Digital transformation of enterprises empowers the development of new productive forces of enterprises

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Abstract. Based on the data of financial statements of A-share listed companies from 2015 to 2022 and ESG index data of Huazheng Company, this paper empirically analyzes the effect and mechanism of digital transformation on the new quality productive forces of enterprises. The results show that digital transformation can significantly promote the improvement of the new quality productive forces of enterprises, and the results are still valid after dealing with endogenous problems, eliminating special years and changing cluster test. Heterogeneity analysis shows that from the perspective of enterprise nature, the digital transformation of state-owned enterprises and high-tech enterprises has a more significant role in promoting the new quality productive forces of enterprises. The mechanism research shows that digital transformation can promote ESG practice of enterprises, and then promote the improvement of new quality productive forces level of enterprises. Therefore, it is proposed to accelerate the green transformation of enterprise development mode, promote the digital transformation of enterprises and corporate social responsibility governance by institutional supply, and strengthen the empowerment effect of internal governance of digital technology, hoping to provide useful reference for the development of new quality productive forces of enterprises.

Keywords: digital transformation; new quality productive forces; ESG; entropy method.

1. Introduction

In September, 2023, General Secretary Xi Jinping put forward the new concept of "new quality productive forces" for the first time when he presided over the symposium on the overall revitalization of Northeast China. The general secretary pointed out that integrating scientific and technological innovation resources will lead the development of strategic emerging industries and future industries and accelerate the formation of new quality productive forces. In 2024, the "Government Work Report" of the two sessions emphasized that "we should vigorously promote the construction of a modern industrial system and accelerate the development of new quality productive forces." At present, China's economy is in a critical period of transformation and upgrading from a high-speed growth stage to a high-quality development stage. The proposal of new productive forces not only enriches the connotation of productivity, but also points out the direction for China's high-quality economic development in the next stage. Compared with the traditional productive forces, the essence of new-quality productive forces is the concrete manifestation of advanced productive forces, with scientific and technological innovation playing the leading role, and on the basis of releasing people's creativity and protecting the ecological environment to the greatest extent, building a modern industrial system with strategic emerging industries and future industries as the pillars. Looking at the development and changes in the world in recent years, the driving force for global economic growth is mostly the change and development brought about by new technologies, thus forming new productive forces. Furthermore, to liberate and develop social productive forces, it is necessary to promote structural adjustment, optimize resource allocation, improve economic operation efficiency and finally achieve the goal of high-quality economic development through technological reform. At the same time, a new round of digital transformation revolution characterized by digitalization, intelligence and networking has brought profound changes to the production concept and management paradigm of enterprises, thus affecting the value creation ability of enterprises and becoming the key to the emergence of new quality productivity. Based on this realistic situation, it is of great significance to study the digital transformation of enterprises for the development of their new productive forces.

By summarizing the relevant literature, this paper finds that the essential characteristics of new quality productivity of enterprises can be understood from three aspects: (1) From the development stage, the development of new quality productivity of enterprises emphasizes the transition from extensive productivity to high-quality, efficient and sustainable production mode, so as to shape a more competitive development paradigm; (2) From the goal setting point of view, the development of enterprise's new quality productive forces should not only achieve economic benefits and meet the interests of shareholders, but also pay attention to social value creation and connect a wider range of stakeholders; (3) From the perspective of means of realization, enterprise innovation is the main driving force for enterprises to achieve the development goal of new quality productive force. Thus, the sustainable development concept of "green, efficient, sharing and innovation" is closer to the core of the new quality productive forces of enterprises. The basic view of natural resources emphasizes that the sustainable competitive advantage of enterprises in the future will come from the resources and ability of enterprises to respond to friendly natural environment. To sum up, this paper holds that the basic view of natural resources provides a suitable theoretical perspective for analyzing the relationship between digital transformation and new quality productive forces of enterprises. Based on this perspective, this paper holds that enterprise digital transformation can empower enterprise ESG practice, and then realize the development of enterprise new quality productivity. Therefore, the second work to be carried out in this paper is to study the intermediary effect of ESG on the new quality productivity of enterprises in digital transformation.

Looking back at the existing literature, first of all, many scholars have focused on the connotation analysis of new quality productive forces and the relationship between digital transformation and new quality productive forces for in-depth theoretical discussion. Jiang Cheng et al. Based on the perspective of complex system, this paper explores the internal mechanism and relationship of new quality productivity from macro, meso and micro levels. Zhai Yun et al based on the theoretical framework of "power-factor-structure", to investigate the development context and systematic impact of new quality productivity from the perspective of digital transformation. Undeniably, there is still a lack of micro-level empirical analysis from the perspective of digital transformation in current academic research. Secondly, the few empirical studies on the relationship between digital transformation and the development of new quality productive forces of enterprises focus on the improvement of the efficiency of financial resources utilization, ignoring the environmental strategy, green innovation and other factors related to the sustainable development of enterprises. Zhao Guoqing et al confirmed that the digital transformation of enterprises can promote the development of new quality productive forces by alleviating the financing constraints of enterprises.

The marginal contribution of this paper may be as follows: First, discuss the relationship between digital transformation and new quality productive forces from the quantitative dimension, and test whether the digital transformation of enterprises can affect the new quality productivity of enterprises, so as to provide useful reference for realizing the sustainable and high-quality development of enterprises. Secondly, from the perspective of ESG, the transmission mechanism of enterprise digital transformation to enterprise new quality productivity is discussed. ESG elements, a kind of normative non-financial information, is an important measure of the implementation level of sustainable development strategy. In this paper, enterprise digitalization, ESG performance and new quality productivity are linked. At present, there are few documents to study whether enterprise digitalization transformation can affect enterprise new quality productivity through ESG performance, which provides a new perspective and idea for revealing the influence mechanism of enterprise digitalization on enterprise new quality productivity.

2. Literature review

2.1 Research on the concept of digital transformation and digital level measurement

Wu Fei et al.believe that digital transformation is a process of reshaping enterprise organizational structure, strategic thinking, business processes and business models by using digital technologies

such as big data, Internet of Things, artificial intelligence, blockchain and cloud computing, and it is a strategy of driving value creation and enhancing core competitiveness through data. Generally speaking, there are three commonly used methods to measure the digital transformation of enterprises at present: ① A "0-1" virtual variable index of whether enterprises are undergoing digital transformation is constructed by manually sorting out the temporary and regular announcements of listed companies ;②Use the proportion of intangible assets related to digital transformation to measure; ③ Using text analysis technology to measure the word frequency related to digital transformation. These three measurement methods have their own advantages and disadvantages. The first method can obtain the degree of digital transformation of the respondents more directly, but considering that virtual variables are prone to over-identification, it cannot accurately reflect the true degree of digital transformation of enterprises; The second method is more targeted, but this method has some limitations because of the differences in industry and enterprise characteristics and sample size; The third kind of data comes from the annual reports of listed companies that have been impartial by third-party organizations, and the selection of digital characteristic keywords is relatively objective, which can truly reflect the level of digital transformation of enterprises. In view of this, this paper refers to the research of Wu Fei et al. to explore the influence of digital transformation on new quality productivity.

2.2 The connotation and promotion of new quality productivity

New-quality productivity is the terminology revolution of Marxist political economy, the theoretical innovation of the modernization of Marxism in China, the unique contribution of Xi Jinping's economic thought and the product of the combination of traditional productivity theory and the reality of China's economic development. Since General Secretary Xi Jinping put forward the concept of new quality productivity, the research literature on new quality productivity in academic circles has expanded greatly, mainly around the following dimensions. First, the connotation analysis of new quality productivity. Huang Qunhui et al. pointed out from the perspective of system theory that new quality productivity is an "element-structure-function" system composed of interrelated and functional productivity elements, productivity structure and productivity function. Zhai Qing et al. pointed out from the perspective of political economy that the new quality productivity belongs to the multi-dimensional breakthrough product of material productivity and spiritual productivity, the transformation of nature and social progress, which reflects the systematic change of the coordinated evolution of production technology mode and organization mode. Second, the impetus of new quality productivity. The research emphasizes that the new quality productivity can help the development of Chinese modernization by empowering modern science and technology, driving economic development and serving a better life. Xu Zheng et al. pointed out that new quality productivity can optimize the layout of major productivity, promote the deep integration and development of regional innovation centers and regional industrial systems, strengthen inter-regional synergy and integration, and drive regional high-quality development.

2.3 Digital Transformation and New Quality Productivity

First of all, the new quality productivity is dominated by technological innovation, which has the motivation of innovation, liberation and development. The proposal of new quality productivity embodies the era connotation of productivity transition caused by digital technology revolution, which has great practical significance. Accelerating the formation of new quality productivity is an important measure to win the initiative of development in the new era and new journey, and the digital transformation of enterprises can play a key role in the emergence of new quality productivity. In recent years, academic research on the impact of digital transformation has become increasingly rich, and research has been carried out in many aspects around the economic effects and non-economic performance of digital transformation. From a macro perspective, Li Ping pointed out that the digital economy can not only create a new industrial format and drive a new round of consumption and investment growth, but also achieve the multiplier effect of industrial total factor productivity by

empowering traditional industries. At the micro level, Song Deyong and others found that the digital transformation of enterprises is conducive to improving the level of green technology innovation of enterprises, and the impact on substantive green innovation is more obvious. The latest research explores the role of enterprise digital transformation in its ESG performance. Digital transformation provides enterprises with more efficient data collection, storage and analysis technology, which helps enterprises to better monitor environmental impact, thus improving environmental performance and helping enterprises to develop new quality productivity. Zhao Bei et al. research shows that enterprise digitalization can dynamically identify the pain points in the interaction between enterprises and society and feedback and evaluate management decisions, improve the communication efficiency with external stakeholders, enhance the level of enterprise information disclosure, further strengthen the information transparency space between enterprises and stakeholders, and finally create comprehensive value covering economy, society and environment.

To sum up, the existing research on digital transformation of enterprises mainly focuses on the impact of digital transformation on total factor productivity, innovation and other aspects, while the analysis of new quality productivity in enterprise digital transformation is relatively scarce. This paper tests the digital transformation of enterprises to promote the development of new productive forces, and expands the related research.

3. Theoretical Analysis And Research Hypothesis

3.1 Digital Transformation and New Quality Productivity

In the process of promoting digital transformation, enterprises integrate data into the whole process of production and operation as basic production factors, and realize the embedding of digital technology and traditional production mode, which can reorganize and optimize the technological process and the utilization of production resources, and realize better output under the original resource boundary by releasing the multiplier and multiplication effect of data elements. Specifically, enterprises applying digital technology to the production process and infiltrating into many factors of productivity can effectively overcome the resource constraints of traditional productivity, break through the constraints of diminishing returns to scale of traditional productivity, and create a production mode with increasing marginal production value, which promotes and causes profound changes and great development of productivity and helps the emergence of new quality productivity.

Therefore, this paper puts forward the following assumptions: digital transformation can promote the development of new quality productive forces.

3.2 Digital Transformation and ESG

ESG is a comprehensive evaluation of enterprise environment, society and corporate governance based on the concept of sustainable development, which emphasizes that enterprises are strictly required to carry out business activities in the field of environment and ethics according to law. Therefore, carrying out ESG practice can reduce short-sighted behavior in enterprise development and obtain long-term sustainable development resources. This paper holds that enterprise ESG performance plays an important role as a bridge between enterprise digital transformation and its new quality productivity. The specific reasons are as follows:

Enterprise digital transformation can empower enterprises to achieve better ESG performance, mainly through two dimensions: ability and motivation.

First, digital transformation helps enterprises to realize the embedding of digital technology and traditional production mode, help enterprises to reorganize and optimize process flow and production resource utilization, improve efficiency, and achieve better output under the original resource boundary. At the same time, digital transformation gives conditions for high-quality integration of green technology resources, helps enterprises to master stronger green innovation ability, and helps enterprises to solve environmental, social and governance problems more efficiently. Second, the digital transformation has improved the efficiency and disclosure quality of ESG-related information.

Enterprises can use digital technology to process the massive data information containing noise generated in production and operation and convert it into standardized usable information, thus increasing the quality and feasibility of enterprise information. Enterprises can also optimize the way of information disclosure through digital technology, which not only improves the ability of enterprises to perceive and obtain stakeholder information, but also can accurately transmit ESG signals to stakeholders, thus reducing the degree of information asymmetry and further improving the quality of information disclosure of enterprises. High-quality information can cover the objective data of environment, society and governance, so as to quantify the efforts made by enterprises in ESG, which is conducive to obtaining the resource support of stakeholders such as government, banks and institutional investors, and thus promoting the development of new quality productivity of enterprises. Third, enterprises can not only apply digital technology to report and disclose internal governance information and decision-making process, improve the level of internal governance, but also easily cross organizational boundaries and carry out high-risk activities such as innovative research and development, promote technological and product innovation on the basis of fully integrating information and knowledge, and promote the coordination and complementarity between internal governance mechanism and external digital economy development environment, thus promoting the continuous development of new quality productivity.

At the same time, the digital transformation of enterprises can also enhance their motivation to improve ESG performance, mainly because of the incentive of sustainable development orientation of enterprises. Digital transformation strengthens the willingness and motivation of enterprises to improve ESG performance by improving the overall operational efficiency of enterprises and promoting them to fulfill more environmental, social and governance responsibilities. The digital transformation of enterprises conforms to the current development trend of digital economy, and such enterprises that conform to the national policy orientation are more likely to be supervised by the government and institutions. This focus magnifies the misconduct in the daily operation of enterprises and greatly increases the internal and external pressures faced by enterprises. At this time, enterprises will avoid bad performance in environmental, social and governance dimensions and improve the ESG performance of enterprises under the consideration of reputation with higher external attention. Especially under the background of the national goal of "accelerating the development of new quality productivity", enterprises need to do better in ESG, which is more in line with the orientation of sustainable development, in order to realize the development of new quality productivity.

Therefore, this paper puts forward the following assumptions: the digital transformation of enterprises can promote the ESG performance of enterprises, and then promote the development of new quality productivity.

4. Model design and variable description

4.1 Sample Selection and Data Source

This paper selects the financial statement data of China A-share listed companies from 2015 to 2022, and the ESG index data of Huazheng Company, and processes the related data as follows: ① Eliminate the samples of listed companies with ST and *ST;②Excluding samples from the financial industry; (3) Keep only enterprises with at least 3 years' observations;④Truncation of all continuous variables at 1% and 99% levels. Finally, an unbalanced panel data set consisting of 13,467 observations was obtained. The data used in this study mainly comes from the national Taian database.

4.2 Description of variables

4.2.1 Interpreted variables

The explained variable in this paper is the enterprise new quality productivity (NPro). This paper mainly refers to the method of Song Jia et al., and uses the entropy method to construct the new quality productivity index of enterprises. The specific method is as follows:

First, select strategic emerging industries and future industries closely related to new quality productivity as samples for calculating new quality productivity.

Second, draw lessons from the existing research, and build a new qualitative productivity index system based on the theory of two elements of productivity. Among them, productivity includes two elements: labor and production tools. Among them, the labor force is composed of living labor and labor objects, while the production tools are composed of hard technology and soft technology. For living labor, the sub-factor indicators are the salary of R&D personnel, the proportion of R&D personnel and the proportion of highly educated personnel. For the labor object, the sub-factor indicators choose the proportion of fixed assets and the proportion of manufacturing expenses to measure; For hard technology, the sub-factors are measured by the proportion of R&D direct investment, depreciation and amortization, rental expenses and intangible assets. For soft technology, the sub-factors are measured by total asset turnover rate and equity multiplier. Considering that the higher the equity multiplier, the higher the financial risk of the enterprise, which is a negative indicator. Therefore, the reciprocal of the equity multiplier is used to represent it. The higher the reciprocal, the lower the risk of the enterprise, indicating that the productivity level of the enterprise is better. The values of the above indicators are shown in Table 1.

Table1 Indicators of new quality productivity of enterprises

considerations	subfactor	norm	Description of Indicator values	weights
Labor force	labor	Percentage of R&D salaries	Research and Development expenses -salaries and wages/operating income	26
		Percentage of R&D staff	Number of R&D staff/Number of employees	2
		Percentage of Highly educated personnel	Number of Undergraduates and above/Numberof employees	3
		Share of manufacturing costs	Fixed assets/total assets	1
	target audience	Share of manufacturing costs	(Subtotal cash outflows from Operating activities+ Depreciation of fixed assets+intangible assets) Amortization+ provision for impairment-cash paid for purchases of goods and services-expenditures (Payments to and on behalf of employees)/ (Cash from operating activities)	1

			Subtotal outflows+ Depreciation of fixed assets+amortization Of intangible assets+ provision for impairment)	
	Hard technology	R&D depreciation and amortization as a percentage of	R&D expenses-depreciation and amortization/operating income	24
		R&D lease payments as a percentage of	Research and development expenses -lease payments/operating	13
Production tool		R&D direct investment as a percentage	R&D expenses-direct inputs/operating income	27
		Intangible assets as a percentage	Intangible assets/total assets	1
	Soft technology	Total asset turnover	Operating income/average total assets	1
		Inverse equity multiplier	Owners' equity/total assets	1
New quality productivity				100

4.2.2 Explanatory variables

Referring to the existing research, this paper adopts the "Enterprise Digital Transformation Word Bank" in CSMAR database to extract the digitization level of the enterprises for measurement. The CSMAR database is based on the research of Wu Fei et al.

4.2.3 Mediating variables

In this paper, we refer to the methodology of Xie Hongjun et al., and adopt the data of CSI ESG rating system, which is divided into nine grades from C to AAA from good to bad, and assigns values 1-9 from low to high. CSI ESG rating system can fully integrate the development of China's capital market and accurately represent the ESG performance of Chinese local enterprises. At the same time, the rating index system distinguishes three dimensions, namely environment, society and governance, with multiple sub-topics and a large number of specific indicators to reflect the level of ESG management practices of enterprises.

4.2.4 Control variables

Referring to the research literature of Song Jia et al., this paper uses firm age (Age),shareholding concentration (TOP), percentage of sole directors (BI), board size (Boa), two positions (Dua), and audit opinion (AO) as the control variables in this paper, respectively. Meanwhile, this paper also sets region, industry and year dummy variables to control region effect, industry effect and year effect. The main variables in this paper are shown in Table 2:

Table2 List of variable definitions

Variable type	Variable name	Variable symbol	Methods of measurement
Explained variable	Enterprises' new quality	NPro	Enterprises’ new quality productivity measured using the

	productivity		entropy method
Explanatory variable	Enterprise Digital Transformation	DT	Adoption of enterprise digitization levels in the CSMAR database
Intermediary variable	Enterprise ESG performance	ESG	Adoption of CSI ESG rating system data
Control variable	Age of business	Age	Current year-year of establishment of the enterprise
	Shareholding concentration	TOP	Percentage of top ten shareholders
	Percentage of sole director	BI	Percentage of independent directors on the board of directors
	Board size	Boa	Logarithm of the number of board members
	Two jobs in one	Dua	If the chairman and general manager are combined,it is 1,and vice versa, it is 0
	Audit opinion	AO	Audit opinion is 1 when the audit is unqualified and 0 when it is not

4.3 Model construction

To test the research hypotheses H_1, the following regression model (1) is constructed in this paper:

$$NPro_{it} = \alpha_0 + \alpha_1 DT_{it} + \Sigma Control_{it} + \Sigma Ind + \Sigma Pro + \Sigma Year + \varepsilon_{it} \quad (1)$$

Among them, NPro stands for the new quality productivity of enterprises; DT stands for digital transformation of enterprises; Control represents all control variables; Ind, Pro and Year are fixed effects, representing industry fixed, region fixed and year fixed respectively; Is a random perturbation term; Subscripts I and T stand for individual enterprise and time respectively.

Mechanism test model. As mentioned above, ESG plays a mechanism transmission role in the influence of digital transformation on the development of new productivity. Considering that there is still controversy in the academic circles about whether the step-by-step test is applicable to the field of economics, following the suggestion of Jiang Boat's intermediary effect operation, and in order to test the research hypothesis, according to Jiang Boat's suggestion on the study of transmission mechanism, this paper constructs the transmission mechanism model as follows:

$$ES_{it} = \beta_0 + \beta_1 DT_{it} + \Sigma Control_{it} + \Sigma Ind + \Sigma Pro + \Sigma Year + \varepsilon_{it} \quad (2)$$

$$NPro_{it} = \delta_0 + \delta_1 ES_{it} + \Sigma Control_{it} + \Sigma Ind + \Sigma Pro + \Sigma Year + \varepsilon_{it} \quad (3)$$

In addition, formula (2) is used to test "the causal relationship between DT and ESG". Assuming that the formula (2) is significantly positive and the formula (3) has empirical support for the influence of ESG on the productivity of new quality, it shows that the transmission mechanism exists.

5. Empirical Analysis

5.1 Descriptive statistics

Descriptive statistical analysis shows that. The average value of NPro, the explained variable, is 5.55, the standard deviation is 5.11, the minimum value is 1.14, and the maximum value is 16.3, which indicates that the level of NPro of different listed enterprises is quite different, and the overall level of NPro of Chinese enterprises is low, so there is still much room for improvement. In addition, there are obvious differences between the minimum value and the maximum value of the explanatory variable enterprise digitalization (DT), which shows that different listed companies have different degrees of digital transformation, and also shows that the sample selected this time covers a wide range, which is also helpful to the representative of the research conclusions. The statistical distribution of other control variables is reasonable and similar to the existing literature. The results of collinearity test of each variable show that the vif values are between 1.005 and 1.570, both of

which are lower than 10, indicating that there is no significant multicollinearity problem in regression, which meets the research conditions.

Table 3 Descriptive statistics

Variant	Obs	Mean	Median	SD	Max	Min
NPro	13467	5.55	2.55	5.11	16.3	1.14
DT	13467	2.31	1.18	2.20	5.46	0.69
Age	13467	2.92	0.30	2.94	3.61	1.95
TOP	13467	0.58	0.15	0.58	0.91	0.21
BI	13467	0.38	0.05	0.36	0.60	0.33
Boa	13467	2.11	0.19	2.20	2.64	1.61
Dua	13467	0.30	0.46	0.00	1.00	0.00
AO	13467	0.98	0.13	1.00	1.00	0.00

Table 4 Variance inflation factor

	VIF	1/VIF
DT	1.036	.965
Age	1.059	.945
TOP	1.059	.944
BI	1.520	.658
Boa	1.570	.637
Dua	1.053	.949
AO	1.005	.995
Mean VIF	1.186	.

5.2 Benchmark model regression

Based on the model (1), the fixed effect model is used to empirically test the research hypothesis, that is, to examine the specific impact of enterprise digitalization (DT) on the new quality productivity of enterprises, so as to verify whether the hypothesis is established. Table 5 shows the benchmark regression results, and column (1) shows the direct regression results between explanatory variables and explained variables; Column (2) and column (3) respectively represent the fixed effect of control and the regression result after adding control variables; Column (4) shows the regression result after controlling the fixed effect of region, industry and year at the same time and adding all control variables. It can be seen from the results that the influence of enterprise digitalization on the new quality productivity level of enterprises is always positive after the control variables and fixed effects are gradually added. In column (4) of Table 5, the influence coefficient of enterprise digitalization (DT) on enterprise new quality productivity (NPro) is 0.264, which passed the significance test at the level of 5%, indicating that enterprise digitalization transformation has a significant positive impact on new quality productivity. This paper assumes that it is true. This means that digital transformation plays a key role in accelerating the emergence of new-quality productive forces. By applying digital technology to the production process and infiltrating many factors of productive forces, it can be transformed into actual productive capacity, which can promote and cause profound changes and great development of productive forces, and promote the development of strategic emerging industries and future industries, so as to realize the emergence of new-quality productive forces.

Table 5 Benchmark model regression results

	(1) NPro	(2) NPro	(3) NPro	(4) NPro
DT	0.475***	0.263**	0.473***	0.264**
	(2.88)	(2.00)	(2.99)	(2.00)
Age			-0.484***	-0.101
			(-2.68)	(-0.72)
TOP			-0.892**	0.084
			(-2.00)	(0.21)

BI			2.792***	1.969**
			(2.79)	(2.39)
Boa			0.932***	0.730***
			(2.85)	(2.66)
Dua			-0.283***	-0.200**
			(-3.40)	(-2.64)
AO			0.181	-0.041
			(1.06)	(-0.26)
_cons	4.454***	4.945***	3.269**	3.004***
	(15.87)	(16.25)	(2.57)	(3.17)
Province	NO	YES	NO	YES
Industry	NO	YES	NO	YES
Year	NO	YES	NO	YES
N	13467	13467	13467	13467
Adj. R2	0.05	0.28	0.06	0.28

Note: *, * * and * * represent the significance levels of 10%, 5% and 1% respectively, and t statistics and industry clustering are in brackets. The same below.

5.3 Research on the Mechanism of Enterprise ESG Performance

Columns (1) and (2) in Table 6 are the regression results with ESG as the intermediate variable. The data in column (1) shows that the influence coefficient of enterprise digital transformation on enterprise ESG performance is 0.554, which is significantly positive at the level of 5%, verifying "the causal relationship between DT and ESG". Column (2) indicates that the hypothesis has been verified, and the empirical results of Song Jia et al.show that ESG development has a significant role in promoting the level of new quality productivity of enterprises, mainly by improving the relationship between enterprises and stakeholders, reducing the level of financing costs and increasing the proportion of institutional ownership. Therefore, it shows that good ESG performance is an intermediary variable for the digital transformation of enterprises to promote the development of new quality productivity, and the hypothesis is confirmed.

Table 6 Mechanism analysis: corporate ESG performance

	(1) ESG	(2) NPro
DT	0.054**	0.264**
	(2.24)	(2.00)
Age	0.155**	-0.101
	(2.53)	(-0.72)
TOP	0.857***	0.084
	(7.62)	(0.21)
BI	2.777***	1.969**
	(8.88)	(2.39)
Boa	0.592***	0.730***
	(7.18)	(2.66)
Dua	-0.100***	-0.200**
	(-2.98)	(-2.64)
AO	0.911***	-0.041
	(9.44)	(-0.26)
_cons	-0.031	3.004***
	(-0.11)	(3.17)
Province	YES	YES
Industry	YES	YES
Year	YES	YES

N	13467	13467
Adj. R2	0.11	0.28

5.4 Endogeneity test

In order to reduce the problem of endogeneity due to omitted variables, this paper adopts the instrumental variable method for endogeneity testing. The development of enterprise new quality productivity is a long-term process, and the impact of enterprise digital transformation may have a lag effect. Therefore, the explanatory variables lagging one and two periods are selected as instrumental variables for endogeneity test respectively. First of all, from the first stage regression results in Table 7, the coefficients of the selected instrumental variables are all significantly positive, which excludes the problem of weak instrumental variables; further from the second stage regression results, the ESG coefficients are all significantly positive at the 5% level, which indicates that after considering the endogeneity problem, the conclusion that the enterprise digital transformation can significantly affect the enterprise's new-quality productivity is established, and this paper's research hypotheses are H_1has been verified again.

Table 7 Endogeneity test

	(1) Phase I	(2) Phase II	(3) Phase I	(4) Phase II
DT		0.369**		0.446**
		(2.27)		(2.43)
L.DT	0.812***			
	(56.03)			
L2.DT			0.708***	
			(35.33)	
Age	0.002	-0.050	0.006	-0.044
	(0.07)	(-0.36)	(0.14)	(-0.32)
TOP	0.071**	0.233	0.132**	0.315
	(2.11)	(0.56)	(2.42)	(0.74)
BI	-0.027	1.914**	-0.052	2.067**
	(-0.22)	(2.06)	(-0.25)	(2.20)
Boa	0.035	0.671**	0.070	0.659**
	(0.85)	(2.32)	(1.12)	(2.11)
Dua	0.029**	-0.226***	0.041**	-0.223**
	(2.39)	(-2.74)	(2.09)	(-2.53)
AO	0.044	-0.124	0.107	-0.010
	(0.94)	(-0.88)	(1.63)	(-0.07)
_cons	0.363***	2.812***	0.493**	2.442**
	(3.44)	(2.69)	(2.46)	(2.14)
Province	YES	YES	YES	YES
Industry	YES	YES	YES	YES
Year	YES	YES	YES	YES
N	10900	10900	9044	9045
Adj. R2	0.80	0.29	0.71	0.29

5.5 Other Robustness Tests

First, anomalous years are excluded. Considering that business operations are affected during the new crown epidemic, business decisions will prefer conservative decisions, which will have an impact on the development of new quality productivity of enterprises. In order to reduce the uncertainty of abnormal years on the research results, the regression is conducted after excluding the three years of data from 2020-2022. From the regression results in column (3) of Table 8, the DT coefficient is significantly positive at the 5% level, which indicates that the digital transformation of enterprises

has a promoting effect on the level of new quality productivity of enterprises after excluding abnormal years, and the hypothesis of this paper is?1 is once again Validated.

Second, change clustering test. This paper controls for industry clustering in the baseline regression, but there are correlations between different industries, firms within different regions, and even between the operations of various firms, so changes in productivity levels between firms may be correlated, and in order to make the research conclusions more robust, this paper carries out further robustness analyses by changing the standard error clustering hierarchy. From the regression results in Table 8, the DT coefficients are all significantly positive at the 1% level after changing to industry ×year clustering and regional clustering, and the coefficient values are unchanged, the constant term is unchanged, and the adjustment. There is also no significant change, indicating that the conclusion that there is a significant positive relationship between enterprise digital transformation and new quality productivity under different clustering levels is valid.

Table 8 Robustness test

	(1) Exclusion anomalous years	(2) Industry Clustering	(3) Year regional clustering
DT	0.231*	0.264***	0.264***
	(1.81)	(5.03)	(4.52)
Age	-0.114	-0.101	-0.101
	(-0.69)	(-1.53)	(-0.68)
TOP	-0.257	0.084	0.084
	(-0.60)	(0.46)	(0.25)
BI	2.337***	1.969***	1.969*
	(3.14)	(4.71)	(1.81)
Boa	0.843***	0.730***	0.730***
	(3.18)	(5.93)	(2.89)
Dua	-0.173*	-0.200***	-0.200***
	(-1.87)	(-4.86)	(-3.28)
AO	-0.210	-0.041	-0.041
	(-0.90)	(-0.35)	(-0.20)
_cons	3.026***	3.004***	3.004***
	(3.44)	(6.62)	(2.78)
Province	YES	YES	YES
Industry	YES	YES	YES
Year	YES	YES	YES
N	7592	13467	13467
Adj. R2	0.27	0.28	0.28

6. Heterogeneity analysis

Next, this paper will conduct a detailed study of the role of digital transformation in different types of enterprises, which will be used to identify the differential response of digital transformation of enterprises with different characteristics to the new quality productivity of the enterprise, so as to complement the conclusions of this paper. First, enterprise property rights heterogeneity. Considering that there are large differences between Chinese SOEs and private firms in terms of policy support, industry status, business objectives, social responsibility, etc., which will undoubtedly have an impact on the promotion of new quality productivity by digital transformation of firms. From the regression results in columns (1) and (2) of Table 9, the promotion effect of digital transformation on new quality productivity is more significant in state-owned enterprises compared to non-state-owned enterprises, reaching the 1% significance level. This may be due to the fact that state-owned enterprises tend to

have more convenient access to government support and resources, as well as more social responsibility, and are subject to stricter government regulation and heated discussions among the public, consumers and investors, etc. , the higher degree of external attention will make state-owned enterprises more inclined to be more in line with the orientation of sustainable development in order to achieve the goal of the development of new-quality productivity; and the process of digital transformation of non-state-owned enterprises is faced with more challenges, limiting the strategic choices, and the digital transformation of non-state-owned enterprises has been more significant in the state-owned enterprises. challenges, limiting strategic choices and focusing more on short-term economic benefits, which in turn inhibits pro development. Second, the heterogeneity of the industry to which the enterprise belongs. The technological level and related technology reserves of enterprises profoundly affect the development strategy of enterprises, and also affect the development of new quality productivity of enterprises. In order to test the differences in the impact of firms' industry heterogeneity on the research findings, this paper divides high-tech firms into one group and non-high-tech firms into another group. From the regression results in columns (3) and (4) of Table 9, the DT coefficients of high-tech firms are significantly positive at the 10% level, and the DT coefficients of non-high-tech firms are insignificant, indicating that the DT development of high-tech firms has a significant contribution to the firms' new productivity, while that of non-high-tech firms is insignificant in promoting the firms' new productivity. This may be due to the following reasons: on the one hand, high-tech enterprises pursue continuous scientific and technological innovation to improve production efficiency and optimize production processes; while non-high-tech enterprises tend to rely on more mature production technology or focus on service level, and rely on a relatively low degree of high-tech content and innovation, as well as a relatively insufficient supply of technology at the same time. On the other hand, high-tech industry competition is fierce, the more the need for digital transformation, to win the digital dividend, to obtain more value growth. And in this process, enterprises use advanced digital technology to realize low-input, high-efficiency business model, save resources and innovate green output, which enhances the new quality productivity of enterprises. In contrast, the lower degree of competition in non-high-tech industries, where firms are less constrained by their competitors, weakens the incentives for firms to utilize digital transformation to improve firms' new-quality productivity in order to gain an advantage.

Table 9 Analysis of firm heterogeneity

	(1) nationalized business	(2) non-state enterprise	(3) High-tech enterprises	(4) Non-high-tech enterprises
DT	0.491***	0.196	0.339*	0.066
	(4.58)	(1.47)	(2.09)	(0.58)
Age	-0.369	-0.121	-0.183	-0.004
	(-1.09)	(-0.89)	(-1.18)	(-0.02)
TOP	0.756	-0.533	-0.211	0.701
	(1.08)	(-1.50)	(-0.56)	(0.93)
BI	-0.538	2.215**	2.755**	0.348
	(-0.48)	(2.43)	(2.73)	(0.33)
Boa	0.541	0.300	0.822*	0.575
	(1.50)	(1.06)	(2.07)	(1.48)
AO	-0.050	0.001	-0.069	0.105
	(-0.13)	(0.01)	(-0.32)	(0.45)
_cons	4.653**	4.084***	3.125**	2.937*
	(2.52)	(5.05)	(2.51)	(1.88)

Province	YES	YES	YES	YES
Industry	YES	YES	YES	YES
Year	YES	YES	YES	YES
N	4042	9042	8398	5069
Adj. R2	0.39	0.27	0.21	0.37

7. Research findings and policy recommendations

7.1 Conclusions of the study

With the vigorous development of a new generation of digital technologies represented by cloud computing, big data, blockchain, artificial intelligence, etc., digital transformation has become an inevitable requirement for enterprise survival and a new kinetic energy for high-quality development. This paper takes Chinese A-share listed companies from 2015-2022 as the research object, and empirically examines the impact of enterprise digital transformation on new quality productivity and its functioning mechanism. The study shows that digital transformation has a significant positive effect on the improvement of new quality productivity, and digital transformation can improve new quality productivity by improving ESG performance. Further tests found that the effect of digital transformation on new productivity is more obvious in state- owned enterprises and high-tech enterprises.

7.2 Recommendations for countermeasures

The findings of this paper have the following three implications for corporate strategic decision making and government policy making: First, accelerate the green transformation of the development mode. "Green development is the underlining color of high-quality development, and new-quality productivity is itself green productivity." The development of new quality productivity, first, to clarify the dialectical relationship between ecological protection and social development. Through digital technology empowered ecological precision management, the use of intelligent means to achieve resource recycling, to meet the use of natural resources, protection of natural values, value-added natural capital of high-quality development needs, and give full play to the good ecological environment on the development of productive forces to promote, support and shape. Second, accelerate the green transformation of production methods. Through green technological transformation and optimization of energy structure, we will accelerate the improvement of energy efficiency of traditional industries and realize the "low-carbon nature" of high-quality development. Adopt advanced energy-saving technologies and clean production methods to reduce energy consumption and pollutant emissions in high-polluting industries; actively promote the use of clean energy and renewable energy, gradually reduce dependence on fossil energy, promote the transformation and upgrading of the energy system, and realize the green development of new productivity. Secondly, the supply of systems to promote the digital transformation of enterprises and corporate social responsibility governance. On the one hand, it is necessary to continuously optimize the macro-policy framework for promoting the digital transformation of enterprises, focusing on the formulation of a policy system that combines innovation policy and industrial policy for the digitalization strategy, so as to promote the acceleration of the construction of the digitalization system of enterprises in the process of high-quality development; on the other hand, it is necessary to accelerate the construction of the governance system of corporate social responsibility in the light of the involvement of digital technology, in particular, the construction of a governance system of corporate digital responsibility. On the other hand, it is necessary to accelerate the construction of corporate social responsibility governance system under the involvement of digital technology, especially to accelerate the construction of social responsibility governance system for digital enterprises, to promote the construction of standardized system of corporate digital governance, and to better promote the development of new quality productivity of enterprises based on the digital transformation and the sustainable development of society. Third, strengthen the enabling effect of

digital technology on internal governance. On the one hand, enterprises need to deeply utilize the empowering opportunities of digital technology, actively adapt to and lead the innovation of internal governance means and modes of governance in the digital context, deeply embed digital intelligent technology in the governance system of enterprise stakeholders, and create a digital space of value transparency and value interaction. On the other hand, enterprises should take the initiative to adapt to the new paradigm of digital governance, and improve the participation and transparency of external stakeholders in corporate governance, especially in the decision-making of major matters. Efforts should be made to build a "governance platform" in the digital context, reconstruct the dynamic mechanism for effective stakeholder participation based on the digital platform, enhance the dynamics and responsiveness of stakeholder participation in the enterprise's operation and management process, and improve the dynamic governance rate of stakeholders' disclosure of the enterprise's operation and social responsibility information.

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