the quality of enterprise environmental disclosure of enterprises in the areas with weak supervision. The results show that anti-corruption plays a more significant role in promoting enterprise environmental information disclosure in weak environmental supervision areas.

The explanation for this is that the corruption problem may be more serious in weak environmental supervision areas. It is easy for environmental protection departments to collude with local related polluting enterprises and take strategic interaction. The environmental regulations of the government are completely invalid, and it is difficult for enterprises to obtain incentives to disclose high-quality environmental information (Sheng et al., 2019). At this time, the enhancement of anti-corruption makes it difficult for enterprises to break through the environmental information regulation through rent-seeking and collusion, forcing enterprises to improve technology and management and ultimately improve the quality of enterprise environmental disclosure. However, the areas with stronger environmental supervision have a lower tolerance to corruption, and anti-corruption has no significant incentive effect on innovation, so it is difficult to influence the quality of enterprise environmental disclosure. Therefore, this paper argues that in areas with weak environmental supervision, anti-corruption plays a greater role in improving corporate the quality of enterprise environmental disclosure.

## 5. Conclusions And Policy Suggestions

Based on the quasi-natural experiment of the anti-corruption campaign, this research uses the data of environmental information disclosure index of heavy polluting enterprises in Shanghai and Shenzhen A-share manufacturing industry over 2008–2018 to construct a double difference model (DID) to estimate the net effect of the anti-corruption campaign on the quality of enterprise environmental disclosure. The main conclusions are as follows: Firstly, the DID regression results indicate that the anti-corruption campaign has a significant positive influence on the quality of enterprise environmental disclosure. The regression results are tested by a series of robustness tests such as parallel trend test and placebo test. Secondly, this paper opens the black box of the relationship between the anti-corruption campaign and the quality of enterprise environmental disclosure through mechanism test and confirms that anti-corruption will increase the violation costs, encourage enterprises to carry out innovation activities, and ultimately improve the quality of enterprise environmental disclosure. Finally, the heterogeneity analysis results of this paper show that non-state-owned enterprises, large enterprises and regions with stronger environmental supervision will improve the quality of enterprise environmental disclosure to a greater extent.

This study not only introduces anti-corruption into the existing research framework of influencing factors of the quality of enterprise environmental disclosure from the perspective of the macro institutional environment but also provides empirical evidence for further promoting the implementation of the Reform Plan of Environmental Information Disclosure System by Law and comprehensively implementing the mandatory enterprise environmental information disclosure system. More importantly, the incentive effect of the anti-corruption campaign on the quality of enterprise environmental disclosure is mainly realized through the path of enterprise innovation. Therefore, in the implementation of environmental regulation policies, the government must increase the illegal cost and punishment of rent-seeking and other corrupt behaviors, create a fairer institutional environment for enterprises, stimulate enterprises' willingness to innovate, and further enlarge the role of anti-corruption in promoting the quality of enterprise environmental disclosure. The government should also perform its social public service function and create a good innovation environment for enterprises by building innovation and R&D platform, introducing and cultivating high-end technical talents, etc. Furthermore, considering that anti-corruption has a more significant impact on the quality of enterprise environmental disclosure of non-state-owned enterprises and small & medium-sized enterprises, this paper argues that the degree of government intervention in resource allocation should be weakened, so that non-state-owned enterprises and small & medium-sized enterprises can grow in a fair competitive environment, and they can obtain more resources from state-owned enterprises and large enterprises through the price competition mechanism. For the enterprises with high-quality of environmental information disclosure, the government should give corresponding encouragement through tax relief, environmental subsidies and other ways, so as to alleviate the environmental protection cost and burden of enterprises and improve their enthusiasm to disclose high-quality environmental information. Finally, anti-corruption can significantly improve the quality of enterprise environmental disclosure in areas with weak environmental supervision, so China should continue to increase the anti-corruption efforts in this area to achieve the purpose of environmental protection.

## Declarations

### Ethical Approval

Not applicable

### Consent to Participate

Not applicable

### Consent to Publish

Not applicable

### Authors Contributions

Ye Wei: Data curation, Analyzed data, Writing-Original draft preparation.

Wenjian He: Conceptualization, Methodology, Analyzed, Writing-Original draft preparation.

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## Competing Interest

The authors declare that they have no conflict of interest.

## Availability of data and materials

The data sets supporting the results of this article are included within the article and its additional files.

## References

Aerts, W., & Cormier, D. (2009). Media legitimacy and corporate environmental communication. *Accounting, Organizations and Society*, 34, 1-27

Aerts, W., Cormier, & D., Magnan, M. (2008). Corporate environmental disclosure, financial markets and the media: an international perspective. *Ecological Economics*, 64, 643-659.

Al-Tuwaijri, S. A., Christensen, T. E., & Hughes, K. E. (2004). The relations among environmental disclosure, environmental performance, and economic performance: a simultaneous equations approach. *Accounting Organizations and Society*, 29(5-6), 447-471.

Brammer, S., & Pavelin, S. (2006). Voluntary environmental disclosures by large UK companies [J]. *Journal of Business Finance & Accounting*, 33(7-8), 1168-1188.

Cheng, Z., Wang, F., Keung, C., & Bai, Y. (2017). Will corporate political connection influence the environmental information disclosure level: Based on the panel data of a-shares from listed companies in shanghai stock market. *Journal of Business Ethics*, 143(1), 1-13.

Clarkson, P. M., Li, Y., Richardson, G. D., & Vasvari, F. P. (2008). Revisiting the relation between environmental performance and environmental disclosure: An Empirical Analysis. *Accounting, Organizations and Society*, 33(4/5), 303-327.

Cormier, D., Magnan, M., & Vothoven, B. V. (2005). Environmental disclosure quality in large German companies: Economic incentives, public pressures or institutional conditions. *European Accounting Review*, 14(1), 3-39.

Cull, R., & Xu, L. C. (2005). Institutions, ownership, and finance: The determinants of profit reinvestment among Chinese firms. *Journal of Financial Economics*, 77(1), 117-146.

Darrell, W., & Schwartz, B. N. (1997). Environmental disclosures and public policy pressure. *Journal of Accounting & Public Policy*, 16(2), 125-154.

Fisman, R., & Svensson, J. (2007). Are corruption and taxation really harmful to growth: firm level evidence. *Journal of Development Economics*, 83(1), 63-75.

Frost, G. R. (2007). The introduction of mandatory environmental reporting guidelines: Australian evidence. *Abacus*, 43(2).

Grigoris, G., Andronikidis, A., & Sariannidis, N. (2019). Determinants of environmental disclosure: investigating new and conventional corporate governance characteristics. *Annals of Operations Research*, (1).

- Hossain, M., & Reaz, M. (2007). The determinants and characteristics of voluntary disclosure by Indian banking companies. *Corporate Social Responsibility & Environmental Management*, 2007, 14(5):274-288.
- Jizi, M. I., Salama, A., Dixon, R., & Stratling, R. (2014). Corporate governance and corporate social responsibility disclosure: evidence from the US banking sector. *Journal of Business Ethics*, 125(4), 601-615.
- Kong, D., Tao, Y., & Wang, Y. (2020). China's anti-corruption campaign and firm productivity: evidence from a quasi-natural experiment. *China Economic Review*, 101535.
- Lewis, B. W., Walls, J. L., & Dowell, G. W. S. (2014). Difference in degrees: CEO characteristics and firm environmental disclosure. *Strategic Management Journal*, 35(5), 712-722.
- Li, P., Lu, Y., & Wang, J. (2016). Does flattening government improve economic performance: evidence from China. *Journal of Development Economics*, 123(11), 18-37.
- Liu, X. B., & Anbumozhi, V. (2009). Determinant factors of corporate environmental information disclosure: an empirical study of Chinese listed companies. *Journal of Cleaner Production*, 17(6), 593-600.
- Paunov, C., 2016. Corruption's asymmetric impacts on firm innovation. *Journal of Development Economics*, 100(118), 216-231.
- Ren, S., Hu, Y., Zheng, J., & Wang, J. (2020). Emissions trading and firm innovation: evidence from a natural experiment in China. *Technological Forecasting and Social Change*, 155.
- Said, R., Omar, N., & Abdullah, W. (2013). Empirical investigations on boards, business characteristics, human capital and environmental reporting. *Social Responsibility Journal*, 9(4).
- Sheng, J., Zhou, W., & Zhang, S. (2019). The role of the intensity of environmental regulation and corruption in the employment of manufacturing enterprises: evidence from China. *Journal of Cleaner Production*, 219(10), 244-257.
- Staden, C. J. A., Hooks, J. A. (2007). Comprehensive comparison of corporate environmental reporting and responsiveness. *The British Accounting Review*, 39, 197-210.
- Wang, P., Wang, F., & Hu, N. (2017). The effect of ultimate ownership on the disclosure of environmental information. *Australian Accounting Review*.
- Wang, X., Fan, G., & Yu, J. (2017). Marketization index of China's provinces: NERI report 2016. Social Sciences Academic Press, Beijing, China (in Chinese).
- Wiseman, J. (1982). An evaluation of environmental disclosures made in corporate annual reports. *Accounting Organization and Society*, 7(10), 553-563.
- Xu, G., & Yano, G. (2017). How does anti-corruption affect corporate innovation: evidence from recent anti-Corruption efforts in China. *Journal of Comparative Economics*, 45(3), 498-519.
- Yusoff, H., & Lehman, G. (2009). Corporate environmental reporting through the lens of semiotics. *Asian Review of Accounting*, 17(3), 226-246.
- Zhang, Q., Yu, Z., & Dongmin, K. (2019). The real effect of legal institutions: environmental courts and firm environmental protection expenditure. *Journal of Environmental Economics and Management*, (98).

# Tables

**Table 1**  
Environmental information disclosure index score table

Category	Content	Score			
		Quantitative		Significance	
		Qualitative disclosure	Quantitative disclosure	Only disclosed in the financial or non-financial part	Disclosure both in financial and non-financial parts
Prior prevention inputs	1. Enterprise environmental protection and pollution control objectives 2. Environmental investment 3. Environmental impact assessment information of production project 4. Environmental emergency plan emergency system 5. Environmental education and training	1	2	1	2
In-process production control	6. Implementation of the three simultaneous systems 7. Construction of environmental protection facilities 8. Pollutant emissions 9. Waste disposal and utilization 10. Energy consumption and savings	1	2	1	2
Post-event output governance	11. Explanation of occurrence and treatment of major environmental problems 12. Corporate incentives for environmental governance 13. Expenses due to pollution 14. Environmental information audit 15. Environmental management system certification ( ISO14001 )	1	2	1	2

**Table 2**  
Distribution and the year of investigated provinces

Year of investigation	Province
2012	Sichuan, Guangdong
2013	Jiangxi, Guangxi, Jiangsu, Inner Mongolia, Guizhou, Hunan, Anhui, Hubei
2014	Yunnan, Shandong, Hebei, Shanxi, Liaoning, Henan, Qinghai, Heilongjiang, Tianjin, Hainan, Shaanxi, Chongqing
2015	Ningxia, Shanghai, Fujian, Zhejiang, Jilin, Gansu, Xizang, Beijing, Xinjiang

**Table 3**  
Summary statistics of variables[2008-2018]

Category	Variable	Abb.	Control group		Treatment group		t-value
			Obs	Mean	Obs	Mean	
Dependent variable	Environmental information disclosure index	<i>EIDI</i>	2837	5.197	3509	12.639	-7.442***
Enterprise-level	Logarithm of total employees	<i>SIZE</i>	2837	7.714	3509	7.682	0.033
	Asset-liability ratio	<i>LEV</i>	2837	0.451	3509	0.403	0.048***
	Book-market ratio	<i>BM</i>	2837	0.638	3509	0.580	0.058***
	Free cash flow per share	<i>OCF</i>	2837	-0.337	3509	-0.156	-0.181***
	Independent director ratio	<i>NED</i>	2837	0.364	3509	0.372	-0.008***
Municipal-level	GDP per capital	<i>PGDP</i>	2837	0.569	3509	0.863	-0.294***
	Marketization index	<i>Index</i>	2837	6.923	3509	8.179	-1.256***
	Foreign Direct Investment	<i>FDI</i>	2837	11.191	3509	11.689	-0.498***

Note: \*, \*\*, \*\*\* indicate that the estimated results are significant at the levels of 1%, 5% and 10%

**Table 4**  
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**Estimated results of the full-sample regression**

	(1)	(2)	(3)
	EIDI	EIDI	EIDI
<i>AntiCorr</i>	0.541** (0.259)	0.495* (0.260)	0.488** (0.259)
Constant	9.821*** (0.161)	12.206*** (2.257)	11.120*** (2.740)
Enterprise-level	NO	NO	YES
Municipal-level	NO	YES	YES
Year fixed effect	YES	YES	YES
Firm fixed effect	YES	YES	YES
City fixed effect 'Trend	YES	YES	YES
Industry fixed effect 'Trend	YES	YES	YES
r2_a	0.823	0.823	0.824
N	5078	5078	5078

Note: \*, \*\*, \*\*\* indicate that the estimated results are significant at the levels of 1%, 5% and 10%, respectively, respectively; the clustering robust standard deviations are in parentheses.

**Table 5**  
**Balance test of PSM**

Covariate	Unmatched/ Matched	Treatment group	Control group	Bias%	t-value	p-value
<i>SIZE</i>	U	7.575	7.667	-8.1	-0.65	0.581
	M	7.563	7.642	-7.0	-0.43	0.664
<i>LEV</i>	U	0.395	0.421	-10.7	-0.91	0.361
	M	0.396	0.409	-4.9	-0.31	0.758
<i>BM</i>	U	0.659	0.685	-11.7	-0.95	0.342
	M	0.660	0.680	-9.0	-0.57	0.571
<i>OCF</i>	U	-0.429	-0.575	13.5	1.10	0.271
	M	-0.432	-0.495	5.9	0.39	0.699
<i>NED</i>	U	0.366	0.362	8.1	0.70	0.484
	M	0.362	0.362	0.3	0.02	0.982
<i>PGDP</i>	U	0.617	0.584	10.4	0.97	0.332
	M	0.611	0.590	6.5	0.41	0.682
<i>Index</i>	U	7.093	6.812	20.1	1.42	0.155
	M	7.084	6.973	7.9	0.52	0.602
<i>FDI</i>	U	11.744	11.390	19.6	1.69	0.091
	M	11.727	11.536	10.6	0.68	0.495

**Table 6**  
**Estimated results of PSM-DID**

	(1)	(2)	(3)
	EIDI	EIDI	EIDI
<i>AntiCorr</i>	0.634** (0.274)	0.568* (0.275)	0.559** (0.275)
Constant	9.848*** (0.162)	10.657*** (2.397)	9.408*** (2.952)
Enterprise-level	NO	NO	YES
Municipal-level	NO	YES	YES
Year fixed effect	YES	YES	YES
Firm fixed effect	YES	YES	YES
City fixed effect 'Trend	YES	YES	YES
Industry fixed effect 'Trend	YES	YES	YES
r2_a	0.821	0.822	0.823
N	4182	4182	4182

Note: \*, \*\*, \*\*\* indicate that the estimated results are significant at the levels of 1%, 5% and 10%, respectively; the clustering robust standard deviations are in parentheses.

**Table 7**  
**Change policy implementation year**

	(1) EIDI	(2) EIDI	③ EIDI	④ EIDI	⑤ EIDI	⑥ EIDI
<i>PRE_1</i>	-0.374*					
	(0.202)					
<i>PRE_2</i>		0.089				
		(0.213)				
<i>PRE_3</i>			0.374			
			(0.230)			
<i>PRE_4</i>				-0.387		
				(0.276)		
<i>PRE_5</i>					-0.275	
					(0.198)	
<i>PRE_6</i>						0.179
						(0.589)
Constant	11.078***	11.043***	10.883***	11.192***	11.119***	11.139***
	(2.740)	(2.743)	(2.743)	(2.741)	(2.741)	(2.747)
Control	YES	YES	YES	YES	YES	YES
Fixed effects	YES	YES	YES	YES	YES	YES
r2_a	0.824	0.824	0.824	0.824	0.824	0.824
N	5078	5078	5078	5078	5078	5078

Note:(1) \*, \*\*, \*\*\* indicate that the estimated results are significant at the levels of 1%, 5% and 10%; (2) Control variables include enterprise-level and municipal-level; (3) Fixed effects include year fixed effect, firm fixed effect, city-by-year fixed effect and industry-by-year fixed effect. (4) PRE\_1- PRE\_6 represent the policy is 1-6 years ahead of schedule, respectively.

**Table 8**  
**Estimated results of the influential mechanism.**

	Management optimization effect		Technological innovation effect	
	(1) Manage	(2) EIDI	(3) Investment	(4) EIDI
<i>AntiCorr</i>	-0.003	0.481*	0.026	0.690**
	(0.002)	(0.259)	(0.043)	(0.313)
<i>Manage</i>		-2.817*		
		(1.681)		
<i>Investment</i>				0.448***
				(0.152)
Constant	0.439***	3.424	15.371***	12.407***
	(0.048)	(5.231)	(0.565)	(4.773)
Sobel test	Z=-2.911,P=0.036		Z=3.178,P=0.015	
Control	YES	YES	YES	YES
Fixed effect	YES	YES	YES	YES
r2_a	0.727	0.824	0.867	0.853
N	5078	5078	3153	3153

Note: \*, \*\*, \*\*\* indicate that the estimated results are significant at the levels of 1%, 5% and 10%, respectively; the clustering robust standard deviations are in parentheses.

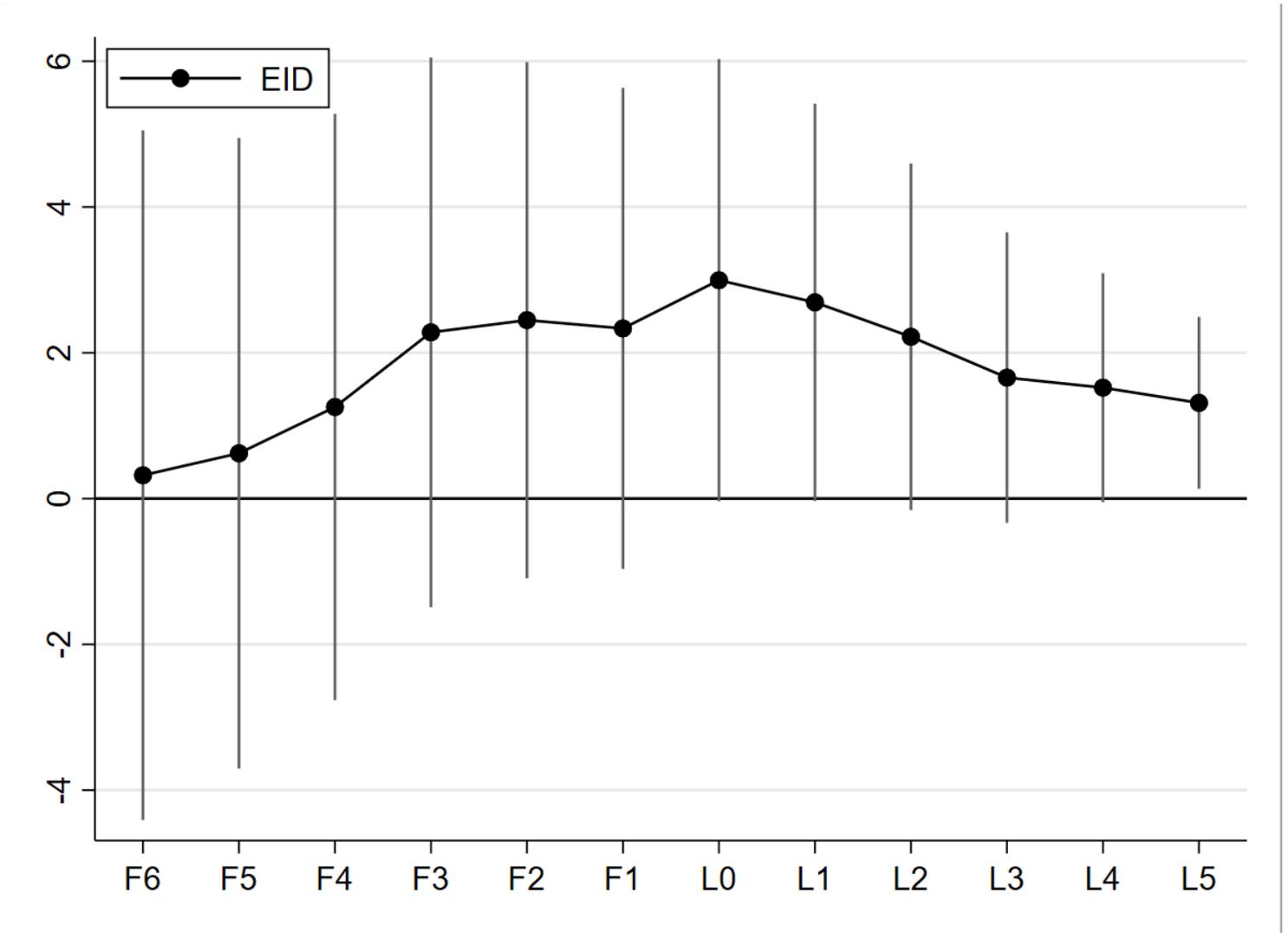
**Table 9**  
**Estimated results of the heterogeneous effect**

	Enterprise nature		Enterprise size		Environmental supervision	
	① EIDI	② EIDI	③ EIDI	④ EIDI	⑤ EIDI	⑥ EIDI
<i>AntiCorr</i>	0.363	0.505*	0.992**	0.518*	0.227	1.353**
	(0.540)	(0.295)	(0.408)	(0.295)	(0.300)	(0.533)
Constant	4.200	16.182***	22.247***	0.721	10.431***	13.074***
	(5.713)	(3.321)	(4.609)	(3.353)	(3.417)	(4.603)
Control	YES	YES	YES	YES	YES	YES
Fixed effect	YES	YES	YES	YES	YES	YES
r2_a	0.846	0.827	0.831	0.857	0.823	0.828
N	1215	3823	2531	2457	3868	1210

Note: \*, \*\*, \*\*\* indicate that the estimated results are significant at the levels of 1%, 5% and 10%; the clustering robust standard deviations are in parentheses.

## Figures

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**Figure 1**

The parallel trend of EIDI. Note: This figure plots the period-by-period estimated coefficients obtained through model (2), and the vertical line indicates the 90% confidence interval of the estimated coefficient.

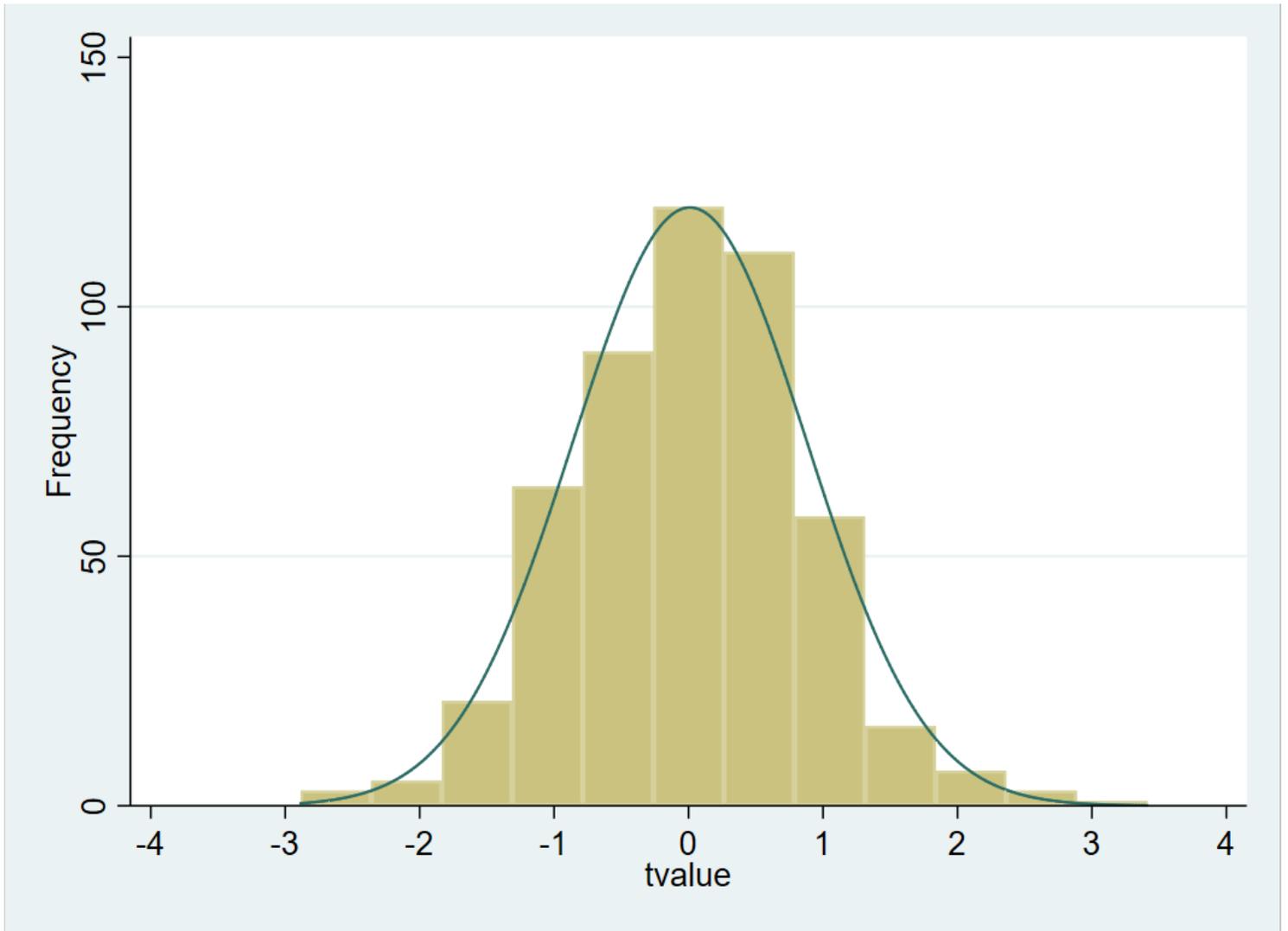


Figure 2

Bootstrap result