

# The Impact of Urban Digital Development on Corporate Environmental Information Disclosure

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Keywords:

ABSTRACT

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Green finance;  
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Based on a market-signaling perspective, this study explores whether and how urban digital development affects corporate environmental information disclosure (EID). Using Chinese A-share listed firms from 2011–2019 as the sample, and employing fixed-effects panel regressions and a series of robustness checks, we find that urban digital development significantly increases both (i) whether firms disclose environmental information and (ii) the quality of such disclosure. Mechanism tests show that urban digital development improves the quality of EID through (1) promoting regional marketization and intensifying market competition, and (2) strengthening green finance development, which enhances financing support and resource allocation efficiency. Heterogeneity analyses indicate that the effect is stronger for state-owned enterprises (SOEs), heavily polluting industries, and firms located in eastern and central China. The findings suggest that in the digital economy era, environmental disclosure should be viewed not only as a passive response to legitimacy pressure but also as a competitive tool that helps firms obtain differentiated resources and green finance support.

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## 1.Introduction

With environmental protection becoming a basic national policy, corporate environmental information disclosure has become an important part of their social responsibility performance. By providing corporate environmental information to different stakeholders, enterprises can meet the needs of external legitimacy evaluation and avoid potential environmental conflicts and disputes (Zeng et al., 2010; Nason et al., 2018). In May 2022, the Ministry of Ecology and Environment issued the "Reform Plan for the Legally Mandated Environmental Information Disclosure System", which further clarified the important value of corporate environmental disclosure, regarding it as a basic component of the ecological civilization system and related to the modern comprehensive management capacity of enterprises.

However, as an important corporate decision, the willingness to disclose and the quality of disclosed information depend on the comprehensive trade-off and game of managers between external pressures and internal development needs (Song Jianbo & Li Dani, 2013; Li Qiang & Feng Bo, 2015).

(1) From the perspective of external pressure, most enterprises in China lack mandatory and in-depth supervision on environmental information disclosure. Firstly, except for key pollution discharge monitoring units, environmental information disclosure is still a voluntary part, and the form and content of disclosure do not need to be subject to external auditing, which provides enterprises with great discretion in "whether to disclose, what to disclose, and how to disclose". For heavily polluting enterprises that themselves cause negative environmental externalities, "not disclosing or not reporting bad news" has become their "taken-for-granted" choice. Secondly, even if higher-level units have mandatory requirements on environmental information disclosure for some enterprises, if the expected cost of publishing false information is low, enterprises may also engage in "false green" behaviors and deliberately conceal true environmental protection information (Zhu Wei et al., 2019). Based on this, there is a potential problem of "information asymmetry" in corporate environmental information disclosure, and it is urgent to strengthen the environmental supervision system to increase their "legitimacy pressure".

(2) From the perspective of internal needs, most enterprises do not pay enough attention to disclosure work, resulting in low disclosure quality. Firstly, among enterprises participating in environmental information disclosure, the form of disclosure reports is relatively random and

fragmented, key indicators are not fully disclosed, and the disclosure is mainly vague, formalistic and difficult-to-verify qualitative disclosure, lacking effective proprietary environmental information (Song Jianbo & Li Dani, 2013); secondly, some enterprises still remain at the "pressure response" level in environmental information disclosure and have not fully realized its market strategic value (Waddock and Graves, 1997; Dowell et al., 2000). Therefore, in addition to necessary regulatory pressure, the government should consider how to drive the enthusiasm of enterprises for information disclosure, making the release of high-quality information an important means of market competition.

Regarding how to drive enterprises to take the initiative to disclose environmental information and improve the quality of information disclosure, academia and industry have mainly sought solutions from the perspectives of strengthening environmental supervision and increasing punishment intensity (Waddock and Graves, 1997; Wu Jianfeng et al., 2015), but few have conducted analysis from the perspective of market-oriented incentives. In view of the fact that previous studies and national policy documents have confirmed the important significance of digital development for the allocation of market factors, this paper will attempt to explore whether urban-level digital development can affect the local enterprise information disclosure work by influencing the local marketization process.

## **2.Literature review**

### ***2.1 Visual Exploration in Early Development***

According to the definition in the "Dictionary of Ecological Civilization Construction" (2016), this paper defines corporate environmental information disclosure as "enterprises disclose various environmental information related to the enterprise to stakeholders through various forms such as financial reports, notes to financial statements, prospectuses, social responsibility reports, environmental reports, sustainable development reports, announcements on major events, and corporate websites."

For environmental information disclosure, this paper will elaborate on the research progress from the perspectives of its motivation, influencing factors, and economic consequences.

Existing studies have summarized the motivations of corporate environmental information disclosure into the following two aspects.

Firstly, enterprises must meet the pressure of environmental legitimacy, and disclosing green

information helps to show what they have done (Mei Xiaohong et al., 2020). With the strengthening of government environmental regulation and the improvement of public participation in environmental protection, social calls for environmental protection have been strengthened, gradually forming a social atmosphere and concept of "resource conservation" and "environmental friendliness", and the demand for corporate green information has increased accordingly (Sun Xiaohua et al., 2023). While pursuing the maximization of economic interests, enterprises must appropriately take into account the demands of external stakeholders, reduce the negative externalities caused by pollution, and take the initiative to disclose to respond to external information needs in order to achieve legitimate recognition.

Secondly, corporate environmental information disclosure helps enterprises obtain good market competitiveness and a social green image to strive for more differentiated resources. At this stage, ESG information has become an important evaluation item in domestic and foreign capital markets, and enterprises with low ratings will encounter obstacles in IPO, investment and financing, business cooperation and other links (Liliana, 2003). High-quality environmental information disclosure sends positive and responsible value signals to the market, and is more likely to obtain resource inclination from the green financial market, which will enhance consumer confidence and ease the pressure of financing costs. Mei Xiaohong et al. (2020) found that in regions with a high degree of marketization and weak factor distortion, due to the lack of relational resources and insufficient rent-seeking space, enterprises are more encouraged to disclose green information to alleviate information asymmetry and improve market attractiveness. However, objectively, disclosing environmental information requires enterprises to have certain slack resources to undertake environmental governance, and also requires external environment to provide supportive conditions, which is not fully studied in the current research.

Current research covers a wide range of influencing factors. Among internal factors, it involves carbon risk awareness, carbon emissions, carbon emission reductions, environmental protection investment, environmental system certification, manager characteristics, etc. (Yan Haizhou & Chen Baizhu, 2017; Yan Huahong et al., 2019); among external factors, it involves climate change, environmental regulation, environmental inspection, public environmental supervision and demands (He Yu et al., 2014; Yan Haizhou & Chen Baizhu, 2017; Qi Fangfang & Wu Xiaowen, 2023).

However, corporate environmental information disclosure is often the result of the joint action of multiple factors and is complex. The institutional logics generated by these factors may have

incompatibility, competition, conflict and other relationships (Wu Danhong et al., 2021). For example, in environmental information disclosure, there may be a phenomenon that "enterprises tend to superficially follow and cater to the political institutional logic, but actually strive to serve the market institutional logic", which is often manifested as: managers perfunctorily fulfill environmental responsibilities and symbolically disclose environmental information in order to save environmental governance costs, leading to the failure of environmental governance work to achieve substantial results.

Based on this, according to the real motives of enterprise management, this paper considers dividing corporate environmental information disclosure into two aspects: the presence or absence of disclosure behavior and disclosure quality: disclosure behavior reflects whether the enterprise has made formal response work to meet the legitimate status; disclosure quality reflects the degree of substantial efforts of the enterprise in the field of environmental governance, and is an important indicator to determine whether the enterprise is "inconsistent in words and deeds".

Regarding the economic consequences of corporate environmental information disclosure, existing literature has found that disclosure work has a promoting value for the medium and long-term development of enterprises, but has a crowding-out effect on short-term economic profits.

For the medium and long-term value effect, relevant literature believes that disclosure has cost reduction, quality improvement and incentive effects: firstly, enterprises' disclosure of positive information on environmental responsibilities can effectively improve equity and debt capital costs, ease financing constraints, and enhance enterprise growth capacity, which is more significant in highly market-oriented regions and developed green financial markets (He Yu et al., 2014; Wu Hongjun et al., 2017); secondly, the green commitments transmitted by environmental information disclosure can internally encourage enterprises to take the initiative to carry out green transformation work, fulfill energy conservation and emission reduction obligations at a higher standard, restrict inefficient resource input, and reduce the uncertainty of environmental protection investment (Yan Haizhou & Chen Baizhu, 2017). Based on this, the voluntary disclosure theory holds that: enterprises will actively and proactively disclose relevant environmental responsibility information when participating in environmental protection investment and achieving good environmental governance results; even under unfavorable conditions, it helps to alleviate the market crash crisis (Sun Xiaohua et al., 2023).

For the short-term effect, relevant literature mainly involves the short-term crowding pressure of

disclosure work. This is because improving the quality of environmental information disclosure requires enterprises to continuously perform environmental protection work and carry out substantial green activities. Once an enterprise becomes a pioneer in environmental information disclosure, it is likely to be placed with higher environmental expectations by the outside world, leading to the high cost pressure of "flogging the fast ox" (Li Qiang & Feng Bo, 2017; Kong Dongmin et al., 2021). With the intensification of market competition related to the main business, enterprises will find it difficult to effectively balance green environmental protection responsibilities, resulting in a dilemma. In addition, some studies also believe that with the increasing social attention to corporate ESG strategies, environmental information disclosure will lead to the leakage of enterprise proprietary information, resulting in imitation by competitors, thereby adversely affecting the enterprise's market position (Yang Ruijuan et al., 2020). These all cause certain disturbances to the development of environmental information disclosure work.

There are few current literatures on the impact of urban digital development on corporate environmental information disclosure. Only a small number of literatures have proposed that "because the Internet wide-area platform can quickly obtain, input information, analyze and process data, and feed back and share in a timely manner, the government should fully develop digital public tools to realize the structured management of information disclosure". In addition, from the enterprise perspective, Dai Yue and Shi Mengge (2016) proposed that based on the environmental information needs of different stakeholders, modular design of information disclosure based on "Internet +" should be carried out to enable local enterprises to provide environmental information efficiently and conveniently.

The above research mainly involves the promotion of digital technology on the form renewal and intelligent transmission of environmental information, and has no direct correlation with the willingness and quality of enterprise information disclosure. How the digital development of the region affects the motives and behaviors of enterprise managers, thereby adjusting the environmental information disclosure behavior (disclosure willingness and quality), remains to be further explored.

Based on the above, current research is not sufficient on whether digital development can affect ESG disclosure business related to corporate social responsibility, and whether ESG disclosure business and economic interests can produce synergy and complementarity. Enterprises are essentially profit-making entities, and participating in ESG projects such as environmental governance is not their

"original intention"; excessive participation will instead have a crowding-out effect on profits. However, if participating in and disclosing ESG projects can be "linked" to economic business and promote the inflow of external resources and policy inclination, it will effectively change the mentality of managers.

Among them, the green financial market is a typical application scenario connecting social responsibility and economic interests. The improvement of this green factor market is an important prerequisite for enterprises to obtain competitive advantages by performing and disclosing environmental responsibilities: due to information asymmetry and environmental uncertainty, buyers are often in an information disadvantage; at this time, by disclosing environmental and other social responsibility information, enterprises can enhance effective communication with investors and obtain organizational reputation and non-relational resources in a way that is more acceptable to stakeholders (Ren Guangqian, 2017). Whether urban digital development can effectively empower new infrastructure such as the green financial market and ultimately promote the enthusiasm of enterprises for green information disclosure remains to be further studied.

## ***2.2 Data Collection***

Disclosure decisions need to balance economic benefits and social responsibilities: the former follows the logic of market competition, while the latter follows institutional logic (Yin Juelin, 2012; Gou Qianwen et al., 2019). Under the constraint of multiple logics, managers may superficially conform to relevant systems to reduce frictions, resulting in certain symbolic rather than substantive behaviors, thereby reducing environmental governance costs. Essentially, this approach serves the logic of market competition.

Based on the above, this study divides corporate environmental information disclosure into two parts: the presence or absence of disclosure behavior and disclosure quality. Among them, the former reflects whether an enterprise formally responds to external demands for disclosing environmental information; the latter is used to measure the authenticity, completeness, timeliness and other aspects of the disclosed information, reflecting the extent to which the enterprise substantially fulfills its environmental responsibilities (Hu Wenxiu et al., 2021). This paper will empirically test the impact of urban digital development on local corporate environmental information disclosure and consider how to regulate corporate disclosure behaviors.

### ***2.2.1 The Impact of Urban Digital Development on Corporate Environmental Information***

### ***Disclosure Behavior***

Urban digital development strengthens the intensity of formal and informal environmental regulations in the region, promotes the spillover and diffusion of green environmental protection knowledge, and enhances local environmental protection awareness. According to the legitimacy theory, these increasing external demanders of environmental information shape the institutional environment and environmental public contracts of the region, forming pressure for legitimate recognition on local corporate environmental governance (Zhu Wei et al., 2019). Under relevant institutional pressures, organizations have to gradually converge with mainstream values at least in external form and appearance, and take the initiative to assume certain environmental responsibilities (Liu Yuhuan et al., 2020). "Even good wine fears deep alleys"—once an enterprise fulfills its environmental responsibilities, it must adopt a relatively public way to make the public aware of the enterprise's relevant situation, which involves the issue of publicizing the enterprise's private information (Shen Yi et al., 2014).

The legitimacy theory holds that enterprises need to actively, appropriately and selectively disclose environmental information to prove their value to society, show that they fulfill social and environmental contracts, guide social recognition of their legitimacy, and avoid potential legal lawsuits (Tang Guoping & Li Longhui, 2011; Xiao Hongjun et al., 2013). Essentially, this disclosure behavior is a self-interested defensive tendency to maintain their own legitimate recognition. Therefore, Hypothesis 1 is proposed.

Hypothesis 1: Controlling for other factors, urban digital development can significantly increase the environmental information disclosure behavior of local enterprises.

### ***2.2.2 The Impact of Urban Digital Development on the Quality of Corporate Environmental Information Disclosure***

Urban digital development effectively alleviates the problem of information asymmetry by strengthening external environmental supervision, forming legitimate pressure on local corporate environmental governance. This urges enterprise managers to accept external supervision and strengthen disclosure behaviors to respond to external environmental demands. However, even if environmental disclosure obligations are fulfilled, whether the disclosure quality is significantly improved still needs further exploration. At present, except for key monitoring units, domestic environmental protection departments still lack specific regulations on the detailed items disclosed by

enterprises, and enterprises still have considerable "discretion" in environmental information disclosure, leading to uneven quality of disclosed information governance (Xiao Shuguang et al., 2017).

Driving enterprise managers to disclose high-quality information requires them to fully recognize the market value of environmental information disclosure and change the past concept of passive response.

First, Market Competition Channel. The impact path of urban digital development on the quality of corporate environmental information disclosure may first be reflected in its "market competition effect". In regions with slow marketization, factor markets are distorted, and relational resources occupy a more important position. At this time, enterprises find it difficult to obtain corresponding factor resources entirely through market-oriented means, and the role of disclosure quality in resource allocation is weakened (Quairel, 2011). In contrast, digital development promotes the free flow, spillover and reallocation of local market factors, improves the level of regional marketization, overcomes resource misallocation and market distortion, improves the development level of various markets, factor allocation and legal systems to be more sound and fair, matures the "contract economy", reduces relational resources, and intensifies market competition. Under the logic and behavioral orientation of marketization, obtaining factors and building competitive advantages require enterprises to strive through market-oriented means (Wang Yaming et al., 2015). This will encourage enterprises to incorporate CSR into their marketing plans, actively improve the quality of environmental information disclosure, and transmit a differentiated "signal strategy" to gain reputation and competitiveness and enhance external confidence.

The underlying logic of the above analysis is: a developed factor market is a necessary prerequisite for enterprises to obtain differential advantages by fulfilling and disclosing green responsibilities (Yan Haizhou & Chen Baizhu, 2017). Rational market investors usually judge the direction of an enterprise's business strategy from the social responsibility information disclosed by the enterprise, identify more positive corporate value signals, reduce investment doubts, and thus continuously and dynamically adjust their investment decisions.

Second, Market Investment and Financing Channel. The impact mechanism of urban digital development on the quality of corporate environmental information disclosure may second be reflected in its "resource matching optimization and financing support" in the field of green finance. Green finance closely links green responsibilities with economic interests, guiding and encouraging

enterprises to establish green concepts and promote green transformation. Among them, environmental information disclosure is an important foundation for the development of green finance: the development of green finance requires the establishment of a more open, transparent and comprehensive corporate environmental information disclosure system.

Specifically, China is currently in a transitional economy and an emerging marketization stage, with fierce market competition and strong corporate financing demand (Du Jinzhu & Wu Zhanyong, 2022). As the market supplier of green financial services, financial institutions need to identify green enterprises through corporate environmental information disclosure. Enterprises that disclose environmental information in a timely and active manner are more likely to obtain financial support with relatively low interest rates and relatively long loan terms (Wang et al., 2020; Hu Wenxiu et al., 2021).

With the rapid digital development of the region, digital technology can form a networked and open ecological information sharing mechanism, providing an upstream and downstream industrial link platform for green finance. While ensuring the safe, effective and free flow of information, this digital platform can improve the matching efficiency of green finance investment and financing on both the supply and demand sides, and alleviate the blindness of market regulation (Vives, 2017; Chen Hua & Shen Yue, 2022). In order to better obtain green financial services and reduce environmental governance costs, enterprises will take the initiative to improve disclosure quality in a sound green financial market environment to gain more market attention and policy inclination.

Based on this, the following hypotheses are proposed.

Hypothesis 2: Controlling for other factors, urban digital development can significantly improve the quality of environmental information disclosure of local enterprises.

Hypothesis 2-1: Controlling for other factors, urban digital development can encourage local enterprises to improve the quality of environmental information disclosure by promoting the process of regional marketization.

Hypothesis 2-2: Controlling for other factors, urban digital development can provide technical support for the development of local green finance, thereby significantly improving the quality of environmental information disclosure of local enterprises.

### ***2.2.3 Variable Selection***

The selection of variable indicators in this paper follows the principles of relevance, accessibility,

data openness and accuracy.

Explained Variables: Corporate Environmental Information Disclosure Behavior and Environmental Information Disclosure Quality

Disclosing an enterprise's environmental management behaviors, purposes, scope and nature can meet the external demand for enterprise information at the level of sustainable development. Essentially, such disclosure belongs to impression management, which balances the enterprise's environmental governance effects and economic performance, and will have an impact on enterprise value and market competitive position.

Previous literature has proposed that environmental information disclosure has a social responsibility decoupling phenomenon of "saying one thing and doing another", that is, although an enterprise has disclosure behaviors, such behaviors are only perfunctory symbolic responses, and the enterprise has not taken substantial environmental protection actions due to economic considerations. This will lead to insufficient disclosure quality and lack of referable effective information. To avoid the disturbance of this "inconsistency between words and deeds" on the research, this paper divides environmental information disclosure into two parts: disclosure behavior and disclosure quality, and sets proxy variables in turn for regression testing.

Selection of Measurement Indicators for Corporate Environmental Information Disclosure Behavior: Corporate environmental information disclosure behavior refers to the enterprise's transmission of its own environmental responsibility information to the public through various information reporting carriers or channels in response to the environmental responsibility pressure in the region, so as to guide social recognition of the legitimacy of its own environmental behaviors. For the measurement of corporate environmental disclosure behavior, a dummy variable is constructed based on whether the enterprise discloses environmental information in the current year (1 if yes, 0 otherwise). This study judges whether the enterprise has disclosure behavior according to whether it has disclosed environmental information in the annual report, social responsibility report and environmental report in the current year (relevant data are from the CSMAR Environmental Governance Series). This behavior reflects the enterprise's willingness and attention to environmental information disclosure work, and is an important way to formally meet external requirements.

Selection of Measurement Indicators for Corporate Environmental Information Disclosure Quality: Corporate environmental information disclosure quality represents the detail level of the

enterprise's disclosure in environmental disclosure work. If an enterprise only completes the disclosure work in form, but the quality of environmental information disclosure does not improve or even decreases, then the enterprise's corresponding disclosure work is likely to be only symbolic disclosure for perfunctory purposes, lacking verifiable, quantifiable and detailed environmental actions.

The practices of existing literature on measuring disclosure quality are as follows. Firstly, Li Qiang and Feng Bo (2015) divided environmental information into 7 parts, including environmental costs, environmental liabilities, environmental performance and environmental governance, and summed the scores of each part to generate a disclosure quality index; secondly, Zheng Jianming and Xu Chenxi (2018) manually selected two dimensions, namely empirical and formal dimensions, of corporate environmental information disclosure, and adopted content analysis method to quantitatively evaluate the quality of corporate environmental information disclosure; thirdly, Kong Dongmin et al. (2021) used the Environmental Research Database in the CSMAR Database to classify environmental information according to whether it is monetized information (Wiseman, 1982): for monetized information, the assignment is 2 for combined quantitative and qualitative disclosure, 1 for qualitative indicators, and 0 for undisclosed indicators; for non-monetized information, the assignment is 2 for disclosed indicators and 0 for undisclosed indicators. These measurement methods all require a certain amount of time for effective classification, with high information collection costs and a certain degree of subjectivity.

Based on the considerations of low cost, easy accessibility, objectivity and reliability of data collection, the data of this study are derived from the Bloomberg Corporate Social Responsibility Disclosure Index. This index involves the total ESG score of the enterprise and the scores of each individual item. Among them, the total ESG score can be traced back to 2006. By measuring the company's performance in environmental, social and governance dimensions, the organization gives each company a score in three dimensions: environmental information (E), social information (S) and corporate governance (G), which are summed to form the total ESG score, ranging from 0.1 to 100. The source of score information is mainly the public information disclosed by the enterprise (such as climate change issues and pollution emission issues, which are also of financial importance and business relevance). The rating indicators involve 21 secondary indicators and 70 evaluation indicators to assist investors in evaluating the enterprise's ESG governance capabilities. This paper takes the total score of environmental information (E) among them as the environmental disclosure quality

score. The higher the score, the better the ESG performance of the enterprise in the environmental field; enterprises that do not obtain a score in the current year are assigned a value of 0.

#### Explanatory Variable: Urban Digital Development

Since the "12th Five-Year Plan", China's digital economy has entered a period of rapid development, and a series of macro-level regional digital measurement indicators have gradually emerged. Current domestic and foreign literature on the measurement of the digital economy mainly comes from the national and provincial levels, while the measurement at the urban level is relatively few (Zhang Bochao and Shen Kaiyan, 2018; Xu Xianchun and Zhang Meihui, 2020). Based on the principles of data accessibility, effectiveness and reliability, the core explanatory variable of this paper is: urban-level digital development, which is more detailed and specific than national and provincial-level indicators.

The level of urban digital development includes both the overall index level, as well as the breadth of digital coverage, depth of use and literacy level. Therefore, this paper measures the level of urban digital development (Dig) from four dimensions: digital foundation, digital input, digital literacy and digital application, so as to better reflect the digital stage of the urban level.

Due to the possible dimensional differences of the above indicators, on the basis of fully drawing on and absorbing the three-level indicator design system of Zhao Tao et al. (2020), this study standardizes all three-level indicators belonging to different dimensions to eliminate dimensional differences; secondly, this study uses the coefficient of variation method to construct a digital development evaluation system including 4 primary indicators, 5 secondary indicators and 6 tertiary indicators. The constructed indicator system is cutting-edge, in line with the characteristics of the digital and information age, and all indicators are positive indicators with accessibility and operability.

In the calculation process, this study assigns weights to each three-level indicator in turn according to the proportion of the coefficient of variation of each three-level indicator in the total coefficient of variation of all three-level indicators (the coefficient of variation is calculated by standard deviation/average value), and weights and summarizes each three-level indicator to calculate the final digital development score of a specific city, with the corresponding score ranging between [0, 1].

Table 1 Digital Development Indicator System

Primary Indicators	Secondary Indicators	Tertiary Indicators	Weight of Tertiary Indicators	Indicator Attribute
Digital Foundation	Broadband Access Level	Number of Regional International Internet Broadband Access Users	0.1237	+
		Number of Regional Mobile Phone Users at the End of the Year	0.1292	+
	Communication Access Level	Total Regional Telecommunications Business Revenue	0.1893	+
Digital Application	Digital Popularization Degree	Regional Digital Inclusive Finance Index	0.068	+
Digital Input	Technology R&D Input	Total Annual Regional Scientific and Technological Expenditure	0.2251	+
Digital Literacy	Human Resource Level	Number of Employees in Regional Information Transmission, Computer Services and Software Industry	0.2647	+

Selection of Control Variables: Based on existing literature (Corr, 1995; Berman et al., 2021; Lee, 2021; Francis, 2021), this paper selects control variables from the following two levels.

Enterprise Level: Disclosure behavior and disclosure quality are closely related to the enterprise's financial status, operating results, property right nature, internal control and management, which directly affect the enterprise's disclosure decisions; in the context of digital development promoting the regional marketization process and market competition, the enterprise's R&D investment and innovation level directly affect its risk resistance capacity. Therefore, this paper selects: enterprise performance level (operating profit rate, operating profit/operating income); enterprise solvency (asset-liability ratio, total liabilities/total assets); enterprise operational capacity (fixed asset ratio, ending fixed assets/total assets); enterprise value level (Tobin's Q value, enterprise market value/total assets); enterprise governance level (proportion of independent directors on the board of directors, number of independent directors/number of board directors; number of board directors; management expense rate, management expenses/main business income; ownership concentration, sum of squares of shareholding ratios of the top ten major shareholders of the company); enterprise innovation level (R&D expense rate, annual R&D expenses/annual operating income); enterprise property right nature (1 if it is a state-owned enterprise, 0 otherwise).

Regional Level: This paper selects: regional marketization degree (collected from Fan Gang's Regional Marketization Index); regional government's environmental regulation degree (number of words in sentences containing environmental protection keywords/total number of words in the regional government work report); regional public environmental supervision degree (in Baidu Index trend analysis, search with "environmental pollution" as the keyword, and the logarithmically processed annual average value of the region).

Finally, industry, annual and individual fixed effects are controlled to overcome the impact of unobservable heterogeneity on endogeneity. The model is constructed with enterprise individuals as units for clustering, and clustered robust standard errors are calculated.

Table 2 Variable Definition Table

Symbol	Indicator	Measurement Method
ED	Environmental Disclosure Behavior	Dummy variable, 1 if the enterprise has environmental information disclosure in the current year, 0 otherwise. See 5.3.1 for details.
EDQ	Environmental Information Disclosure Quality	Selected from the environmental score item of the Bloomberg Database. See 5.3.1 for details.
Dig	Urban Digital Development	Referring to Zhao Tao et al. (2020), the weighted total score of 6 sub-indicators is calculated by using the objective weighting method. See 4.3.1 for details.
Profit	Enterprise Performance Level	Operating profit rate, operating profit/operating income
Leverage	Enterprise Solvency	Asset-liability ratio, total liabilities/total assets
FA	Enterprise Operational Capacity	Fixed asset ratio, ending total fixed assets/total assets
Tobin Q	Enterprise Value	Tobin's Q value, enterprise market value/total assets
Ind		Proportion of independent directors, number of independent directors/number of board directors
Board	Enterprise Governance	Number of board directors
AC	Level	Management expense rate, management expenses/main business income
HHI_10		Ownership concentration, sum of squares of shareholding ratios of the top ten major shareholders of the company
R&D	Enterprise Innovation Level	R&D expense rate, annual R&D expenses/annual operating income
Dummy_State	Enterprise Property Right Nature	Dummy variable, 1 if it is a state-owned enterprise, 0 otherwise
Marketization	Regional Marketization Degree	Fan Gang's Marketization Index

Symbol	Indicator	Measurement Method
ER	Regional Government	Number of words in sentences containing environmental protection keywords/total number of words in the regional government work report
	Environmental Regulation Degree	
Pub	Regional Public	In Baidu Index trend search, input "environmental pollution" as the keyword, and logarithmically process the annual average value of the region
	Environmental Supervision Degree	

#### ***2.2.4 Data Collection and Preprocessing***

This study collects listed companies on China's Shanghai and Shenzhen A-shares from 2011 to 2019 as the research population. It is sorted out according to the annual reports of Shanghai and Shenzhen listed companies, and the regional and enterprise indicator datasets are effectively merged using STATA 16 software. In the period of 2011-2019, to ensure the reliability of sample selection, some samples are excluded according to the following principles: ST and \*ST companies; companies with missing variable indicator data; companies with negative total assets; insolvent companies; sample companies in Tibet. After effectively merging different datasets, a total of 3,051 listed companies and 19,096 "enterprise-year" observation samples are obtained.

The explained variables, explanatory variables and control variables are from different databases. Among them: corporate environmental information disclosure is collected from Bloomberg ESG disclosure scores, and the environmental sub-item score is selected as the proxy indicator; internal control, property right nature and financial statement indicators are collected from the Company Research Series of the CSMAR Database; among the relevant data on digital development, the regional inclusive finance data adopts the Digital Inclusive Finance Index compiled by Peking University; the number of broadband access users, mobile phone users, total telecommunications business revenue, total scientific expenditure, and the number of employees in information transmission, computer services and software industry are taken from the annual data of the National Bureau of Statistics and the "China Urban Statistical Yearbook"; environmental regulation intensity data are from the "China Environmental Yearbook", "China Urban Statistical Yearbook" and "China Statistical Yearbook"; public environmental supervision data are from Baidu Index search; for the measurement of

marketization process, the disclosure data of Wang Xiaolu and Fan Gang in the annual "China Marketization Index—Report on the Relative Process of Marketization in Various Regions" are adopted; for the regional green finance index, the data are from the "China Statistical Yearbook", "China Insurance Yearbook" and statistical yearbooks of various provinces.

All continuous variables are subjected to WINSORIZE treatment at the 1% and 99% quantiles.

### 2.2.5 Theoretical and Empirical Model Construction

Based on theoretical analysis and hypotheses, this paper has constructed a theoretical research model of "urban digital development—corporate environmental information disclosure", as shown in Figure 1.

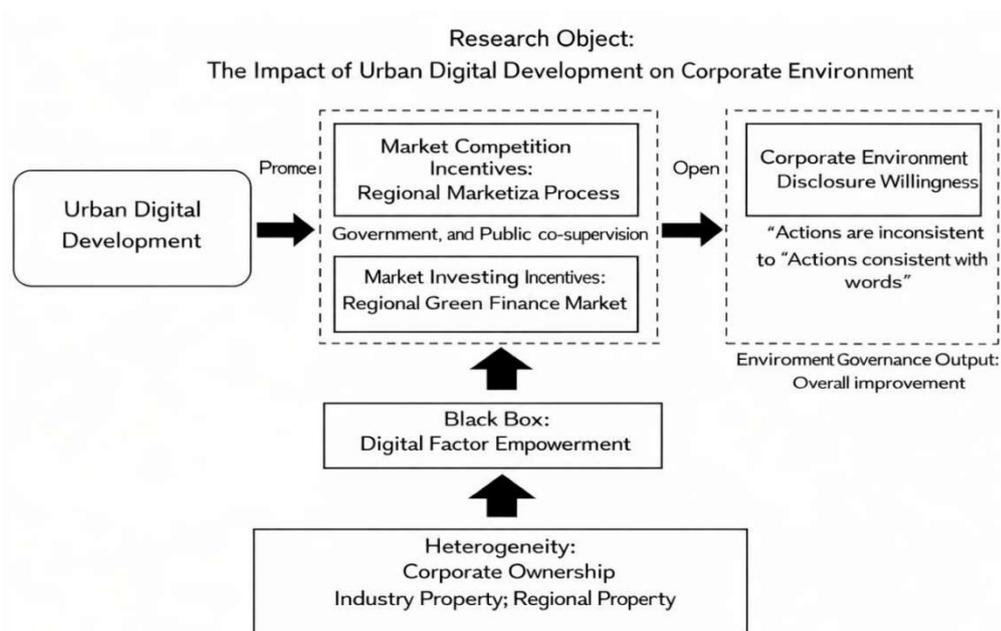


Figure 1 Theoretical Model of "Urban Digital Development—Corporate Environmental Information Disclosure"

For the relationship between urban digital development and corporate environmental information disclosure behavior, a high-dimensional panel fixed effect model is constructed to verify the hypothesis. The benchmark model will control for annual, industry or firm fixed effects.

$$ED_{i,t} = \alpha + \beta_1 * Dig_{i,t} + Controls + Fixed\ effects + \epsilon_{i,t}$$

## 3. Experiments and Results

### *3.1 Descriptive Statistics*

This section first conducts a descriptive analysis of the selected variables, and the results are shown in Table 3.

For the presence or absence of corporate environmental disclosure behavior (ED) within the current year, a higher mean value of the corresponding indicator indicates a higher probability of disclosure behavior - the mean value of the corresponding indicator ED is 0.323, the standard error is only 0.467, and the median is 0, showing a significant right-skewed distribution. This means that more than half of the enterprise samples lack the behavior of disclosing environmental information.

Correspondingly, the overall quality of corporate environmental information disclosure is relatively low. With a maximum value of 65.625 and an upper quartile of 6.9767, the mean value is only 3.516 and the standard deviation is 6.762, indicating that there are significant differences in the quality of environmental disclosure among enterprises, and there are significant differences in the choices of enterprises on how to disclose environmental information.

In the control variable group: the corporate financial leverage level, operating profit rate, management cost and asset liquidity structure are relatively normal, and the differences of these indicators among enterprises are relatively insignificant; the corporate ownership concentration is relatively low, with a maximum value of only 0.561 and a mean value of 0.166, indicating that shareholders in most enterprises have a certain degree of mutual checks and balances, which will strengthen the restraint on the self-interested behaviors of the largest shareholder and managers, and alleviate the disclosure distortion under information asymmetry; for the marketization level of the enterprise's location, the mean value of the relevant indicator is 8.431 (median is 8.89), the maximum value is 10.96, and its first quartile value is 7.09, showing that the marketization process in most regions of China is relatively fast, and a certain height of market economy construction has been achieved; in the current external environmental supervision, both the government and the public have formed a certain environmental binding force on enterprises, with the mean values of ER and Pub being 0.065 and 4.865 respectively.

Table 3 Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
EDQ	21622	3.516	6.762	0	65.625
Dig	21616	.239	.204	.019	.74
ED	21622	.323	.467	0	1
Leverage	21622	.428	.217	.007	.999
Profit	21617	.098	.197	-1.234	.732
AC	21314	.098	.09	.003	.729
Tobin Q	20875	1.995	1.304	.876	9.833
Board	21612	8.678	1.819	5	15
FA	21622	.202	.163	.002	.706
Ind	21610	.375	.053	.333	.571
Marketization	21622	8.431	1.78	3.59	10.96
ER	21622	.065	.02	.032	.125
Pub	21622	4.865	.332	3.784	5.371
HHI_10	21620	.166	.116	.015	.561
Dummy_State	21106	.398	.49	0	1

### 3.2 Correlation Analysis

In Table 4, this paper conducts a correlation analysis between core variables based on the Pearson two-tailed test. At the 1% significance level, digital development (Dig) is significantly positively correlated with corporate environmental disclosure behavior (ED), with a correlation coefficient of 0.075. As analyzed earlier, urban digital development may promote the latter by alleviating information asymmetry and increasing external supervision.

Similarly, at the 1% significance level, digital development (Dig) is significantly positively correlated with the quality of corporate environmental information disclosure (EDQ), with a correlation coefficient of 0.119. This may mean that regional digital factors can improve the effective information content of corporate information disclosure and alleviate the phenomenon of low-quality

disclosure.

In the mechanism indicator group, the pairwise correlation coefficients between indicators are all lower than 0.8, indicating that there is no strong correlation (multicollinearity). Among them, at the 1% significance level, the correlation coefficient between public environmental supervision (Pub) and marketization level (Marketization) reaches 0.701, which may indicate that the marketization process provides more circulating information and resources for public environmental participation, and creates a better environment for public opinion supervision and material infrastructure for exercising rights.

*Table 4 Correlation Analysis*

Variables	(1)	(2)	(3)	(4)	(5)	(6)
(1) EDQ	1.000					
(2) ED	0.766***	1.000				
(3) Dig	0.119***	0.075**	1.000			
(4) Marketization	0.015***	*	0.530**	1.000		
(5) ER	-	-	-	0.117**	1.000	
(6) Pub	0.022***	-0.005	0.187***	*	0.208**	1.000
	0.021***	0.018***	0.334**	0.701**	*	*

\*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$

### **3.3 Benchmark Regression Results**

Regarding the relationship between regional digital development and corporate environmental disclosure, this paper conducts regression analysis from two dimensions: the presence or absence of disclosure behavior and the quality of disclosure, so as to verify the research hypotheses proposed earlier.

#### **3.3.1 Regression Results of the Presence or Absence of Environmental Disclosure Behavior**

According to Hypothesis 1 (regional digital development significantly promotes corporate environmental disclosure behavior), this paper first tests the relationship between urban digital development (Dig) and corporate environmental disclosure behavior (ED). The regression results are shown in Table 5: at the 1% significance level, digital development (Dig) is significantly positively correlated with corporate environmental disclosure behavior (ED), with a regression coefficient of 0.166 and a standard error of 0.0469. This result verifies Hypothesis 1, indicating that the improvement of regional digitalization level can effectively promote enterprises to carry out environmental disclosure activities.

In terms of control variables, corporate environmental disclosure behavior, as an important part of corporate governance decisions, is jointly affected by internal and external factors: corporate leverage (Leverage) and profitability (Profit) reflecting financial status are significantly positively correlated with ED at the 1% level, indicating that enterprises with better financial conditions are more willing to bear the cost of environmental disclosure and convey positive signals to the outside world; management expense rate (AC) is significantly negatively correlated with ED at the 5% level, which may be due to the fact that enterprises with higher management costs have limited resource allocation capacity and are unwilling to invest additional resources in environmental disclosure; the number of board members (Board) and the proportion of independent directors (Ind) are significantly positively correlated with ED at the 1% level, indicating that a sound corporate governance structure can strengthen the supervision of management and promote enterprises to fulfill their environmental disclosure obligations; government environmental regulation (ER) is significantly positively correlated with ED at the 5% level, reflecting the binding effect of external institutional pressure on corporate behavior; the nature of state-owned property rights (Dummy\_State) is significantly positively correlated with ED at the 1% level, which is because state-owned enterprises bear more social responsibilities and are more responsive to policy guidance. After controlling for year and industry fixed effects, the  $R^2$  of the benchmark model is 0.190, indicating that the model has a certain explanatory power for corporate environmental disclosure behavior.

Table 5 Benchmark Regression Results (I)

		(1)Full Sample
VARIABLES		ED
Dig		0.166*** (0.0469)
Leverage		0.350*** (0.0411)
Profit		0.209*** (0.0290)
AC		-0.202** (0.0875)
Tobin Q		-0.00641 (0.00503)
Board		0.0413*** (0.00522)
FA		0.0643 (0.0587)
Ind		0.801*** (0.147)
Marketization		0.000767 (0.00733)
ER		0.566** (0.284)
Pub		-0.0104 (0.0450)
HHI_10		0.130* (0.0695)
Dummy_State		0.137***

		(1)Full Sample
VARIABLES		ED
		(0.0202)
Constant		-0.592***
		(0.209)
Year Fixed Effect		Yes
Industry Fixed Effect		Yes
Observations		20,160
R2		0.190

*Robust standard errors in parentheses and cluster at firm level; \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$*

### 3.3.2 Regression Results of Environmental Disclosure Quality

Hypothesis 2 proposes that regional digital development can significantly improve the quality of corporate environmental disclosure. To verify this hypothesis, this paper takes EDQ as the dependent variable and conducts benchmark regression again, with the results shown in Table 6. It can be seen from the table that digital development (Dig) is significantly positively correlated with the quality of corporate environmental disclosure (EDQ) at the 1% significance level, with a regression coefficient of 3.563 and a standard error of 0.668. This result verifies Hypothesis 2, indicating that regional digitalization not only promotes enterprises to carry out environmental disclosure activities, but also effectively improves the quality of disclosure, making corporate environmental information more comprehensive, accurate and useful.

The survival and development of enterprises are inseparable from economic benefits. Economic performance pressure tends to increase short-sighted behavior, making environmental governance difficult to be placed in a priority strategic position (Barcena and Espinosa, 1996; Hu Nan et al., 2021). In the work of environmental information disclosure, will enterprises disclose environmental responsibility information in a detailed and responsible manner, or only respond to external demands and gain recognition formally?

If enterprises focus on the former, they will actively disclose more high-quality information, display substantive content such as corporate environmental governance and performance, distinguish

themselves from other enterprises with proprietary environmental information, and strive for the favor of the green financial market; if enterprises only respond to external environmental demands and alleviate public pressure, the disclosure behavior is essentially a decoupling behavior of "saying one thing and doing another", and enterprises will only conduct more symbolic disclosure rather than substantive disclosure of what they have done (Gou Qianwen et al., 2019; Zhao Xiaoyue et al., 2022).

This response method of "talking better than doing" solves the "urgent need" to a certain extent, and balances economic efficiency and legal pressure. It seems to be a more efficient, rational and convenient response method (Hemingway and Maclagan, 2004). However, the empirical results above support the former: regional digital development promotes enterprises to carry out substantive environmental disclosure and improve disclosure quality.

In terms of control variables, corporate profitability (Profit) is significantly positively correlated with EDQ at the 1% level, with a regression coefficient of 1.937, indicating that good financial performance provides sufficient financial support for enterprises to improve the quality of environmental disclosure, which is consistent with the research conclusions of Liu Yuhuan et al. (2020); corporate leverage (Leverage) is significantly positively correlated with EDQ at the 1% level, which may be because enterprises with higher leverage need to convey positive environmental signals to creditors to reduce financing costs; management expense rate (AC) and Tobin Q are significantly negatively correlated with EDQ at the 1% level, indicating that enterprises with higher management costs or overvalued market value are less willing to invest resources in improving environmental disclosure quality; the number of board members (Board) is significantly positively correlated with EDQ, reflecting the positive role of corporate governance structure in promoting high-quality environmental disclosure.

*Table 6 Benchmark Regression Results (II)*

	(1)
VARIABLES	EDQ
Dig	3.563*** (0.668)
Leverage	4.289***

	(1)
VARIABLES	EDQ
	(0.579)
Profit	1.937***
	(0.342)
AC	-2.603***
	(0.894)
Tobin Q	-0.193***
	(0.0584)
Board	0.538***
	(0.0774)
FA	1.539*
	(0.832)
Ind	12.83***
	(2.098)
Marketization	0.0110
	(0.106)
ER	2.068
	(3.770)
Pub	0.723
	(0.646)
HHI_10	4.183***
	(1.197)
Dummy_State	1.963***
	(0.272)
Constant	-13.73***
	(2.987)
Year Fixed Effect	Yes
Industry Fixed Effect	Yes

	(1)
VARIABLES	EDQ
Firm Fixed Effect	No
Observations	20,160
R2	0.210

*Robust standard errors in parentheses and cluster at firm level; \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$*

### ***3.4 Mechanism Test Results***

Before elaborating on the mechanism of action, this paper needs to illustrate that: since firm fixed effects and industry fixed effects belong to the micro and meso dimensional levels, it is inappropriate to conduct regression tests on environmental regulation which belongs to the macro dimensional level; therefore, this paper conducts regression tests while controlling for regional-level variables as well as annual and urban heterogeneity.

#### ***3.4.1 Marketization Process Mechanism***

Based on the signal transmission theory, the impact mechanism of urban digital development on the quality of environmental information disclosure of local enterprises is first reflected in the change of the marketization process. With the in-depth development of urban digitalization, digital factors are effectively integrated into urban market-oriented operations, guiding the optimal allocation of resources in accordance with market logic, government intervention and relational resources are diluted, and the relevant legal systems, intermediary organizations, and infrastructure are also more improved (Wang Yaming et al., 2015). On this basis, the effect of signal transmission is more obvious: more enterprises in the region will take the initiative to disclose value-based information to gain competitive advantages, and market investors will also judge truly valuable enterprises from the information disclosure.

The regression results are shown in Table 7. In Column (1), the coefficient of Dig is more significant both in economic and statistical significance under the high marketization group. Hypothesis 2-1 is verified here.

This paper verifies that: the positive effect of urban digital development on corporate environmental information disclosure needs to be realized by optimizing the allocation of factor

resources and improving market competitiveness. A sound factor market is a necessary prerequisite for enterprises to obtain differential advantages by disclosing green responsibilities.

Table 7 regression results(I)

	(1) High Marketization	(2) Low Marketization
VARIABLES	EDQ	EDQ
Dig	3.114*** (0.713)	3.003* (1.565)
Year Fixed Effect	Yes	Yes
Industry Fixed Effect	Yes	Yes
Firm Fixed Effect	No	No
City Fixed Effect	No	No
Observations	10294	9866
R2	0.282	0.188

Robust standard errors in parentheses and cluster at city level; \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$

### 3.4.2 Green Finance Incentive Mechanism

The impact mechanism of digital development on corporate environmental information disclosure is also reflected in the renewal and improvement of the green financial market.

This paper holds that the establishment of a green financial system will increase redundant financial resources and alleviate the cost of corporate environmental governance. From the perspective of the global investment and financing market, enterprises with good green responsibility information will more smoothly pass the environmental verification for refinancing, and the "greenwashing" motivation of enterprises due to insufficient funds will also be reduced (Hu Wenxiu et al., 2021). However, in an effective green financial market, liquid financial capital needs to identify or distinguish behaviors such as "true green", "light green" or "non-green" through environmental information (Yan Haizhou and Chen Baizhu, 2017; Wang Yulin and Zhou Yahong, 2022).

On the basis of existing literature, this paper argues that: with the in-depth development of regional digitalization, the information asymmetry between markets and enterprises in the region will

be effectively alleviated, the free flow of environmental resource information and the green supply-demand matching mechanism will be more reasonable and efficient. Enterprises with good environmental information disclosure are more likely to attract the attention and favor of the green financial market and be given more green financial support. This will form a continuous "green market incentive" for corporate environmental information disclosure, and enterprises will have more motivation to fulfill their environmental obligations, disclose more detailed, accurate and proprietary environmental information, and shape a green image to gain recognition from market investors.

The regression results are shown in Table 8: urban digital development can significantly promote the local green financial market, verifying Hypothesis 2-2 here.

Based on this, this paper has tested the optimal allocation function of digital factors in price discovery and supply-demand matching in the green finance scenario. Under green finance incentives, the cost pressure faced by environmental information disclosure (Li Qiang and Feng Bo, 2015) is reduced, and the value signal function is more pure. Environmental information disclosure can gradually be regarded as a competitive tool.

*Table 8 regression results(II)*

VARIABLES	(1) Regions with High Green	(2) Regions with Low Green
	Finance Level	Finance Level
	EDQ	EDQ
Dig	3.043*** (0.734)	2.066 (1.700)
Year Fixed Effect	Yes	Yes
Industry Fixed Effect	No	Yes
Observations	10091	10065
R2	0.288	0.181

*Robust standard errors in parentheses and cluster at city level; \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$*

In summary, urban digital development can simultaneously improve the behavior and quality of

corporate environmental information disclosure. In the digital economy era, the phenomenon of information asymmetry has been significantly alleviated, hidden pollution behaviors will face more transparent external supervision pressure, and the probability of enterprises being discovered and punished for "greenwashing" and "false green" has increased; in addition, if enterprises hope to obtain competitive advantages and financing support through environmental disclosure, they also need to improve the disclosure quality to a certain level, otherwise low-quality disclosure will be difficult to effectively exert its image effect and mitigation effect (Sun Zhihui et al., 2017; Zhan Hua, 2021). Enterprises should attach importance to environmental disclosure work and incorporate it into their development strategies, rather than staying at "symbolic disclosure".

### ***3.5 Heterogeneity Test Results***

#### ***3.5.1 Nature of Corporate Ownership***

This paper holds that: urban digital development will continuously shape a fair and effective "contract economy" in the region, compressing the space for rent-seeking, and this effect is more obvious in state-owned enterprises.

Relevant empirical results provide empirical support. As shown in the first two columns of Table 9, in the state-owned enterprise group, the marginal coefficient of digital development is 5.773, which is significant at the 1% probability level; while in the non-state-owned enterprise group, the marginal coefficient of digital development is 1.276 and significant at the 5% probability level. After testing, the difference between the coefficients of the two groups is significant at the 1% probability level, and the former is significantly better than the latter. Therefore, in guiding the internal reform of state-owned enterprises, market-oriented mechanisms can be considered to enable managers to actively pay attention to market trends and respond positively to competitive threats.

#### ***3.5.2. Whether the Enterprise Belongs to a Heavily Polluting Industry***

Digital development promotes the development of the local marketization process and the green financial market at the same time, and the two mechanisms will coordinately adjust the quality of corporate environmental disclosure. With the acceleration of the marketization process, green production factors often flow to and concentrate in innovative enterprises. Heavily polluting enterprises with negative environmental externalities have inherent disadvantages in market competition, and they need to perform substantive environmental governance work and improve the quality of environmental disclosure to make up for the disadvantages in market competition (Wang

Yaming et al., 2015); with the improvement of the green financial market, green financial tools will support enterprises' green innovation activities by reasonably matching returns and risks and reducing financing constraints (Du Jinzhu and Wu Zhanyong, 2022), which creates a development opportunity for heavily polluting enterprises with weak high-tech foundations and insufficient innovation. At the same time, the green credit market has a significant financing penalty and investment inhibition effect on heavily polluting enterprises, which will force heavily polluting enterprises to accelerate green transformation and the quality of environmental information disclosure to maintain organizational legitimacy.

Relevant empirical research results provide empirical support. In Table 9, Columns (3)-(4) report the heterogeneous effects of the two types of enterprises. In Column (3), at the 1% probability level, digital development will significantly improve the environmental disclosure quality of heavily polluting enterprises, with a Dig coefficient of 6.807, which has highly significant economic significance; while in Column (4) of the non-heavily polluting industry sample group, the Dig coefficient is 2.611 and significant at the 1% probability level. After the inter-group coefficient difference test, the coefficient difference of Dig is 4.196, which is significant at the 1% probability level. It can be concluded that digital development will have a more significant role in improving the disclosure quality of heavily polluting enterprises.

### ***3.5.3 Region Where the Enterprise is Located***

In China, the eastern and central regions are economically developed and have good market infrastructure and supporting legal systems, creating favorable conditions for the integration of relevant digital factors into industrial operations (Li Bing, 2016) — it not only forces enterprises to transmit green market signals through factor optimization allocation and strengthening competition effects, but also encourages enterprises to improve the quality of environmental disclosure through more transparent information flow to obtain green financial support.

Relevant empirical research results provide empirical support. Considering the prominent regional economic specificity in China, Columns (5)-(6) of Table 9 compare the differences in the role of digital development in different regions of China: it can be found that in China's eastern and central regions, digital development can significantly improve the quality of corporate environmental information disclosure, with a Dig coefficient of 3.179 and significant at the 1% probability level; while in the western region, the Dig coefficient is not significant.

Table 9 Heterogeneity Test Results

	(1)	(2)	(3)	(4)	(5)	(6)
	SOEs	Private Enterprises	Heavily Polluting	Non-Heavily Polluting	East & Central	West
VARIABLES	EDQ	EDQ	EDQ	EDQ	EDQ	EDQ
Dig	5.773*** (1.341)	1.267** (0.626)	6.807*** (1.872)	2.611*** (0.648)	3.179*** (0.670)	3.604 (4.206)
Control	Yes	Yes	Yes	Yes	Yes	Yes
Constant	- 14.01*** (5.061)	- 8.542*** (3.275)	- 18.98*** (5.285)	- 10.67*** (3.545)	- -9.117** (3.673)	- -14.14** (6.722)
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	8,020	12,137	5,464	14,696	16,525	2,646
R2	0.257	0.115	0.237	0.188	0.230	0.269

Robust standard errors in parentheses and cluster at firm level; \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$

### 3.6 Endogeneity and Robustness Test Results

#### 3.6.1. Robustness Test

First, this paper will conduct robustness tests, including replacing the regression model, adding control variables, strengthening fixed effects, deleting problematic samples, and replacing the explained variable.

Replacing the Benchmark Regression Model.

In the benchmark regression model of this chapter, there are a certain number of enterprises that choose not to disclose environmental information in specific years, as well as phenomena where the

environmental information quality score is zero. Therefore, during the sample period, the corporate disclosure quality data is significantly right-skewed. Therefore, this paper considers replacing the benchmark regression model with a restricted regression model: Tobit model for regression testing. The relevant results are shown in Column (1) of Table 10. The Dig coefficient is 3.563, which is significant at the 1% probability level.

#### Adding New Control Variables.

Digital development will adjust the quality of corporate environmental disclosure through market-oriented incentive mechanisms. However, among them, the new market competition pressure makes enterprises have to pay attention to cost management and resource allocation. To a large extent, the "greenwashing" decoupling behavior existing in some enterprises lies in resource scarcity and environmental constraints. If enterprises are endowed with more redundant resources, it will enhance their ability to resist liquidity risks and respond to market competition (Lise, 2013; Gou Qianwen et al., 2019; Gao et al., 2021). The mitigation of financial constraints will help enterprises adjust their green motivation, increase substantive environmental protection behaviors, and strengthen differential information disclosure.

Based on the above analysis, this part adds two relevant control variables: according to the external environment, "government environmental subsidies" are added. Such green subsidies will alleviate the cost pressure of corporate environmental governance, and good information disclosure will also help them obtain more green financial quotas; according to the internal environment, "capital accumulation rate" is added, because internal capital accumulation can reduce corporate financing constraints and enhance enterprises' confidence in responding to operational risks and market competition (Cui et al., 2021). The relevant results are shown in Table 10. With the addition of two new control variables, the Dig coefficient is 3.534, which is significant at the 1% probability level, and the conclusion of the benchmark regression still holds.

#### Controlling for Regional Heterogeneity.

Due to the inevitable multiple differences in systems, cultures, policies, etc. between locations, which will promote or restrict marketization development and corporate environmental disclosure, Column (3) in Table 10 controls for the fixed effects at the provincial and municipal levels where the enterprise is located to control the impact of unobservable regional heterogeneity on the quality of environmental disclosure. The coefficient of the Dig indicator is 3.229, which is significant at the 1%

probability level.

#### Excluding Problematic Samples.

In the full sample, it is inevitable that some enterprises will be subject to key investigations or severe penalties by relevant departments due to sudden environmental accidents, environmental violations or environmental petitions in the current year. Such enterprises face certain legitimacy pressure in the short term and have to abandon "greenwashing", increase substantive environmental protection behaviors, and improve the quality of environmental information disclosure to alleviate external environmental recognition pressure. Therefore, the improvement of the information disclosure quality of involved enterprises is likely to be a public relations measure deliberately "forced" by environmental accidents. Therefore, this paper will exclude such samples of involved enterprises. The results are shown in Column (4) of Table 10: the marginal coefficient of Dig is 4.223, which is still significant at the 1% probability level.

#### Replacing the Explained Variable.

According to the form of corporate environmental disclosure, it is divided into three categories: mixed disclosure, social responsibility report disclosure and independent environmental report disclosure. Among them, the first category is reflected in the appearance of environmental governance information in the corporate financial annual report, and the form of information disclosure is not significant; while the second and third categories are reflected in the enterprise issuing special reports related to ESG to display the corporate green image in a relatively systematic, comprehensive and detailed manner, improving information salience.

This paper replaces the explained variable with a dummy variable "whether to disclose a special report", denoted by EDQ2. If an independent environmental report is disclosed in the current year, this indicator is recorded as 1, otherwise it is 0. The results are shown in Column (5) of Table 10: the marginal coefficient of Dig is 0.152, which is significant at the 1% probability level, and the original relationship holds.

Table 10 Robustness Test Results

	(1)	(2)	(3)	(4)	(5)
VARIABLES	EDQ	EDQ	EDQ	EDQ	EDQ2
Dig	3.563*** (0.666)	3.534*** (0.667)	3.229*** (1.097)	4.223*** (1.268)	0.152*** (0.0447)
Control	Yes	Yes	Yes	Yes	Yes
Subsidy		-0.527*** (0.0708)			
Capital		0.200*** (0.0542)			
Constant	-16.059*** (2.956)	-13.66*** (2.981)	-11.59*** (4.115)	1.855 (3.871)	-0.245 (0.200)
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes
State Fixed Effect	No	No	Yes	No	No
Industry Fixed Effect	No	No	No	No	No
Observations	20,161	20,131	20,160	19,793	20,160
R2/Pseudo R2	0.0356	0.215	0.228	0.818	0.165

Robust standard errors in parentheses and cluster at firm level; \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$

### 3.6.2. Endogeneity Test

#### Exogenous Policy Shock

Urban digital development is often promoted and implemented through specific policies. Relative to individual enterprises in the region, policies are often exogenous, and there is less reverse causality. However, the traditional research method to evaluate the effect of digital policies mainly sets a dummy variable about "whether the policy has occurred" and incorporates it into the regression model for

testing; in contrast, the Difference-in-Differences (DID) method can more accurately evaluate the effect of digital policies.

In summary, this paper will use the multi-period Difference-in-Differences (DID) model to conduct endogeneity tests. This part takes the "Broadband China" strategy as an exogenous shock to urban digital development. With the implementation of the "Broadband China" strategy, it provides better digital and intelligent infrastructure for government environmental supervision and public environmental supervision; it will also accelerate the market-oriented and efficient reallocation of factors in the region, restrain enterprise monopoly and rent-seeking phenomena, and increase local market competition.

Referring to the practice of Li Jun and Li Jing (2021), a dummy variable  $Notice_{j,t}$  is set according to whether city  $j$  where the enterprise is located is nominated by the "Broadband China" strategy in year  $t$  and later: 1 if yes, 0 otherwise. The relevant multi-period DID model is shown below:

$$EDQ_{i,t} = \alpha + \beta_1 * Notice_{j,t} + Controls_{i,t} + Year\ Dummies + Industry\ Dummies + \varepsilon_{i,t}$$

$$EDQ_{i,t} = \alpha + \beta_1 * Notice_{j,t} + Controls_{i,t} + Year\ Dummies + Firm\ Dummies + \varepsilon_{i,t}$$

From 2011 to 2019, taking the year when the city where the enterprise is located was nominated as the base period (this period's dummy variable will be excluded in the test), the parallel trend test is first conducted to ensure that there are no systematic differences between cities before the implementation of the strategy. This paper sets 9 annual dummy variables: Pre4, Pre3, Pre2, Pre1, Current, Post1, Post2, Post3, and Post4, according to whether the city where the enterprise is located belongs to the year. Before conducting the multi-period DID model, a parallel trend test is performed.

After controlling for year and industry fixed effects, the relevant results are shown in Column (1) of Table 11: although the marginal effect of the time dummy variable has a certain lag, it gradually becomes statistically significant from the second period after nomination, and the economic significance is also more significant, showing a "accumulate strength for a take-off" trend. Column (3) includes firm fixed effects into the regression, and the results remain robust.

Columns (2) and (4) of Table 11 show the test results of the multi-period DID model. Compared with cities not nominated by the "Broadband China" strategy, in cities that have been nominated, the environmental information quality of local enterprises shows a more obvious improvement. The marginal effects of  $Notice_{j,t}$  are 0.671 and 0.335, which are significant at the 1% and 5% probability

levels, respectively.

*Table 11 Endogeneity Test Results (I)*

	(1)	(2)	(3)	(4)
VARIABLES	EDQ	EDQ	EDQ	EDQ
Pre4	0.0941 (0.189)		-0.0120 (0.127)	
Pre3	0.184 (0.202)		-0.0719 (0.123)	
Pre2	0.285 (0.209)		0.0254 (0.123)	
Pre1	0.338 (0.207)		0.117 (0.112)	
Current				
Post1	0.440** (0.200)		0.228** (0.107)	
Post2	0.727*** (0.229)		0.490*** (0.163)	
Post3	0.974*** (0.295)		0.674*** (0.226)	
Post4	1.219*** (0.363)		0.777*** (0.297)	
Notice		0.671*** (0.224)		0.335** (0.159)
Control	Yes	Yes	Yes	Yes
Constant	-13.30*** (3.012)	-13.14*** (2.986)	2.418 (4.096)	2.451 (3.961)
Year Fixed Effect	Yes	Yes	Yes	Yes

	(1)	(2)	(3)	(4)
VARIABLES	EDQ	EDQ	EDQ	EDQ
Industry Fixed Effect	Yes	Yes	No	No
Firm Fixed Effect	No	No	Yes	Yes
Observations	20,165	20,165	19,993	19,993
R2	0.205	0.205	0.819	0.818

*Robust standard errors in parentheses and cluster at firm level; \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$*

#### Instrumental Variable Method.

There may be a mutual causal relationship between urban digital development and the quality of local enterprises' environmental disclosure. As mentioned earlier, a developed factor market is a necessary prerequisite for enterprises to obtain competitive advantages by disclosing environmental information. Rational investors will make effective judgments on enterprises' operating conditions and investment value through the disclosed information (Yan Haizhou and Chen Baizhu, 2017). Based on this, to drive enterprises to disclose high-quality environmental information, achieve the effects of lowering financing thresholds, increasing stock prices, and enhancing market competitiveness, it is objectively necessary to rely on the local good marketization level, green financial market construction, and relatively developed urban information technology to improve the dissemination effect of disclosure. All these put forward new requirements for urban digital development.

To alleviate the above endogeneity problem, this paper considers using the Instrumental Variable (IV) method to conduct 2SLS regression. This paper selects "the contemporaneous average of digital development levels of all other cities in the same province" as the instrumental variable on an annual basis, for the following reasons: within the same province, cities often have similar digital development environments, enjoying similar regional digital economy policies, talent structures, and scientific and technological resources; however, the digital situation of other cities in the same province is relatively exogenous, which will not directly affect the environmental information disclosure quality of enterprises in a specific city, and the latter at the micro level is

even less likely to directly affect the former at the macro level.

Table 12 Endogeneity Test Results (II)

	(1)	(2)	(3)
VARIABLES	Dig	EDQ	EDQ2
Dig		4.163*** (0.805)	0.215*** (0.052)
LProvincial_Dig	0.981*** (0.005)		
Controls	Yes	Yes	Yes
Constant	-0.002 (0.027)	-18.384*** (2.401)	-0.459*** (0.165)
Year Fixed Effect	Yes	Yes	Yes
Industry Fixed Effect	Yes	Yes	Yes
Observations	17,425	17,425	17,425
R2	0.866	0.21	0.16

*Robust standard errors in parentheses and cluster at firm level; \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$*

As shown in Table 12, Columns (1)-(2) correspond to the two stages of 2SLS regression, respectively. In the first stage, the marginal coefficient of LProvincial\_Dig, as the instrumental variable, is 0.981, which is significant at the 1% probability level, and the goodness of fit of the corresponding model reaches 86.6%. In the second stage, this paper takes Dig, which overcomes other disturbance factors and is only affected by the exogenous instrumental variable, as the explanatory variable. After incorporating it into the regression analysis, it is found that: in Column (2), the marginal coefficient of Dig on EDQ is 4.163, which is significant at the 1% probability level, and the goodness of fit of the corresponding model reaches 21%; in Column (3), after replacing the explained variable with the robustness indicator "whether to disclose a special report", the marginal coefficient of Dig on EDQ is 0.215, which is significant at the 1% probability level, and the goodness of fit of the corresponding model reaches 16%. The above empirical data confirms the robustness of the positive relationship

between the two.

## **4. Conclusion**

### ***4.1 Discussion on Research Results***

Corporate environmental information disclosure is driven by both legitimacy pressure and competitive pressure, with certain game characteristics: for example, Li Qiang and Feng Bo (2015), Gou Qianwen et al. (2019) found that even if enterprises respond to external demands and carry out environmental information disclosure work, there may still be problems such as unclear disclosure, low content of effective information, and even symbolic disclosure. Therefore, the research on environmental information disclosure needs to integrate multiple theoretical logics.

Guided by the legitimacy theory and signal transmission theory, this paper conducts a series of empirical tests and finds that: urban digital development increases local environmental supervision, and enterprises increase environmental disclosure under the pressure of legitimacy to respond to the needs of stakeholders for their own environmental information, which is essentially the maintenance of organizational legitimacy (Xiao Hongjun et al., 2013; Gou Qianwen et al., 2015; Gou Qianwen et al., 2019; Zhang Qi et al., 2019); and the quality of disclosure also continues to improve, with the mechanism of action manifested as the dual incentives of market-oriented competition and green financial market. This is because digital factors can promote the optimal allocation of local market resources, dilute relational resources, and promote the development of contractual economy, making the acquisition of resource factors more dependent on market competition. In a more improved, fair and effective market environment, enterprises can enhance market competitiveness and strive for differentiated resources by transmitting differentiated signals such as green responsibility.

Compared with the studies of Li Qiang and Feng Bo (2015), Gou Qianwen et al. (2019), Zhu Shujin et al. (2022), the empirical evidence of this paper shows that macro digital factors help enterprises substantially improve the quality of disclosure and alleviate the past symbolic disclosure behavior (perfunctory disclosure lacking effective information content). In contrast, previous studies mainly regarded disclosure work as an additional high-cost task, which may not have fully paid attention to the medium and long-term value of information disclosure, nor effectively combined with financing channels such as the green financial market, resulting in partial differences in views among

the literature.

In addition, the empirical results of this paper also indicate that with the in-depth development of urban digitalization, high-quality environmental information disclosure will obtain more institutional support (such as a more improved green financial market), helping enterprises alleviate financing constraints and strive for differentiated resources. Therefore, green disclosure should not be limited to passive response, but should be used as a competitive tool. This result helps alleviate the concern mentioned by Li Qiang and Feng Bo (2015) that enterprises may suffer from the "fast cow effect" when becoming "green models".

#### ***4.2 Relevant Development Suggestions***

First, enterprise managers should strengthen their understanding of environmental strategies and explore the market value of information disclosure. Environmental information disclosure is not only used to respond to the pressure from stakeholders and meet the external demand for environmental information, but also can be used as a display of the enterprise's own green image, transmitting differentiated signals to the market, distinguishing itself from other enterprises, and thus enhancing consumer confidence.

Second, enterprises should consider how to link environmental governance with economic performance in their daily activities, create conditions for future economic profit growth through environmental governance, and realize a green operation path.

Third, enterprises should pay close attention to the policy trends of local environmental supervision, such as changes in green financial market policies, take this as an opportunity to carry out green investment and transformation, improve the quality of information disclosure through more substantive environmental actions, and respond to the environmental information needs of the government, the public, and green financial institutions in a targeted manner to enhance market reputation.

In the perspective of government, on the one hand, the government should use market-oriented means to reward and certify enterprises with good information disclosure. The government should encourage local enterprises to consciously participate in environmental information disclosure, and invite third-party professional institutions to conduct professional review and evaluation of enterprises that issue disclosure reports. After the relevant content is verified and rated, enterprises with good disclosure quality will be given preferential treatments such as reducing environmental taxes and fees,

lowering green barriers in the corresponding market, and awarding the honorary title of "Green Model". When enterprises realize that high-quality disclosure can bring practical benefits to themselves, they will be more motivated to participate in substantive environmental governance and abandon the long-term greenwashing behavior.

On the other hand, the government should issue clear and well-defined disclosure guidelines with distinct rewards and punishments, standardize the form and content of enterprise disclosure, and guide enterprises to actively disclose substantive behavioral information such as environmental governance performance and transmit their own unique green information. For enterprises with environmental emergencies, excessive pollution, poor disclosure quality, or proven "greenwashing", the government should conduct differentiated disclosure management, and implement more strict disclosure standard management and supervision on them (such as inviting third-party institutions to conduct auditing and certification), so as to build an orderly environment for protecting the legitimate interests of investors, consumers, and the general public.

In addition, the government should focus on encouraging ordinary enterprises to issue professional social or environmental responsibility reports, and appropriately mandate heavily polluting industries to issue "Environmental Reports" to disclose detailed information in detail, so as to improve the visibility of their own environmental disclosure, facilitate public supervision, and promote their better performance of environmental responsibilities in the future.

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