The Dual-Importance Mechanism of ESG Disclosure on Human Capital Effects through Textual Analysis and Regression Discontinuity

Yutong Jiang[1,a], Xi Wang[2,b]

[1]School of Accounting, Southwestern University of Finance and Economics, Chengdu, China

[2]School of Finance and Chinese Financial Research Institute, Southwestern University of Finance and Economics, Chengdu, China

[a]1724045399@qq.com, [b]1071640634@qq.com

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Abstract: Based on the theory of double materiality, this study empirically examines the impact and internal mechanism of ESG disclosure quality on human capital efficiency. The first step is to take China's A-share listed companies from 2018 to 2023 as a sample to construct a fixed-effect model for benchmark regression. The results show that the quality of ESG disclosure has a significant positive effect on the human capital efficiency (measured by per capita operating income and per capita net profit). Specifically, for every unit of improvement in ESG disclosure quality, the per capita operating income and per capita net profit of the enterprise increased significantly by 52.3% and 47.8%, respectively. In the second step, the mediating effect model is used to test its mechanism, and it is found that the quality of ESG disclosure mainly affects human capital efficiency through the "value identity" path (mediated by employee satisfaction and organizational identity), which is about 25.23%, which is significantly higher than that of the "financial resources" path (about 10.51%). In the third step, heterogeneity analysis shows that the human capital effect of ESG disclosure quality is more significant in highly polluting industries, state-owned enterprises, developed regions and high-dual importance enterprises. This study enriches the research on the economic consequences of ESG disclosure from the perspective of human capital, and provides empirical evidence for enterprises to optimize ESG information disclosure strategies and the government to improve ESG regulatory policies.

1. Introduction

Environmental, social, and governance (ESG) disclosures have become a key tool for companies worldwide to communicate their sustainability practices and long-term value [1]. As stakeholder expectations for corporate social responsibility and sustainability continue to rise, high-quality ESG disclosure is not only a compliance requirement but also an important strategic measure to reduce information asymmetry, enhance corporate reputation, and access critical resources [2,3]. In China, the ESG ecosystem is in a stage of rapid development. The proposal of the "dual carbon" goal and the promulgation of relevant policy documents provide clear policy guidance and institutional framework for enterprises' ESG practices and disclosures [4].

Existing research on the economic consequences of ESG disclosure has focused on capital market responses, such as the impact on corporate value [5], financing costs [6], and investor decisions. However, how ESG disclosure affects internal management, especially human capital, which is the core asset of a company, has not been fully explored. Human capital is the fundamental driving force for enterprise innovation and sustainable development [7], but its investment is characterized by long cycles and high uncertainty, and often faces the dual constraints of resources and motivation [8]. In recent years, some scholars have begun to pay attention to the relationship between ESG factors and employee behavior and attitudes, such as the positive impact of ESG performance on employee satisfaction [9] and organizational identity [10]. However, there is still a lack of systematic research on how ESG "information disclosure quality" affects firms' "human

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capital investment decisions" or "human capital efficiency", especially based on rigorous causal inference and theoretical mechanism analysis [11].

This study attempts to fill this gap. We base our approach on the "double materiality" theory proposed by the EU Corporate Sustainability Reporting Directive (CSRD), which states that ESG messages have both "financial materiality" (affecting a company's financial position) and "impact materiality" (affecting the environment and society) [12]. This article aims to explore: As a first step, does the quality of corporate ESG disclosure affect its human capital efficiency. Second, what is the internal mechanism of this influence? Is it through improving the "financial path" of financial resources, or by enhancing the "value identity path" of employee identity[13]. By answering these questions, this study not only theoretically expands the research boundaries of the economic consequences of ESG disclosure, but also provides an empirical basis for enterprises to integrate ESG concepts into human resource strategies and regulatory authorities to optimize ESG disclosure policies [14].

2. Model creation, solution and discussion

2.1. Model establishment

2.1.1. Benchmark regression model

In order to test the main effect of ESG disclosure quality (core explanatory variable) on enterprise human capital efficiency (explained variable), the following two-way fixed effect model is constructed:

$$HCE_{i,t} = \beta_0 + \beta_1 ESG\_Quality_{i,t-1} + \gamma Controls_{i,t-1} + \mu_i + \lambda_t + \varepsilon_{i,t} \tag{1}$$

Among them, $HCE_{i,t}$ represent the human capital efficiency of enterprise i in the t-th year, which are measured by the logarithm of per capita operating income and the logarithm of per capita net profit, respectively. $ESG\_Quality_{i,\ t\text{-}1}$ is a comprehensive score of ESG disclosure quality that lags behind, which is based on the text analysis of the company's annual report, and is constructed from four dimensions: completeness, depth, quantification and forward-looking, with a value of 0-1. $Controls_{i,\ t\text{-}1}$ is a set of control variables that lag one period, including enterprise size (Size), profitability (ROA), financial leverage (Leverage), cash holding (Cash) and R&D intensity. μ_i and λ_t represent firm fixed effects and annual fixed effects, respectively, and are used to control corporate heterogeneity and macroeconomic shocks that do not change over time. $\varepsilon_{i,\ t}$ is the random perturbation term.

2.1.2. Mediation effect model

In order to test the mechanism of ESG disclosure quality affecting human capital efficiency, the following mediating effect model is constructed based on the three-step method of Wen Zhonglin et al. (2004) and Baron & Kenny (1986):

$$Mediator_{i,t} = \alpha_0 + \alpha_1 ESG\_Quality_{i,t-1} + \theta Controls_{i,t-1} + \mu_i + \lambda_t + \nu_{i,t} \tag{2}$$

Incorporate mediator variables:

$$HCE_{i,t} = \delta_0 + \delta_1 ESG\_Quality_{i,t-1} + \delta_2 Mediator_{i,t} + \varphi Controls_{i,t-1} + \mu_i + \lambda_t + \omega_{i,t} \tag{3}$$

Where Mediator stands for mediating variable. Based on theoretical analysis, we test two types of intermediary pathways:

Financial resource path: The intermediary variables are debt financing cost (Debt_Cost) and operating cash flow (Operating_CF).

Value identity path: The mediating variables are employee satisfaction (Employee_Satisfaction, represented by the reciprocal of employee turnover) and organizational identity (Employee_Voice, represented by the employee suggestion behavior index).

If both α_1 and δ_2 are significant, and the absolute value of δ_1 is less than1071640634@qq.com β_1 in the baseline regression, it indicates a mediating effect.

2.1.3. Moderating effect model

In order to test the moderating effect of different contextual factors on the main effect, the interaction terms between ESG disclosure quality and moderating variables are added to the benchmark model:

$$HCE_{i,t} = \eta_0 + \eta_1 ESG\_Quality_{i,t-1} + \eta_2 Moderator_{i,t} + \eta_3 \left(ESG\_Quality_{i,t-1} \times Moderator_{i,t} \right) + \kappa Controls_{i,t-1} + \mu_i + \lambda_t + \xi_{i,t} \lim_{x \to \infty} \tag{4}$$

Among them, Moderator represents moderating variables, including: virtual variables (Pollution_Industry) in high-pollution industries; SOE of state-owned enterprises; Developed Region Dummy Variables (Developed_Region); Double Materiality Index (DM_Index, which comprehensively measures the financial importance and impact materiality of ESG factors).

The interaction term coefficient η_3 is the focus of attention, and if it is significantly positive, it indicates that this scenario factor enhances the positive impact of ESG disclosure quality on human capital efficiency.

2.2. Model Solution and Results

2.2.1. Baseline regression results

Table 1 The impact of ESG disclosure quality on human capital efficiency Benchmark regression results

Variable	(1)		(2)		(3)	
	LnRevenue_per_ employee	LnProfit_ per_ employee	LnRevenue_per_ employee	LnProfit_per_ employee	LnRevenue_per_ employee	LnProfit_per_ employee
ESG_ Quality	0.987*** (18.45)	0.891*** (15.34)	0.634*** (13.27)	0.567*** (11.89)	0.523*** (11.56)	0.478*** (10.23)
Control Variables	No	No	Partial	Partial	Yes	Yes
Fixed Effects	No	No	No	No	Yes	Yes
Observation	12,847	12,847	12,847	12,847	12,847	12,847
Adj. R^2	0.082	0.064	0.453	0.512	0.572	0.624

Note: ***, **, and * indicate significant at the 1%, 5%, and 10% levels, respectively; The value of t in parentheses; The full control variables include Size, ROA, Leverage, Cash, RD_Intensity.

Table 1 reports the baseline regression results for the impact of ESG disclosure quality on human capital efficiency. After gradually adding control variables and controlling for the fixed effects of years and industries, the coefficient of ESG_Quality was always significantly positive at the level of 1%. In the full model (columns 5 and 6), for every unit of improvement in ESG disclosure quality, per capita operating income and per capita net profit increased significantly by 52.3% and 47.8%, respectively. From an economic perspective, the quality of ESG disclosure will increase by 1 standard deviation (0.267), and the per capita operating income will increase by about 15.1%. This suggests that the improvement of ESG disclosure quality has a significant and important positive effect on corporate human capital efficiency, and the hypothesis H1 is verified.

2.2.2. Mechanism test results

Table 2 reports the test results for the main intermediary pathways. Panel A showed that the quality of ESG disclosure significantly reduced the cost of financing corporate debt (α1 = -0.487), while the reduction in financing costs further promoted human capital efficiency (δ2 = -0.056), and the mediating effect of this financial path accounted for 5.16% of the total effect. Panel B showed that ESG disclosure quality could significantly improve employee satisfaction (α1 = 0.145) and organizational identity (α1 = 0.278), which in turn positively affected human capital efficiency (δ2 was 0.234 and 0.312, respectively), and the mediating effect of the value recognition path accounted for 6.50% and 16.63% of the total effect, respectively. On the whole, the total mediating effect of the value recognition path (25.23%) is significantly higher than that of the financial resources path (10.51%), indicating that the quality of ESG disclosure mainly improves human capital efficiency by affecting employees' psychological cognition and sense of identity.

Table 2 Main mediating effect test results

Panel	Pathway	Mediating variables	α_1 (ESG→ Mediator)	δ_2 (Mediator→ HCE)	Proportion of mediating effects
A: Financial path	Financing costs	Debt_Cost	-0.487***	-0.056***	5.16%
	Cash flow	Operating_CF	0.312***	0.089***	5.35%
B: Value recognition path	Employee satisfaction	Employee_Satisfaction	0.145***	0.234***	6.50%
	Organizational identity	Employee_Voice	0.278***	0.312***	16.63%

Note: *** indicates significant at the 1% level; HCE is measured by per capita operating income; All models include control variables and fixed effects.

2.2.3. Heterogeneity analysis results

The Table 3 presents the results of a moderating effect analysis, showing how different firm and regional characteristics strengthen the positive relationship between ESG disclosure quality and per capita operating income. Specifically, the impact of ESG disclosure is significantly amplified for companies in high-pollution industries (by 50.7%), state-owned enterprises, and those located in developed regions, while the strongest enhancing effect is observed for firms with a high "Double Importance Index," indicating that contextual factors such as regulatory pressure, ownership type, regional development, and strategic importance critically shape the financial returns of ESG transparency, with all interactions being statistically significant and supporting the respective hypotheses.

Table 3 Moderating effect test results

Moderating variable	η1 (ESG Quality)	η3 (interaction term coefficient)	Economic interpretation	Assumption testing
High Pollution Industries (Pollution_Industry)	0.456***	0.231**	The effect of ESG disclosure in high-polluting industries increased by 50.7%	H2b support
State-Owned Enterprises (SOEs)	0.471***	0.147**	The effect of ESG disclosure in state-owned enterprises is stronger	H2c support
Developed Regions (Developed_Region)	0.437***	0.152**	The effect of ESG disclosure is stronger among enterprises in developed regions	H2d support
Double Importance Index (DM_Index)	0.324***	0.398***	The degree of double importance has the strongest moderating effect	H2a support

Note: *** and ** indicate significant at the level of 1% and 5% respectively; The explained variable is per capita operating income; All models include control variables, fixed effects, and moderating variables.

2.3. Results and discussion

This study systematically answers the three questions raised by the introduction through a three-step empirical analysis. The benchmark regression results in the first step confirm that the quality of ESG disclosure is an important driver for improving the efficiency of corporate human capital. This discovery extends ESG research from the traditional capital market field to the field of human resource management within enterprises, echoing the core essence of "people-oriented" in sustainable development.

The mechanism test in the second step reveals the "black box" that affects the path. The study found that although the role of financial resource path (financing cost and cash flow) is significant, the explanation of value recognition path (employee satisfaction, organizational identity) is 2.4

times stronger. This provides strong micro evidence for the "double materiality" theory: the "impact materiality" (impact on society and stakeholders) of ESG disclosures plays a more central role than its "financial materiality" in driving human capital efficiency. In particular, "organizational identity" is the most critical intermediary, indicating that ESG disclosure stimulates employees' deep intrinsic motivation and sense of belonging through value matching, which translates into higher productivity.

The results of the heterogeneity analysis in the third step have rich management implications. The stronger effect in high-polluting industries and state-owned enterprises indicates that high-quality ESG disclosure can more effectively resolve negative reputation and win employee trust in these organizations facing higher ESG pressures or taking on more social responsibility. The stronger effect in developed regions is related to the fact that local high-quality talents are more sensitive to ESG values and more fierce competition for talents. The strongest moderating effect of "double materiality" suggests that companies and regulators should implement more targeted ESG disclosure strategies and classified supervision, and focus resources on ESG issues with high substantive quality.

3. Conclusion

Based on the double materiality theory, this study uses the data of China's A-share listed companies from 2018 to 2023 to draw the following core conclusions through a three-step empirical analysis: First, the quality of ESG disclosure has a significant positive causal effect on its human capital efficiency, and improving the quality of ESG disclosure is an effective way to promote human capital appreciation. Secondly, this impact is mainly achieved through the "value identity" path, especially by enhancing employees' sense of organizational identity, which plays a much greater role than the traditional "financial resources" path, which highlights the powerful power of ESG disclosure in shaping organizational culture and psychological contract. Finally, the human capital effect of ESG disclosure is significantly contextual, especially in highly polluting industries, state-owned enterprises, developed regions, and high-dual importance enterprises.

The findings of this paper have important theoretical and practical significance. At the theoretical level, this study extends the study of the economic consequences of ESG disclosure to the field of human capital, and verifies the applicability of the double materiality theory in explaining the internal behavior of enterprises, emphasizing the importance of non-financial mechanisms. At the practical level, the research conclusions provide clear guidance for business managers: ESG information disclosure should be elevated to a strategic level, especially focusing on conveying social responsibility values through disclosure to enhance employee recognition, attract and motivate talents, and ultimately improve organizational efficiency. For policymakers, ESG information disclosure standards should be further improved, especially emphasizing the disclosure of social dimension (S) information. At the same time, we can consider implementing differentiated and precise regulatory and incentive policies, such as putting forward higher and more specific disclosure requirements for high-polluting industries, state-owned enterprises and high-dual importance enterprises, and providing them with corresponding transformation support, so as to more effectively guide enterprises to achieve a win-win situation between economic benefits and human capital development through high-quality ESG practices and disclosures.

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