

# ESG performance, Digital transformation and High quality energy development

Lin Liang<sup>1</sup>, Wenya Fang<sup>1</sup>, Ronghua He<sup>1</sup>, Jing Luo<sup>2</sup>

1.Southwest Petroleum University, Chengdu 610000, China

2.PetroChina Shandong Rizhao Sales Branch, Shandong 276800, China

---

**Abstract:** Promoting the adoption of Environmental, Social, and Governance (ESG) development ideas and digital transformation in energy firms is crucial given the current commitment to sustainable development and high-quality development. Using unbalanced panel data of listed businesses in the A-share energy industry from 2012 to 2022, this study empirically investigates the impact of ESG performance on high-quality development of energy and the moderating effect of digital transformation on it. A two-way fixed effects model is adopted. It is found that good ESG performance has a significant facilitating effect on promoting the high-quality development of the energy industry. In addition, digital transformation plays a positive moderating role in this process.

**Keywords:** ESG Performance, Quality Development, Digital Dransformation

---

## 1 Introduction

High-quality development of energy has become a new stage of China's energy development in the new era. Currently, research in related fields is mostly explored from the perspectives of policy environment, technological innovation, and corporate governance structure. Some studies have shown that the government's policy orientation and the degree of intervention can significantly affect the investment decisions of enterprises<sup>[1]</sup>, while technological innovation is the core driving force for promoting the high-quality development of energy enterprises<sup>[2]</sup>. In addition, too many management levels and long corporate chains of enterprises may lead to insufficient supervision and management of subsidiaries by parent companies<sup>[3]</sup>. However, little literature has focused on the impact of ESG performance on high-quality development in the energy industry. In the energy industry, ESG performance is not only related to the economic efficiency of enterprises<sup>[4]</sup>, but also to their environmental responsibility, social responsibility and governance structure.

This paper aims to reveal the impact of ESG performance on energy high-quality development, and it will enrich the research related to energy high-quality development and the economic consequences of ESG performance, and also provide some references for the high-quality development of the energy industry.

## 2 Theoretical analysis and Research hypothesis

### 2.1 ESG performance and High quality energy development

In terms of the impact of ESG performance on the high-quality development of energy companies, stakeholder theory and resource dependence theory suggest that good ESG performance, such as actively undertaking environmental and social responsibility, helps energy companies achieve high-quality development. According to stakeholder theory, when businesses take on environmental and social responsibility, they can show their stakeholders that they are reliable, protect their rights and interests, encourage them to work with businesses that perform better in terms of environmental, social, and governance (ESG), and increase the effectiveness of stakeholder involvement in the creation of corporate value<sup>[5]</sup>. Resource Dependence Theory suggests that firms need to draw resources from the external environment to survive and grow, and therefore taking on environmental and social responsibility can help firms access key strategic resources held by stakeholders to build their competitive advantage<sup>[6]</sup>. Good ESG performance implies that firms can fulfill their contracts with stakeholders with high quality, thus winning the trust and support of stakeholders and obtaining the resources and environment necessary for high-quality development. Based on this, this paper proposes:

Hypothesis 1: Good ESG performance contributes to high quality development in the energy sector

## 2.2 The moderating role of Digital transformation

Digital transformation plays an important moderating role in ESG for high-quality development of energy companies. It not only helps companies manage and improve their ESG performance more effectively, but also provides technical support and strategic opportunities for companies to achieve sustainable development at the economic, environmental and social levels<sup>[7]</sup>. Through digital transformation, energy companies can enhance their capacity to monitor and manage environmental impacts. One way to do this is by introducing technologies like artificial intelligence (AI), which can lower costs, boost productivity, and make it possible to incorporate ESG data into decision-making<sup>[8]</sup>. Based on this, this paper proposes:

Hypothesis 2: Digital transformation positively moderates between ESG performance and high quality energy development

## 3 Research Design

### 3.1 Sample Selection and Data Processing

The data of ESG ratings in this paper are from Shanghai Huazheng database, and the rest are from CAMAR database. A-share companies in the energy industry from 2012 to 2022 are selected as samples and screened according to the following principles: exclude ST and ST\* listed companies; exclude observations with more missing values, and finally obtain 1,229 observations. In order to avoid the interference of extreme values, all continuous type variables are subjected to the shrinking of upper and lower 1%.

### 3.2 Variable Definition

#### 3.2.1 Implicit Variable

High-quality development is measured by Total Factor Productivity (TFP), which represents the contribution to output growth of all factors other than traditional factors of production such as capital and labor<sup>[9]</sup>. Drawing on the research of Lu and Lian Yujun [10], the OP method is used to TFP, the following is the model:

$$\ln Y_{i,t} = \beta_0 + \beta_1 \ln K_{i,t} + \beta_2 \ln L_{i,t} + \beta_3 \ln M_{i,t} + \varepsilon_{i,t}$$

Where Y denotes main business revenue; M denotes cash paid for purchased goods and services; L denotes total number of employees; K denotes net fixed assets. The regression residual of the model is the TFP of the enterprise.

#### 3.2.2 Independent Variable

ESG performance has emerged as one of the most important metrics for investors to evaluate the risk and value of firms due to the growing emphasis on sustainability around the world. [11]. This paper draws on existing studies and selects Huazheng ESG rating data, assigning values from 1 to 9 to the ratings (C-AAA nine ratings) to measure the ESG performance of energy companies<sup>[12]</sup>.

#### 3.3.3 Moderator Variable

Digital transformation is a comprehensive and profound change process that utilizes digital technology to redesign an enterprise's business processes, culture and other aspects. In this paper, we draw on Wu Fei et al. to use the natural logarithm of the sum of word frequencies of five dimensions in a company's annual report as a measure of a firm's digital transformation<sup>[13]</sup>.

#### 3.3.4 Control Variable

In order to control the indicators related to firm characteristics, this paper adds six control variables such as gearing ratio (Lev) and corporate return (Roa) to the core explanatory variables. The specific definitions of the variables are shown in Table 1.

Table 1 Description of main variables

Type	Name	Symbol	Description
Implicit Variable	High-quality development	TFP_OP	TFP using the OP method
Independent Variable	ESG performance	ESG	Assign a value of 1~9 to Huazheng's ESG rating.
Moderator Variable	Digital transformation	DT	Metrics for enterprise-level digital transformation

Control Variables	Gearing	Lev	Total liabilities/total assets
	Enterprise rate of return	Roa	Net profit/total assets
	Enterprise size	Size	Natural logarithm of total assets of the enterprise at the end of the period
	Shareholding concentration	Top10	Sum of shareholdings of the top 10 largest shareholders of the enterprise
	Management shareholding	Mshare	Number of shares held by management/total shares
	Cash flow intensity	Cash	Net cash flows from operating activities/total assets

### 3.3 Model Design

The baseline regression model in this paper is a two-way fixed effects model controlling for individuals and time. Model (1) is used to test Hypothesis 1 and examine the impact of ESG performance on energy quality development.

$$TFP\_OP_{i,t} = \beta_0 + \beta_1 ESG_{i,t} + \beta_2 Control_{i,t} + \alpha_i + \lambda_t + \epsilon_{i,t} \quad (1)$$

where  $i$  denotes an individual,  $t$  denotes a year,  $\alpha_i$  denotes an individual fixed effect,  $\lambda_t$  denotes a time fixed effect,  $\epsilon_{i,t}$  is a perturbation term that varies with individual and time, and Controls is a control variable, as follows.

Model (2) is used to test Hypothesis 2 by examining the moderating effect of digital transformation on the relationship between firms' ESG performance and high-quality energy development by introducing an interaction term between ESG performance and digital transformation.

$$TFP\_OP_{i,t} = \beta_0 + \beta_1 ESG_{i,t} + \beta_2 ESG_{i,t} \times DT_{i,t} + \beta_3 Control_{i,t} + \alpha_i + \lambda_t + \epsilon_{i,t} \quad (2)$$

## 4 Empirical results and Analysis

### 4.1 Descriptive Statistics

The mean value of TFP\_OP is 6.974, indicating that the level of high-quality development of the energy industry still needs to be improved; the standard deviation is 0.858, indicating that the level of high-quality development of China's energy industry is uneven. The mean value of ESG performance is 3.998, indicating that the average rating of ESG performance of the sample firms is in the range of CCC-B, which is a poor performance; the standard deviation is 1.078, indicating that there are some differences in the ESG performance of the sample companies. The mean value of the degree of digital transformation is 0.635, indicating that the scale of digital technology and development in China's energy industry is still at a low level; the standard deviation is 0.781, indicating that there is a significant difference in the degree of digital transformation among energy enterprises. The descriptive statistics of the variables are shown in Table 2.

Table 2 Descriptive statistics for variables

Variables	Sample size	Mean	Standard deviation	Min	Max
TFP_OP	1229	6.974	.858	4.495	9.049
ESG	1229	3.998	1.078	1	6
DT	1229	.635	.781	0	3.135
Lev	1229	.549	.183	.065	1.65
Roa	1229	.025	.074	-1.22	.29
Size	1229	23.414	1.604	19.525	28.298
Top10	1229	63.631	16.904	14.6	96.47
Mshare	1229	1.826	7.353	0	53.88
Cash	1229	.068	.057	-.154	.249

### 4.2 Analysis of regression results

Column (1) of Table 3 shows the test results of the impact of ESG performance on energy high-quality development, and the ESG per-

formance of the sample firms is significantly positive at the 5% level, indicating that good ESG performance can significantly contribute to energy high-quality development, Hypothesis 1 is basically verified. Meanwhile, some of the control variables are significantly positive at the 1% level, suggesting that a reasonable gearing structure, for example, is conducive to high-quality energy development. The specific regression results are shown in Table 3.

Column (2) of Table 3 shows the test results of the moderating effect of digital transformation in the relationship between ESG performance and energy high-quality development. The coefficient of the interaction term between ESG and DT is 0.011, which is significantly positive at the 1% level, indicating that digital transformation positively moderates the relationship between ESG performance and energy high-quality development, thus Hypothesis 2 is verified.

Table 3 Regression results statistics

	(1) TFP_OP	(2) TFP_OP
ESG	0.028**(2.45)	0.037***(3.16)
ESG×DT		0.011***(2.95)
Lev	-0.386***(-4.12)	-0.387***(-4.15)
Roa	0.771***(4.80)	0.750***(4.68)
Size	0.253***(11.57)	0.245***(11.19)
Top10	0.004***(3.02)	0.004***(3.10)
Mshare	0.004(1.51)	0.004(1.50)
Cash	0.902***(4.73)	0.919***(4.83)
_cons	1.043**(2.26)	1.222***(2.63)
N	1229	1229
adj.R2	0.891	0.891
id	YES	YES
year	YES	YES

t statistics in parentheses. \* p < 0.1, \*\* p < 0.05, \*\*\* p < 0.01

## 5 Conclusions

By analyzing the impact of ESG performance on energy quality development and how digital transformation plays a role in this relationship, this study concludes that good ESG performance has a facilitating effect on energy quality development, and that digital transformation plays a positive moderating role in this process, which suggests that firms are able to contribute more effectively to innovation and upgrading of the energy sector by improving their ESG performance in the digital environment.

Based on the above findings, this paper makes the following recommendations: First, energy companies should emphasize and enhance their ESG performance and strategically front-load it in order to gain a competitive advantage in long-term business practices, win the trust of investors and consumers, and promote the sustainable development of themselves and the industry. Second, governments and regulators should formulate appropriate policies and standards, providing incentives such as tax incentives and green credit support to encourage energy companies to integrate ESG factors into their business models and decision-making processes. Third, the energy industry should accelerate the pace of digital transformation and strengthen talent training and technological innovation capabilities, which can not only optimize resource allocation and improve energy efficiency, but also significantly reduce environmental impact. Fourth, as key players and transmitters of market, investors and consumers should integrate corporate ESG performance into their investment decisions and consumption choices to incentivize companies to optimize their products, and to promote green and sustainable development of the market.

## References

- [1] Chen Xiaoshan, Chen Simin, Liu Hongduo. Do government environmental governance subsidies enhance corporate ESG perfor-

mance under the “dual-carbon” goal[J/OL]. Journal of China University of Geosciences (Social Science Edition): 1-14.

[2] Chen, Qi. Does environmental protection investment increase firm productivity? --An empirical analysis based on the mediating effect of corporate innovation[J]. Nankai Economic Research, 2020,(06):80-100.

[3] Si Xiaotao. Research on the relationship between corporate organizational change and strategic human resource management in the context of high-quality development[J]. Marketing World, 2023, (20): 35-37.

[4] Jun X , Wataru N , Michiyuki Y ,et al.Do environmental, social, and governance activities improve corporate financial performance?[J].Business Strategy and the Environment, 2019.

[5] ZHOU Shenbei,WANG Wenyue,LI Hongyang. Do stakeholder expectations of corporate ESG performance affect corporate economic value [J]. Journal of Finance and Accounting, 2024, 45 (04): 20-27.

[6] LI Wei-An,LI Ding,ZHOU Ning,et al. Why does government environmental protection subsidy induce corporate green governance deviation behavior? --Based on the perspective of resource dependence theory[J]. Accounting Research, 2024, (03): 138-149.

[7] Zhao Xuan, Dong Nai-Bin. Digital Finance, Corporate Digital Transformation and ESG Performance - Empirical Evidence Based on Shanghai and Shenzhen A-share Listed Companies from 2011-2021[J]. Journal of Southwest University (Social Science Edition): 1-11.

[8] Zhang Yan,2021.Digital economy spillover effect and TFP enhancement[J]. Guizhou social science(3):139-145.

[9] Solow R M. Technical change and the aggregate production function[J]. The review of Economics and Statistics, 1957, 45(3): 312-320.

[10]Lu Xiaodong,Lian Yujun,2012.Estimation of TFP of Chinese industrial enterprises:1999-2007[J/OL]. Economics(Quarterly), 11(2): 541-558.

[11]Zhang, L., Zhao, H., 2019. Does corporate environmental, social and corporate governance (ESG) performance affect corporate value? --an empirical study based on A-share listed companies[J]. Wuhan Finance (10): 36-43.

[12]Wang D,Zhang D. ESG performance, manufacturing quality development and digital transformation[J]. Statistics and Decision Making, 2023, 39 (19): 172-176.

[13]Wu Fei, Hu Huizhi, Lin Huiyan, Ren Xiaoyi. Corporate digital transformation and capital market performance - Empirical evidence from stock liquidity<sup>[7]</sup>. Management World (7): 130-144.