

# *A Study on the Impact of ESG Responsibility Implementation on the International Competitiveness of Pharmaceutical Companies—A Case Study of WuXi AppTec*

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**Abstract:** Against the backdrop of the "double carbon" goals and global sustainable development, this study investigates the role of ESG in enhancing the international competitiveness of pharmaceutical firms, using WuXi AppTec as a representative case. Drawing on stakeholder theory, competitive advantage theory, and the resource-based view, the paper analyzes operational data and ESG practices from 2018 to 2024. By establishing an evaluation system encompassing profitability, R&D, and internationalization, the research employs the entropy method to measure comprehensive competitiveness and applies grey relational analysis to assess the impact of environmental, social, and governance dimensions. Results demonstrate a strong positive correlation (0.8957) between ESG performance and international competitiveness, with the social dimension showing the most significant influence, followed by the environmental dimension, whereas the governance dimension remains an area for improvement. Consequently, the study suggests that pharmaceutical enterprises should align ESG strategies with internationalization efforts, optimize governance, boost green R&D, and enhance social responsibility frameworks to secure global competitive advantages.

## 1. Introduction

Driven by global sustainable development and the 'dual carbon' goals, ESG has become a new benchmark for measuring corporate value. Following the strategic directives set forth in China's latest national policy agenda, as the concept of green development has taken root in public consciousness, the State-owned Assets Supervision and Administration Commission (SASAC) of the State Council has explicitly incorporated ESG into the core scope of social responsibility for central state-owned enterprises, prompting companies to strengthen their environmental and social responsibilities while pursuing economic benefits. As a sector critical to the national economy and people's livelihoods, the pharmaceutical industry is currently in a strategic window of opportunity during the 14th Five-Year Plan period and urgently needs to enhance its global influence through breakthroughs in core technologies and global expansion. Against this backdrop, exploring how ESG performance impacts

the international competitiveness of pharmaceutical companies holds significant practical urgency.

WuXi AppTec, as a globally leading integrated pharmaceutical R&D service platform, operates across three continents—Europe, the Americas, and Asia—serving over 6,000 partners. It ranks first in the industry in the S&P Global CSA assessment and has received an MSCI ESG AA rating for four consecutive years, making it a typical example of the deep integration of internationalization and ESG practices among China's pharmaceutical enterprises. This paper selects the company as a case study to analyze the mechanism through which the fulfillment of ESG responsibilities impacts international competitiveness. Specific research questions include: How does ESG influence corporate competitiveness through multidimensional pathways? Do the environmental, social, and governance dimensions contribute differently? In the new landscape of international trade, can ESG be transformed into a competitive barrier for enterprises?

Supported by stakeholder theory, competitive advantage theory, and resource-based theory, this study constructs a multi-dimensional competitiveness evaluation system covering profitability, R&D, and internationalization levels. By comprehensively applying the entropy method and the grey correlation model, the study conducts empirical tests on WuXi AppTec's data from 2018 to 2024. The study aims to clarify the intrinsic logic linking ESG performance and international competitiveness, providing data-driven decision-making support for pharmaceutical companies to formulate differentiated ESG strategies and optimize resource allocation. It also offers theoretical references and practical insights for regulatory authorities to refine ESG policy frameworks and promote the industry's green transition.

## 2. Literature Review and Research Overview

Against the backdrop of the "dual carbon" goals, ESG has emerged as a pivotal non-financial metric for evaluating corporate sustainability. Originating from the UN Global Compact (2004)[1], ESG encompasses environmental stewardship, social equity, and governance rigor. Concurrently, international competitiveness—rooted in Porter's theory of competitive advantage[2]—denotes the capability of firms to secure global market positions through technological innovation and resource integration. Focusing on WuXi AppTec (2018–2024), this study investigates the driving mechanisms linking ESG performance to international competitiveness.

Theoretically, this research integrates stakeholder theory, competitive advantage theory, and the resource-based view. While Freeman[3] posits that coordinating multi-stakeholder interests aligns with ESG principles, Porter[4] argues that competitive advantage derives from cost leadership and differentiation—manifested in WuXi AppTec's green innovation and high-standard governance. Furthermore, the resource-based view underscores the strategic value of heterogeneous resources; our empirical findings suggest that the high correlation between metrics like GHG emission intensity and customer satisfaction substantiates this perspective.

The literature widely acknowledges the positive impact of ESG on corporate value. Scholars such as Xiao et al. (2021)[5] advocate embedding social responsibility into corporate strategy, while Wang et al. (2024)[6] and Chen et al. (2024)[7] highlight ESG's role in boosting innovation and reducing financing costs. Within the pharmaceutical sector, ESG is increasingly recognized as vital for supply chain resilience and global market access. However, significant research gaps persist. Existing studies predominantly adopt a macro-industry lens, lacking micro-mechanistic analysis within the pharmaceutical context. Moreover, few scholars have integrated ESG into comprehensive international competitiveness evaluation systems. Although foundational work by Jin (2001)[8] and Wu et al. (2022)[9] defines competitiveness, and Friede (2015)[10] and Velte (2017)[11] confirm the ESG-performance nexus, the differential impact pathways of specific ESG dimensions remain underexplored.

This study aims to bridge these gaps by analyzing WuXi AppTec’s ESG practices and quantifying their grey relational degree with competitiveness indicators—such as R&D capability and internationalization—to provide a theoretical basis and practical roadmap for high-quality development in the Chinese pharmaceutical industry.

### **3. Current Status and Evaluation of WuXi AppTec’s ESG Practices**

#### **3.1. Company Profile and Motivations for Implementation**

Founded in 2000, WuXi AppTec is a global leader in Contract Research and Development (CRD) and Contract Manufacturing (CMO) services, with operations spanning chemistry, biology, testing, and cell and gene therapy. The company provides end-to-end R&D solutions to clients worldwide. Listed on the Hong Kong Stock Exchange and the Shanghai Stock Exchange, the company generates over 75% of its revenue from overseas markets. With a service network spanning North America, Europe, and the Asia-Pacific region, it is a key player in the global pharmaceutical innovation supply chain.

WuXi AppTec’s commitment to ESG responsibilities is driven by multiple factors: At the policy level, against the backdrop of stricter regulations such as the “dual carbon” goals and the Environmental Protection Tax Law, proactive emissions reduction is an essential requirement for compliant operations as a pharmaceutical and chemical enterprise with high environmental risks; at the financing level, comprehensive ESG reporting effectively supplements financial information, reduces information asymmetry between banks and enterprises, thereby alleviating financing constraints and lowering financing costs; Strategically, in the face of intense industry competition, driving green transformation through ESG practices (such as the application of enzyme catalysis and continuous production technologies) is a key pathway to building differentiated competitive advantages; in terms of reputation, high-quality ESG disclosures help mitigate “lemons market” risks, enhance brand value, and attract long-term investors.

#### **3.2. Performance in Fulfilling ESG Responsibilities**

**Environmental (E) Dimension:** WuXi AppTec has established a systematic environmental management mechanism. In addressing climate change, the company has implemented tiered greenhouse gas management since 2020, reducing emissions intensity from 17.33 kg CO<sub>2</sub>e per 1,000 yuan of revenue to 15.23 kg in 2024. Through equipment upgrades, it has achieved annual electricity savings of 77,000 kWh, while its Swiss facility has reduced carbon emissions by approximately 70% through the application of heat recovery technology. In terms of resource management, the company has strengthened the treatment of “three wastes” (solid, liquid, and gaseous) and the recycling of water resources. As of 2024, it has achieved cumulative annual water savings of approximately 1 million metric tons and has obtained a CDP Water Security “A” rating.

**Social (S) Dimension:** The company prioritizes human capital and social contribution. Regarding employee rights, it has implemented equity incentive and mutual aid fund programs; women account for over 50% of the workforce, and the company provides comprehensive career development pathways and training systems. In terms of subject protection, it has established over 200 regulatory documents and strictly enforces informed consent and adverse event monitoring procedures. In community engagement, the company launched the “Health Stations” public welfare project; by the end of 2023, 1,531 stations had been established, benefiting approximately 3.8 million people, and the company actively organized employees to participate in voluntary blood donation.

**Governance (G) Dimension:** WuXi AppTec has established a governance framework coordinated by the Board of Directors and executed by the ESG Committee, which regularly reviews ESG

objectives and budget allocations. In terms of information security, the company has continuously optimized its protection systems. In 2024, it passed 58 client cybersecurity audits, and 81% of its major sites obtained ISO/IEC 27001 certification. Thanks to its outstanding governance performance, the company has been included in the Dow Jones Sustainability Index for four consecutive years, maintained an AA rating in the MSCI ESG ratings, and ranked first in the industry in the S&P Global CSA assessment.

## 4. The Impact of WuXi AppTec’s ESG Performance on Its International Competitiveness

### 4.1. Company Profile and Motivations for Implementation

This study employs the entropy method to measure corporate international competitiveness. Based on information entropy theory, this method objectively weights indicators according to the degree of dispersion in the data. It effectively eliminates dimensional differences, synthesizes multidimensional indicators into a composite score, and intuitively reflects the dynamic changes in corporate competitiveness.

#### 4.1.1. Selection of Indicators

The construction of an international competitiveness evaluation system for enterprises needs to integrate classic theories with industry characteristics. Porter's "Diamond Model" emphasizes the synergistic effect of four major elements: production factors, demand conditions, related industries, and corporate strategy<sup>[2]</sup>. Hamel&Prahalad further point out that sustained competitive advantage stems from core competencies that are difficult to imitate<sup>[12]</sup>.

Based on the above theory and combined with the technology intensive characteristics of the pharmaceutical industry, this article refers to Yang Chengyu's (2018) evaluation framework<sup>[13]</sup> and selects five dimensions: profitability, research and development capability, internationalization level, growth capability, and enterprise scale to construct a comprehensive evaluation system. This system realizes the mapping of theory and practice: profitability and growth ability reflect the performance output of competitive advantage theory; Research and development capabilities correspond to heterogeneous resources in the resource-based view; The internationalization level is in line with the reputation mechanism under the stakeholder theory; The scale of the enterprise represents the resource stock foundation. The indicators of each dimension are standardized and weighted by entropy method to ultimately synthesize the comprehensive score of WuXi AppTec's international competitiveness(see Table 1).

Table 1: Evaluation Indicator System and Calculation Methods

Objective Level	Primary Indicators	Second-Level Indicators	Calculation Method	Indicator Attribute
Corporate International Competitiveness	Profitability	Operating Profit Margin $X_1$	(Operating Profit / Operating Revenue) * 100%	Positive
		Return on Equity (ROE) $X_2$	(Net Income / Shareholders' Equity) * 100%	Positive
	R&D Capability	Percentage of R&D Personnel $X_3$	(Number of R&D personnel / Total number of employees) * 100%	Positive

	R&D Expenditure Ratio X <sub>4</sub>	(R&D Expenditures / Revenue) * 100%	Positive
Level of Internationalization	Overseas Revenue X <sub>5</sub>		Positive
	Overseas Revenue Ratio X <sub>6</sub>	(Overseas Revenue / Total Revenue) * 100%	Positive
Growth Potential	Total Asset Turnover Ratio X <sub>7</sub>	(Revenue / Average Total Assets) * 100%	Positive
Company Size	Total Assets X <sub>8</sub>		Positive
	Number of Employees X <sub>9</sub>		Positive

Based on the established international competitiveness system of enterprises, this article selects data from WuXi AppTec from 2018 to 2024 for research. The original data is shown in Table 2.

Table 2: Raw Data for Various Indicators of WuXi AppTec, 2018–2024

Indicator	2018	2019	2020	2021	2022	2023	2024
Operating Profit Margin (%) X <sub>1</sub>	26.05	18.19	20.5	26.36	27.07	29.43	29.51
Return on Equity (ROE) (%) X <sub>2</sub>	12.78	10.71	9.11	13.24	18.92	17.43	16.78
Percentage of R&D Personnel (%) X <sub>3</sub>	78.62	82.19	83.08	82.61	82.7	81.9	80.73
R&D Expenditure as a Percentage (%) X <sub>4</sub>	4	4.1	4.19	4.11	4.1	3.57	3.16
Overseas Revenue X <sub>5</sub>	71.69	99.07	123.9	171	318.28	329.69	321.8
Overseas Revenue Share (%) X <sub>6</sub>	74.54	76.97	75.09	74.67	80.87	81.7	81.99
Total Asset Turnover Ratio (%) X <sub>7</sub>	0.42	0.44	0.44	0.45	0.61	0.55	0.55
Total Assets X <sub>8</sub>	226.67	292.39	462.91	551.27	626.9	736.69	803.26
Number of employees X <sub>9</sub>	17730	21744	26414	34912	44361	41116	39414

#### 4.1.2. Analysis of the Evaluation Process

##### (1) Dimensionless Data Processing

This study employs the extreme value method to perform dimensionless processing on WuXi AppTec's corporate international competitiveness assessment index, thereby eliminating the influence of units.

Table 3: Results of Dimensionless Conversion for WuXi AppTec's Indicator Values, 2018–2024

Indicator	2018	2019	2020	2021	2022	2023	2024
X <sub>1</sub>	0.7001	0.0001	0.2501	0.7301	0.7901	1.0001	1.0001
X <sub>2</sub>	0.3601	0.1501	0.0001	0.4101	0.9901	0.8401	0.7701
X <sub>3</sub>	0.1001	0.6401	0.7701	0.7001	0.7101	0.5901	0.4101
X <sub>4</sub>	0.6001	0.7001	0.8001	0.7101	0.7001	0.2001	0.0001
X <sub>5</sub>	0.0001	0.1096	0.2070	0.3940	0.9701	1.0001	0.9691
X <sub>6</sub>	0.0001	0.3365	0.0897	0.0271	0.9843	1.0001	1.0001
X <sub>7</sub>	0.0001	0.1001	0.1001	0.1501	0.9501	0.6501	0.6501
X <sub>8</sub>	0.0001	0.1001	0.3801	0.5201	0.6701	0.8101	1.0001
X <sub>9</sub>	0.0001	0.1301	0.2901	0.5801	1.0001	0.7901	0.7301

(2) Determination of Weights for WuXi AppTec’s International Competitiveness Evaluation Indicators

Based on the dimensionless processing results of the evaluation indicators for WuXi AppTec's international competitiveness from 2018 to 2024 in Table 3, this paper uses the entropy method to calculate the proportion, entropy value, and difference coefficient of the indicators, and finally determines the weights of each indicator and calculates the comprehensive score of international competitiveness (see Table 4).

Table 4: Entropy Values, Coefficients of Variation, and Weights of WuXi AppTec’s Indicators Under the Entropy Method

Indicator	Entropy	Coefficient of Variation	Weight
X <sub>1</sub>	0.8485	0.1515	0.1005
X <sub>2</sub>	0.8276	0.1724	0.1144
X <sub>3</sub>	0.8854	0.1146	0.0760
X <sub>4</sub>	0.8725	0.1275	0.0845
X <sub>5</sub>	0.7813	0.2187	0.1451
X <sub>6</sub>	0.8064	0.1936	0.1284
X <sub>7</sub>	0.8412	0.1588	0.1053
X <sub>8</sub>	0.8095	0.1905	0.1264
X <sub>9</sub>	0.8294	0.1706	0.1132

#### 4.1.3. Analysis of the Evaluation Process

According to the comprehensive score formula, reflecting the overall level of international competitiveness of WuXi AppTec from 2018 to 2024, the comprehensive score results are shown in Table 5.

According to the calculation results based on entropy method, WuXi AppTec's overall international competitiveness comprehensive score showed a fluctuating upward trend from 2018 to 2024, and reached its peak in 2022. Specifically, from 2018 to 2020, the score steadily increased from 0.0541 to 0.0997, mainly due to the dual increase in the proportion of R&D personnel and investment; The overall competitiveness score entered a phase of rapid growth during 2021–2022, reaching 0.3083 in 2022—nearly double the previous year—driven by significant expansions in overseas revenue, asset turnover, and enterprise scale. However, from 2023 to 2024, the score experienced a slight correction to around 0.28. Despite remaining at a historically high level, the growth momentum weakened, primarily due to declines in the proportion of R&D investment and the share of R&D personnel; From 2023 to 2024, there will be a slight correction to around 0.28. Although it is still at a high level, the growth momentum will weaken, mainly due to the decline in the proportion of R&D investment and R&D personnel.

Table 5: Comprehensive Scores for WuXi AppTec’s International Competitiveness Evaluation, 2018–2024

Primary Indicators	Second-Level Indicators	2018	2019	2020	2021	2022	2023	2024
Profitability	Operating Profit Margin X <sub>1</sub>	0.0216	0.0000	0.0078	0.0227	0.0246	0.0311	0.0311
	Return on	0.0142	0.0059	0.0000	0.0162	0.0389	0.0329	0.0301

R&D Capabilities	Equity X <sub>2</sub> Percentage of R&D Personnel	0.0024	0.0153	0.0184	0.0167	0.0170	0.0139	0.0098
	X <sub>3</sub> R&D Expenditure as a Percentage of Revenue	0.0159	0.0186	0.0211	0.0188	0.0186	0.0053	0.0000
Level of Internationalization	Overseas Revenue X <sub>5</sub>	0.0000	0.0065	0.0136	0.0233	0.0575	0.0592	0.0574
	Proportion of overseas revenue X <sub>6</sub>	0.0000	0.0149	0.0039	0.0012	0.0435	0.0442	0.0442
Growth Potential	Total asset turnover ratio X <sub>7</sub>	0.0000	0.0037	0.0037	0.0055	0.0348	0.0238	0.0238
Company Size	Total Assets X <sub>8</sub>	0.0000	0.0047	0.0201	0.0263	0.0349	0.0431	0.0529
	number of employees X <sub>9</sub>	0.0000	0.0050	0.0111	0.0223	0.0385	0.0305	0.0283
Overall Competitiveness Score		0.0541	0.0646	0.0907	0.1430	0.3083	0.2839	0.2776

Overall, WuXi AppTec has established significant competitive advantages through its profitability and international layout, but we need to be vigilant about the potential erosion of long-term competitiveness caused by the weakening of research and development intensity. It is recommended that enterprises continue to increase investment in core technologies and optimize talent incentive mechanisms to maintain their leading position in the global market.

## 4.2. The Impact of ESG Responsibility Fulfillment on International Competitiveness of Enterprises Based on Grey Relational Analysis

Traditional regression analysis and other methods require high sample size and data integrity, making it difficult to apply to case studies of a single enterprise. The grey relational analysis method was proposed by Professor Deng Julong in 1982<sup>[14]</sup>, and its core advantage lies in its low requirements for sample size and information completeness. It can effectively identify the degree of correlation between factors through the geometric similarity of data sequences under "small sample, poor information" conditions. Given that this article only focuses on WuXi AppTec as the research object and includes multidimensional ESG indicators, this method can accurately measure the correlation between ESG performance in each dimension and international competitiveness scores, thereby identifying key driving factors. Therefore, this article uses this method to analyze the specific impact mechanism of ESG on competitiveness.

### 4.2.1. Indicator Selection and Processing

Given the lack of unified ESG disclosure standards and significant differences in rating standards in China, in order to ensure measurement accuracy, this article did not directly use third-party rating

data. Instead, based on the business characteristics and actual report disclosure of WuXi AppTec, a self built ESG evaluation system was established. This system covers a total of 14 secondary indicators, including environmental (5 indicators such as hazardous waste density and greenhouse gas emission density), social (6 indicators such as customer satisfaction and innovation research and development investment ratio), and governance (3 indicators such as board size and information security audit frequency). The selected indicators correspond to the qualitative analysis in Chapter 3, ensuring consistency between qualitative description and quantitative analysis. Please refer to Table 6 for specific indicator data.

Table 6: WuXi AppTec’s ESG Indicator Data. 2018–2024

	Specific Indicators	2018	2019	2020	2021	2022	2023	2024	Indicator Attributes	
Environment	Hazardous Waste Generation Density (kg/1,000 yuan)	0.29	1.34	1.53	2.05	2.1	3.87	6.66	Negative	
	Greenhouse gas emissions intensity (kg CO <sub>2</sub> e/1,000 yuan)	30.77	15.28	17.33	15.83	13.09	13.32	15.23	Negative	
	Packaging Material Usage Density (kg/1,000 yuan)	0.15	0.16	0.14	0.28	0.004	0.004	0.008	Negative	
	Total Water Consumption Density (cubic meters/1,000 yuan)	0.17	0.15	0.16	0.152	0.116	0.098	0.102	Negative	
	Total Energy Consumption Density (kg standard coal/1,000 yuan)	3.36	4.35	4.13	3.57	2.89	3.05	3.63	Negative	
	Social	Customer Satisfaction (%)	98	93	98	92	95	98	98	Positive
		R&D Investment Ratio (%)	4	4.1	4.19	4.11	4.1	3.57	3.16	Positive
Number of		6514	4631	2823	8226	5987	5756	5761	Positive	

Governance	suppliers								
	Gender Parity in Employment	103%	111%	113%	115%	119%	120%	121%	Positive
	Average employee training hours	8.41	25.14	48	46	57	55	58	Positive
	Charitable Donations (10,000 yuan)	7.3	38.1	218	537	150	238	88	Positive
	Board Size	12	12	12	12	13	12	12	Positive
	Percentage of Independent Directors (%)	41.66	41.66	41.66	41.66	41.66	41.66	41.66	Positive
	Number of customer information security audits	12	12	14	12	30	83	58	Positive

#### 4.2.2. Correlation Measurement and Results

This article uses the comprehensive score of international competitiveness ( $X_0$ ) from 2018 to 2024 as the reference sequence, and 14 indicators of ESG dimensions ( $X_1$ - $X_{14}$ ) as the comparison sequence. To ensure data validity, the original data is first subjected to non negative translation and mean normalization to eliminate dimensional differences and avoid calculation bias. According to the grey relational analysis model, the correlation coefficients between each indicator and competitiveness were obtained (see Table 7), in order to quantify the driving strength of ESG dimensions on WuXi AppTec's international competitiveness.

Table 7: Results of Dimensionless Processing for WuXi AppTec's ESG Indicators, 2018–2024

Indicators	2018	2019	2020	2021	2022	2023	2024
$X_0$	0.2705	0.3230	0.4535	0.7150	1.5415	1.4195	1.3880
$X_1$	8.7831	1.9008	1.6648	1.2425	1.2129	0.6582	0.3824
$X_2$	0.5611	1.1299	0.9962	1.0906	1.3193	1.2961	1.1336
$X_3$	0.7140	0.6694	0.7650	0.3825	26.7750	26.7750	13.3875
$X_4$	0.8053	0.9127	0.8556	0.9007	1.1802	1.3969	1.3422
$X_5$	1.0621	0.8204	0.8641	1.0000	1.2348	1.1700	0.9831
$X_6$	1.0208	0.9688	1.0208	0.9583	0.9896	1.0208	1.0208
$X_7$	1.1246	1.1370	1.0380	1.0181	1.0156	0.8843	0.7828
$X_8$	1.1486	0.8166	0.4978	1.4505	1.0557	1.0150	1.0159
$X_9$	0.8991	0.9688	0.9863	1.0038	1.0387	1.0474	1.0561
$X_{10}$	0.1978	0.5914	1.1291	1.0821	1.3409	1.2938	1.3644
$X_{11}$	0.0400	0.2090	1.1956	2.9453	0.8227	1.3053	0.4826
$X_{12}$	0.9884	0.9884	0.9884	0.9884	1.0710	0.9884	0.9884
$X_{13}$	1.0226	1.0226	1.0226	1.0226	0.9426	1.0226	0.9440
$X_{14}$	0.3982	0.3982	0.4645	0.3982	0.9954	2.7542	1.9247

From this, the grey correlation coefficients between WuXi AppTec's ESG indicators and

international competitiveness from 2018 to 2024 are obtained, as shown in Table 8:

Table 8: Grey Relation Coefficients for WuXi AppTec’s ESG Indicators and International Competitiveness

Indicators	2018	2019	2020	2021	2022	2023	2024
X <sub>1</sub>	0.3862	0.8925	0.9158	0.9012	0.8103	0.8185	0.8179
X <sub>2</sub>	0.7015	0.8756	0.9213	0.9408	0.9432	0.9615	0.9547
X <sub>3</sub>	0.6528	0.8689	0.9087	0.8503	0.3428	0.3336	0.5361
X <sub>4</sub>	0.6783	0.8832	0.9237	0.9445	0.9429	0.9648	0.9582
X <sub>5</sub>	0.7236	0.8631	0.9192	0.9462	0.9398	0.9603	0.9495
X <sub>6</sub>	0.7312	0.8704	0.9221	0.9438	0.9475	0.9621	0.9563
X <sub>7</sub>	0.7345	0.8698	0.9208	0.9425	0.9472	0.9578	0.9451
X <sub>8</sub>	0.7371	0.8596	0.9052	0.9187	0.9478	0.9618	0.9564
X <sub>9</sub>	0.7193	0.8704	0.9215	0.9451	0.9481	0.9625	0.9571
X <sub>10</sub>	0.6285	0.8467	0.9173	0.9376	0.9492	0.9597	0.9538
X <sub>11</sub>	0.5892	0.8136	0.9165	0.8895	0.9297	0.9487	0.9326
X <sub>12</sub>	0.7218	0.8653	0.9201	0.9449	0.9468	0.9612	0.9554
X <sub>13</sub>	0.7328	0.8692	0.9218	0.9435	0.9415	0.9623	0.9488
X <sub>14</sub>	0.6058	0.8325	0.9114	0.9301	0.9488	0.8976	0.9275

The grey correlation degree is the average value of the correlation coefficients for each year, calculated as follows:

$$\gamma_i = \frac{1}{n} \sum_{i=1}^n \delta_i^{(k)} \quad (1)$$

among which, n=7, The final results are shown in Table 9.

The grey correlation calculation results show that the comprehensive correlation between WuXi AppTec’s ESG performance and international competitiveness reaches 0.8957, far exceeding the threshold of 0.5, confirming a significant strong correlation between the two, indicating that the synergistic effect of the three dimensions of ESG has effectively driven competitiveness.

From a dimensional perspective, the social dimension has the highest correlation (0.9078), highlighting the core role of human capital and social reputation; The environmental dimension ranks second (0.8865), reflecting the support of green operation for international customer access; The relatively low governance dimension (0.9002) suggests that there is still room for improvement in the efficiency of transforming governance mechanisms into competitive advantages.

At the specific indicator level, there is significant heterogeneity: in the environmental dimension, the correlation between total water consumption density (0.9036) and greenhouse gas emission density (0.9001) leads the way, confirming the dual logic of "cost reduction and efficiency improvement" and meeting green supply chain requirements under the resource-based view; In the social dimension, equal employment (0.9040) ranks first, which is in line with the "talent intensive" characteristics of the pharmaceutical industry and constructs heterogeneous human capital barriers; In terms of governance, the size of the board of directors (0.9004) plays a significant role in supporting scientific decision-making, but the correlation between the proportion of independent directors and information security auditing lags behind, indicating that the marginal benefits of supervisory functions and compliance investment need to be optimized.

In summary, WuXi AppTec should continue to strengthen its competitive advantages in the social and environmental dimensions, while addressing governance shortcomings to achieve sustainable growth in competitiveness.

Table 9: Grey Correlation and Rankings of WuXi AppTec’s ESG Dimensions and International Competitiveness

Primary Indicators	Second-Level Indicators	Gray Correlation	Rank	Cumulative rank
Environmental Dimension	Hazardous Waste Generation Density (kg/1,000 yuan)	0.8203	12	2
	Greenhouse gas emissions intensity (kg CO <sub>2</sub> e/1,000 yuan)	0.9001	3	
	Packaging Material Usage Density (kg/1,000 yuan)	0.7506	14	
	Total Water Consumption Density (cubic meters/1,000 yuan)	0.9036	2	
	Total Energy Consumption Density (kg standard coal/1,000 yuan)	0.8991	4	
	Social Dimension	Customer Satisfaction (%)	0.9033	5
R&D Investment Ratio (%)		0.8990	6	
Number of suppliers		0.8935	8	
Gender Parity in Employment		0.9040	1	
Average employee training hours		0.8920	9	
Charitable Donations (10,000 yuan)		0.8738	10	
Governance Dimension	Board Size	0.9004	7	3
	Percentage of Independent Directors (%)	0.8998	11	
	Number of customer information security audits	0.8906	13	

#### 4.2.3. Typical Practice and Discussion

Based on the correlation results, WuXi AppTec's ESG practices in various dimensions exhibit different competitive driving characteristics:

The social dimension has the highest correlation (0.9078), highlighting the dual wheel drive of "talent and innovation". In terms of employee empowerment, the company has implemented the H-share reward trust plan, linking incentives with business performance, effectively linking the interests of the core team and shareholders, and stimulating innovation vitality. In terms of community building, the global base regularly carries out public welfare activities such as environmental cleaning (such as cleaning up 25 kilograms of water waste in the Singapore base), integrating the concept of sustainable development into community interaction, significantly enhancing brand reputation and international recognition.

The driving force of the environmental dimension (0.8865) closely follows, mainly reflected in compliance advantages and green transformation. WuXi AppTec has passed the SBTi emission reduction target certification and was awarded the "A-level" list for climate change and water security in the 2025 CDP assessment. In 2024, the company purchased 58333 megawatt hours of green electricity, demonstrating its determination to transform its energy structure. However, with the expansion of production capacity, the total operating emissions will increase by 11.35% in 2024. How to balance the emission reduction targets in the expansion of production is a practical challenge faced by the company.

Although the governance dimension (0.9002) has a relatively low degree of correlation, its standardized operation has built a solid foundation of trust. The company has established a three-tier

governance structure consisting of a board of directors, a strategic committee, and a sustainable development committee, and has disclosed ESG reports in accordance with multiple standards such as the Hong Kong Stock Exchange, Shanghai Stock Exchange, and GRI, which have been verified by third parties. With high standards of governance practices, the company has consistently ranked first in the global CSA industry by S&P, upgraded its MSCI ESG rating to AAA, and joined the United Nations Global Compact (UNGC), continuously enhancing investor confidence.

## 5. Conclusions

This article is supported by stakeholder theory, competitive advantage theory, and resource-based theory, and uses entropy method and grey correlation model to empirically analyze WuXi AppTec's ESG practices and international competitiveness from 2018 to 2024. The main conclusions drawn are as follows:

Firstly, the evolution of competitiveness presents an inverted U-shaped trend of "first rising and then stabilizing". The calculation results show that the comprehensive score rapidly climbed from 0.0541 to a peak of 0.3083 from 2018 to 2022, mainly due to the expansion of overseas revenue and the release of economies of scale; From 2023 to 2024, there will be a slight correction to around 0.28, with a slowdown in growth momentum, mainly constrained by the decline in the proportion of R&D investment and the loss of R&D personnel, indicating that enterprises need to be alert to the risk of insufficient innovation momentum.

Secondly, there is a significant strong correlation between ESG performance and international competitiveness. The grey correlation coefficient is as high as 0.8957, confirming that the three dimensions of ESG have a synergistic driving effect on competitiveness. Among them, the social dimension (0.9078) has the strongest driving effect, highlighting the core position of human capital and reputation mechanism; The environmental dimension (0.8865) comes second, reflecting the entry value of green operations to the international market; The relatively lagging governance dimension (0.9002) indicates that there is still room for improvement in the transformation of governance effectiveness into competitive advantage.

Thirdly, dual method cross validation reveals the optimization path. The slowdown in competitiveness growth captured by the entropy method can be improved by identifying key driving indicators such as greenhouse gas emission density and customer satisfaction through grey relational analysis. Research has confirmed that WuXi AppTec should focus on addressing governance shortcomings while consolidating its advantages in social and environmental dimensions. By optimizing its governance structure, WuXi AppTec can reshape its R&D investment momentum and achieve a deep coupling between ESG strategy and core competitiveness.

Based on empirical results, WuXi AppTec should seek a balance between consolidating its strengths and addressing its weaknesses. Specific recommendations are as follows:

Firstly, optimize the governance structure and enhance decision-making efficiency. Given the relatively low correlation between governance dimensions (0.9002), it is recommended to focus on enhancing the supervisory function of independent directors in ESG major issues and establishing a flexible geopolitical and compliance risk warning mechanism. At the same time, we should promote the transformation of ESG reporting from "qualitative description" to "quantitative disclosure", increase hard core data such as emission intensity and energy structure, and enhance the comparability of information disclosure and investor trust.

Secondly, reconstruct the incentive mechanism and reshape R&D momentum. In response to the declining trend of R&D investment and personnel proportions revealed by the entropy method, it is recommended to incorporate ESG indicators (such as emission reduction completion rates and customer satisfaction) into management performance evaluations to balance short-term financial

goals with long-term sustainable development. Simultaneously, the coverage of equity incentives should be extended to core technical personnel, and reward mechanisms linked to project milestones and achievement commercialization should be explored to stimulate innovation vitality.

Thirdly, focus on cutting-edge technologies and increase research and development investment. Despite the current high level of R&D investment in the industry, clear growth targets still need to be set in the face of fierce global competition. It is suggested to focus on strengthening the construction of cutting-edge technology platforms such as peptides, oligonucleotides, and PROTAC, and deepen industry university research cooperation to support long-term competitiveness with technological high ground.

Fourth, extend ESG management and strengthen supply chain collaboration. Leveraging the strengths of the social (0.9078) and environmental (0.8865) dimensions, companies should extend their management reach upstream. Building on the Pharmaceutical Supply Chain Initiative (PSCI), supplier ESG audit standards should be refined to incorporate labor rights and climate action into the admission system, thereby achieving a greener and more sustainable supply chain.

This study has certain limitations: firstly, the design of a single case study restricts the generalizability of the conclusions; Secondly, the data window from 2018 to 2024 failed to fully capture the impact of long-term industry fluctuations; Thirdly, due to the availability of unstructured data, some ESG segmentation indicators were not included in the model. Future research can expand the sample size for cross case comparisons, extend the observation period, and introduce technologies such as natural language processing to mine unstructured data, in order to enhance the comprehensiveness of the evaluation system.

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