

The Impact of Enterprise Digitization on Investor Protection: Evidence from China

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Abstract: This paper takes China listed companies from 2011 to 2021 as a sample to explore the impact of digital transformation on investor protection. The study finds that the digital transformation of enterprises improves the level of investor protection, and the intermediary mechanism test shows that digital transformation improves the level of investor protection by improving corporate transparency. Further analysis shows that the level of enterprise risk exposure has a negative moderating effect in the process of improving the level of investor protection in the process of enterprise digital transformation, while executive shareholding and corporate ESG disclosure have a substitute role. This paper provides important enlightenment for protecting investors' interests, enhancing investors' investment confidence, and increasing the proportion of direct financing.

Keywords: Corporate Digitalization, Investor Protection, Corporate Transparency, Capital Market Development.

1. Introduction

The capital market is the core of the modern financial system, capable of driving technological innovation, supporting the development of the real economy and the improvement of industrial chains, and promoting the expansion and upgrading of consumption. It serves as a pivotal platform for optimizing resource allocation and plays a crucial role. In the construction of a new development pattern, the capital market can provide strategic support. Increasing direct financing can promote enterprise development and innovation, enhance the efficiency and liquidity of the capital market, and thus drive economic growth. La Porta et al. (1997) found, through a study of 49 stock markets, that improving investor protection levels is beneficial for the development of a country's capital market. Furthermore, La Porta et al. (2000) argued that enhanced investor protection can increase external financing. Strengthening capital market protections for investors can boost their confidence and trust, thereby increasing their participation and enthusiasm, and raising the proportion of direct financing (McLean et al., 2012). According to the "2022 China Listed Companies Accounting Investor Protection Evaluation Report," the overall level of accounting investor protection among Chinese listed companies in 2022 remains low and needs further improvement.

Driven by digital technology and influenced by market conditions, an increasing number of enterprises are actively pursuing digital transformation to adapt to the rapidly changing business environment and seek sustainable competitive advantages (Chen Qingjiang et al., 2021). Digital transformation involves utilizing digital technologies and information systems to change the way enterprises operate and interact. It alters business processes (Leonardi and Treem, 2020), organizational structures (Hess et al., 2016), management activities (Verhoef and Bijmolt, 2019), and business models (Rachinger et al., 2018). These changes create new growth opportunities for enterprises. However, digital transformation is not merely an internal business strategy; the changes it brings also provide possibilities for improving investor protection, although this has rarely been

explored from an investor protection perspective. Digital transformation can lead to a shift in enterprise structure from centralization to decentralization, trending towards flattening, and breaking down internal and external organizational boundaries (Qi Yudong and Xiao Xu, 2020). This increases enterprise transparency and reduces the impact of "information power." Therefore, enterprise digitalization may improve investor protection levels by enhancing transparency. However, there is a lack of systematic research on this topic, and this empirical proposition urgently requires further scientific investigation.

In summary, this paper uses a sample of China listed companies from 2011 to 2021 and employs a panel fixed effects model to explore the impact and mechanisms of enterprise digitalization on investor protection. This research enhances the understanding of investor protection in the digital era, expands the study of the economic consequences of enterprise digitalization, and provides important insights for boosting investor confidence.

2. Theoretical Analysis and Hypothesis Are Proposed

2.1. Digitalization and Investor Protection

Internal managers of enterprises typically possess more information about the company than external investors, leading to issues of information asymmetry and agency problems (Healy & Palepu, 2001). Traditional voluntary disclosure by enterprises may result in untimely, distorted, or even illegal disclosures (Jensen & Meckling, 1976). This can enable managers to make investment or operational decisions that harm the interests of external investors. Digitalization can compel enterprises to disclose information passively and automate the preparation of electronic reports. This reduces the complexity of traditional reports, enhances their relevance, and encourages more substantive financial reporting (Rowbottom et al., 2021). Consequently, the passive disclosure induced by digitalization may enhance investor protection.

On one hand, digitalization mitigates issues of untimely, distorted, or illegal disclosures to some extent by providing

more accurate, real-time information. This improves investors' understanding of the enterprise's operations and financial status, thereby increasing transparency (Zhong, 2018). Enhanced transparency allows investors to engage in supervisory activities, reducing the risk of managers infringing on investor rights and increasing investor trust and protection. On the other hand, passive disclosure makes it more difficult for management to conceal information. Greater transparency invokes a sense of accountability, as more transparent enterprises are more likely to fulfill social responsibilities and protect investor interests (Heinberg et al., 2021).

Based on the above, the following hypotheses are proposed:

H1: Digital transformation of enterprises has a significant positive impact on investor protection.

H2: Enterprise transparency mediates the relationship between digital transformation and investor protection.

2.2. Corporate Risk-Taking Levels and Investor Protection

Risk-taking level refers to the degree to which a company or investor is willing to assume risk when faced with uncertainty. A higher level of risk-taking indicates a greater willingness to engage in risky ventures, showing a preference for high-risk, high-reward investment projects (Yu Minggui et al., 2013). This entails a readiness to allocate more resources and bear higher costs in the pursuit of profit (Lumpkin & Dess, 1996). Digital transformation requires enterprises to invest considerable resources and effort (Zhang et al., 2022). Imbalanced resource allocation can lead managers to overlook critical areas necessary for investor protection, thereby diminishing the positive impact of digitalization on investor protection.

Based on the above, the following hypothesis is proposed:

H3: The level of risk-taking negatively moderates the positive impact of digital transformation on investor protection.

2.3. Executive Ownership and Investor Protection

Executive shareholding can serve as an incentive mechanism, aligning executives' personal interests with corporate value and shareholder value by granting them equity shares. This practice allows executives to share the risks and rewards of the company with investors, thus reducing short-termism (Chen & Yang, 2022; Chung & Pruitt, 1996). It enhances executives' identification with and responsibility towards the company, mitigates agency problems, and improves investor protection. Additionally, digital transformation can facilitate better information disclosure by executives, reducing information asymmetry. Therefore, executive shareholding may either have a complementary effect or a substitutive effect on the enhancement of investor protection through digital transformation, warranting further exploration.

Based on the above, the following hypotheses are proposed:

H4a: Executive shareholding positively moderates the impact of digital transformation on investor protection.

H4b: Executive shareholding has a substitutive effect on the impact of digital transformation on investor protection.

2.4. ESG Disclosure and Investor Protection

ESG disclosure provides investors with information about a company's environmental, social, and governance aspects,

allowing them to identify risks and opportunities not revealed in traditional financial statements (Sridharan, 2018). This enhances investors' understanding of the company's sustainability, reduces information asymmetry (Feng & Wu, 2021), and aids in making better investment decisions, thereby improving investor protection. As previously hypothesized, digital transformation can also provide additional information, increase transparency, reduce information asymmetry, and mitigate agency problems, thus enhancing investor protection. Therefore, the role of ESG disclosure is similar to that of digital transformation and warrants further exploration.

Based on the above, the following hypothesis is proposed:

H5: ESG disclosure has a substitutive effect on the impact of digital transformation on investor protection.

3. Research Design

3.1. Research Samples and Data Sources

This study uses a sample of all China listed companies in China from 2011 to 2021. Basic company information and major financial data are sourced from the CSMAR database, while the investor protection index is obtained from the "Accounting Investor Protection Index" published by the Investor Protection Research Center at Beijing Technology and Business University. The research data underwent the following treatments: (1) exclusion of financial industry data; (2) exclusion of ST and *ST data. Additionally, given the focus on the digital transformation of non-computer enterprises, companies in the computer, information transmission, communication, software, and information technology services industries, as well as other electronic equipment manufacturing industries, were excluded based on the studies by Adachi (2021) and Fang Mingyue (2022); (3) exclusion of samples with missing financial data. After these treatments, a total of 23,863 observations were obtained. Furthermore, the continuous variables in the data were winsorized at the top and bottom 1% to eliminate the influence of outliers on the research conclusions. The data processing in this study was conducted using Excel and Stata17.

3.2. Research Variables

Dependent Variable: Drawing on the methodology of Wang Yuncheng et al. (2017), the key dependent variable is the measure of investor protection, using the "Accounting Investor Protection Index" published by the Investor Protection Research Center at Beijing Technology and Business University. This index is based on a theoretical framework for accounting investor protection and evaluates five aspects of listed companies to assess their level of protection for investor interests. It has been validated to effectively measure the protection level of accounting investors in Chinese listed companies and can explain future violations, accounting earnings, and other outcomes (Xie Zhihua et al., 2014).

Independent Variable: The independent variable in this study is the degree of digital transformation (DCG). Following the approach of Wu Fei et al. (2021), a digital dictionary was constructed, including the dimensions of "artificial intelligence technology," "digital technology applications," "cloud computing technology," "blockchain technology," and "big data technology." Using Python, we extracted the text from the annual reports of listed companies,

summing the frequency of keywords related to digitalization across these five dimensions to obtain the total word frequency. Further, the logarithm of the total word frequency plus one was taken to measure the degree of digital transformation of the enterprises.

Mediating Variable: Information transparency (Dscore). This study follows the research of Xin Qingquan et al. (2014) and Li Xiaohui & Yang Kun (2016), using data disclosed by the Shenzhen and Shanghai stock exchanges from the CSMAR database. The transparency of listed companies for different years and entities was evaluated, categorized as fail, pass, good, and excellent, and assigned values of 1, 2, 3, and

4, respectively.

Control Variables: Referring to existing literature (Li Shanmin et al., 2016; Wang Yuncheng et al., 2017), this study incorporates several factors that may influence investor protection into the regression model. These control variables include company size (Size), debt-to-asset ratio (Lev), return on assets (Roe), compensation incentives (Pay), growth (Growth), audit fees (Fee), separation of ownership and control (CV), largest shareholder's shareholding ratio (Top), CEO duality (Dual), and enterprise nature (Soe). Detailed definitions are provided in Table 1.

Table 1. Variable definition table

	Variable	Variable definitions
Dependent Variable	IP	Accounting Investor Protection Index
Independent Variable	DCG	Digital transformation word frequency + 1.
Mediating Variable	Dscore	A=Excellent, B=Good, C=Pass, D=Fail, based on disclosures by the Shenzhen and Shanghai stock exchanges.
Control Variables	Size	Ln (Total Assets)
	Lev	End-of-period Total Liabilities divided by End-of-period Total Assets
	Roa	Net Profit divided by Total Assets
	Fee	Natural logarithm of the audit fees of the company
	Pay	Natural logarithm of the total compensation for the top three executives
	Growth	Operating income growth rate
	CV	The difference between ownership and control in the company
	Top	The shareholding ratio of the largest shareholder
	Dual	Assign a value of 1 if the CEO concurrently serves as the Chairman of the Board; otherwise, assign a value of 0.
	Soe	Assign a value of 1 if the company is state-owned; otherwise, assign a value of 0.

3.3. Research Model Construction

This study conducts empirical analysis by constructing the following fixed effects regression models:

First, Model (1) is established as the baseline regression to examine whether digital transformation can enhance investor protection activities, testing Hypothesis 1. In this model, DCG represents the degree of digital transformation, and IP represents the investor protection index.

Second, following the methodology of Wen Zhonglin and Ye Baojuan (Wen Zhonglin & Ye Baojuan, 2014), we test whether enterprise transparency mediates the relationship between digital transformation and investor protection by establishing Models (2) and (3). In the second step, Model (2) is established to examine the impact of digital transformation on enterprise transparency, where Dscore represents the level of enterprise transparency. In the third step, Model (3) includes both the degree of digital transformation and enterprise transparency in the regression model for investor protection, thereby testing Hypothesis H2.

In these models, i represents the sample enterprises, t represents the years, and ϵ is the random error term.

$$IP_{it} = \alpha_0 + \alpha_1 DCG_{it} + \alpha X_{it} + \sum indi + \sum year + \epsilon_{it} \quad (1)$$

$$Dscore_{it} = \beta_0 + \beta_1 DCG_{it} + \beta X_{it} + \sum indi + \sum year + \epsilon_{it} \quad (2)$$

$$IP_{it} = \gamma_0 + \gamma_1 DCG_{it} + \gamma_2 Dscore_{it} + \gamma X_{it} + \sum indi + \sum year + \epsilon_{it} \quad (3)$$

4. Empirical Analysis

4.1. Descriptive Statistics

Table 2 presents the results of the descriptive statistics. The mean value of the Investor Protection Index (IP) is 55.43, with a maximum of 74.43 and a minimum of 28.17, indicating significant variation in the level of investor protection among Chinese listed companies. The mean value of Digital Transformation (DCG) is 1.053, with a maximum of 6.107 and a minimum of 0, demonstrating considerable differences in digital transformation across companies. The mean value of the mediating variable, Enterprise Transparency (Dscore), is 2.316, with a maximum of 4 and a minimum of 0, suggesting substantial variation in transparency levels among different companies. The descriptive statistics for the control variables are consistent with existing literature.

Table 2. Descriptive statistical results of variables

Variable	Obs	Mean	Std.dev.	Min	Max
IP	23,863	55.43	4.610	28.17	74.43
DCG	23,863	1.053	1.163	0	6.107
Dscore	23,863	2.316	1.408	0	4
Size	23,863	22.295	1.356	16.117	28.636
Lev	23,863	0.455	0.350	0.00750	31.47
Roa	23,863	0.0520	0.264	-29.02	11.01
Fee	23,863	13.85	0.739	11.51	21.42
Pay	23,863	14.40	0.738	10.38	18.20
Growth	23,863	4.246	390.4	-11.68	59412
CV	23,863	4.977	7.803	-7.640	54.32
Top	23,863	0.354	0.150	0.0220	0.900
Dual	23,863	0.250	0.433	0	1
soe	23,863	0.404	0.491	0	1

4.2. Corporate Digital Transformation, Transparency, and Investor Protection Index Regression

Table 3 below presents the regression results of foreign ownership and the degree of corporate internationalization. Column (1) displays the regression outcomes without considering control variables, year fixed effects, and industry fixed effects. In this column, the regression coefficient for Digital Transformation (DCG) is 0.5126 ($t=20.1430$), showing a positive correlation at the 1% significance level. This indicates that higher levels of digital transformation are associated with higher levels of investor protection as measured by the investor protection index.

Columns (2) and (3) build upon Column (1) by sequentially incorporating control variables, year fixed effects, and industry fixed effects into the regression model. The results demonstrate that the coefficient for Digital Transformation (DCG) remains positively significant at the 1% level even after accounting for these factors. These findings suggest that digital transformation significantly enhances investor protection, accounting for the relevant control variables.

The economic implication is as follows: after controlling for variables and year and industry effects, the coefficient for Digital Transformation (DCG) is 0.2395 ($t=9.1606$). This implies that holding other factors constant, an increase of 1 standard deviation in the degree of digital transformation corresponds to a 5.8% improvement in investor protection, equivalent to the sample standard deviation of 0.2395 * (1.163/4.610). These results highlight the economic significance of digital transformation. Hypothesis H1 is confirmed, and the VIF test values are between 1 and 2, all below 10, indicating no issues of multicollinearity.

Table 3. Regression result

	(1)	(2)	(3)
	IP	IP	IP
DCG	0.5126*** (20.1430)	0.2196*** (8.9699)	0.2169*** (8.3841)
Size		0.7314*** (21.4066)	0.8071*** (23.3921)
Lev		-2.0626*** (-21.8816)	-2.2252*** (-23.6732)
Roa		-0.9206*** (-7.5919)	-1.0561*** (-8.8692)
Fee		0.1535*** (2.6284)	0.3035*** (5.1634)
Pay		1.3017*** (29.9165)	1.1771*** (26.3516)
Growth		-0.0003*** (-4.7848)	-0.0003*** (-4.7843)
CV		0.0147*** (4.1677)	0.0114*** (3.2871)
Top		1.6201*** (8.4909)	1.8749*** (9.9656)
Dual		-0.4067*** (-6.1852)	-0.4113*** (-6.4037)
soe		0.4321*** (6.8054)	0.4163*** (6.5010)
YearFE	NO	NO	YES
IndFE	NO	NO	YES
_cons	54.8930*** (1.4e+03)	18.2889*** (28.9552)	19.4451*** (28.4406)
N	23863	23863	23863
r2_a	0.0167	0.1800	0.2221

5. Robustness Test

5.1. Replace Explanatory Variables

Extracting digital transformation frequency from annual reports as a measure of the degree of corporate digital transformation may suffer from inaccuracies due to companies intentionally inflating digital transformation-related word frequencies in their reports. Following the practices of Fang Mingyue (2022), Pang Ruizhi, and Liu Dongge (2022), this study uses the ratio of software investments and digital hardware investments to total assets (DCG2) as an alternative indicator to measure the level of digital transformation. Software investments are manually screened ERP and financial software system amounts from

the Guotai An database's intangible assets, while digital hardware investments are amounts for office electronic equipment and self-service devices from the Guotai An database's fixed assets. As shown in Table 4, using the proportion of software and hardware investments to total assets as explanatory variables, the coefficients remain significantly positive at the 1% level. Robustness tests confirm the robustness and reliability of Hypothesis H1 conclusions in this study.

Table 4. Replace the explanatory variable regression results

	(1)	(2)	(3)
	IP	IP	IP
DCG2	100.5903*** (9.3342)	86.8858*** (8.7092)	85.9937*** (8.6907)
Size		0.7626*** (22.1293)	0.8485*** (24.4846)
Lev		-2.0713*** (-21.9769)	-2.2213*** (-23.6336)
Roa		-0.9116*** (-7.5144)	-1.0297*** (-8.6448)
Fee		0.1624*** (2.7847)	0.2863*** (4.8612)
Pay		1.3252*** (30.6940)	1.1682*** (26.1170)
Growth		-0.0003*** (-4.7878)	-0.0003*** (-4.8047)
CV		0.0133*** (3.7574)	0.0103*** (2.9659)
Top		1.5760*** (8.2599)	1.8674*** (9.9264)
Dual		-0.3957*** (-6.0213)	-0.4062*** (-6.3259)
soe		0.3844*** (6.0908)	0.3774*** (5.9269)
YearFE	NO	NO	YES
IndFE	NO	NO	YES
_cons	55.3155*** (1.7e+03)	17.3031*** (28.1401)	18.9622*** (27.9755)
N	23863	23863	23863
r2_a	0.0036	0.1799	0.2222

5.2. Instrumental Variable Method (2SLS)

To further mitigate endogeneity issues, this study adopts the method proposed by Fang Mingyue (2022) and Ni Kejin and Liu Xiuyan (2021), using the industry and year-specific mean of digital transformation (DCG3) as an instrumental variable. Given that this study employs only one instrumental variable, there is no issue of overidentification. Weak instrumental variable tests indicate that the first-stage F-statistic = 2898.43 > 10, with a Partial R-squared of 0.1316, suggesting that DCG3 has good explanatory power over the endogenous explanatory variable and does not suffer from weak instrument problems.

In summary, the selection of instrumental variables in this study is deemed reasonable. Table 5 below presents the results of the 2SLS regression. Column (1) shows the first stage of the 2SLS regression, where the instrumental variable (DCG3) regresses on the endogenous explanatory variable (DCG) with a coefficient of 0.9253 ($t = 53.8371$), significant at the 1% level. Column (2) presents the second stage of the 2SLS regression, indicating that the coefficient of the instrumental variable (DCG3) is 0.5626 ($t = 8.1719$), also significant at the

1% confidence level. These results demonstrate that even after considering potential endogeneity issues, digital transformation significantly enhances the level of investor protection, affirming the robustness of Hypothesis H1 conclusions.

Table 5. Instrumental variable method regression results

	(1)	(2)
	first	second
VARIABLES	DCG	IP
DCG3	0.931*** (0.012)	
DCG		0.526*** (9.47)
Size	0.059*** (0.008)	0.744*** (21.66)
Lev	-0.122*** (0.022)	-2.028*** (-21.41)
Roa	-0.121*** (0.029)	-0.878*** (-7.21)
Fee	0.196*** (0.014)	0.063 (1.04)
Pay	0.202*** (0.010)	1.212*** (26.35)
Growth	0.000 (0.000)	-0.000*** (-4.77)
CV	-0.004*** (0.001)	0.016*** (4.60)
Top	-0.232*** (0.045)	1.662*** (8.68)
Dual	0.086*** (0.016)	-0.441*** (-6.66)
soe	-0.239*** (0.015)	0.523*** (8.00)
YearFE	YES	YES
IndFE	YES	YES
_cons	-6.617*** (0.146)	20.174*** (28.66)
N	23,863	23,863
r2_a	0.275	0.175

6. Mediation Mechanism Testing

Table 6 presents the results of the examination of the direct relationship between digital transformation and investor protection. In column (1), the coefficient for digital transformation degree (DCG) is 0.2395, indicating a significant total effect on investor protection at the 1% level. Column (2) shows that the regression coefficient between digital transformation degree and transparency level is 0.0580, also significant at the 1% level, suggesting that enhanced digital transformation can improve corporate transparency.

Column (3) reveals that after simultaneously including digital transformation degree and transparency level in the regression model for investor protection, the coefficient for digital transformation degree remains significant at the 1% confidence level, albeit decreasing from 0.2395 in the first step to 0.2008. The coefficient for transparency level is 0.6675 and significant at the 1% level. This indicates that corporate transparency mediates the relationship between digital transformation degree and investor protection. Specifically, the total effect of digital transformation on investor protection is 0.2395, while the indirect effect through

improved transparency, as a mediator, is 0.0387 (= 0.0580 * 0.6675). The mediation effect of transparency accounts for approximately 16% of the total effect, validating Hypothesis 3.

To further validate this mediation mechanism, the study employs the Sobel test and bootstrap method (500 bootstrap samples with replacement). The results, as shown in the table, confirm the existence of the mediation effect. Therefore, Hypothesis H2 is supported by these findings.

Table 6. The Regression Results of Mediation Effect Test

	(1)	(2)	(3)
	IP	Dscore	IP
Dscore			0.6675*** (30.8217)
DCG	0.2395*** (9.1606)	0.0580*** (7.5565)	0.2008*** (7.8230)
Lev	-2.0161*** (-21.3036)	-0.2880*** (-10.3741)	-1.8239*** (-19.6079)
Roa	-0.8558*** (-7.1243)	-0.0555 (-1.5741)	-0.8188*** (-6.9501)
Fee	1.2135*** (27.2336)	-0.3087*** (-23.6198)	1.4196*** (32.1136)
Pay	1.4461*** (33.1254)	0.2346*** (18.3207)	1.2895*** (29.9103)
Growth	-0.0003*** (-4.4530)	0.0000 (0.3926)	-0.0003*** (-4.6192)
CV	0.0157*** (4.4999)	-0.0010 (-0.9588)	0.0164*** (4.7801)
Top	2.4502*** (12.9877)	0.1449*** (2.6191)	2.3534*** (12.7190)
Dual	-0.5068*** (-7.8172)	0.1040*** (5.4680)	-0.5762*** (-9.0576)
soe	0.7605*** (12.0647)	-0.2631*** (-14.2273)	0.9361*** (15.0798)
YearFE	YES	YES	YES
IndFE	YES	YES	YES
_cons	20.5311*** (29.7592)	2.2641*** (11.1868)	19.0197*** (28.0387)
N	23863	23863	23863
r2_a	0.2042	0.2661	0.2347
Sobel test	z =7.626		
Bootstrap test	(0.0305802, 0.0497549)		

7. Moderation and Substitution Effects Test

To further test the research hypothesis H3 proposed in this study, which suggests that risk tolerance level negatively moderates the relationship between digital transformation and investor protection, we adopt the approach used by Yu et al. (2013). Given that the tenure of senior executives in Chinese listed companies is typically three years, the company's risk tolerance level (Risk) is measured using the volatility of the company's asset returns over the past three years (i.e., Roa rolling standard deviation). Model (6) is then established accordingly.

$$AdjRoa_{it} = \frac{EBIT_{it}}{ASSET_{it}} - \frac{1}{X} \sum_{K=1}^X \frac{EBIT_{it}}{ASSET_{it}} \quad (4)$$

$$Risk = \sqrt{\frac{1}{T-1} \sum_{t=1}^T (AdjRoa_{it} - \frac{1}{T} \sum_{t=1}^T AdjRoa_{it})^2} \quad (5)$$

$$IP_{it} = \delta_0 + \delta_1 DCG_{it} + \delta_2 Risk_{it} + \delta_3 DCG_{it} \times Risk_{it} + \delta X_{it} + \sum indi + \sum year + \varepsilon_{it} \quad (6)$$

In equation (4), EBIT_{it} represents the Earnings Before Interest and Taxes for firm *i* in year *t*; ASSET_{it} represents the assets of firm *i* at the end of year *t*; EBIT_{it}/ASSET_{it} represents the Return on Assets (Roa) for firm *i* in year *t*; AdjRoa_{it} represents the adjusted Roa for firm *i* in year *t* after industry-average Roa adjustment; *X* represents the total number of firms in the industry where firm *i* operates in year *t*; *T* denotes the rolling years for Roa, set to 3 in equation (5). In equation (6), Risk_{it} represents the risk tolerance level of firm *i* in year *t*, and DCG_{it} × Risk_{it} represents the interaction term between digital transformation and risk tolerance level for firm *i* in year *t*.

To further test the research hypotheses H4a and H4b proposed in this study, which examine whether executive shareholding acts as a substitute effect or a positive moderation effect on the relationship between digital transformation and investor protection, we establish model (7). Here, Mng_{it} represents the proportion of executive shareholding for firm *i* in year *t*, and DCG_{it} × Mng_{it} represents the interaction term between digital transformation and executive shareholding for firm *i* in year *t*.

$$IP_{it} = \theta_0 + \theta_1 DCG_{it} + \theta_2 Mng_{it} + \theta_3 DCG_{it} \times Mng_{it} + \theta X_{it} + \sum indi + \sum year + \varepsilon_{it} \quad (7)$$

To further test the research hypotheses H5a and H5b proposed in this study, which examine whether corporate ESG disclosure acts as an additive effect or a substitute effect in the relationship between digital transformation and investor protection, we establish model (8). Here, ESG_{it} represents the ESG score of firm *i* in year *t* as rated by Huazheng, which is widely recognized and applied in the Chinese market due to its broad coverage, timeliness, and acceptance in academia and industry (Lian et al., 2023; Li et al., 2021). DCG_{it} × ESG_{it} represents the interaction term between digital transformation and ESG score for firm *i* in year *t*.

$$IP_{it} = \mu_0 + \mu_1 DCG_{it} + \mu_2 ESG_{it} + \mu_3 DCG_{it} \times ESG_{it} + \mu X_{it} + \sum indi + \sum year + \varepsilon_{it} \quad (8)$$

Based on the research model set in (6), the regression results in Table 7 demonstrate the following: In column (1), the regression results indicate that the level of risk-taking negatively moderates the promotion effect of digital transformation on investor protection. The coefficient of the interaction term (DCGRisk) is -0.3410, significant at the 5% level. This suggests that as the level of risk-taking by the firm increases, the enhancing effect of digital transformation on investor protection diminishes. Hypothesis H3 is supported. In column (2), the regression results show that the coefficient of Mng is 1.4648, significant at the 1% level. The coefficient of the interaction term (DCGMng) is -0.3403, significant at the 5% level. This indicates that managerial shareholding acts as a substitute in the process where digital transformation enhances investor protection in the firm. Hypothesis H4 is supported. In column (3), the regression results reveal that the coefficient of ESG is 0.8367, significant at the 1% level. The coefficient of the interaction term (DCGESG) is -0.0680, significant at the 1% level. This shows that corporate ESG disclosure acts as a substitute in the process where digital transformation enhances investor protection in the firm. Hypothesis H5b is supported.

These findings provide empirical support for the research hypotheses regarding the interaction effects of risk-taking, managerial shareholding, and ESG disclosure on the relationship between digital transformation and investor protection.

Table 7. The Regression Results of Moderating and Substitution Effect Tests

	(1)	(2)	(3)
	IP	IP	IP
DCG	0.2574*** (7.9784)	0.2758*** (9.1375)	0.4867*** (5.4058)
Risk	-0.0642* (-1.6793)		
DCGRisk	-0.3410** (-2.4322)		
Mng		1.4648*** (5.8819)	
DCGMng		-0.3403** (-2.4105)	
ESG			0.8367*** (23.5588)
DCGESG			-0.0680*** (-3.2543)
Lev	-1.8342*** (-17.2465)	-1.9673*** (-20.7281)	-1.8392*** (-18.2255)
Roa	-0.8869*** (-6.6557)	-0.8367*** (-6.9683)	-0.9223*** (-7.6777)
Fee	1.0955*** (21.2978)	1.2422*** (27.6374)	1.1400*** (25.9638)
Pay	1.4858*** (29.2901)	1.4444*** (33.1079)	1.2080*** (27.7130)
Growth	-0.0003*** (-4.1135)	-0.0003*** (-4.4684)	-0.0003*** (-3.9935)
CV	0.0145*** (3.6069)	0.0216*** (5.9445)	0.0197*** (5.7448)
Top	2.0586*** (9.4054)	2.3775*** (12.5860)	1.7154*** (9.2326)
Dual	-0.5653*** (-7.3836)	-0.5408*** (-8.3093)	-0.5144*** (-8.0837)
soe	0.6017*** (8.2066)	0.8959*** (13.3643)	0.6035*** (9.7496)
YearFE	YES	YES	YES
IndFE	YES	YES	YES
_cons	21.6767*** (27.2609)	20.0242*** (28.7426)	21.9791*** (32.1850)
N	18420	23863	23620
r2_a	0.1797	0.2054	0.2299

8. Conclusions and Implications

Strengthening investor protection can enhance confidence in capital markets, thereby increasing the proportion of direct financing. In light of this, this study uses data from China listed companies from 2011 to 2021 to empirically examine the impact and mechanisms of corporate digital transformation on investor protection levels. After a series of analyses, the following conclusions were drawn: corporate digital transformation enhances investor protection levels. This conclusion remains robust after substituting explanatory variables and conducting two-stage least squares (2SLS) regressions for validation. Mediation analysis reveals that digital transformation increases corporate transparency,

which in turn enhances investor protection, with transparency mediating approximately 16% of the effect. Further research shows that corporate risk-taking levels negatively moderate the effect of digital transformation on enhancing investor protection; managerial shareholding acts as a substitute mechanism in enhancing investor protection through digital transformation; and ESG disclosure similarly acts as a substitute mechanism in enhancing investor protection through digital transformation.

Based on these empirical findings, the following recommendations are proposed to protect investor interests and enhance investor confidence: The government should actively support corporate digital transformation through policy guidance and the establishment of exemplary standards to enhance corporate transparency and governance levels. It should strengthen the supervision of corporate transparency and integrate the provision of guidance and information related to corporate digital transformation to bolster investor confidence and safeguard investor rights. Additionally, financial support, tax incentives, and innovation funds should be provided to mitigate risks and reduce costs for companies, thereby alleviating their burdens. Companies should be encouraged to adopt diversified executive incentive mechanisms beyond equity incentives. Government initiatives could promote the introduction of alternative incentives such as long-term performance rewards, stock options, and profit-sharing to align managerial interests with investor protection goals. The government should establish mandatory ESG disclosure requirements and collaborate with industry associations, professional organizations, and international bodies to develop industry-specific standards and certification mechanisms tailored to China's circumstances. This ensures that ESG disclosures are comparable and credible, aiding investors in better assessing comprehensive risks and values, thereby enhancing investor protection. Companies should develop clear digital transformation strategies, positioning them as a key driver of corporate development and enhancing investor value. Digital transformation strategies should include goals to enhance corporate transparency and governance levels and should be aligned with the company's long-term strategies and values. Companies should leverage the advantages of digital transformation to enhance transparency by providing investors with clear operational and financial reports through accurate and comprehensive disclosures. Companies with higher risk-taking profiles should strengthen internal controls and risk management, establish appropriate feedback mechanisms for operational decisions, actively engage with investors, strengthen governance mechanisms, and promptly rectify and improve unreasonable decisions to enhance investor protection. Companies should design reasonable executive incentive mechanisms tailored to their specific needs, including both equity and non-equity incentives. In terms of equity incentives, companies can implement differentiated stock ownership plans to ensure that managerial long-term interests align with investor protection goals. Finally, companies should integrate robust ESG management into their strategies and operations, considering it a vital component of sustainable corporate development. They should establish a comprehensive ESG management system, including dedicated ESG committees or departments, and develop relevant policies and guidelines to ensure that ESG principles are fully considered in corporate decision-making and practices, thereby further promoting investor protection.

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