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Technological innovation and the quality of environmental information disclosure: Evidence from a-share companies listed on China's Shanghai and Shenzhen stock exchanges

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ABSTRACT

High costs of technological innovation and insufficient technological innovation capabilities may impede the ability of firms to communicate relevant environmental protection information to the public. This study aims to analyze the impact of technological innovation on the quality of environmental information disclosure conducted by firms. A non-balanced panel dataset comprising A-share listed companies in Shanghai and Shenzhen from 2007 to 2020 was subjected to ordinary least squares (OLS) regression analysis in the study. The model included year-fixed and industry-fixed effects to eliminate the influence of unobservable factors during the sample period. The results revealed a statistically significant positive relationship between the quality of environmental information disclosure by enterprises and the quantity and quality of technological innovation. The study's findings indicate that technological innovation offers a more sustainable path for the advancement of environmental information disclosure. By utilizing environmentally friendly and energy-saving technologies, the negative impact of the environment on technological innovation can be mitigated, leading to a more sustainable approach to environmental information disclosure. The practical implications of this study include fostering innovation to enhance disclosure quality, which benefits policymaking and industry practices. The understanding of the positive relationship between technological innovation and environmental information disclosure is enriched by the empirical evidence from this study, emphasizing its role in promoting sustainability and transparency.

Contribution/Originality: Using a panel dataset of A-share listed companies in Shanghai and Shenzhen, this study investigates the relationship between corporate technological innovation and the quality of environmental information disclosure based the quantity and quality dimensions of firms' innovation.

1. INTRODUCTION

As people's environmental awareness continues to increase, stakeholders, including governments, investors, and the general public, highly emphasize a company's social responsibility performance in environmental protection (Jose & Lee, 2007). Therefore, environmental information disclosure (EID) has emerged as a viable means for companies to demonstrate their environmental accountability to the public. Fulfilling environmental responsibilities has gained significance over time as a crucial evaluation factor for risk assessment among investors, who hope that companies will fully disclose their environmental performance (Zhang, 2017). Technological innovation and environmental accounting are important indicators for measuring a company's development (National Bureau of

Statistics, 2016). As environmental issues are closely intertwined with the economy, environmental accounting has emerged to complement traditional accounting by classifying and tallying complex environmental issues from multiple angles for companies. Environmental accounting relates environmental protection to economic development, fostering the establishment of a society that emphasizes resource conservation and environmental friendliness. In China, the development and promotion of environmental accounting have raised companies' awareness of environmental protection while providing the public with valuable information regarding their environmental status and improvement strategies through transparent disclosure practices. Strengthening the supervision of companies' environmental issues enables them to consciously focus on the environment, assume social responsibilities, and avoid one-sided and extensive development.

Liang, Wang, Foley, and Ma (2023) identified multiple approaches for evaluating companies' quality of environmental information disclosure. Among these, the first prevalent approach involves utilizing an environmental information disclosure index. The assessment of the quality of environmental information disclosure (QEID) in companies frequently relies on the widespread adoption of the environmental information disclosure index (EIDI) (Wang, 2008; Yang, Yao, & Li, 2020). The index, which typically consists of multiple dimensions of indicators, such as information transparency, accuracy, and reliability, is commonly employed to measure comprehensiveness and QEID. The second assessment method utilizes social responsibility reports as carriers for disclosure. Social responsibility reports are comprehensive documents that record companies' performance in meeting their social responsibilities, including environmental information disclosure. An examination of social responsibility reports can provide valuable insights into the QEID within companies. Additionally, Xiao and Hu (2004) highlighted that conducting surveys involving stakeholders, such as shareholders, customers, employees, and other relevant parties, provides a valuable means of assessing the status and the QEID within companies. Independent auditing is another method for evaluating the QEID. Independent auditing involves the verification of companies' environmental information disclosure, which serves as an evaluation of their quality. As the primary approach for evaluating the QEID in companies, this study employs the environmental information disclosure index. This method was prioritized based on its advantages, which include strong comparability, relative objectivity, and high transparency. The EIDI includes five core dimensions of EID: Environmental Certification Disclosure, Environmental Performance and Governance Disclosure, Environmental Management Disclosure, Environmental Information Disclosure Vehicles, and Environmental Liability Disclosure.

High-quality environmental information disclosure can help companies understand and manage their environmental risks better, thereby promoting technological innovation. The enhancement of a company's environmental behavior is also facilitated by effective environmental information disclosure quality. Companies can publicly disclose their environmental behaviors and condition through EID, subjecting themselves to social supervision and public pressure. This process promotes the improvement of their environmental behaviors and enhances their corporate image and reputation. Environmental information disclosure assists companies in gaining a comprehensive understanding of their environmental footprints, environmental risks, and the effectiveness of their environmental management measures. By adopting this approach, companies can formulate relevant environmental protection strategies and plans. Additionally, they can promptly identify environmental issues and employ technological innovations to address them effectively. Moreover, high-quality environmental information disclosure can attract higher investment and research and development (R&D) resources, promoting technological innovation and enhancing corporate competitiveness. Therefore, differences in corporate technological innovation capabilities result in variations in the influence of environmental information disclosure on companies.

Against the backdrop of China's economy entering a new development stage of the "new normal," relying on an innovation-driven development strategy to promote economic transformation and upgrading becomes a necessary choice for solving existing resource and environmental constraints. Innovation and green development, as the core drivers of China's transformation, are emphasized in the "14th Five-Year Plan," which was ratified in 2021. In

March 2020, the State Council issued the "Guiding Opinions on Building a Modern Environmental Governance System," which explicitly delineated "*strengthening the support of the environmental protection industry, enhancing independent innovation of key environmental protection technology products, promoting the demonstration application of the first major environmental protection technology equipment, and accelerating the improvement of the technical level of environmental protection industry equipment.*"

Technological innovation is the process where entrepreneurs rely on advanced technology to recombine production factors, establish new production systems, and obtain economic benefits (Xiang, Li, & Li, 1996). Generally, enterprise technological innovation is measured from the following five aspects: 1) the quantity and quality of patents, 2) R&D investment (Wang, 2018), 3) new products and technologies, 4) partners and technology transfers, and 5) science and technology awards and certifications. In this study, the first measure, the quantity and quality of patents, was adopted for two reasons. Firstly, the "number of patents" pertains to the count of patents that enterprises have either applied for or obtained during a specific timeframe. The level of technological innovation activity within the enterprise is assessed by this metric, which serves as a significant indicator. A higher number of patents indicates that the enterprise has made numerous investments and R&D work in technological innovation and achieved certain results. Nevertheless, the level and quality of enterprise technological innovation cannot be fully explained by focusing exclusively on the number of patents since a potential situation may exist where many patents of poor quality are present. The second indicator, patent quality, is introduced to supplement the deficiency of patent quantity. Patent quality is a crucial indicator for measuring enterprise technological innovation levels, including the innovation and influence of patents in multiple aspects. An enterprise's competitiveness and market position are significantly influenced by the level of technological innovation, which is reflected not only in patents of higher quality but also in other factors (Li, 2021). The level and strength of enterprise technological innovation can be accurately reflected by the quality of patents, in contrast to solely relying on the number of patents. Therefore, considering both the quantity and quality of patents enables a comprehensive assessment of enterprise technological innovation performance. Strong technological innovation capability and advantages can be attributed to an enterprise that has attained remarkable performance in both the quantity and quality of patents (Bai, 2019). Increasing the quantity of technological innovation is commonly believed to promote the collection and integration of environmental information, thereby enhancing the quality and transparency of a company's EID. The quality of technological innovation can contribute to the improvement of a company's environmental information disclosure. The EID performance of a company is not necessarily ensured by the quantity of technological innovation, although it may reflect the company's innovation capability and activity. The quality of a company's environmental information disclosure is influenced by various factors, including corporate culture, governance structure, and regulatory requirements. Therefore, improving a company's environmental performance and sustainability may be facilitated by an increase in the quantity of technological innovation. Nevertheless, it does not guarantee an improvement in disclosure quality. Controversies surround the impact of the quantity of technological innovation on the quality of a company's EID.

It is evident that higher-quality technological innovations enhance a company's environmental protection capabilities when considering the impact of technology innovation quality on EID. As a result, a company can effectively disclose comprehensive and accurate environmental data and information, reflecting their level of environmental management. On the other hand, technology innovation quality can improve a company's EID methods and means. For example, the efficiency of environmental data collection, transmission, and analysis can be improved by introducing digital and information technologies, thereby enhancing the quality and reliability of the disclosure. Therefore, technological innovation has a positive influence on the improvement in QEID.

The impact of technological innovation on QEID is examined in this study from both the quantity and the quality dimensions. By considering potential variations in measuring technological innovation using different proxy variables, the study provides comprehensive insights. The investigation of the relationship between technological innovation and EID forms the significance of this study, as it contributes to the existing literature. The findings suggest that by adopting more environmentally friendly and energy-saving technologies, enterprises can mitigate the adverse effects of the environment on technological innovation and enhance the sustainability of EID. Policymakers and industry practitioners seeking to promote eco-friendly practices and ensure effective environmental information disclosure can derive practical implications from the study's findings.

Despite its contributions, this study has certain limitations. The study does not consider the impact of enterprises' investment in innovative technology and the rate of return on investment. This leaves an opportunity for future research to explore the overlooked factors to better understand the relationship between technological innovation and EID.

2. LITERATURE REVIEW

2.1. Environmental Information Disclosure Quality

Experts and researchers have investigated a variety of views while analyzing the variables that affect the quality of environmental information disclosure (QEID). These factors can be divided into internal and external elements. Internal influencing factors primarily include ownership nature, company characteristics, and governance structure, among others. Based on empirical research on disclosure behavior in developed markets, Chau and Gray (2002) explored the relationship between ownership structure and the disclosure behavior of listed companies in the Asian region, particularly Singapore and Hong Kong. Through the analysis of annual reports from these companies, a positive correlation was discovered between the degrees of external ownership and voluntary disclosure by companies. Profitability was shown to have a considerable impact on the overall disclosure, according to the findings of Alnajjar (2000), who examined the social responsibility disclosure patterns of Fortune 500 corporations in the United States. Additionally, the total disclosure was identified as a function of company size. This conclusion refutes the findings of Cowen, Ferreri, and Parker (1987), who stated that corporate profitability is an unimportant factor affecting social information disclosure by using the logarithm of the internal control index from the CSMAR database to measure corporate internal control. In their examination, the authors discovered a positive correlation between internal control and the QEID. External factors include laws and regulations, media attention, industry standards, investor demand, external pressures, and others. Wang (2008) investigated the link between EID, industry differences, and external regulatory pressure using firms listed on the Shanghai Stock Exchange in China as an example. The results showed that EID is significantly impacted by variations in the industry and external regulatory forces. Moreover, different polluting sectors have a wide range of environmental information disclosure policies, which correlate significantly with the external regulatory pressure observed across industries. Therefore, the improvement in the transparency of environmental information is greatly helped by external regulatory mechanisms. In order to investigate listed companies operating in China's heavily polluting industries, Shen and Feng (2012) utilized the legitimacy theory from political science. Their research sought to examine how government regulation and public opinion monitoring affected corporate disclosure of environmental information in China's highly polluting sectors and also how public opinion monitoring was affected by government regulation. Their research findings indicated the following:

(1) Significant promotion of corporate environmental information disclosure occurs through media reporting on corporate environmental performance.

(2) Local government regulations on corporate EID have led to a substantial improvement in the QEID and an enhanced role of public opinion supervision.

Li, Tang, Feng, and Chen (2023) found that government environmental audits improve the QEID in companies by examining the effectiveness of government environmental audits. Furthermore, government environmental audits enhance the QEID through the mediation of the government's environmental governance efforts and corporate environmental performance at the government and corporate oversight levels.

2.2. Technological Innovation

In modern society, technological innovation plays a crucial role as a significant driving force for social development and economic growth. Scholars have also conducted relatively mature research on technological innovation. Scholars have long concluded that technological innovation is a critical force driving social development and economic growth. Freeman (1994) summarized the importance of technological innovation for social development and economic growth and provided evidence for different types of technological innovation and factors that drive it. Croitoru (2012) introduced the concept of "innovation economics" by stating that technological innovation is the main force driving economic development and a key factor in modern economic growth. His views have been widely recognized and are important in modern economics.

Extensive research has been conducted on the various factors that influence technological innovation, including internal organizational factors, national innovation systems, knowledge flow, enterprise size, and others. These factors are crucial in the success or failure of technological innovation. Zhang, Yang, and Li (2015) explored the influencing factors of technological innovation by examining software companies in China and abroad as an example. The study revealed that innovation in business models could become a new way to promote technological innovation. Therefore, companies should prioritize technological innovation and promote the software industry to actively engage in technological innovation to maintain market competitiveness and development prospects.

From the perspectives of internal innovation, industrial organization, institutional environment, and technological spillover effects, Zhang et al. (2015) explored the primary factors and mechanisms affecting technological innovation in China's high-tech industries. Using a panel data model, they examined the factors that impacted technological innovation in high-tech industries between 1998 and 2011. The findings indicated that R&D investment emerged as the primary driver of technological innovation in China's high-tech sectors. Nevertheless, excessive government investment had a detrimental effect on the output of technological innovation. The rise in the share of state-owned property rights exhibited a notable adverse influence on technological innovation within the industry. Conversely, the technological spillover effects stemming from foreign direct investment exerted a more substantial impact on technological innovation compared to acquiring domestic technology. The impact of R&D investment, R&D personnel, the number of patents, and education level on the performance of the new energy industry was investigated by Huang, Ye, Zhang, Zeng, and Chen (2021). Furthermore, their study examined the interaction effects of R&D investment and patents, as well as R&D personnel and patents, on industry performance. The results indicated that strengthening the support for technological innovation positively affects the financial sustainability of companies.

2.3. Technological Innovation and QEID

From the standpoint of technological innovation, Bi (2017) examined the issue of environmental accounting information disclosure, as the literature on the relationship between technological innovation and EID remains limited. Nevertheless, the prevailing viewpoint suggests a significant positive correlation between the two. The analysis revealed several factors contributing to the problem, including insufficient investment leading to limited voluntary disclosure of environmental accounting information, outdated technological conditions hindering the establishment of standardized disclosure patterns, and a narrow focus on technological innovation resulting in incomplete disclosure of environmental accounting information. The study presented a comprehensive analysis of technological innovation based on three key aspects: input, output, and subsidies. The findings established a distinct positive relationship between environmental accounting information disclosure and technological innovation. Huang (2019) conducted an empirical study on listed companies in the chemical industry in Zhejiang Province. The study arrived at a similar conclusion, revealing a positive correlation between the level of R&D expenditure input and the disclosure level of environmental accounting information. In other words, companies that allocate higher levels of R&D investment tend to exhibit a greater degree of disclosure of environmental accounting information.

Enterprises with larger investments have higher levels of technological innovation R&D and environmental accounting information disclosure and stronger technological innovation output capabilities than other enterprises. Li, Huang, and Ren (2018) conducted a study on samples obtained from China's Carbon Disclosure Project (CDP) from 2008 to 2012. The findings revealed a significant negative impact of environmental legitimacy on the likelihood of corporate carbon information disclosure. Moreover, the study identified that green process innovation played a mediating role in this relationship, whereas green product innovation did not exhibit a significant mediating effect. Corporate carbon emissions are influenced by environmental legitimacy in a dual manner. It indirectly affects the likelihood of carbon information disclosure while directly influencing it through green process innovation. Consequently, in order to facilitate carbon information disclosure and ensure long-term sustainability, companies are encouraged to enhance both informal and formal mechanisms. These mechanisms include external environmental legitimacy and internal green process innovation.

Foreign studies on the impact of corporate technological innovation on EID reached similar conclusions. Radu and Francoeur (2017) discovered that innovation drives corporate environmental disclosure using data from US listed firms. In contrast to non-innovative firms, innovative firms exhibit a greater inclination to disclose corporate environmental information in response to stakeholder demands, aiming to enhance their environmental performance. Ren, Cao, and Zhang (2021) conducted an empirical analysis of 110 listed companies in the pharmaceutical and communication equipment industries. They found that exploratory and exploitative innovation promote strategic knowledge disclosure in companies, but the effect of exploratory innovation is highly significant. Different types of technological innovation have varying effects on the strategic knowledge disclosure of companies. Nevertheless, some scholars offered opposing views. Friedman (2007) suggested that improving the quality of companies' environmental information disclosure can negatively impact factors such as company value by considering the additional costs and subsequent decline in profitability.

In summary, technological innovation and EID are vital in current development. By examining the interrelationship between the two factors, this article establishes a comprehensive analysis. It concludes that technological innovation can effectively improve the QEID by promoting the common development and progress of both. Moreover, this article extends the scope to include A-share listed companies in the Shanghai and Shenzhen stock markets, while the samples in the above literature are limited to a specific industry or region.

3. DATA AND METHODOLOGY

3.1. Data

The study utilizes panel data encompassing all A-share listed companies spanning the period from 2008 to 2020. The analysis is conducted using annual data, and the initial sample is screened based on the following criteria to ensure the reliability and precision of the research findings:

(1) Exclusion of samples from the financial industry.

(2) Exclusion of samples categorized as ST[1], SST[2], ST[3], and PT[4].

(3) Exclusion of samples with missing or abnormal values for relevant variables.

Following the criteria listed above, the study successfully obtained unbalanced panel data comprising 28,602 enterprise-year observations. The substantial size of the sample enhances the reliability and validity of the research findings, ensuring the credibility of the conclusions.

The data analyzed in this study were sourced exclusively from the China Stock Market & Accounting Research

[1] ST: Special treatment – Companies facing consecutive annual losses receive special handling.

[2] SST: Companies facing consecutive annual losses receive special handling, plus they have not completed a stock reform.

[3] ST: Companies facing three consecutive years of losses receive a delisting warning.

[4] PT: Particular Transfer – Trading is suspended and prices reset to zero for stocks awaiting delisting.

(CSMAR) database. In order to ensure the robustness of the regression results, a winsorizing technique was applied to all continuous firm-level variables. This technique involved capping extreme values at the 1% lower and 99% upper percentiles, thereby addressing the potential impact of outliers in the empirical analysis. The data analysis and processing were primarily conducted using Stata 17.0 software. Additionally, firm-level clustering was employed to adjust the standard errors of the regression coefficients, aiming to eliminate the potential clustering effect in the sample data.

The research variables in this study comprise three main components: environmental information disclosure, number of innovations, quality of innovation, and control variables. Table 1 lists the definitions of the variables.

Table 1. Variable definitions.

Variable type	Name	Abbreviation	Definition
Dependent variable	Environmental information disclosure	EID	Environmental information disclosure index
Independent variables	Number of innovations	Ninvention	Ninvention = ln(1 + Total independent patent applications for the year)
	Quality of innovation	Qinvention	Qinvention = ln(1 + Total number of patents granted independently during the year)
Control variables	Asset and liability levels	Lev	Total liabilities at the end of the period / Total assets at the end of the period
	Growth	Growth	Operating income growth rate at the end of the period
	Cash flow capacity	CFO	Net cash flow from operations / Total assets
	Nature of ownership	SOE	The state of enterprise. State-owned enterprise = 1, and 0 otherwise.

3.2. Dependent Variable

As the explanatory variable, this study examines the QEID utilizing the environmental research database from the CSMAR database. A scoring system is applied as per the classifications of corporate EID, which distinguish between monetized and non-monetized information (Wiseman, 1982). Monetized information is assigned a value of 2, qualitative indicators are assigned a value of 1, and undisclosed indicators are assigned a value of 0 in a combination of quantitative and qualitative disclosure. For non-monetized information, disclosure indicators are assigned a value of 2 if disclosed and a value of 0 if undisclosed. Specifically, the indicators related to Environmental Liabilities Disclosure, Environmental Performance, and Governance Disclosure are classified as monetized information within the scope of this study. On the other hand, indicators related to Environmental Management Disclosure, Environmental Certification Disclosure, and Environmental Information Disclosure Vehicle are categorized as non-monetized information. QEID, a comprehensive indicator representing the QEID, is calculated by subjecting the aggregated ratings of the 25 rating items across five aspects for both types of information to logarithmic transformation.

3.3. Independent Variable

The innovation capability of a company can be measured in three ways (Yang, 2004). The first measurement is from the perspective of technological activity inputs (Brown, Fazzari, & Petersen, 2009) or outputs (He & Tian, 2013). The second measurement is a disaggregated measure based on different types of innovation, and the third measure is based on enterprise product production, value production, and knowledge production processes.

This study argues that a firm's innovation output provides a highly prepared and integrated picture of the results of a firm's use of various resources for innovation. Therefore, this study adopts the method by Lai and

Cheng (2016) to measure the innovation capability of firms using two indicators, the quantity and the quality of innovation. This study uniquely employs the number of innovations (Ninvention) as a measure of the quantity of technological innovation and the quality of innovation (Qinvention) as a measure of the quality of technological innovation. The calculation process is as follows in Equation 1 and Equation 2.

$$\begin{aligned} &Total\ independent\ patent\ applications\ for\ the\ year\ = \\ &Number\ of\ inventions\ independently\ applied\ for\ in\ the\ year\ + \\ &number\ of\ utility\ models\ independently\ applied\ for\ in\ the\ year\ + \\ &number\ of\ designs\ independently\ applied\ for\ in\ the\ year \end{aligned} \quad (1)$$

$$\begin{aligned} &Total\ independent\ patent\ granted\ for\ the\ year\ = \\ &Number\ of\ inventions\ independently\ granted\ for\ in\ the\ year\ + \\ &number\ of\ utility\ models\ independently\ granted\ for\ in\ the\ year\ + \\ &number\ of\ designs\ independently\ granted\ for\ in\ the\ year \end{aligned} \quad (2)$$

3.4. Econometric Model

In order to control for unobservable factors that may affect the results during the sample period, this study incorporates year-fixed and industry-fixed effects. The regression analysis is conducted using the following models:

$$EID_{it} = a_0 + a_1 Ninvention + a_2 Lev + a_3 Growth + a_4\ CFO + a_5\ SOE + a_6 \sum ind + a_7 \sum year + e1 \quad (3)$$

$$EID_{it} = a_0 + a_1 Qinvention + a_2 Lev + a_3 Growth + a_4\ CFO + a_5\ SOE + a_6 \sum ind + a_7 \sum year + e2 \quad (4)$$

Where:

EID = Environmental information disclosure index.

Ninvention = Independent variable.

Qinvention = Independent variable.

Lev = Level of assets and liabilities.

Growth = Growth rate of operating income at the end of the period.

CFO = Cash flow capacity.

SOE = Nature of ownership.

a_0 = Constant term.

$a_1 \sim a_7$ = Regression coefficient.

$e1$, $e2$ = Disturbance term.

Table 2. Fisher unit root test.

Variable	Lag	Chi-square	Prob > Chi-square	Stationarity
lnEID	1	9737.091	0.000	Non-stationary
Ninvention	1	7707.640	0.000	Non-stationary
Qinvention	1	8977.734	0.000	Non-stationary
Lev	1	8540.283	0.000	Non-stationary
Growth	1	14100.000	0.000	Non-stationary
CFO	1	13600.000	0.000	Non-stationary
SOE	1	126.185	1.000	Stationary

4. RESULTS AND DISCUSSION

4.1. Unit Root Test

Table 2 above presents the findings of the Fisher unit root test with lag 1 for various variables. The chi-square statistic and probability values indicate the significance of the test. Additionally, a column has been added to describe the stationarity of each variable. At a significance level of 0.05, the findings indicate that the null hypothesis of a unit root is rejected for variables lnEID, Ninvention, Qinvention, Lev, Growth, and CFO. Thus, these variables are non-stationary. On the other hand, the variable SOE exhibits a chi-square statistic of 126.1853 with a probability value of 1.0000. The results indicate that there is insufficient evidence to reject the null hypothesis of a unit root. Therefore, the variable SOE is considered stationary.

4.2. Regression Analysis

The regression results for models (1) and (2) are displayed in Table 3. The model's overall fit, as indicated by the R-squared values of 0.264 and 0.262 for models (1) and (2), respectively, demonstrates the strong explanatory power of the selected independent variables. The F-values of the model are 128.7484 and 126.8638, respectively, which are significant at the 1% level and indicate that the model fits well.

Table 3. Regression analysis results.

Variable	lnEID	lnEID
Ninvention	0.093*** (12.500)	-
Qinvention	-	0.095*** (11.780)
Lev	0.513*** (8.960)	0.512*** (8.890)
Growth	-0.065*** (-5.690)	-0.060*** (-5.260)
CFO	1.264*** (11.340)	1.277*** (11.450)
SOE	0.290*** (10.360)	0.293*** (10.440)
_cons	0.172** (2.000)	0.195** (2.260)
Industry	Yes	Yes
Year	Yes	Yes
N	28602	28602
R^2	0.264	0.262
adj. R^2	0.263	0.261
F	128.748	126.864

Note: *t* statistics are in parentheses.
** $p < 0.05$, *** $p < 0.01$.

The regression results in column (1) for fixed industry and year in both directions demonstrate that the coefficient of Ninvention on lnEID is 0.0934, and the standard error of this coefficient is 12.50. Ninvention has a significant positive effect on lnEID at the 1% level, indicating that an increase of one unit in Ninvention leads to a 0.0934 unit increase in the mean value of lnEID. The significance level of this result is very high, indicating that the explanation of Ninvention for lnEID is statistically significant.

The coefficient of Lev on lnEID is 0.5129, and the standard error of this coefficient is 8.96. The significance marker of the coefficient of 1% indicates a highly statistically significant value. Thus, when the value of Lev increases by one unit in this regression model, the mean value of lnEID increases by 0.5129 units. This result has a very high level of significance, demonstrating that Lev explains lnEID in a statistically significant way.

The coefficient of Growth on lnEID is -0.0652, and the standard error of this coefficient is -5.69. The significance mark of the coefficient of 1% indicates that it is highly statistically significant. Thus, Growth has a significant negative effect on lnEID in this regression model. The mean value of lnEID decreases by 0.0652 units when the value of Growth increases by one unit. The significance level of this result is very high, indicating that Growth has a statistically significant effect on the interpretation of lnEID.

The coefficient of CFO on lnEID is 1.2635, and the standard error of this coefficient is 11.34. The significance marker of 1% for the coefficient indicates that it is highly statistically significant. Thus, when the value of CFO increases by one unit, the mean value of lnEID increases by 1.2635 units. This result has a very high level of significance, demonstrating that CFO explains lnEID in a statistically significant way.

The coefficient of SOE on lnEID is 0.2904, and the standard error of this coefficient is 10.36. The significance marker of 1% for the coefficient indicates that it is highly statistically significant. Therefore, the mean value of lnEID increases by 0.2904 units when the value of SOE increases by one unit. This result also has a very high level of significance, indicating that SOE explains lnEID in a statistically significant way.

From the regression results in column (2) for fixed industry and year in both directions, the coefficient of Qinvention on lnEID is 0.0949, and the standard error of this coefficient is 11.78. The analysis reveals a significant positive effect of Qinvention on lnEID at the 1% level. Specifically, for every unit increase in Qinvention, lnEID increases by 0.0949 units. The significance level of this result is very high, indicating that Qinvention explains lnEID in a statistically significant way.

In the regression analysis in column (2), the coefficient of Lev on lnEID is 0.5119, and the standard error of this coefficient is 8.89. The significance marker of 1% for the coefficient indicates that it is highly statistically significant. Thus, the mean value of lnEID increases by 0.5119 units when Lev increases by one unit. This result has a very high level of significance, demonstrating that Lev explains lnEID in a statistically significant way.

The coefficient of Growth on lnEID is -0.0602, and the standard error of this coefficient is -5.26. The significance mark of the coefficient of 1% indicates that it is highly statistically significant. Thus, the mean value of lnEID decreases by 0.0602 units when the value of Growth increases by one unit. The significance level of this result is very high, indicating that Growth explains lnEID in a statistically significant way.

The coefficient of CFO on lnEID is 1.2770, and the standard error of this coefficient is 11.45. The significance marker 1% for the coefficient indicates that it is highly statistically significant. Thus, the mean value of lnEID increases by 1.2770 units when the value of CFO increases by one unit. This result has a very high level of significance, demonstrating that CFO explains lnEID in a statistically significant way.

The coefficient of the control variable SOE on lnEID is 0.2929, and the standard error of this coefficient is 10.44. The significance marker 1% for the coefficient indicates that it is highly statistically significant. Therefore, the mean value of lnEID increases by 0.2929 units when the value of SOE increases by one unit. This result has a very high level of significance, indicating that SOE explains lnEID in a statistically significant way.

The prevailing view that there is a significant and positive association between technological innovation and environmental information disclosure aligns with this result. The importance of innovation aligns with Li et al. (2018) and Radu and Francoeur (2017), who found that corporate environmental information disclosure is promoted by technological innovation. Therefore, the impact of technological innovation on the regulatory framework for corporate environmental information disclosure is crucial.

5. CONCLUSIONS AND RECOMMENDATIONS

In this study, the non-balanced panel data of A-share listed businesses in Shanghai and Shenzhen from 2008 to 2017 were analyzed using the ordinary least squares (OLS) regression analysis approach. Year and industry fixed effects models were introduced to control the influence of unobservable factors during the sample period. The research findings contribute to the understanding of the significance of internal management in the QEID among listed companies by assessing the extent to which it is influenced by corporate technological innovation. Moreover, by demonstrating a positive and significant relationship between the QEID and corporate technological innovation, this study strengthens the existing evidence. As technological innovation and EID are positively correlated, companies are recommended to actively promote and integrate technological innovation with EID. The recommendations based on the results are as follows:

5.1. Strengthen the Management of Technological Innovation

Enterprises should establish sound management systems for technological innovation, attach importance to the investment in technological innovation, and strengthen the organization, coordination, and management of technological innovation to improve its effectiveness.

5.2. Improve the Quality of Environmental Information Disclosure (QEID)

Enterprises should prioritize the QEID and ensure timely and accurate dissemination of environmental information to society. Concurrently, they should actively respond to the public's concerns regarding environmental issues and continuously focus on providing quality environmental information disclosure.

5.3. Strengthen Internal and External Cooperation

Enterprises can cooperate with other companies, governments, academic institutions, and others to jointly promote technological innovation and environmental information disclosure. Through cooperation with other companies, resources and experience can be shared to enhance the efficiency of technological innovation. Policy support and market opportunities can be obtained through cooperation with governments. Subsequently, technical support and research results can be obtained through cooperation with academic institutions.

In summary, technology innovation and environmental information disclosure are complementary to each other. Enterprises should actively promote environmental information disclosure while strengthening technology innovation to achieve sustainable development.

This study differs from previous studies in the following ways:

5.3.1. Different Sample Selection

Previous studies primarily focused on heavy industry companies. In contrast, this study encompasses a wider range of industries or regions by analyzing A-share listed companies in the Shanghai and Shenzhen stock markets.

5.3.2. Updated Time Period

The choice of the time span from 2007 to 2020 has certain economic and political background reasons. By providing a comprehensive perspective on the QEID, this extended period sheds light on the impact of environmental regulations. This time period encompasses key environmental regulatory policies and events, including the introduction of the "Interim Measures for the Disclosure of Corporate Environmental Information" in 2007, the establishment of the "Regulations on the Disclosure of Environmental Information" in 2010, the amendment of the Environmental Protection Law in 2015, and the implementation of the revised Environmental Protection Law in 2018. Selecting this time span ensures the reliability and validity of the research data.

Although this study has significant implications, it has limitations. Firstly, several limitations exist in constructing the environmental disclosure quality index, which may result in an incomplete indicator system. The indicator system used in the environmental disclosure index may not be comprehensive, accurate, or fully reflect companies' QEID. Evaluation standards for the environmental disclosure index are subject to strong subjectivity as evaluation agencies or expert groups develop them. This subjective nature of the standards introduces a certain degree of personal bias and is susceptible to controversy. Additionally, the environmental disclosure index requires large data collection, including corporate information disclosure, survey questionnaires, government regulatory data, and others. The data is difficult to collect, and data quality and reliability are difficult to determine.

Secondly, this study only considers the impact of the quantity and quality of technological innovation on environmental information disclosure in measuring corporate technological innovation. It fails to consider other related factors, such as the input-output ratio of technological innovation. Therefore, the research scope in the future should be expanded to enhance the measurement standards of environmental information disclosure quality, consider highly appropriate proxy variables related to technological innovation, and enrich the study of the relationship between corporate technological innovation and environmental information disclosure quality.

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