Econometric Validation of Sectoral Environmental Innovation Drivers

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Abstract: While traditional sustainability analyses examine firms' general environmental performance (E-Score), this metric mainly reflects the status quo of current operational emissions and resource efficiency. To evaluate long-term competitiveness amid the ecological transition, a deliberate shift toward forward-looking metrics is essential. Consequently, this empirical research focuses on the environmental innovation score, which captures a firm's future-oriented capacity to generate new market opportunities through eco-design and green technologies. The central research question investigates how corporate governance quality, social performance, and financial architecture shape environmental innovation across five distinct economic sectors (financial, consumer, energy, healthcare, and industrial). This paper employs an exploratory quantitative approach with multiple linear regression (OLS) models on disaggregated panel data of EURO STOXX 600 firms (2008–2022). This first empirical assessment shows significant sectoral heterogeneity. The statistical analysis suggests that corporate governance and social performance are not universal catalysts for green technologies. These factors are negatively associated, suggesting a potential resource trade-off: social and governance scores are significantly negatively associated with environmental innovation in the consumer and financial sectors. Investments in social programs or strict governance compliance may restrict the resources available for disruptive green technologies. Return on Assets (ROA) presents a decoupling between environmental performance and innovation. Previous work indicates that ROA drives the general E-Score in the consumer sector; this study finds it has no significant impact on environmental innovation in that same sector. Instead, ROA acts as a significant positive driver of environmental innovation in the financial sector and demonstrates a significant negative effect in the healthcare sector.

Keywords*:* Corporate governance, Environmental innovation, ESG integration, Financial structure, Sectoral analysis, Stakeholder theory

1. Introduction

While valuable for assessing present-day compliance, these backward-looking metrics are methodologically ill-equipped to capture the dynamic, forward-looking, and highly risky capital investments required to successfully navigate the macroeconomic transition toward a low-carbon, circular economy. Environmental innovation is fundamentally different from these static compliance measures. This proactive, strategic capacity enables a firm to develop disruptive green technologies, design environmentally friendly products, and re-engineer supply chains that actively reduce environmental costs for consumers and create new market paradigms (Horbach, 2008).

Existing ESG approaches generally posit a synergistic relationship across all dimensions of sustainability, suggesting that high social performance and strong corporate governance are natural and frictionless pathways to environmental innovation (Freeman et al., 2004). However, absolute resource scarcity dictates the financial reality of corporations. The strategic decision to allocate significant financial assets toward expansive social programs or exhaustive governance audits inevitably draws from the exact same pools of liquidity required to fund high-risk environmental R&D. The probability of such resource conflict suggests that sustainability must be evaluated in terms of competitive trade-offs, rather than presumed to be universally complementary.

2. Theoretical Framework and Econometric Specifications

Traditional stakeholder theory suggests that the satisfaction of various competing interest groups leads to a virtuous cycle of increasing trust and better financial performance (Freeman et al., 2004). In this context, firms with good social performance and transparent corporate governance should theoretically be more environmentally innovative.

Conversely, the trade-off theory explicitly accounts for the finite nature of corporate capital. It suggests that an excessive deployment of capital toward broad social or governance mandates leads to a severe dilution of available financial resources. This resource conflict greatly limits the budgets for capital-intensive environmental R&D. The paper evaluates the stakeholder theory and the trade-off theory and tests the relevance of slack resource theory in different sectors. The paper uses a multivariate linear regression model to analyze firms from 2008 to 2022.

$$EIS_{i,t} = \beta_0 + \beta_1 ENV_{i,t} + \beta_2 SOC_{i,t} + \beta_3 GOV_{i,t} + \sum_{k=1}^{K} \gamma_k Z_{k,i,t} + \epsilon_{i,t}$$

In this specification, $EIS_{i,t}$ represents the dependent variable, the Environmental Innovation Score, for firm *i* at time t. β_0 represents the intercept. $ENV_{i,t}$, $SOC_{i,t}$, $GOV_{i,t}$ represent the aggregate ESG pillar scores, respectively. The term $Z_{k,i,t}$ denotes a vector of *K* firm-specific financial control variables (such as ROA, EBITDA, or market capitalization) applied to control for omitted variable bias, with acting γk as their corresponding slope coefficients. Finally, $\epsilon_{i,t}$ captures the idiosyncratic error term.

3. Research Design

The disaggregation of the dataset into five distinct economic sectors is theoretically motivated by the transition dynamics of the circular economy. Because industries interact with physical and regulatory environmental risks differently, treating ESG as a monolithic concept masks profound structural reality. Furthermore, the inclusion of heterogeneous financial control variables across the sectoral models is theoretically grounded in the Sustainability Accounting Standards Board (SASB) Materiality Map. The SASB framework establishes that sustainability-related risks, opportunities, and the financial metrics that constrain them manifest differently across industries. Standardizing the control variables across all sectors would introduce bias by forcing inappropriate financial structures onto incompatible business models.

Empirical Results and Sectoral Heterogeneity

The consolidated regression results (Table 1) validate the structural heterogeneity of environmental innovation drivers across sectors.

Table 1: Results

Explanatory Variables & Model Diagnostics	Consumer (*β*)	Energy (*β*)	Financial (*β*)	Healthcare (*β*)	Industrial (*β*)
Independent ESG Pillars	-	-	-	-	-
Social Score	-0.244**	-0.330*	-0.245**	0.016	-0.425***
Governance Score	-0.155**	-0.236*	-0.292***	-0.493***	-
Environmental Controls	-	-	-	-	-
Resource Use Score	-0.443***	-0.955***	-0.407***	-	-
Emissions Score	-1.009***	-1.177***	-0.275***	-	-0.721***
SASB Financial Controls	-	-	-	-	-
ROA	-0.050	0.796	1.789***	-2.023**	-
ROE	-	0.247	-0.420**	-	-
Net Margin	-	-3.656***	-0.538	-	-4.753**
Market Capitalization	-	1.169e-5	-3.002e-6*	-	2.058e-5**
EBITDA	-4.153e-5**	3.985e-5	1.004e-5	-	-
Model Diagnostics	-	-	-	-	-
Adjusted R^2	.931	.736	.841	.687	.834
Observations (N)	314	305	354	306	340

Note: Unstandardized coefficients are presented. Significance levels: *p < .10, **p < .05, ***p < .01. Missing variables (-) are structurally excluded based on sectoral SASB materiality mappings.

Shifting the focus to the non-tautological variables reveals critical strategic insights. The models strongly support the resource trade-off theory regarding non-environmental pillars. Across the consumer, financial, and industrial sectors, high social scores act as a significant statistical barrier to green innovation. This suggests that firms allocating substantial capital to broad social compliance exhaust the specific liquidity required for forward-looking eco-design. Likewise, the corporate governance compliance is known as a significant negative constraint, it is the primary barrier in the healthcare sector.

The Slack Resources Theory finds significant validation only in the financial sector, where ROA acts as a strong positive determinant, indicating that pristine asset efficiency supplies the vital risk buffer for green markets. Conversely, the healthcare sector contradicts this theory: an elevated ROA exerts a significant negative impact on innovation. This implies that massive ROA, potentially generated by lucrative legacy patents, leads to institutional complacency rather than pioneering sustainable drug alternatives. Finally, margin analysis in the energy sector reveals that artificially boosting bottom-line net margins to shareholders involves slashing the capital-intensive R&D budgets needed for green technological breakthroughs.

4. Conclusion

This study of the EURO STOXX 600 shows that corporate environmental innovation is driven by different organizational and financial factors than ESG compliance. While effective ESG strategies may be universal, they are unlikely to be suitable for all market environments, and the conflation of ESG as a single metric results in confusion. The demands of corporate governance and social performance can obstruct disruptive green innovation and support the trade-off theory of capital allocation. Decision makers seeking to simultaneously optimize all dimensions of ESG face capital constraints and risk mediocrity. It is important to recognize these inherent trade-offs so that management teams can strive to balance formal operational compliance with the disruptive ecological progress needed to sustain macroeconomic competitiveness over the long term. Future research, using sophisticated dynamic panel methodologies, should build on these exploratory findings to further disentangle these important governance trade-offs.

Acknowledgements

The authors thank the anonymous reviewers of the 22nd ECMLG 2026 for their constructive feedback.

Ethics Declaration: This research did not require ethical clearance because it uses publicly available financial and ESG data from the EURO STOXX 600 index. No human subjects or sensitive information was used.

AI Declaration: Authors independently conducted research, data analysis, and interpretation. AI tools were used only for minor language polishing. No sections were fully generated by AI.

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