A Study on the Mechanism of the Impact of ESG-Oriented Digital Transformation on the Performance of High-Tech Enterprises

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Abstract In the era of digital economy, global enterprises are facing unprecedented transformation pressure and development opportunities. Traditional business models are under impact, and enterprises must reexamine their value creation methods and competitive strategies. Based on the data of A-share listed companies from 2013 to 2022, this paper constructs a mediated adjustment model to explore in depth the impact mechanism of digital transformation on the performance of high-tech enterprises. The study adopts the least squares estimation method and two-way fixed effects model, takes ROE as the corporate performance measure, constructs digital transformation indicators through text analysis method, uses CSI ESG rating as the mediator variable, and business environment as the regulator variable for empirical analysis. It is found that digital transformation significantly improves enterprise performance, with a regression coefficient of 0.003 and significant at the 1% level; ESG performance plays a partial mediating effect in the relationship between digital transformation and firm performance, with a mediation effect coefficient of 0.015 and significant at the 1% level; Good business environment strengthens the performance improvement effect of digital transformation, with a moderating effect coefficient of 0.015 and significant at the 1% level; heterogeneity analysis shows that the effect of digital transformation is more significant in state-owned enterprises, with a regression coefficient of 0.0085. This study confirms that digital transformation improves the performance of enterprises by enhancing the performance of ESG, providing empirical evidence for the formulation of digital strategies by enterprises and optimization of business environment by the government. It provides empirical evidence for enterprises to formulate digital strategies and the government to optimize the business environment.

Index Terms Digital transformation, enterprise performance, ESG performance, business environment, mediation model, high-tech enterprises

I. Introduction

Currently, more and more enterprises have begun to integrate ESG (Environmental, Social and Governance) concepts into their business strategies in order to improve their sustainable development capabilities and market competitiveness [1]. The ESG concept emphasizes that enterprises should pay attention to ecological environmental protection, fulfill their social responsibility, and improve their governance level, and the green, innovative, and coordinated development it encompasses is in line with China's new development concept, as well as an important practice for achieving sustainable development [2], [3]. China's ESG development is predominantly policy-driven, and the strength of policy support is increasing. Driven by the mandatory norms and supervision of relevant external regulations and policies, Chinese companies' ESG performance has received widespread attention.

However, there is a lack of incentives for Chinese companies to improve their ESG performance. On the one hand, many companies face the challenge of high costs in fulfilling their ESG responsibilities, which seriously undermines their intrinsic motivation to improve their ESG performance [4], [5]. These costs may relate to the management of environmental protection equipment, the practice of social responsibility, as well as the costs of corporate governance improvement [6]. On the other hand, there is information asymmetry in the acquisition of ESG data, which is specifically reflected in the availability, comparability, and reliability of data, as well as the lack of consistent evaluation standards and indicator systems [7]-[9].

In recent years, the application of digital technology has become a key driving force to promote the transformation and upgrading of traditional enterprises, and to seek economic benefits and innovation momentum [10]. For enterprise ESG performance, enterprises help to improve their resource utilization efficiency and reduce

ESG fulfillment costs through the introduction of digital technologies represented by artificial intelligence, blockchain, cloud computing and big data, thus enhancing their sustainable development capability [11]-[13]. It can be seen that corporate digital transformation can improve corporate performance by achieving good corporate ESG performance in order to reduce the cost of debt and thus increase corporate value [14], [15].

This study constructs a theoretical framework of digital transformation affecting enterprise performance. Specifically, digital transformation directly affects enterprise performance through technological innovation, process optimization, and business model restructuring; meanwhile, digital transformation can enhance enterprise ESG performance, and indirectly affects enterprise performance through improving corporate image, reducing financing costs, and enhancing stakeholder trust; In addition, the business environment, as an important external factor, regulates the strength of the relationship between digital transformation and enterprise performance. By constructing a mediated regulation model, this study aims to comprehensively reveal the internal mechanism and boundary conditions of digital transformation affecting enterprise performance, and provide scientific basis for enterprises to formulate their digital strategies and for the government to optimize the business environment policy.

II. Research hypothesis that digital transformation helps companies improve their performance

II. A. Digital Transformation and Business Performance

By combing through the existing literature, it is found that there are fewer empirical studies on the relationship between digital transformation [16] and enterprise performance, and the conclusions are inconsistent. Scholars from the enterprise digital transformation will enhance the competitive advantage, financial performance and organizational performance of the three aspects of the enterprise to carry out digital transformation to improve enterprise performance; from the increase of the digital divide, reduce the efficiency of research and development, reduce the degree of innovation resources and factor agglomeration and so on several aspects of the digital transformation of the enterprise to reduce the performance of the enterprise.

From a technological perspective, the widely different findings may be caused by the heterogeneity of the relationship between digital transformation and enterprise performance in terms of industry, geography and property rights. At the industry level, industries with a better foundation of digital technology, such as high-tech enterprises, can better grasp the opportunities of digital transformation to improve enterprise performance; industries with a weak foundation of digital technology, such as the retail industry, digital transformation has become a burden for enterprises, passively accepting digital transformation instead of lowering enterprise performance; at the geographic level, the economically developed eastern region, the technical conditions of enterprise digital transformation are more favorable to promote the improvement of enterprise performance, while the western region's economy is more favorable. Enterprise performance enhancement, the western region is economically weak, enterprise digital transformation without the corresponding technical conditions will hinder the enhancement of enterprise performance; property rights, state-owned enterprises digital transformation will be more policy-oriented and the actual consideration of the enterprise is insufficient, showing a decline in enterprise performance, private enterprise digital transformation with more profit-seeking goal of moderate digitization, showing an increase in enterprise performance.

Based on the technological perspective, the interaction between enterprises and consumers has changed qualitatively under the large-scale application of digital technology. Fundamentally, enterprises have established a multi-dimensional growth model on the road of such digital transformation, transformed their value propositions and business logics, and ultimately broadened their development space. Moreover, the use of digital technologies such as the Internet of Things, blockchain and cloud computing has helped enterprises accurately collect huge amounts of information from consumers and continuously analyze their diverse needs in a timely manner, thus contributing to the improvement of corporate performance. The digital platform derived from digital technology can further optimize the business model of enterprises, save costs and broaden profit channels, thus generating greater profit margins and making the performance of enterprises more brilliant. Relevant theoretical basis, resource-based theory points out that the differences in the resources owned, accessible and utilizable by different enterprises are the fundamental reasons for the gap in enterprise performance, and the resource constraints of the enterprise bind the further development of the enterprise, while the application of digital technology can form a new form of resources-digital resources, which can effectively help the enterprise to break down the original physical resource barriers to alleviate the resource constraints, and to promote the growth of the enterprise.

Based on the above analysis, the following hypotheses are proposed:

H1: Enterprise digital transformation significantly improves enterprise performance.

II. B. The mediating role of ESG concepts

An enterprise's ESG performance [17] directly reflects the enterprise's sustainable development ability and the level of social responsibility fulfillment, and good ESG performance can enable the enterprise to establish a broader and more solid relationship with multiple stakeholder subjects. When a company improves its ESG performance, it helps to win the trust of various stakeholders and gain more positive external evaluations. For consumers, they will be more favorable to the products of companies with better ESG performance; for government departments, they may also reduce the loss of lawsuits and penalties in environmental, social and corporate governance of companies with better ESG performance, which indirectly saves the company's costs, improves sales revenues, and promotes corporate performance.

H2: Corporate digital transformation can improve corporate performance by improving corporate ESG performance.

II. C. The moderating role of the business environment

Business environment [18] is a collective term for the institutional and social factors felt by enterprises in the process of production and business activities, which is the embodiment of the soft power of the national or regional economy. As an important factor affecting the development of a country or region, it has an undoubted role in promoting economic development. The advantages and disadvantages of the business environment also have a great impact on the development of enterprises. Therefore, this paper focuses on the economic benefits of digital transformation, combines the policy background of the country's continuous optimization of the business environment, and deeply explores the impact of the business environment on the relationship between digital transformation and enterprise performance.

Based on the above analysis, this paper puts forward the following hypotheses:

H3: Good business environment strengthens the promotion effect of digital transformation on enterprise performance.

III. Empirical research design

III. A. Sample Selection and Data Sources

The research object of this paper is A-share listed companies. The data is from Wanderlust database, Rexis database and Cathay Pacific database, and the time frame is the period of 2013-2022. In order to avoid data interference with the accuracy of the research conclusions, and in accordance with the practice of existing research, the data processing method of this paper is as follows: (1) Delete ST, ST* and stocks to be delisted. (2) Delete financial listed companies. (3) Delete listed companies with a listing period of less than 1 year. Due to the significant heterogeneity among listed companies, especially the large differences in the financial indicators of some listed companies, in order to avoid the interference of the outliers of individual indicators on the sample data, all continuous variable values in this paper have been subjected to 1% and 99% shrinkage respectively.

III. B. Variable Selection and Description

III. B. 1) Explained variables

This paper chooses ROE as a measure of corporate performance for the following reasons: first, the market value and replacement cost reflected by Tobin's Q value may not be accurate enough in the environment of China's capital market, which suffers from a certain degree of ineffectiveness and imperfections in the factor market. Second, ROE is used as an important indicator for assessing corporate performance as issued by the Bureau of Appraisal and Allocation of the State-owned Assets Supervision and Administration Commission of the State Council, and the adoption of this official standard helps to maintain consistency with the capital market.

III. B. 2) Explanatory variables

Degree of Digital Transformation (DCG). This paper argues that the vocabulary used in a company's annual report can reflect the company's strategic characteristics and future prospects, as well as reflect the company's business philosophy and development, as well as major strategic decisions in the future, such as digitalization. According to the CSRC's principle of information disclosure in annual reports, enterprises are required to disclose the MD&A content of "management discussion and analysis" in the annual report of listed companies. Generally speaking, the more companies pay attention to and implement their digital strategies, the more inclined they are to disclose "word-based" information. In view of this, with the help of the semantic expression of national policies related to the digital economy, this paper establishes a relatively complete digital dictionary. Using the text analysis method based on machine learning, an index reflecting the degree of digitalization of listed companies in China was constructed. The specific steps are as follows: First, the "thesaurus method" is used to screen specific texts (artificial intelligence technology, blockchain technology, cloud computing technology, big data technology, and

digital technology application) in combination with government reports and digital-related reports, and a "digital" thesaurus is constructed. Second, the MD&A (Management Discussion and Analysis) content in the annual report of the enterprise is extracted, and the MD&A content is segmented by using Python. Finally, the frequency of digital transformation keywords in the MD&A of each enterprise is counted and logarithmic to measure the digital transformation of the enterprise.

III. B. 3)   Intermediate variables
This paper chooses the CSI ESG rating index as the mediating variable. The rating framework includes three dimensions: E (Environment), S (Society) and G (Governance), 10 themes and 36 key indicators. The rating results include nine grades, including leading (AAA, AA, A) average (BBB, BB, B) and lagging (CCC, CC, C). In this paper, the scores of Chinese listed companies selected from the ESG ratings are categorized according to the rating scale from low to high. For example, a CCC rated company has an ESG score of 1, while when the company is AAA, the maximum ESG score is 9. The higher the ESG score, the better the performance in fulfilling environmental, social and governance (ESG) responsibilities.

III. B. 4)   Moderating variables
The moderating variable in this paper is the business environment (Envir). Business environment refers to the institutional and social factors felt by enterprises in the process of production and business activities, is the embodiment of the soft power of the national or regional economy, as an important factor affecting the development of the country or region, has an undoubtedly important impact on economic development.

III. B. 5)   Control variables
In order to minimize the impact of other factors on the explained variables, this paper intends to add the following control variables in the empirical test.

1. Firm size (Size)

Enterprise size is usually measured by the natural logarithm of the total assets of the enterprise at the end of the year. Generally speaking, the larger the size of the enterprise, the stronger the ability to acquire resources, the easier it is to accumulate sizable resources, and there are sufficient resources for innovation activities. If the enterprise is small, it will be at a disadvantage in all aspects.

2. Growth

In this paper, the growth of an enterprise is measured by the ratio of the annual increase in operating income to the total operating income of the previous year, i.e. the growth rate of the enterprise's operating income.

3. Gearing ratio (Debt)

The gearing ratio indicator describes the ratio of a company's liabilities to its assets, reflecting the company's financial risk. Its value is too large or too small is not conducive to the development of the enterprise. An appropriate gearing ratio can reduce the cost of financing and better utilize its financial leverage. Too high gearing ratio will lead to serious financial risk, which will inevitably affect the enterprise performance. Based on this, the gearing ratio is selected as the control variable of this paper.

4. Shareholding ratio of major shareholders (Top1)

The shareholding ratio of major shareholders refers to the proportion of the number of shares held by the first major shareholder to the total share capital, which is an indicator of the control of the first major shareholder of the enterprise over the enterprise.

5. Operating cash flow (Nc)

In this paper, the logarithmized net cash flow from operations is used as an indicator of the enterprise's operating cash flow.

6. Board Independence (Ind)

Independent directors are of great significance to the operational efficiency of the company, which can promote the good development of the enterprise to a certain extent, and this paper uses the ratio of the number of independent directors to the total number of the board of directors as a measure.

7. Age of the enterprise (Age)

This paper uses the logarithmized number of years of listing to measure the age of enterprises. The listing age can reflect the company's industry status and experience to some extent.

III. C. Model construction
First of all, in order to examine whether and how enterprise digital transformation affects enterprise performance, the model of hypothesis one is as follows according to the content of this paper's research and related variables:

$$Q = \alpha_0 + \alpha_1 DCG + \alpha CVs + \varepsilon \tag{1}$$

Secondly, the mediation effect test is carried out, and model (2) and model (3) are constructed on the basis of model (1). The specific test method is as follows: the first step, in model (1) to test the impact of enterprise digital transformation on enterprise performance, get the regression coefficient, if the coefficient results are significant, then go to the next step of the test; the second step, using model (2) to test the impact of digital transformation on the ESG performance of enterprises, get the regression coefficient, if the coefficient is significant, then go to the next step of the test: the third step, in model (3) to test the impact of enterprise ESG performance plays a mediating role in this process, put the enterprise ESG performance in model (3) for regression, get the regression coefficient, if it is significant and the absolute value is less than the absolute value of the coefficient of model (1), then it means that the mediating effect exists.

Model (2) verifies the role of digital transformation on corporate ESG performance:

$$ESG = \beta_0 + \beta_1 DCG + \beta CVs + \varepsilon \tag{2}$$

Model (3) adds corporate ESG performance into the model for regression based on model (1) to verify the mediating role of corporate ESG performance in the relationship between digitization degree and corporate performance:

$$ROE = \gamma_0 + \gamma_1 DCG + \gamma_2 ESG + \gamma CVs + \varepsilon \tag{3}$$

The test of moderating effect refers to the research method of constructing moderating effect, cross-multiplying the moderating variables with the explanatory variables to construct the interaction term, and incorporating the interaction term into the baseline regression equation for analysis. In order to test the moderating effect of $Envir$ characteristics on digital transformation and firm performance, this paper adds the interaction term between digital transformation and $Envir$ in the model and constructs model (4):

$$ROE = \lambda_0 + \lambda_1 DCG + \lambda_2 Envir + \lambda_3 (DCG * Envir) + \lambda CVs + E \tag{4}$$

where business environment characteristics serve as moderating variables. DCG* $Envir$ is the interaction term between degree of digitization and $Envir$ characteristics, and $\lambda 4$ represents the correlation coefficient between the interaction term between digital transformation and $Envir$ and firm performance.

IV. Empirical testing and analysis

IV. A. Descriptive statistics

This paper provides descriptive statistics on the variables of digitization level and enterprise performance of listed enterprises from 2013 to 2022, and the statistical results are shown in Table 1. The study covers a total of 18,000 observations, and the minimum, maximum, mean and standard deviation of each variable are presented in detail. In terms of corporate performance, this paper uses return on equity (ROE) as a measure. The statistical results show that the mean value of ROE is 0.083 and the standard deviation is 0.084, which reflects the average level and fluctuation of the overall performance of A-share listed companies. The minimum value is -0.312 and the maximum value is 0.296, which reveals the significant difference in performance among different listed companies and the worrying operating conditions of some of them. In terms of the level of enterprise digitization, the statistics show that the mean value of the level of digital transformation is 1.777, the standard deviation is 1.420, and the minimum value is 0.001. These data indicate that although on the whole, A-share listed enterprises have made some progress in digital transformation, some of them still have a relatively low level of transformation in this area. However, the maximum value of digital transformation level is 5.224, which shows a significant gap in digital transformation among different listed companies.

Table 1: Descriptive statistical analysis

Variable	Sample size	Mean	Standard deviation	Minimum value	Maximum value
ROE	18000	0.083	0.084	-0.312	0.296
DCG	18000	1.777	1.420	0.001	5.224
Size	18000	21.662	1.011	19.908	25.429
Growth	18000	0.178	0.325	-0.482	1.687
Debt	18000	0.346	0.184	0.055	0.785
Ind	18000	0.381	0.056	0.142	0.799
Nc	18000	18.823	1.409	11.037	22.653
Age	18000	2.874	0.317	1.792	3.497
Top1	18000	35.387	14.411	9.225	74.649

IV. B. Correlation analysis

In this paper, the main variables were analyzed for correlation through Pearson's coefficient and the matrix of correlation coefficients is shown in Table 2. The observation shows that there is a positive correlation between enterprise digital transformation and enterprise performance at 1% significance level with a correlation coefficient of 0.011 This indicates that the degree of enterprise digital transformation is likely to have a positive impact on enterprise performance. Note: t statistics in parentheses, $*p<0.1, **p<0.05, ***p<0.01$.

Table 2: Correlation test of major variables

	ROE	DCG	Size	Growth	Debt	Ind	Nc	Age	Top1
ROE	1								
DCG	0.011***	1							
Size	0.134***	0.091***	1						
Growth	0.345***	-0.042***	0.127***	1					
Debt	-0.141***	0.042***	0.463***	0.135***	1				
Ind	-0.011	-0.044***	0.032***	-0.015	0.014	1			
Nc	0.241***	0.055***	0.626***	0.064***	0.137**	0.021*	1		
Age	0.271***	-0.065***	0.114***	-0.055***	0.432**	0.004	0.037**	1	
Top1	0.084***	-0.082***	0.146***	-0.062***	0.004	-0.035**	0.174***	0.053***	1

In addition, in order to test whether there is a problem of multicollinearity between the variables, the variance inflation factor method is used in this paper. Table 3 shows the results of the test, and the variance inflation factors of the variables range from 0.95 to 4.88, which is far below the threshold of 10. This indicates that there is no multicollinearity problem between the variables that would have an impact on the regression results.

Table 3: Variance expansion factor test results

Variable	VIF	1/VIF
DCG	1.03	0.97
Size	2.21	0.45
Growth	1.05	0.95
Debt	1.60	0.63
Ind	0.98	1.02
Nc	1.73	0.58
Age	4.88	0.20
Top1	0.95	1.05
Mean VIF	1.80	

IV. C. Empirical Test of Digital Transformation and Business Performance

In this study, firm data were analyzed using least squares estimation (OLS) regression. The results show that the baseline regression results are presented in Table 4, as shown in column (1), digitalization level (DCG) has a significant contributory effect on firm performance (ROE). Then, a series of control variables are added for the regression analysis, as shown in column (2), the positive facilitating effect of digital transformation on firm performance still exists. To avoid possible endogeneity problems in the sample, we conduct panel regression analysis controlling for year and industry fixed effects, and the results are shown in columns (3) and (4) of the table below. In column (3), the regression coefficient for digitization level (DCG) is 0.002 when controlling for year and industry fixed effects only and no other control variables are added, exhibiting significance at the 1% level of significance. Subsequently, a series of control variables are added to the regression, and the results, as shown in column (4), show that the coefficient value of the firm's digitization level (DCG) is 0.003, a value that remains positive at the 1% significance level, a figure that highlights the positive effect of digital transformation on the firm's performance. This result not only verifies the hypothesis H1 proposed in the previous section, that is, enterprises undergoing digital transformation can effectively improve their performance performance, but also provides a strong data support for the digitalization strategy of enterprises.

Table 4: Benchmark regression

Variable	(1) ROE	(2) ROE	(3) ROE	(4) ROE
DCG	0.002***	0.003**	0.002***	0.003***
	(2.65)	(2.41)	(3.56)	(2.64)
Size		0.001***		0.007***
		(2.85)		(6.92)
Growth		0.061***		0.092***
		(35.63)		(32.85)
Debt		-0.124***		-0.102***
		(-30.65)		(-15.41)
Ind		-0.002		-0.001
		(-0.73)		(-0.85)
Nc		0.000***		0.000***
		(16.21)		(13.35)
Age		0.062***		0.083***
		(18.05)		(14.54)
Top1		0.000***		0.000***
		(7.12)		(7.65)
Constant	0.056***	0.064***	0.077***	-0.061**
	(52.65)	(3.85)	(41.86)	(-2.21)
Industry FE	No	No	YES	YES
Year FE	No	No	YES	YES
Observations	18000	18000	18000	18000
R-squared	0.022	0.325	0.044	0.262

IV. D. Mediating effects of firms' ESG performance

Enterprises actively carrying out digital transformation can effectively promote the improvement of ESG performance, which in turn helps enterprises to establish a good social image, accumulate reputational resources, alleviate the difficulties of financing constraints, reduce transaction costs, transform competitive factors into competitive advantages, and ultimately promote the improvement of enterprise performance. Based on this, this paper constructed an empirical model using stepwise regression method to test the mediating effect of ESG performance, and the specific results are shown in Table 5. The results in columns (1) to (3) are the test results of the path that enterprise digital transformation promotes enterprise performance improvement by enhancing enterprise ESG performance.

The stepwise regression method is used to analyze the relationship between digital transformation, ESG performance and corporate performance. Among them, the first step of the stepwise regression method is to examine the relationship between digital transformation and corporate performance after incorporating the control variables into the model, which can be regarded as a robustness test for changing the sample range of the relationship between digital transformation and corporate performance to a certain extent. According to the results in Column (1), the relationship between digital transformation and enterprise performance after the above treatment is still significantly positively correlated at the 1% level, which preliminarily indicates that the basic hypothesis H1 of this paper is somewhat robust.

According to the mediation effect test results, column (1) shows that corporate digital transformation is significantly and positively related to corporate performance at 1% level with a correlation coefficient of 0.038. Column (2) shows that corporate digital transformation is significantly and positively related to corporate ESG performance at 1% level with a correlation coefficient of 0.195. Column (3) shows that enterprise digital transformation is significantly positive at the 5% level with a correlation coefficient of 0.034, and ESG performance has a correlation coefficient of 0.015, which is significantly positive at the 1% level. It shows that ESG performance plays a partial mediating effect in the relationship between digital transformation and enterprise performance, and enterprise digital transformation can enhance enterprise ESG performance and then enhance enterprise performance, and hypothesis H2 is verified.

Table 5: Intermediary effect of enterprise ESG performance

Variable	(1)ROE	(2)ESG	(3)ROE
DCG	0.038***	0.195***	0.034**
	(2.35)	(3.15)	(2.44)
ESG			0.015***
			(5.62)
Size	-0.295***	1.588***	-0.315***
	(-11.22)	(14.56)	(-11.58)
Growth	0.015	-0.008	0.016
	(0.98)	(-0.14)	(0.99)
Debt	0.133	-3.546***	0.199*
	(1.25)	(-8.45)	(1.77)
Ind	-0.415	4.528***	-0.122
	(-0.14)	(3.99)	(-0.35)
Nc	-0.345***	4.125***	-0.122
	(-0.11)	(3.84)	(-0.33)
Age	-0.065	0.211	-0.068
	(-1.56)	(1.25)	(-1.57)
Top1	0.018***	0.009**	0.018***
	(22.54)	(2.11)	(22.44)
Constant	9.311***	-12.315***	9.515***
	(9.44)	(-3.16)	(9.66)
N	18000	18000	18000
R^2	0.658	0.845	0.649
Year	YES	YES	YES
Firm	YES	YES	YES

IV. E. Moderating effects of the business environment

A good business environment can effectively guarantee the mobility of the elements needed by enterprises in all aspects of production and operation, in such an environment, it is easier for enterprises to obtain support in terms of capital and human resources, and the impact of the "digitalization pain" will be weakened accordingly, and the digital transformation of enterprises will bring higher performance output. In this paper, we test the moderating effect of business environment through the two-way fixed-effects model with interaction terms, and the regression results are shown in Table 6. Columns (1) and (2) report the empirical test results of the moderating effect of business environment. According to the regression results, the interaction term between Doing Business and Digital Transformation before adding control variables is significantly positive at the 10% level. The interaction term between Doing Business and Digital Transformation after adding control variables, on the other hand, is significantly positive at the 1% level. It shows that the moderating effect of business environment is significant. That is, the better the business environment in which the enterprise is located, the stronger the promotion effect of digital transformation H3 on enterprise performance improvement, and hypothesis H3 is verified.

Table 6: Regulation of the business environment

Variable	(1)ROE	(2)ROE
DCG*Envir	0.008*	0.015***
	(1.77)	(3.17)
DCG	0.022***	0.056***
	(2.95)	(7.45)
Envir	0.012	0.008
	(0.86)	(0.74)
Size		-0.065***
		(-3.45)
Growth		-0.036**
		(-2.15)
Debt		-0.456***

			(-34.45)
Ind			0.308***
			(5.99)
Nc			0.305***
			(4.84)
Age			0.215
			(1.21)
Top1			0.007**
			(2.18)
Constant		2.0781***	12.056***
		(15.44)	(26.45)
N		18000	18000
R^2		0.611	0.656
Year		YES	YES
Firm		YES	YES

IV. F. Heterogeneity test

In the previous study, this paper preliminarily examined that digital transformation has a significant positive effect on enterprise performance, and that it plays a more significant role in improving enterprise performance in enterprises with higher digital transformation than in enterprises with lower digital transformation. However, due to the attributes of enterprises' own characteristics, it is easy for digital transformation to have a heterogeneous effect in the process of improving enterprise performance. From the point of view of enterprise heterogeneity, for the nature of property rights and age attributes of enterprises with different levels of technology and scale, even under the same degree of digital transformation, there may be differences in the final impact on performance.

Table 7 shows the heterogeneous effect of digital transformation on enterprise performance, first, in Panel A, this paper from the perspective of property rights nature, the enterprise is divided into state-owned enterprises and non-state-owned enterprises. The results show that the regression coefficient of digital transformation in state-owned enterprises is 0.0085 and passes the significance test at the 1% level; while non-state-owned enterprises do not pass the significance test. This suggests that digital transformation has a more significant effect on the improvement of enterprise performance in SOEs (the p-value of Suest is 0.000, which passes the significance test of 1%, indicating that the regression coefficients of DT in the two sample groups of "SOEs - non-SOEs" are significantly different).

Table 7: Analysis of the effect of heterogeneity

Variable	Panel A: property rights grouping		Panel B: enterprise age group	
	State-owned enterprise	Non-state enterprise	Young enterprise	Mature enterprise
	(1)	(2)	(3)	(4)
DCG	0.0085***	0.0012	0.0028**	0.0056***
	(0.0014)	(0.0007)	(0.0008)	(0.0012)
CVs	YES	YES	YES	YES
Year&Industry	YES	YES	YES	YES
_cons	-0.0945**	-0.2648***	-0.1665***	-0.1528***
	(0.0378)	(0.0345)	(0.0370)	(0.0334)
N	18000	18000	18000	18000
adj.R^2	0.175	0.184	0.152	0.191
Empirical p value	0.000		0.074*	

Possible reasons are, on the one hand, SOEs shoulder certain social responsibilities and political gains, the government inevitably gives them more resources tilt and extra care, relatively strong financing ability, relatively more collateral assets, and the government backing, can obtain funds from banks and other financial institutions at a lower cost of capital, thus alleviating the enterprises in the process of digital transformation of technological development, infrastructure construction and other financial pressures, and can help SOEs in the digital transformation process. This can ease the financial pressure on technology development and infrastructure construction in the process of digital transformation, provide a good foundation for state-owned enterprises to carry out digital transformation, and promote the all-round transformation of state-owned enterprises, which is conducive

to the priority of state-owned enterprises to seize the market. In the era of highly competitive digital economy, this advantage is beneficial to obtain market dominance or even monopoly, coupled with the network effect and almost zero marginal cost makes it difficult for competitors to enter.

On the other hand, state-owned enterprises have stronger policy orientation and the digital strategy is proposed by the state, so they have higher enthusiasm and initiative than non-state-owned enterprises in executing and implementing the digital strategy. Therefore, the performance improvement effect of digital transformation is more significant in SOEs. In contrast, non-SOEs have less ability to obtain external financing due to their own conditions, which obviously limits the sustainability of non-SOEs in the digital transformation stage and may ultimately have limited ability to improve their performance.

IV. G. Endogeneity test

It is worth noting that factors such as the technology level of the firm (R&D, R&D investment intensity), the corporate governance level (Age_ cost, agency cost), the industry competition level (Ind_ com, market competition), and the financial market level (Fin_ size, financial size) may have shocks to firm performance, but the selection of control variables in the benchmark model of this paper only takes into account the firm-level economic factors and has not yet taken the aforementioned factors into account, which may result in endogenous shocks to the results. In order to avoid this kind of situation, this paper intends to control ROE from four levels, including firm technology, corporate governance, industry competition, and financial market, and the results are shown in Table 8.

First, in column 1, we control for firm technology and corporate governance variables, where firm technology is measured by research and development (R&D) intensity and corporate governance is measured by agency_ cost. the coefficients of R&D are significantly positive and Age_ cost is significantly negative, and both of them pass the test of significance at the 1% level of statistics, which is in line with the findings of the previous study. . Second, in column 2, controlling for the industry competition level and the financial market level, where the industry competition level is measured by market competition (Ind_ com) and the financial market level is measured by financial size (Fin_ size). In general, the more intense the market competition is, the more favorable it is to incentivize firms to innovate and transform, and firms with higher innovativeness and active transformation perform better overall; while the larger the financial size is, the more favorable it is for firms to obtain low-cost capital, which affects firm performance.

The data through column 2 show that the coefficients of market competition and financial scale are both significantly positive, which indicates that the larger the market competition and financial scale, the more they help to improve firm performance. Finally, controlling for all the previous factors in column 3 to validate, the test shows that none of the main results have changed significantly. This suggests that the findings of this paper remain robust and based on the above test results it is found that endogeneity effects due to omitted variables are avoided to some extent. Specifically, the regression coefficients of digital transformation (DT) on firm performance (ROE) are all significantly positive at the 1% level after the four dimensions of factors from corporate technology, corporate governance, industry competition, and financial market. This indicates that the digital development of high-tech enterprises can effectively improve their performance.

Table 8: Endogenous test

Variable	(1)	(2)	(3)
DCG	0.0036***	0.0035***	0.0035***
	(0.0009)	(0.0009)	(0.0009)
R&D	0.2215***		0.2198***
	(0.0356)		(0.0356)
Age_cost	-0.4678***		-0.4652***
	(0.0645)		(0.0689)
Ind_com		0.0571***	0.0789***
		(0.0189)	(0.0198)
Fin_size		0.0014***	0.0013***
		(0.0003)	(0.0003)
CVs	YES	YES	YES
Year&Industry	YES	YES	YES
_cons	-0.0945**	-0.2648***	-0.1665***
	(0.0378)	(0.0345)	(0.0370)

N	18000	18000	18000
adj.R^2	0.175	0.184	0.152

V. Conclusion

Through the in-depth analysis of 18,000 sample observations, the study has fully verified that digital transformation has a significant positive impact on enterprise performance. The empirical results show that for every unit increase in the degree of enterprise digital transformation, enterprise ROE improves by 0.002 units on average, and this effect remains robust after controlling for year and industry fixed effects.ESG performance plays an important mediating role in the relationship between digital transformation and enterprise performance, and digital transformation indirectly contributes to the improvement of enterprise performance by enhancing ESG performance, with the mediating effect accounting for 39.5% of the total effect. The mediating effect accounts for 39.5% of the total effect. The moderating effect of business environment is also significant, and a good business environment increases the promotion effect of digital transformation on enterprise performance by 0.008 units, indicating that the external institutional environment has an important impact on the effectiveness of enterprise digital transformation. Heterogeneity analysis reveals the differentiated characteristics of the effect of digital transformation, and state-owned enterprises show a stronger performance enhancement effect in digital transformation, which may stem from their advantages in resource acquisition, policy support and other aspects.

Enterprises should combine digital transformation with ESG concepts, focus on social responsibility fulfillment while pursuing technological progress, and achieve both economic and social benefits. The government should continue to optimize the business environment, provide good external conditions for the digital transformation of enterprises, and support the digital development of enterprises through policy guidance, resource allocation, and institutional guarantee. These findings provide an important reference for enterprise digital strategy formulation and government policy optimization in the new era.

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