



The Impact of Top Management Team Heterogeneity on ESG Performance in Manufacturing Enterprises

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Abstract. Drawing on Upper Echelons Theory and Emergence Theory, this study examines how TMT heterogeneity—in age, education, and professional background—affects ESG performance in Chinese A-share manufacturing listed firms (2013–2023), and tests the mediating role of strategic choice. Results show that overall TMT heterogeneity positively correlates with ESG performance; however, effects diverge markedly across dimensions: heterogeneity primarily promotes governance (G), may suppress environmental (E), and has unstable effects on social (S) performance. Age heterogeneity increases coordination costs and weakens ESG, while educational and professional heterogeneity enhance ESG through knowledge complementarity and resource integration. Strategic choice partially mediates these relationships.

Keywords: Executive Team Heterogeneity; ESG Performance; Strategic Choice; Upper Echelons Theory; Manufacturing Enterprises.

1 Introduction

ESG performance has become a critical indicator of corporate sustainable value and long-term competitiveness. For manufacturing enterprises—characterized by high energy consumption, strict emission constraints, and complex supply chains—ESG improvement relies heavily on the top management team's (TMT) continuous decisions regarding resource allocation and strategic prioritization.

Existing research explains ESG variation through ownership, board structure, financing constraints, and institutional pressure, yet pays insufficient attention to TMT characteristics^[1,2]. Upper Echelons Theory holds that TMT members' observable backgrounds shape their cognitive bases and strategic frameworks^[3,4]. Thus, differences in age, education, and professional experience affect how firms identify ESG risks, allocate green resources, and design governance systems.

However, TMT heterogeneity has dual effects. Emergence Theory suggests diverse teams achieve capabilities exceeding the sum of individual abilities through knowledge complementarity, yet member differences may also increase communication costs and cognitive conflicts. In manufacturing ESG, educational and professional diversity can

improve issue identification, while excessive age disparity may weaken strategic execution^[5,6]. This paper addresses three questions: whether TMT heterogeneity affects manufacturing ESG performance; whether effects differ across E, S, and G dimensions; and whether strategic choice mediates these relationships.

This paper offers three contributions: Explaining manufacturing ESG performance through TMT structure, expanding the micro-foundations of sustainability research; Decomposing TMT heterogeneity into age, education, and professional dimensions to reveal heterogeneous effects; And distinguishing E, S, and G sub-dimensions to show that TMT heterogeneity produces “marked governance improvement but insufficient environmental improvement.”

2 Theoretical Analysis and Research Hypotheses

Upper Echelons Theory holds that strategic choices reflect top managers' experiences and cognitive bases^[7,8]. Greater TMT heterogeneity enriches information and problem-interpretation frameworks^[9]. Emergence Theory explains that team capabilities emerge dynamically from interaction and integration processes. Thus, TMT heterogeneity has dual effects: diverse backgrounds broaden stakeholder perspectives, while excessive differences reduce consensus and execution efficiency.

Age heterogeneity reflects differences in risk preferences, career stages, and time horizons. Wide age spans may amplify disagreements on ESG investment horizons and risk-taking, weakening execution consistency. Thus:

H1: TMT age heterogeneity has a negative impact on the ESG performance of manufacturing enterprises.

Educational background heterogeneity reflects diversity in knowledge structures and cognitive frameworks. Multi-disciplinary training helps identify ESG issues from technology, finance, legal, and social perspectives, improving comprehensive judgment. Knowledge complementarity outweighs discussion costs in complex ESG decisions. Thus:

H2: TMT educational background heterogeneity has a positive impact on the ESG performance of manufacturing enterprises.

Professional background heterogeneity reflects diverse functional experience across production, R&D, marketing, finance, law, and management. Manufacturing ESG spans energy conservation, process upgrading, employee safety, and supply chain management; no single functional background covers all areas. Diversity enables cross-functional resource integration. Thus:

H3: TMT professional background heterogeneity has a positive impact on the ESG performance of manufacturing enterprises.

Strategic choice translates TMT cognitive structures into organizational action. Proactive strategies—higher R&D, market expansion, and resource reallocation—provide foundations for ESG improvement. TMT heterogeneity influences strategic orientation through strategic discussion and risk-taking, ultimately affecting ESG. Thus:

H4a: TMT heterogeneity significantly affects the strategic choices of manufacturing enterprises.

H4b: Proactive strategic choice has a positive impact on the ESG performance of manufacturing enterprises.

H4c: Strategic choice mediates the relationship between TMT heterogeneity and the ESG performance of manufacturing enterprises.

Based on the above hypotheses, this paper constructs a conceptual framework incorporating mediation, with the specific structural relationships illustrated in Figure 1.

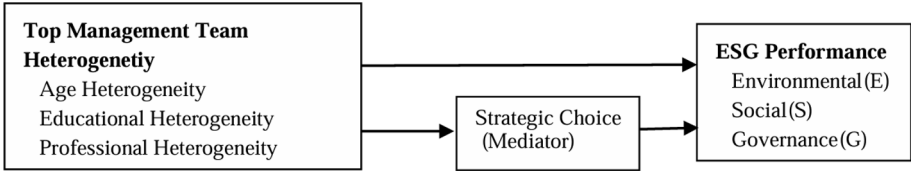


Fig. 1. Conceptual Framework of TMT Heterogeneity and ESG Performance

3 Research Design

3.1 Sample and Data Sources

This study uses A-share manufacturing listed companies (Shanghai and Shenzhen) from 2013 to 2023. Manufacturing constitutes a key entity in China’s green transition, with production involving energy consumption, emissions, employee safety, and supply chain responsibility. Data are from Wind, CSMAR, CNRDS, and Sino-Securities ESG Ratings.

Screening excluded ST/PT firms, observations with missing key variables, and extreme values, yielding 867 valid firm-year observations. All continuous variables were winsorized at 1% and 99%. VIF tests confirm no serious multicollinearity.

3.2 Variable Definitions

Dependent variable: ESG performance, measured using Sino-Securities ratings converted to numerical values (1–9). ESG is further decomposed into environmental (E), social (S), and governance (G) sub-dimensions. Ordered Logit models supplement the OLS baseline as robustness checks.

Independent variables: TMT heterogeneity (HMT). Age heterogeneity is measured via the coefficient of variation; educational and professional background. Heterogeneity use the model $H = 1 - \sum_{i=1}^n p_i^2$, where p is the proportion of each category). Overall HMT is the average of the three standardized scores.

Mediating variable: Corporate strategic choice (Stra), constructed as a continuous composite score from R&D intensity, sales growth, expense intensity, staffing, employee turnover, and fixed asset ratio. Higher values indicate more proactive strategic orientation.

Control variables: Firm size (Size), profitability (Roe), board size (Boardsize), ownership concentration (Qwc), leverage, cash flow, ownership nature, CEO duality,

independent director ratio, and industry competition. Standard errors are clustered at the firm level.

3.3 Baseline Model

The baseline model is specified as follows:

$$ESG_{it} = \alpha + \beta_1 HMT_{it-1} + \gamma Controls_{it-1} + \mu_i + \lambda_t + \varepsilon_{it} \quad (1)$$

where μ_i denotes firm fixed effects, λ_t denotes year fixed effects. To mitigate reverse causality, TMT heterogeneity (HMT) and control variables are lagged by one period.

4 Empirical Results

4.1 Descriptive Statistics

Descriptive statistics (Table 1) reveal substantial variation in ESG performance and TMT heterogeneity, providing an empirical foundation for analysis.

Table 1. Descriptive statistics of main variables

Variable	N	Mean	SD	Min	Max
ESG	867	4.105	1.058	1	8
E	867	2.007	1.175	1	8
S	867	4.198	1.104	1	8
G	867	5.285	1.355	1	9
HMT	867	0.317	0.071	0.100	0.539
Stra	867	18.134	5.013	6.092	29.426
Size	867	22.102	1.223	17.641	27.621
Boardsize	867	9.148	1.143	5	11
Qwc	867	41.724	15.499	3.62	65.48
Roe (%)	867	0.054	0.678	-85.647	2.379

Note: ESG = ESG composite score (1-9); E = Environmental score; S = Social score; G = Governance score; HMT = TMT heterogeneity index (Blau index); Stra = Corporate strategic choice (continuous composite score of six indicators); Size = Natural logarithm of total assets; Boardsize = Number of board members; Qwc = Ownership concentration (shareholding ratio of the largest shareholder, %); Roe = Return on equity. N = 867 firm-year observations.

4.2 Baseline Regression Results

As shown in Table 2, overall HMT is significantly positively correlated with ESG performance (Column 1). Sub-dimension results reveal pronounced heterogeneity: HMT promotes governance (Column 4: $\beta = 0.141$, $p < 0.01$), negatively affects environmental

performance (Column 2: $\beta = -0.009$, $p < 0.05$), and has no significant effect on social performance (Column 3). This suggests TMT diversity preferentially improves institutionalized, governance-intensive dimensions, while environmental improvements require capital investment that heterogeneity-related coordination costs may undermine.

Further decomposition shows that age heterogeneity reduces ESG strategic consensus through divergent time horizons, while educational and professional heterogeneity enhance ESG identification and governance capacity through knowledge complementarity.

Table 2. Regression results

Variable	(1) ESG	(2) E	(3) S	(4) G
HMT	0.011*** (3.67)	−0.009** (−2.77)	0.007 (1.147)	0.141*** (5.201)
Size	0.287*** (5.245)	0.190*** (1.789)	0.266*** (5.367)	0.220*** (3.455)
Boardsize	0.00734 (3.877)	0.00119 (0.802)	0.00961 (1.087)	−0.0277** (−3.736)
Qwc	0.00219 (0.3166)	−0.00909 (−1.031)	0.00173 (0.369)	0.00208** (2.090)
Roe	−0.00286 (−0.579)	−0.0164*** (−3.470)	0.00674 (1.108)	−0.00156 (−0.178)
Constant	−1.642*** (−3.134)	−2.156*** (−4.519)	−1.245** (−2.326)	2.284*** (3.086)
Year FE	Y	Y	Y	Y
Industry FE	Y	Y	Y	Y
Observations	867	867	867	867
Adj. R ²	0.035	0.055	0.122	0.141

Note: t-values in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Year fixed effects and industry fixed effects are included in all specifications.

As shown in Table 3, Mediation tests confirm that strategic choice is a significant pathway linking TMT heterogeneity and ESG performance: educational and professional heterogeneity promote proactive strategies and ESG improvement, while age heterogeneity weakens strategic coherence ^[10].

Table 3. Mediating effect results

Variable	(1) ESG	(2) Stra	(3) ESG	(4) ESG
Stra			0.05 00*** (5.0195)	0.050*** (6.0195)
Hage	−0.0378*** (−6.186)	−0.0994** (−2.0383)		−0.0292*** (−5.1860)
Hedu	0.1250*** (3.0490)	−0.1072 *** (−2.6391)		0.0285*** (2.4941)

Hcar	0.0421 *** (4.1192)	0.1652 *** (3.0551)		0.0513*** (10.1193)
Constant	-1.642*** (-3.134)	-2.156*** (-4.519)	-1.245** (-2.326)	2.284*** (3.086)
control variable	Y	Y	Y	Y
Industry / Year FE	Y	Y	Y	Y
Observations	867	867	867	867
Adj. R ²	0.1152	0.1275	0.1032	0.1341

Note: t-values in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

5 Conclusions and Implications

Drawing on Upper Echelons and Emergence Theories, this paper finds that TMT heterogeneity's impact on ESG performance is dual and differentiated across both heterogeneity sources and ESG dimensions^[9]. Educational and professional diversity promote ESG through knowledge complementarity and cross-functional synergy, while age heterogeneity weakens ESG via increased coordination costs.

The impact across ESG dimensions is uneven: governance improves readily through TMT knowledge and awareness, while environmental performance requires substantial technological and capital commitments that are vulnerable to coordination costs^[11]. Researchers should treat ESG as a heterogeneous construct with distinct institutional logics across E, S, and G dimensions.

In practice, manufacturing firms should prioritize converting TMT diversity into strategic synergy through cross-functional committees, dedicated ESG mechanisms, and environmental-management executive appointments. Regulators should strengthen executive background and ESG disclosure standards to enhance sustainable development capacity at the governance level.

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