WEP Warwick Evans Publishing

Transactions on Economics, Business and Management Research
ISSN: 2960-1789, eISSN: 2960-2254 | Volume 6
FEMS 2024

Research on the Impact of Digital Transformation on Enterprise ESG Rating Performance

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Abstract. Up against a new round of technological revolution, it has become an important strategic means for enterprises to accelerate digital development and promote the digital transformation of economic activities. Empirically testing the impact and mechanism of digital transformation of listed companies on ESG performance, this paper draws the following conclusions. Digital transformation of enterprises can significantly improve ESG performance, and the higher the quality of enterprises' internal control, the more positive the effect of digital transformation on ESG performance. For non-state-owned enterprises, the positive impact of digital transformation on ESG performance is more significant. This article incorporates digital transformation and ESG performance into the same analysis framework, expands existing research, and puts forward corresponding suggestions and prospects.

Keywords: Enterprise Digital Transformation; ESG; Internal Control.

1. Introduction

ESG puts forward requirements for enterprises to fulfill their environmental responsibilities and achieve green development, which is a further manifestation and extension of corporate social responsibility (CSR) [1]. After the dual carbon goal was proposed, China accelerated the regulations of ESG information disclosure and the information disclosure system was improved. According to data from the China Securities Regulatory Commission, a total of more than 1,700 listed enterprises will disclose sustainable development-related reports in 2023. ESG ratings usually reflect the strength of an enterprise's ability to deal with environmental risks. Enterprises with good ESG performance have been shown to have a higher sense of social responsibility and a more optimized governance structure. With the increasing importance of issues such as global climate change, social justice, and corporate transparency, the status of ESG in corporate operations and investment decisions has been further enhanced.

According to the 14th Five-Year Plan, the digital economy is a vital means to promote economic development in the future. Conducting a comprehensive digital transformation of China's existing economy can generate more efficient productivity value for existing production relations and production elements, and build a firm cornerstone for the rapid development of China's economy in the future. As the micro-subject of the market economy, the quality of its digital construction will directly determine the development of the digital economy. Enterprises' digital transformation is a process of relying on new digital means to improve the data liquidity and the distribution structure of production factors, so as to ultimately enhance the enterprises' competitiveness in the market [8].

Many scholars have researched digital transformation, but there are few related literature on the relationship between digital transformation and ESG performance. Some scholars have mentioned that digital transformation can optimize the allocation of internal and external resources of enterprises, enhance sustainable development capabilities, and achieve green and inclusive growth [4]. Qi Huaijin et al. focused on the achievements of digital technology and digital transformation of enterprises [6], which found that the development of digital finance, especially the improvement of coverage and depth of use, has significantly promoted enterprises to fulfill their social responsibilities. Most scholars mainly discuss digital transformation and corporate economic performance or financial

performance, while research on non-economic performance such as corporate digital transformation and ESG performance is still relatively scarce. Hence, there is a lack of corresponding mechanism research.

The possible marginal contributions of this paper are reflected as the following. First, enterprise digital transformation and enterprise ESG performance are incorporated into the same analysis framework to explore the economic effects of digital transformation from the perspective of enterprise ESG performance and broaden the existing research on enterprise ESG. Secondly, this paper uses the data of Shanghai and Shenzhen A-share listed companies from 2009 to 2022 to prove the relationship between digital transformation and ESG. At the same time, it studies the impact of the interaction between internal control and digital transformation on ESG. Thirdly, this paper divides the whole sample into different time periods and enterprise nature, which verifies the relationship between digital transformation and ESG performance in different samples.

2. Literature Review

(1) Research on ESG

With regard to the research on ESG ratings, Zumente and Lāce analyzed the ESG rating methods of different rating agencies [9], which proposed that ESG ratings are not only important for investors, but also for enterprises. Fama and Mac proved the positive correlation between ESG rating and return on investment through regression [12]. However, Gerhard and Gregor put forward that it is difficult for investors to verify their positive correlation, and the correlation between ESG rating and investment return is very low [13]. Meanwhile, Drei et al. found that the correlation between factor investment and ESG investment is increasing [14].

As for the research on the impact of enterprise ESG, domestic and foreign literature lay more emphasis on the impact of enterprise ESG performance on enterprise financial performance, enterprise value, and market risk. Giese et al. analyzed how enterprise ESG affects enterprise financial performance through transmission mechanisms including cash flow, unsystematic risk and valuation, which concluded that ESG rating is a vital indicator reflecting enterprise financial status [15]. According to Cerqueti et al., during the period of low volatility, the relative market value loss of funds with high ESG ratings is lower than that of funds with low ESG ratings, and then concluded that ESG can reduce systemic risk, which is crucial for asset managers and policymakers [16].

(2) Research on Digital Transformation

Through empirical evidence obtained by Tu Xinyu and Yan Xiaoling, it is concluded that the digital transformation of enterprises can improve the enterprises' total factor productivity by accelerating the knowledge spillover effect [24]. Based on the empirical evidence of text analysis methods and empirical analysis, Huang Dayu et al. found that digital transformation can significantly promote the enterprises' value, and the channel mechanism of improving technological innovation capabilities and factor allocation through digital transformation has once again verified that digital transformation can improve the enterprises' value [25]. With a five-sector input-output model including the digital economy, Wang Kaike et al. proved that the digital economy has a significant effect on improving social production efficiency [27].

(3) Research on Digital Transformation and ESG

Wang & Esperança divided digital transformation into digital resources, digital organization, digital adoption and digital innovation culture [28]. Through fsQCA and PLS-SEM, it is found that digital transformation and enterprise competitiveness can positively affect enterprise ESG performance through its intermediary variable of market performance, which discovered that digital innovation culture can positively affect ESG performance through two paths: digital adoption and enterprise competitiveness, digital adoption and digital management.

Zhong et al. [29] found that digital transformation has a significant positive impact on enterprise ESG performance through empirical research and figured out three driving factors of digital transformation such as reducing management myopia, improving the transparency of enterprise internal information, and promoting enterprise technological innovation. Through the spatial Durbin model, Kwilinski et al. found that digital transformation has a significant spatial spillover effect on ESG performance [30].

3. Theoretical Mechanism and Research Hypotheses

(1) Enterprise Digital Transformation and Enterprise ESG Performance

In addition to optimizing energy utilization and production processes through real-time monitoring and data analysis, digital transformation can improve resource utilization efficiency and environmental sustainability, help enterprises reduce environmental risks and impacts, and promote environmental sustainability.

Digital transformation provides more social and interactive channels, enabling enterprises to better communicate and collaborate effectively with employees, customers, suppliers and other stakeholders. Through the digital platform, enterprises can provide better customer service and user experience to meet diverse users' needs.

According to the theory of information asymmetry, digital transformation can help enterprises disclose information efficiently, which is beneficial for internal and external stakeholders to obtain information and enhance the transparency of enterprise internal information, thereby increasing the opportunity for real information to be disclosed in public, reducing enterprise greenwashing risks, and enhancing the transparency and efficiency of enterprises in terms of governance. Digital technology provides more efficient tools for data collection, processing and analysis, enabling enterprises to achieve better decision-making and risk management. Digital transformation can also improve the internal communication and collaboration of enterprises, promote the optimization of organizational structure and processes, and improve the efficiency and quality of enterprise operations.

From this, hypothesis 1 is proposed:

H1: Enterprise digital transformation can improve ESG performance.

During the digital transformation, enterprises face many risks and challenges such as information security and privacy protection. Accurately identifying, assessing and managing these risks is crucial to the sustainable development of enterprises. High-quality internal control can effectively reduce potential risks and avoid risk events such as information security leakage and data loss. At the same time, it can improve the governance of enterprises, better fulfill social responsibilities, and fully consider environmental friendliness and social interests.

During the digital transformation, enterprises need to cooperate and communicate with various stakeholders such as employees, suppliers, investors, and consumers. High-quality internal control can help companies establish reliable data and information communication channels, protect the rights and interests of stakeholders, and enhance their trust in the enterprise, thus providing stronger support for digital transformation, which will help enterprises better achieve ESG goals and improve corporate image and reputation.

Therefore, hypothesis 2 is proposed:

H2: With other conditions unchanged, the higher the quality of enterprise internal control, the more digital transformation can improve ESG performance.

4. Data Sources, Research Design and Indicator Construction

(1) Indicator Construction

1. Selection of Dependent Variable (ESG performance)

Enterprise ESG Performance (ESG). According to Hu Jie et al. [2], Xie Hongjun and Lu Xue [3], the data of the ESG rating system from the Sino-Securities Index Information Service Co., Ltd is used in the benchmark model to measure the enterprise ESG performance. The evaluation indicators at the current development such as the quality of information disclosure, punishment by the China Securities Regulatory Commission, targeted poverty alleviation, etc., are divided into 9 grades, each assigned 1-9 points. In the robustness test, the enterprise ESG performance ratings provided by Bloomberg and Wind are further selected as alternative explanatory variables for testing to ensure the robustness of the conclusions.

2. Selection of Independent Variable (enterprise digital transformation)

Enterprise Digital Transformation (Digital). Drawing on Wu Fei et al. [19], this paper uses the word frequency statistics on digital transformation in the annual report to build enterprise digital transformation indicators, such as word frequencies of "artificial intelligence technology", "big data technology", "blockchain technology", "Cloud computing technology" and so on are summarized to build enterprise digital transformation indicators.

3. Moderating Variable

Internal Control (Inside). Internal control is the rational allocation of resources and internal constraints for enterprises to improve production efficiency. Based on Liu Bin et al. [20], Chen Xiaojun and Ji Fuxing [21], Chinese A-share listed enterprises are selected to score their internal control. The database is the DIBO internal control quality database.

4. Control Variables

Table 1. Control Variables

Name	Symbol	Definition
Enterprise Size	Size	Natural logarithm of total assets at the end of the year
Asset-Liability Ratio	Lev	Total Liabilities/Total Assets
Return on Assets	ROA	Average balance of net profit/total assets
Cash Flow Ratio	Cashflow	Net cash flows from operating activities/Total current liabilities
Operating Income Growth Rate	Growth	(Amount of operating income for the current year—Amount of operating income for the same period last year)/(Amount of operating income for the same period last year)
Board Size	Board	Number of board directors
Independent Director Ratio	Index	Ratio of the number of independent directors to the size of directors
Equity Concentration	Top10	Shareholding ratio of Top10 shareholders
CEO Duality	Dual	Whether the chairman and the general manager are the same person, 0 = no, 1 = yes
Equity balance	SharesBalance	Shareholding ratio of the 2nd to 5th largest shareholder/shareholding ratio of the largest shareholder
Audit Opinion Type	Audit	Whether the type of opinion issued by the audit firm on the content of the annual report after the audit is a standard unqualified opinion, 0 = No, 1 = Yes
Whether the Auditors Come from the International Big Four	Big4	Whether the domestic audit firm is one of the international big four in the world, 0 = No, 1 = Yes

To improve the accuracy of the research, this paper refers to the data sources of Wu Fei et al. [19], Xiao Jing and Zeng Ping [22], Zhang Qincheng and Yang Mingzeng [23]. A series of possible control variables that have an impact on the enterprise ESG performance are added, including enterprise size (Size), asset-liability ratio (Lev), return on assets (ROA), cash flow ratio (Cashflow), operating income growth rate (Growth), board size (Board), independent director ratio (Index), equity concentration (Top10), CEO duality (Dual), shares balance (SharesBalance), audit opinion type

(Audit) and whether the auditor comes from the international big four (Big4), as seen in Table 1 for specific definitions.

(2) Model Design

$$ESG_{it} = \alpha_0 + \alpha_1 digt_{it} + \alpha_2 Z_{it} + \mu_i + \delta_t + \varepsilon_{it} \quad (1)$$

The explained variable is the enterprise ESG performance (ESG), the core explanatory variable is the enterprise digital transformation (digt), Z is the aforementioned control variable, μ_i is the fixed effect of industry, δ_t is the fixed effect of time, and ε_{it} is the random error term in the benchmark model. Parameter α1 reflects how the enterprise digital transformation affects enterprise ESG performance.

(3) Data Sources and Descriptive Statistics

This paper selects Shanghai and Shenzhen A-share listed companies from 2009 to 2022 as the research object and screens them according to the following steps. (1) Exclude financial listed companies. (2) Eliminate samples with missing financial data or insolvency. (3) Strip out samples that are labeled ST or *ST in the current year. Cluster regression is performed on the sample at the enterprise level to eliminate the interference of differences between data groups and reasonably control for the impact of heteroscedasticity. The financial data used in the study are derived from the CSMAR database.

Table 2 is the descriptive statistics. The mean value of the ESG ratings of the explained variable is 3.850 and the standard deviation is 1.334, indicating that there are certain differences in ESG performance between different companies, but the overall concentration is at the middle and lower levels. The core explanatory variable Enterprise Digital Transformation (Digital1) has an average of 1.061 and a standard deviation of 1.343, indicating that there are large differences between the degrees of digital transformation of enterprises. For the descriptive statistics of control variables, comparing the existing relevant literature shows a high degree of consistency [19] [22].

Table 2. Descriptive Statistics

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	N	mean	sd	min	max	p25	median	p75
ESG	43559	3.850	1.334	0	8	3.250	4	4.750
Digital1	43559	1.061	1.343	0	6.301	0	0.693	1.946
Digital2	43559	0.756	1.133	0	5.938	0	0	1.386
Size	43559	22.160	1.526	10.84	31.31	21.14	21.91	22.89
Lev	43559	0.475	1.654	-0.195	1.783	0.262	0.427	0.597
ROA	43559	0.041	0.467	-64.82	64.75	0.013	0.039	0.074
Cashflow	43559	0.045	0.316	-11.06	62.79	0.005	0.045	0.087
Growth	43559	3.817	6.334	-1.309	1.346	-0.031	0.108	0.276
Board	43559	2.133	0.212	0	3.045	1.946	2.197	2.197
Index	43559	0.375	0.0560	0	1	0.333	0.357	0.429
Top10	43559	0.585	0.158	0.013	1.012	0.472	0.594	0.708
Dual	43559	0.287	0.452	0	1	0	0	1
SharesBalance	43559	0.757	0.633	0.003	4	0.263	0.593	1.085
Audit	43559	0.949	0.219	0	1	1	1	1
Big4	43559	0.067	0.250	0	1	0	0	0

Table 3 shows the correlation analysis of this paper. The correlation coefficient between ESG and Digital_CSMAR1 is 0.045 at the significance level of 1%, indicating that ESG and Digital_CSMAR1 are positively correlated. Meanwhile, the correlation coefficients between other variables are less than 0.5, indicating that there is no serious Collinearity with a reasonable relationship between variables, and regression analysis can be carried out.

Table 3. Correlation Analysis

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) ESG	1.000						
(2) Digital1	0.045***	1.000					
(3) Size	0.321***	0.113***	1.000				
(4) Lev	-0.020***	-0.020***	-0.030***	1.000			
(5) ROA	0.023***	-0.003	0.001	-0.152***	1.000		
(6) Cashflow	0.065***	-0.006	0.002	0.004	-0.002	1.000	
(7) Growth	-0.006	-0.004	-0.002	0.001	0.000	0.000	1.000
(8) Board	0.084***	-0.039***	0.319***	0.010**	0.007	0.012**	0.001
(9) Index	0.060***	0.061***	0.014***	0.007	0.000	-0.009*	-0.004
(10) Top10	0.023***	0.010**	0.154***	-0.034***	0.037***	0.025***	0.004
(11) Dual	-0.088***	0.081***	-0.161***	-0.024***	0.009*	0.003	-0.002
(12) SharesBalance	-0.062***	0.119***	-0.036***	-0.013***	0.004	-0.013***	-0.003
(13) Audit	0.169***	0.019***	0.123***	-0.130***	0.046***	0.040***	0.001
(14) Big4	0.121***	0.037***	0.434***	0.015***	0.002	0.012***	-0.001
Variables	(8)	(9)	(10)	(11)	(12)	(13)	(14)
(8) Board	1.000						
(9) Index	-0.486***	1.000					
(10) Top10	0.027***	0.024***	1.000				
(11) Dual	-0.187***	0.110***	0.049***	1.000			
(12) SharesBalance	0.034***	-0.019***	0.028***	0.068***	1.000		
(13) Audit	0.041***	-0.008*	0.139***	0.005	-0.039***	1.000	
(14) Big4	0.170***	0.024***	0.179***	-0.062***	0.025***	0.046***	1.000

5. Empirical Analysis

(1) Benchmark Regression

Table 4 shows the benchmark regression results and constants in tables cannot be forgotten. Column (1) (3) of Table 4 is the regression results with only the core explanatory variables Digital_CSMAR1 and Digital_CSMAR2 added respectively. According to the results, the enterprise digital transformation has a positive promotion effect on the enterprise ESG performance at a significance level of 1%. Column (2) of Table 4 shows the regression results after adding the core explanatory variable Digital_CSMAR1 and related control variables. Column (4) of Table 4 indicates the regression results after adding the core explanatory variable Digital_CSMAR2 and related control variables. Both results prove that enterprise digital transformation has a positive promotion effect on enterprise ESG performance at a significance level of 1%. Thus, hypothesis 1 is valid.

Table 4. Benchmark Regression

	(1) ESG	(2) ESG	(3) ESG	(4) ESG
Digital_CSMAR1	**0.082*** **	**0.057*** **		
	(15.21)	**(11.73)**		
Digital_CSMAR2			**0.094*** **	**0.083*** **
			(15.53)	**(15.14)**
Size		0.252***		0.254***
		(53.41)		(53.88)
Lev		-0.012		-0.011
		(-0.81)		(-0.80)
ROA		0.164**		0.165**
		(2.02)		(2.02)
Cashflow		0.485***		0.492***
		(4.29)		(4.28)
Growth		-0.000***		-0.000***
		(-18.51)		(-18.43)
Board		0.040		0.044
		(1.14)		(1.24)
Index		1.489***		1.481***
		(12.10)		(12.06)
Top10		-0.361***		-0.355***
		(-9.22)		(-9.06)
Dual		-0.085***		-0.088***
		(-6.33)		(-6.56)
SharesBalance		-0.063***		-0.065***
		(-6.65)		(-6.90)
Audit		0.934***		0.928***
		(30.68)		(30.56)
Big4		-0.053**		-0.053**
		(-2.10)		(-2.10)
_ cons	3.642***	-2.975***	3.649***	-3.006***
	(116.63)	(-23.78)	(116.65)	(-24.07)
Firm FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
N	43559	42062	43559	42062
adj. R^2	0.024	0.149	0.024	0.151

(2) Robustness Analysis

1. Replace Explanatory Variables

In the baseline regression, this paper uses the total indicators of enterprise digital transformation for regression. In the robustness test, based on the practice of Hu Jie et al. [14], the core explanatory variables of the five digital dictionaries are replaced for the robustness test, including “artificial intelligence”, “blockchain”, “cloud computing”, “big data” and “digital application” respectively.

According to the results in Table 5, the enterprise digital transformation still has a significant positive impact on the dependent variable after replacement.

Table 5. Robustness Test-Replace Explanatory Variables

	(1)	(2)	(3)	(4)	(5)
	ESG	ESG	ESG	ESG	ESG
AITtechnology	**0.004*****				
	(4.43)				
BlockChainTechnology		**0.029*****			
		(2.84)			
CloudComputingTech			**0.007*****		
			(10.21)		
BigDataTechnology				**0.005*****	
				(7.61)	
DigitalTechApplication					**0.001****
					(2.01)
Controls	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes
N	42062	42062	42062	42062	42062
adj. R^2	0.147	0.146	0.149	0.147	0.146

2. Replace Explained Variables

In the robustness test, this paper uses the enterprise ESG performance data (BloombergESG, WindESG) to replace the enterprise ESG performance data (ESG) from Sino-Securities Index Information Service Co., Ltd used in the benchmark model for regression. After replacing the explained variables for regression, the enterprise digital transformation is still positively significant to the enterprise ESG performance at the significance level of 1%, indicating that the benchmark regression results are relatively stable as shown in Table 6.

Table 6. Robustness Test-Replace Explained Variables

	(1) BloombergESG	(2) BloombergESG	(3) WindESG	(4) WindESG
Digital_CSMAR	0.265***	0.259***	0.055***	0.074***
	(5.14)	(4.77)	(11.96)	(14.62)
Controls	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
N	15351	15351	19580	19580
adj. R^2	0.713	0.713	0.104	0.107

6. Further Analysis

(1) Mechanism Inspection

1. Enterprise Digital Transformation, Internal Control and ESG Performance

According to Table 7, Digital_CSMAR×Inside represents the intersection of enterprise digital transformation and internal control quality, which is decentralized. The results show that the cross-multiplier coefficients are all positively significant at the significance level of 1%, proving that the higher the quality of enterprise internal control, the more significant the positive promotion effect of digital transformation on ESG performance, thus verifying hypothesis 2.

Table 7. Enterprise Digital Transformation, Internal Control and ESG Performance

	(1) ESG	(2) ESG
Digital_CSMAR1	0.020***	
	(3.68)	
Digital_CSMAR2		0.036***
		(6.21)
Digital_CSMAR×Inside	0.000***	0.000***
	(5.03)	(2.92)
Inside	0.00145***	0.00144***
	(49.36)	(48.86)
Controls	Yes	Yes
Firm FE	Yes	Yes
Time FE	Yes	Yes
N	35339	35339
adj. R^2	0.022	0.022

(2) Heterogeneity Analysis

1. Heterogeneity Analysis of the Nature of Enterprise Ownership

In the context of the Chinese socialist market economic system, corporate behavior is affected by the nature of ownership, which will also be reflected in the ESG performance of enterprise digital transformation. According to the nature of enterprise ownership, state-owned and non-state-owned enterprises are grouped and regressed as shown in Table 9. Compared with state-owned enterprises, the digital transformation of non-state-owned enterprises has a more significant effect on improving ESG performance, and the regression coefficient is positively significant at the significance level of 1%. This may be related to the fact that non-state-owned enterprises are relatively young and dynamic, which are more willing to accept institutional systems. State-owned enterprises are relatively traditional with the lower speed of digital transformation.

Table 8. Heterogeneity Test-Property of Equity

	(1) ESG (State-Owned Enterprises)	(2) ESG (Non-State-Owned Enterprises)
Digital_CSMAR	0.046***	0.060***
	(4.22)	(6.66)
Controls	Yes	Yes
Firm FE	Yes	Yes
Time FE	Yes	Yes
N	14405	27242
adj. R^2	-0.017	-0.034

7. Conclusion and Enlightenment

With the continuous development of digital technology and the call for a green economy, the importance of enterprises using digital technology to improve their internal structure, efficiency and ESG performance has become increasingly prominent. Selecting China's Shanghai and Shenzhen A-share listed companies from 2009 to 2022 as research samples, this paper empirically tests the impact and mechanism of digital transformation on enterprise ESG performance in the digital economy. According to the empirical test results, firstly, the enterprise digital transformation has a significant role in promoting the enterprise ESG performance, which is still robust after passing the heterogeneity analysis of time and the nature of enterprise ownership as well as the robustness test of replacing explanatory variables and explained variables. Secondly, enterprise digital transformation can promote enterprise ESG performance through internal control. Thirdly, digital transformation in non-state-owned enterprises has a stronger role in promoting enterprise ESG performance, which has certain practical significance for enterprises to achieve high-quality sustainable development in the digital economy era.

Based on the above research conclusions, this paper puts forward the following suggestions:

From the perspective of the macro government, on the one hand, the government should introduce incentive policies to create a good macro market environment for enterprise digital transformation, promote enterprises to combine digital technology with original technology, and innovate in operation. On the other hand, in an era oriented by sustainable development, the government should strengthen the promotion of the importance of ESG and encourage enterprises to use digital transformation to enhance operational efficiency and ESG performance.

From the perspective of the micro enterprise, on the one hand, enterprises must adapt to the times, pay attention to the enterprise ESG performance under the background of the digital economy and green economy, and promote green innovation and internal control of enterprises through digital transformation and other methods, so as to improve the enterprise ESG performance. On the other hand, relatively traditional state-owned enterprises should comply with the call of Chinese digital transformation with a more open and inclusive attitude, and actively conduct digital transformation, thereby improving the ESG performance of state-owned enterprises and realizing high-quality and sustainable development of enterprises in the new era.

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