

ESG Disclosure Quality and Human Capital Investment: The Moderating Role of Financing Constraints and the Mediating Effect of Managerial Talent Allocation

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Abstract: Taking Chinese A-share listed companies from 2015 to 2024 as the research sample, this paper empirically tests the impact of ESG disclosure quality on corporate human capital investment, and deeply explores the mediating role of managerial talent allocation and the moderating role of financing constraints. The study finds that high-quality ESG disclosure can significantly improve the level of corporate human capital investment, and this conclusion remains robust after replacing core variables, changing the sample interval, controlling firm fixed effects, and using instrumental variable method and propensity score matching method to alleviate endogeneity. Managerial talent allocation plays a partial mediating role between ESG disclosure quality and human capital investment, that is, ESG disclosure indirectly promotes corporate human capital investment by attracting excellent managerial talents. Financing constraints have a negative moderating effect on the above relationship, and the higher the degree of financing constraints, the weaker the promoting effect of ESG disclosure on human capital investment. This paper enriches the research literature on the economic consequences of ESG and the influencing factors of human capital investment, and provides empirical evidence for enterprises to optimize human capital allocation, regulatory authorities to improve ESG disclosure system and investors to make investment decisions.

Keywords: ESG Disclosure Quality; Human Capital Investment; Managerial Talent Allocation; Financing Constraints; Mediating Effect

1. Research Hypotheses

1.1. ESG Disclosure Quality and Human Capital Investment

The human capital investment activities of enterprises, such as employee training investment, improvement of salary and benefits, and career development planning, can not only enhance the skills and efficiency of employees, but also strengthen their sense of belonging and loyalty, ultimately transforming into the long-term value creation ability of the enterprise [1-6].

ESG disclosure can influence a company's human capital investment decisions from multiple perspectives. High-quality ESG disclosure can convey to the market the signals that the enterprise actively fulfills social responsibilities and attaches importance to sustainable development, has a positive effect. Good corporate reputation helps attract more outstanding job seekers, reduces the recruitment costs of the enterprise, and also improves the job satisfaction and retention willingness of existing employees, thereby motivating the enterprise to increase investment in human capital. ESG disclosure requires enterprises to pay attention to contents in the social dimension such as employee rights protection, occupational health and safety, training and development, which to some extent exerts external pressure on the enterprise, prompting the enterprise to improve employee benefits and increase investment in employee training. Finally, a complete ESG governance structure can enhance the



internal management level of the enterprise, make the enterprise attach more importance to long-term development strategies, and human capital investment, as an important foundation for the long-term development of the enterprise, will naturally receive more attention and resource allocation. In addition, the latest advances in computational linguistics and image processing enable researchers to construct a multimodal ESG disclosure quality index by combining BERT based semantic embeddings in annual report texts with density scores derived from quantitative tables and charts using computer vision. These machine learning enhanced metrics not only capture the explicit content of disclosure, but also its implicit information and readability, enabling more accurate identification of the causal impact of disclosure quality on corporate investment behavior.

H1: The improvement of ESG disclosure performance has significantly promoted the human capital investment of enterprises.

1.2. The Mediating Role of Management Talent Allocation

Management talents constitute the core component of an enterprise's human capital. Their strategic vision, decision-making ability, and management level directly influence the development direction and operational performance of the enterprise. High-quality ESG disclosure not only attracts ordinary employees but also outstanding management talents with advanced management concepts and rich experience. On one hand, excellent management talents usually pay more attention to the long-term sustainable development of the enterprise and its fulfillment of social responsibilities. They are more inclined to join enterprises that perform well in ESG. On the other hand, high-quality ESG disclosure can convey to management talents the signals of good corporate governance and promising development prospects, reducing their expected career risks.

When enterprises attract more outstanding management talents, these management talents will have a positive impact on the human capital investment decisions of the enterprise. Excellent management talents are more aware of the importance of human capital for the long-term development of the enterprise and will incorporate human capital investment into the strategic planning of the enterprise, increasing investment in employee training and salary incentives. Using named entity recognition and semantic similarity matching for text-based parsing of executive resume data can construct high-dimensional talent quality agents that go beyond simple education ratios. These computational tools allow for non parametric estimation of indirect paths, reduce model dependencies, and reveal whether mediation effects are stronger in companies with more complex organizational structures. This data-driven approach supplements traditional regression based mediation testing and provides deeper insights into human capital channels for ESG disclosure operations.

H2: Management talent allocation plays a mediating role between ESG disclosure quality and enterprise human capital investment.

1.3. The Moderating Role of Financing Constraints

The human capital investment activities of enterprises require a large amount of capital support, and the financing capacity of enterprises directly determines the scale of funds available for investment. When enterprises face high financing constraints, even if they have the intention to invest in human capital, they may be unable to implement it due to a lack of funds.

For enterprises with lower financing constraints, high-quality ESG disclosure can further reduce their financing costs, broaden financing channels, and enable them to have more funds for human capital investment. At the same time, enterprises with lower financing constraints usually have stronger risk tolerance and are more willing to make long-term and high-risk human capital investments. For enterprises with higher financing constraints, their primary goal is to solve the problem of survival, and funds are mainly used to maintain daily operations. Even if the ESG disclosure quality improves, the additional funds that can be obtained are limited and difficult to be invested in human capital investment in large quantities. Natural language processing can quantitatively manage risk perception and capital shortage narratives, providing alternative agents for financing frictions that interact with ESG disclosure. In addition, ensemble learning methods can help identify the interaction patterns between disclosure quality and constraint levels, thereby more accurately estimating the inhibitory effects under different levels of financial pressure.

H3: The existence of financing constraints can reverse interfere with the promotion effect of ESG disclosure quality on human capital investment.

2. Research Design

2.1. Sample Selection and Data Sources

2.1.1. Sample Selection and Screening Criteria

Take all domestic companies listed on the A-share market from 2015 to 2024 as the initial research subjects. The starting point of the study is 2015, mainly because the China Securities Regulatory Commission released the "Guidelines for the Relationship between Listed Companies and Investors" in 2015, which clearly required listed companies to enhance ESG disclosure. Since then, the ESG disclosure level of listed companies in China has gradually improved.

To ensure reliability, this study conducts the following screening on the initial sample:

Exclude financial companies, as the financial statement structure and business activities of financial enterprises are significantly different from those of other industries;

Exclude ST and *ST companies, as their financial conditions are abnormal and the business risks are high;

Exclude companies with severely missing data;

Exclude companies that have been listed for less than one year, as the operating data of new-listed companies may be unstable.

After the above screening, we obtained 23689 valid data at the company year level. In order to avoid biased conclusions with individual maximum or minimum values, we have truncated the extreme values at both ends of all continuous variables (i.e. the highest and lowest 1%).

2.1.2. Data Sources and Processing

The data on ESG disclosure quality in this study is sourced from the Huazheng ESG Rating Database, which has become one of the important data sources in China's ESG research field due to its extensive coverage and application foundation. Its rating results have high authority and credibility. Human capital investment, management talent allocation, financing constraints.

To fully utilize unstructured textual information, this study also utilized Python programming language and natural language processing (NLP) technology to conduct word frequency analysis and sentiment analysis on relevant texts in social responsibility reports and sustainable development reports disclosed by listed companies, as a supplementary verification of rating data. However, the main regression still used Huazheng rating.

For some missing data, this study uses linear interpolation to supplement. For data that cannot be supplemented by interpolation, the corresponding observations are excluded. All data processing and empirical analysis are completed using Stata software. Some text processing assistance uses Python's pandas, jieba, and snownlp libraries.

2.2. Variable Definition and Measurement

2.2.1. Dependent Variable: Human Capital Investment

Following the practice of existing literature, this study measures the level of human capital investment of enterprises (HCI) by the ratio of the cash paid by the enterprise to its employees and the cash paid for employees to its operating income. This indicator can comprehensively reflect the investment of the enterprise in employee compensation, benefits, and training.

2.2.2. Independent Variable: ESG Disclosure Quality

This article uses the Huazheng ESG rating system (from Level 9 C to AAA, with 1-9 points) to measure the quality of corporate ESG disclosure, with higher scores indicating better performance.

In order to leverage the complementary advantages of computer vision and text analysis, we introduce the "Multimodal ESG Disclosure Quality Index (ESG_ML)". This index integrates: 1) vectorized scores obtained by embedding contextual semantics into ESG chapters in annual reports based on the BERT model; 2) Score the density of quantitative data tables in ESG reports based on computer vision (OCR+chart recognition). By using the Stacking ensemble learning method to weight and fuse the above scores with the Huazheng rating, a more robust measure of digital disclosure quality is obtained.

2.2.3. Mediating Variable: Management Talent Allocation

Following the practice of existing literature, this study measures the level of management talent allocation of enterprises (MTA) by the proportion of personnel with a bachelor's degree or above in the enterprise's senior management team. This indicator can reflect the overall quality and ability level of the enterprise's management team to a certain extent. To test the reliability of our research findings, we

also used another standard to measure the "management talent allocation" of enterprises - this time looking at the proportion of personnel with master's degrees or above in the executive team.

2.2.4. Regulating Variables: Financing Constraints

Use the SA index to measure corporate financing constraints. The specific algorithm is to first calculate the logarithm of total assets and the number of years of listing, and then substitute it into the formula $SA = -0.737 \times \text{Size} + 0.043 \times \text{Size}^2 - 0.04 \times \text{Age}$. The calculated SA value must be negative. The larger the absolute value of this negative number, the more difficult it is for the company to obtain funding, and the more severe the financing constraints.

2.2.5. Control Variables

Following the practices in existing literature, enterprise size (taking the logarithm of total assets, the larger the asset size), debt ratio (Lev, total liabilities divided by total assets, reflecting how much debt is owed), profitability (ROA, net profit divided by total assets, reflecting the efficiency of asset profitability), growth opportunities (growth, expressed as revenue growth rate, depending on the speed of business expansion), enterprise age (age, taking the logarithm of the number of years listed, representing the company's qualifications), equity concentration (Top1, the proportion of the largest shareholder's shareholding, the higher the shareholding, the stronger the discourse power), board size (taking the logarithm of the number of directors, the number of directors affects decision-making efficiency), and the proportion of independent directors (Indep, the proportion of independent directors). The proportion of the total number of board members, which measures whether supervision is in place, and dual positions (dual, If the chairman and general manager are the same person, mark it as 1; otherwise, mark it as 0 to determine whether the rights and responsibilities are concentrated. In addition, we also take into account industry and annual specific fixed differences to avoid these macro or industry level factors interfering with our core conclusions.

2.3. Model Specification

2.3.1. Main Effect Model

To test Hypothesis **H1**, this paper constructs the following main effect model:

$$HCI_{i,t} = \alpha_0 + \alpha_1 ESG_{i,t} + \sum \alpha_k Controls_{i,t} + \sum Industry + \sum Year + \varepsilon_{i,t} \quad (1)$$

Among them, i represents the enterprise, t represents the year, HCI is the dependent variable - human capital investment, ESG is the explanatory variable - ESG disclosure quality, Controls is a series of control variables, Industry is the industry dummy variable, Year is the annual dummy variable, and ε is the random error term.

2.3.2. Mediating Effect Model

To test Hypothesis **H2**, which states that the allocation of management talents plays a mediating role between ESG disclosure quality and enterprise human capital investment, this paper adopts the three-step mediating effect test procedure proposed by Wen Zhonglin et al., and constructs the following mediating effect model:

$$MTA_{i,t} = \beta_0 + \beta_1 ESG_{i,t} + \sum \beta_k Controls_{i,t} + \sum Industry + \sum Year + \varepsilon_{i,t} \quad (2)$$

$$HCI_{i,t} = \gamma_0 + \gamma_1 ESG_{i,t} + \gamma_2 MTA_{i,t} + \sum \gamma_k Controls_{i,t} + \sum Industry + \sum Year + \varepsilon_{i,t} \quad (3)$$

Among them, MTA is the mediating variable representing management talent allocation. The steps for testing the mediating effect are as follows: Test whether α_1 in the main effect model is statistically significant. If it is significant, proceed to the next step of testing; Test whether β_1 in the mediating effect model is statistically significant. If it is significant, proceed to the next step of testing; Test whether γ_1 and γ_2 in the mediating effect model are statistically significant. If both γ_1 and γ_2 are significant, it indicates the existence of a partial mediating effect; if γ_1 is not significant while γ_2 is significant, it indicates the existence of a full mediating effect.

2.3.3. regulatory effect model

To test the third hypothesis (**H3**), a model is established to analyze whether a certain variable will change the relationship between the other two variables, as follows.

$$HCI_{i,t} = \delta_0 + \delta_1 ESG_{i,t} + \delta_2 FC_{i,t} + \delta_3 ESG_{i,t} \times FC_{i,t} + \sum \delta_k Controls_{i,t} + \sum Industry + \sum Year + \varepsilon_{i,t} \quad (4)$$

In this model, FC refers to financing constraints, which we consider as a moderating variable to see if it will change the impact of ESG disclosure quality on other factors; $ESG \times FC$ is a new term obtained by multiplying the variables of ESG disclosure quality and financing constraints, called the interaction term, which is specifically used to test whether and to what extent financing constraints have a moderating effect.

3. Empirical Results and Analysis

3.1. Descriptive statistics

Table 1 shows some basic information about the main variables we use. For example, during the sample period, the average investment level of enterprises in human capital was 0.168, while the fluctuation degree between different enterprises was 0.112, indicating that the differences in investment among different enterprises were not particularly significant, indicating significant differences in investment in employee compensation, training, and other aspects among different enterprises. The average ESG disclosure quality is 4.236, which is at a moderate level overall, and there is significant differentiation in disclosure quality among companies. The average allocation of management talents is 0.685, indicating that nearly 70% of the sample companies' executive teams have a bachelor's degree or above. The average financing constraint is -3.682, indicating that listed companies generally face certain financing pressures. The distribution of control variables conforms to the characteristics of the A-share market, and there is no abnormal deviation in the data.

Table 1. Descriptive statistics of main variables

Variable	Observation count	Mean value	Standard deviation	Minimum value	Median	Maximum value
HCI	23689	0.168	0.112	0.023	0.135	0.657
ESG	23689	4.236	1.158	1.000	4.000	9.000
MTA	23689	0.685	0.213	0.125	0.714	1.000
FC	23689	-3.682	0.527	-5.263	-3.625	-2.145
Size	23689	22.135	1.264	19.542	21.964	26.325
Lev	23689	0.462	0.205	0.051	0.458	0.958
ROA	23689	0.045	0.058	-0.162	0.042	0.215
Growth	23689	0.183	0.452	-0.526	0.125	2.365
Age	23689	2.654	0.536	1.098	2.708	3.806
Top1	23689	0.342	0.153	0.085	0.321	0.723
Board	23689	2.213	0.185	1.792	2.197	2.708
Indep	23689	0.375	0.053	0.250	0.364	0.571
Dual	23689	0.268	0.443	0.000	0.000	1.000

3.2. Correlation analysis and multicollinearity test

Correlation tests were conducted on these main variables using Table 2. The results showed that the correlation coefficient between ESG disclosure quality and human capital investment was 0.236, which was statistically significant, indicating a clear positive relationship between the two. This provides preliminary validation for our first hypothesis. The variable of management talent allocation is also significantly positively correlated with ESG disclosure quality and human capital investment. Financing constraints are significantly negatively correlated with human capital investment, which is in line with theoretical expectations. All variables have absolute correlation coefficients less than 0.5 and variance inflation factors less than 5, indicating no serious multicollinearity issue.

Table 2. Correlation Analysis of Main Variables

Variable	HCI	ESG	MTA	FC	Size	Lev	ROA
HCI	1.000						
ESG	0.236***	1.000					
MTA	0.185***	0.215***	1.000				
FC	-0.162***	-0.183***	-0.095***	1.000			
Size	0.124***	0.264***	0.183***	-0.632***	1.000		
Lev	-0.085***	-0.092***	-0.063***	0.215***	-0.125***	1.000	
ROA	0.153***	0.175***	0.124***	-0.136***	0.163***	-0.185***	1.000

Note: * * p<0.01, * * p<0.05, * p<0.1, the same applies below.

3.3. Benchmark Regression Results

3.3.1. Main effect regression results

We will focus on the third column of Table 3, where the coefficient corresponding to ESG disclosure quality is 0.012, improving ESG disclosure quality can significantly promote companies to increase human capital investment, and **H1** has been verified. Among the controlled variables, enterprise size, profitability, and human capital investment are positively correlated, the debt ratio has a negative effect on corporate human capital investment.

Table 3. Main Effect Regression Results

Variable	(1)	(2)	(3)
ESG	0.015***	0.013***	0.012***
Size		0.008***	0.007***
Lev		-0.012***	-0.011***
ROA		0.125***	0.118***
Growth		0.005**	0.004**
Age		0.003	0.002
Top1		-0.006*	-0.005*
Board		0.012**	0.011**
Indep		0.025	0.023
Dual		-0.004	-0.003
Constant term	0.123***	0.085**	0.076**
Industry effect	Uncontrolled	Control	Control
Annual effect			
Observation count	Uncontrolled	Uncontrolled	Control
Constant term	23689	23689	23689
R^2	0.056	0.124	0.142

3.3.2. Mediation Effect Regression Results

As shown in Table 4, the quality of ESG disclosure has a significant promoting effect on the allocation of management talents, with an estimated coefficient of 0.021. After incorporating management talent allocation into the main model, both the ESG coefficient and the management talent allocation coefficient are significantly positive, indicating that management talent allocation plays a partial mediating role, and **H2** holds true. The quality of ESG disclosure indirectly enhances the level of human capital investment in enterprises by optimizing the allocation of management talents.

Table 4. Regression Results of Mediating Effects

Variable	HCI	MTA	HCI
ESG	0.012***	0.021***	0.009***
MTA			0.142***
Control variables	Control	Control	Control
Industry effect	Control	Control	Control
Annual effect	Control	Control	Control
Observation count	23689	23689	23689
R^2	0.142	0.115	0.168

3.3.3. Regression results of moderation effect

Use Stata's reghdfe command in conjunction with Python's linearmodels library to perform mutual validation of bidirectional fixed effects estimation, ensuring the numerical stability of coefficient estimation values. Table 5 confirms the moderating effect of financing constraints: the coefficient of the interaction term is -0.004 (significant), indicating that financing constraints constitute a constraint threshold. When companies face high financing pressure, the promotion effect of ESG disclosure on human capital investment will be significantly weakened. **H3** has been verified. The more abundant the company's funds are, the more the resource support brought by ESG information transmission can be transformed into human capital investment.

Table 5. Regression results of moderation effect

Variable	Coefficient
ESG	0.018***
FC	-0.025***
ESG×FC	-0.004**
Control variables	Control
Industry effect	Control
Annual effect	Control
Observation count	23689
R^2	0.153

3.4. Robustness test

3.4.1. Replacement of core variable measurement methods

This article uses the following alternative variables for regression analysis:

The dependent variable: human capital investment is replaced with the ratio of cash paid to and for employees to total assets (HCI2) to avoid interference from fluctuations in operating income on the indicator.

Explanatory variable: Replace ESG disclosure quality with Hexun ESG rating (ESG2), and assign 1-9 points to the nine levels of C to AAA.

Mediating variable: Replace the management talent allocation with "the proportion of personnel with a master's degree or above in the executive team" (MTA2) to more strictly measure the quality of management talent.

4. Adjusting variables: Replace financing constraints with the KZ index (FC2), where a larger KZ index indicates a higher degree of financing constraints for the enterprise.

Table 6 reports the regression results after replacing the core variables. The ESG2 coefficient in the main effect is 0.011 and significantly positive at the 1% level; The mediation effect test showed that the coefficient of ESG2 on MTA2 was significantly positive. After incorporating MTA2, the coefficients of ESG2 and MTA2 were both significant, and some mediation effects were established; In the robustness test, the interaction coefficient between ESG2 and FC2 was -0.003 (5% significant), indicating that even if the variable measurement method was changed, the inhibitory effect of financing constraints on ESG promotion still existed, and the main conclusion did not undergo substantial changes.

Table 6. Robustness test results of replacing core variable measurement methods

Variable	HCI2	MTA2	HCI2	HCI2
ESG2	0.011***	0.019***	0.008***	0.016***
MTA2			0.156***	
FC2				-0.022***
ESG2×FC2				-0.003**
Control variables	Control	Control	Control	Control
Industry effect	Control	Control	Control	Control
Annual effect	Control	Control	Control	Control
Observation count	23689	23689	23689	23689
R^2	0.135	0.108	0.162	0.146

3.4.2. Changing the sample interval

To eliminate the impact of early disclosure irregularities on the results, this study shortened the

sample interval to 2018-2024 for re regression.

In this section, we additionally utilized Python's change point library to perform breakpoint detection on the time trend of ESG human capital investment. We found that the slope significantly increased after the policy revision in 2018, which was statistically validated with the regression coefficient improvement (0.012 to 0.013) in Table 7 under computer-aided detection.

The results in Table 7 show that the ESG coefficient in the main effect is 0.013 (significant at the 1% level), slightly higher than the benchmark regression's 0.012, indicating that with the improvement of the ESG system, its promoting effect on human capital investment has been enhanced; The results of mediation and moderation effects are basically consistent with the baseline regression, and the core conclusion is not affected by the selection of sample intervals.

Table 7. Results of robustness test for changing sample intervals

Variable	HCI	MTA	HCI	HCI
ESG	0.013***	0.023***	0.010***	0.019***
MTA			0.138***	
FC				-0.027***
ESG×FC				-0.004**
Control variables	Control	Control	Control	Control
Industry effect	Control	Control	Control	Control
Annual effect	Control	Control	Control	Control
Observation count	16842	16842	16842	16842
R^2	0.151	0.122	0.175	0.162

3.4.3. Control fixed effects of enterprises

This article incorporates fixed effects of enterprises to alleviate omitted variable bias. Table 8 further controls for firm fixed effects, with an ESG coefficient of 0.009 and highly significant ($p < 0.01$), once again verifying the positive effect of ESG disclosure on human capital investment, although the coefficient size has decreased, the significance remains unchanged; The mediating and moderating effects still hold true. This indicates that after controlling for the inherent characteristics of the enterprise, the promotion effect of ESG disclosure quality on human capital investment is still significant.

Table 8. Results of robustness test for controlling fixed effects of enterprises

Variable	HCI	MTA	HCI	HCI
ESG	0.009***	0.016***	0.007***	0.015***
MTA			0.125***	
FC				-0.021***
ESG×FC				-0.003**
Control variables	Control	Control	Control	Control
Industry effect	Control	Control	Control	Control
Annual effect	Control	Control	Control	Control
Observation count	23689	23689	23689	23689
R^2	0.215	0.186	0.232	0.224

3.5. Endogenous Treatment

3.5.1. Instrumental variable method

We constructed an instrumental variable called IV-ESG, which measures the average ESG rating of all other companies in the same industry and city as this company. This variable satisfies:

Relevance: Enterprises in the same industry and city face similar institutional environments and competitive pressures, and ESG disclosure behavior has spillover effects;

Exogeneity: ESG disclosures from other companies will not directly affect the company's human capital investment decisions.

From the instrumental variable regression in Table 9, the F-value in the first stage is 125.63, much higher than 10, indicating that the instrumental variable we selected is not a weak tool and is reliable; The coefficient of ESG in the second stage is 0.015, indicating that the quality of ESG disclosure is indeed a reason for promoting human capital investment, not just a correlation.

Table 9. Results of instrumental variable regression

Variable	ESG	HCI
IV_ESG	0.682***	
ESG		0.015***
Control variables	Control	Control
Industry effect	Control	Control
Annual effect	Control	Control
Observation count	23689	23689
R^2	0.325	0.138
Weak instrumental variable F value	125.63	

3.5.2. Propensity score matching method

This article uses propensity score matching (PSM) to alleviate sample self selection bias. Firstly, companies are divided into a treatment group ($ESG \geq 4$, high disclosure quality) and a control group ($ESG < 4$, low disclosure quality) based on the median ESG score. Using the three indicators of company size, debt ratio, and profitability as the matching criteria, use a 1:1 nearest neighbor method to find the most similar control group sample for each treatment group sample.

From Table 10, it can be seen that the differences between the treatment group and the control group in all aspects after matching are very small, indicating that these two groups are now comparable. Following that, Table 11 was re run with the matched samples, and the results were similar to before, indicating that our conclusion was not caused by the samples themselves and was more reliable.

Table 10. Results of propensity score matching balance test

Variable	Before matching		After matching		Standardized deviation change (%)
	Mean of the treatment group	Mean of the treatment group	Mean of the treatment group	Mean of the treatment group	
Size	22.568	21.702	22.456	22.421	96.3
Lev	0.445	0.479	0.452	0.456	91.7
ROA	0.052	0.038	0.049	0.047	85.2
Growth	0.195	0.171	0.188	0.185	87.5
Age	2.712	2.596	2.685	2.679	94.8
Top1	0.335	0.349	0.339	0.341	92.1
Board	2.225	2.201	2.218	2.215	88.9
Indep	0.376	0.374	0.375	0.375	95.4
Dual	0.256	0.280	0.262	0.265	90.3

Table 11. Regression results after propensity score matching

Variable	HCI	MTA	HCI	HCI
ESG	0.011***	0.020***	0.008***	0.017***
MTA			0.140***	
FC				-0.024***
ESG×FC				-0.004**
Control variables	Control	Control	Control	Control
Industry effect	Control	Control	Control	Control
Annual effect	Control	Control	Control	Control
Observation count	18962	18962	18962	18962
R^2	0.145	0.118	0.171	0.156

4. Research Conclusions and Implications

4.1. Main research conclusions

This article uses Chinese A-share listed companies from 2015 to 2024 as samples to empirically test the impact of ESG disclosure quality on corporate human capital investment, as well as the mediating role of management talent allocation and the moderating role of financing constraints. The main

conclusions are as follows:

Firstly, the quality of ESG disclosure significantly improves the level of human capital investment in enterprises. High quality ESG disclosure can incentivize companies to increase investment in employee compensation, benefits, training, and other aspects by enhancing corporate reputation, reducing information asymmetry, and improving internal governance mechanisms. This conclusion still holds true after multiple robustness tests and endogeneity treatments.

Secondly, the allocation of management talents plays a partial intermediary role between the two. High quality ESG disclosure can attract more outstanding management talents, who place greater emphasis on the long-term value of human capital. They will incorporate human capital investment into corporate strategic planning, design scientific human resource management systems, and indirectly promote increased investment in human capital.

Thirdly, the human capital investment of enterprises requires a large amount of financial support. When faced with high financing constraints, even if the enterprise has the willingness, it is difficult to implement relevant investments; Enterprises with lower financing constraints can invest more of the resource increment brought by ESG disclosure into human capital.

4.2. Policy Implications and Suggestions

4.2.1. Suggestions for Enterprises

Firstly, incorporate ESG disclosure into the company's long-term development strategy. Enterprises should abandon the notion of viewing ESG disclosure as a burden and fully recognize its important role in attracting talent, expanding financing channels, and enhancing corporate value. Enterprises should improve the quality and transparency of ESG disclosure, with a focus on disclosing human capital related content such as employee rights protection, occupational health and safety, training and development. At the same time, using NLP text generation technology to write standardized ESG report chapters can improve disclosure efficiency and ensure content compliance through semantic similarity detection.

Secondly, optimize the allocation of management talents. Enterprises should attract and retain excellent management talents by improving recruitment mechanisms, providing competitive compensation and benefits, and creating good career development opportunities. At the same time, management talents should be given more decision-making power, encouraged to develop scientific human capital investment plans.

4.2.2. Suggestions for regulatory authorities

Firstly, improve the ESG disclosure system and enhance the mandatory and standardized level of disclosure. Regulatory authorities should gradually expand the scope of mandatory disclosure, clarify the content and format requirements for disclosure, establish a unified ESG disclosure standard, and improve the comparability and reliability of ESG information.

Secondly, strengthen the supervision of ESG disclosure. Establish a sound supervision and inspection mechanism for ESG disclosure, impose severe penalties on companies that fail to disclose or make false disclosures in accordance with regulations, and increase the cost of violations.

Finally, supportive policies should be introduced to encourage enterprises to invest in human capital. Guide financial institutions to increase credit support for companies with good ESG performance and launch green financial products suitable for small and medium-sized enterprises. The government should increase financial support for human capital investment, such as providing tax incentives for employee training expenses of enterprises, and providing subsidies for human capital investment of high-tech enterprises.

4.2.3. Suggestions for Investors

Firstly, transform the investment philosophy and incorporate ESG and human capital into the investment decision-making system. Investors should not only focus on the short-term financial performance of enterprises, but also on their long-term sustainable development capabilities. Enterprises with good ESG performance and high levels of human capital investment typically have stronger competitiveness and more stable long-term returns.

Secondly, actively leverage the supervisory role of shareholders. Investors can provide suggestions on ESG disclosure and human capital investment to companies through channels such as shareholder meetings and board meetings.

Finally, institutional investors should promote the popularization of ESG investment concepts. By

issuing ESG themed funds and conducting ESG research, we can guide more funds to flow to companies with good ESG performance, form a virtuous cycle, and promote the sustainable development of the capital market.

4.3. Research Limitations and Future Prospects

On the one hand, this article mainly adopts classic linear regression and mediation effect models. Although some machine learning assistance is introduced, future research can further adopt more cutting-edge causal machine learning frameworks to accurately identify the nonlinear causal chain of ESG disclosure quality under different heterogeneous treatment effects of enterprises. On the other hand, due to computational limitations, the semantic analysis of ESG texts in this article is mainly based on the BERT base model. Future research can use larger scale pre trained language models to extract deeper semantic implications from ESG texts, and combine computer vision technology to analyze the authenticity of chart data in ESG reports. Finally, the research sample is limited to Chinese A-shares. Future studies can use web crawling technology to obtain ESG raw reports from listed companies in multiple countries around the world, construct cross-border panel big data, and explore the external effectiveness of computer-driven ESG quantification methods under different institutional environments.

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