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This study empirically examines how firms' environmental and social (E and S) activities affect labor productivity using E and S metrics provided by the Korea Corporate Governance Service (KCGS). Using a panel of listed firms over 2015–2023, we find that both the ES rating and the ES score are significantly and negatively associated with labor productivity, which remains robust when we use the overall ESG rating or the E and S pillar ratings. We further provide channel evidence consistent with a cost-burden mechanism: firms with higher ES exhibit a higher total operating cost ratio (TOCR), suggesting that the ES–productivity relationship may be linked to operating cost pressure. Subcategory analyses reveal heterogeneous pathways within ES. In the environmental category, operational/management and communication-oriented activities are negatively related to labor productivity, consistent with higher coordination and management costs. In contrast, community engagement in the social category is positively related to labor productivity, pointing to a complementary pathway through trust, reputation, and relationship capital. Finally, firm- and industry-level analyses indicate substantial heterogeneity in the ES–productivity relationship across firms and industries. Overall, by combining cost-based channel evidence, subcategory-level decompositions, and heterogeneity analyses, this study highlights that evaluating the economic implications of sustainability initiatives requires attention not only to aggregate ES/ESG metrics but also to cost structure, activity types, and firm and industry characteristics.

Keywords: ESG, ES activities, Labor productivity, Manufacturing firms

JEL Classification: D24, E24, G30, Q50

I. Introduction

At the firm level, productivity is typically defined as output relative to inputs and captures the overall efficiency with which multiple factors—such as labor, capital, and land—are transformed into output. Productivity can be measured using total factor productivity (TFP) or multifactor productivity (MFP), but these measures require detailed data and involve complex estimation and measurement procedures. By contrast, single-factor productivity (SFP) relates output to a single input (e.g., labor or capital), which makes it easier to compute and more comparable across firms, industries, and countries. Among these measures, labor productivity—output per unit of labor input—is the most widely used indicator of productive efficiency (OECD, 2025). Prior studies (Fallahi et al., 2010; Laureti and Viviani, 2011) emphasize that improvements in labor productivity are a key determinant of firm competitiveness in domestic and international markets, in part by lowering unit production costs. Moreover, labor productivity reflects not only human-capital-related factors but also the influence of other inputs and organizational efficiency, including physical capital, intangible assets, production technology, and managerial organization (OECD, 2025).

Meanwhile, growing attention to climate change and broader environmental challenges, as well as corporate social responsibility, has heightened the importance of firms' non-financial performance in addition to their financial outcomes. Under the traditional shareholder-oriented view, firm performance is primarily evaluated in terms of financial results that maximize shareholder value. In contrast, stakeholder theory posits that firms should account for the interests of a broader set of stakeholders—including employees, customers, local communities, and the natural environment—rather than focusing exclusively on shareholders. ESG[1)], an acronym for Environmental, Social,

1) ESG is widely understood to have originated from the United Nations Environment Programme Finance Initiative (UNEP FI), launched in 2003, and to have gained broader traction following the establishment of the United Nations Principles for Responsible Investment (UN PRI) in 2006. As of end-August 2025, UNEP FI has more than 500 member institutions—including banks, insurers, and institutional investors—and supports the financial sector in incorporating environmental and social sustainability considerations.

and Governance, summarizes firms' sustainability-related non-financial activities, and ESG ratings and scores are now widely used as investment-screening metrics by global investors, including international investment banks.[2)] A notable turning point was the 2020 annual letter by Larry Fink, CEO of BlackRock, widely regarded as the world's largest asset manager; its assets under management are estimated to exceed USD 10 trillion as of 2025. The letter highlighted sustainability as a core investment consideration and signaled a stronger stance toward fossil-fuel producers. Following the COVID-19 pandemic, ESG investing has also been framed as part of a broader reassessment of environmental degradation and as a potential source of new growth in the context of economic recovery. Prior studies report increased capital flows into firms with strong ESG performance and more favorable market outcomes (Barrymore and Sampson, 2009; Khan, Serafeim, and Yoon, 2016; Nagy, Kassam, and Lee, 2016). Taken together, these developments suggest that corporate ESG activities may enhance firm value by strengthening nonfinancial performance and stakeholder relations.

However, it is important to assess how these sustainability-related activities ultimately affect labor productivity, a key determinant of firms' competitiveness. Motivated by this concern, the present study investigates the relationship between firms' environmental and social (ES) activities and labor productivity in the Korean manufacturing sector from multiple angles and draws policy-relevant implications. We focus on ES as the primary explanatory variable because governance-related (G) activities are more closely tied to internal control systems and shareholder protection, implying mechanisms that differ from those of E and S and are less directly linked to labor productivity. Accordingly, we exclude G from our main analyses and use it primarily for robustness checks.

UN PRI, developed under UNEP FI as a set of principles for the asset management and investment community, has more than 5,000 institutional investors as signatories and promotes the integration of ESG factors into investment decision-making processes.

2) Bank of Korea also incorporates ESG considerations into its foreign reserve asset management, for example by adopting a negative-screening approach that excludes companies associated with ESG controversies, and is reviewing a longer-term shift toward an ESG integration strategy that would more comprehensively embed ESG factors across the portfolio.

The main empirical findings are as follows. First, in the full-sample analysis, both the ES rating and the ES score are consistently and negatively associated with labor productivity. This negative relationship remains after controlling for key firm characteristics—such as firm size, capital intensity, wages, and R&D—and is broadly robust to alternative ESG measures, including the overall ESG rating and the E, S, and G pillar ratings. Second, our channel analyses suggest that the negative ES–productivity relationship may be linked to firms' cost burden and the composition of ES activities. Specifically, firms with higher ES exhibit a higher total operating cost ratio (TOCR), and the negative ES coefficient is attenuated when TOCR is included as a control variable. Moreover, when we decompose the ES score into environmental and social subcategories, we find heterogeneous patterns: operational/management and stakeholder-engagement components in the environmental category are negatively related to labor productivity, whereas community engagement in the social category is positively related. Third, the productivity effects of ES vary across firms and industries. In interaction models, the adverse association of ES is partially mitigated under certain financial conditions, and industry-level analyses show pronounced negative effects in selected manufacturing industries—such as paper, metals, and electronic components—while the relationship is not statistically significant in major export industries or in high greenhouse-gas-emitting sectors.

Relative to prior studies that focus primarily on aggregate ESG ratings or a single pillar, this study provides a more comprehensive assessment of how firms' ES activities relate to labor productivity. We jointly consider (i) both ES ratings and continuous ES scores, (ii) channel evidence based on the total operating cost ratio (TOCR), (iii) decompositions of the environmental (E) and social (S) pillars into detailed subcategories, and (iv) heterogeneity across firms and industries. In particular, the TOCR-based analysis and the subcategory decomposition together suggest that the ES–productivity relationship is not a single uniform effect but may operate through cost burdens and activity-specific pathways. By incorporating continuous score data, we also capture variation that may be limited in rating-based measures

and provide additional robustness checks. Finally, by documenting that ES effects can differ by firm characteristics and industry environments, we offer policy-relevant implications: effective policy design may require approaches tailored to industry and firm conditions rather than uniform prescriptions. Overall, our approach contributes empirical evidence that helps clarify the mechanisms through which sustainability-related activities may be linked to productivity.

The remainder of this paper is organized as follows. Section II reviews the related literature. Section III describes the data. Section IV presents the empirical results. Section V concludes.

II. Literature Review

Corporate ESG activities can affect labor productivity through multiple channels, with potentially positive or negative aspects. On the positive side, strong environmental and social practices may enhance employees' social identity[3)] and strengthen job satisfaction and mutual ties within the workplace. These improvements can foster knowledge sharing, innovation, and organizational efficiency, ultimately raising labor productivity (Turban and Greening, 1997; Jones and Volpe, 2011; Delmas and Pekovic, 2012). Firms with superior social and environmental performance may also build a reputation as desirable employers, facilitating recruitment and increasing the likelihood of attracting higher-quality workers. Such employees may exhibit greater job satisfaction and align more closely with the firm's values, which can translate into higher effort and, in turn, improved labor productivity (Ambec and Lanoie, 2008; Brekke and Nyborg, 2008; Wagner, 2011; Barrymore and Sampson, 2021). In addition, appropriately designed environmental standards and innovation in production processes can reduce production costs and improve factor productivity, thereby strengthening firm competitiveness (Porter

3) Originally developed by social psychologists Henri Tajfel and John Turner, social identity refers to an individual's self-concept—shaping self-esteem, attitudes, and behaviors—that arises from perceived membership in a particular social group.

and van der Linde, 1995; Delmas and Montiel, 2009; Alberti, 2013; Ma et al., 2020). Finally, as investors increasingly incorporate ESG considerations into investment decisions, firms with strong environmental and corporate social responsibility (CSR) performance may obtain external financing at lower cost (Bassen et al., 2006; Atan et al., 2017).

On the other hand, strengthening firms' environmental and social management may adversely affect labor productivity if it diverts key inputs—such as capital, labor, raw materials, and energy—away from core production processes toward non-core activities (Jaffe et al., 1995; Becker, 2011; Jackson et al., 2014). Large-scale investments and the adoption of new production technologies to comply with stringent environmental standards may also reduce organizational flexibility, potentially undermining labor productivity and competitiveness (Aguilera-Caracuel and Ortiz-de-Mandojana, 2013; Lannelongue et al., 2017). In addition, environmental management often entails additional expenditures, and firms may face heightened uncertainty and risk stemming from changes in environmental regulation and related policies (Walley and Whitehead, 1994; Hoffmann et al., 2009).

The empirical literature on the relationship between firms' ESG (or broader environmental and social) performance and labor productivity remains largely inconclusive. Below, we summarize a set of studies reporting positive associations. Goss and Roberts (2011), using U.S. firms over 1991–2006, examine the link between corporate social responsibility (CSR) and loan pricing and find that firms with stronger CSR obtain loans at lower interest rates. This can be interpreted as a reduction in financing costs and may, in turn, support productivity improvements. Delmas and Pekovic (2012), based on a cross-section of more than 5,000 French firms in 2006, report that firms adopting environmental standards such as ISO 14001[4)] exhibit higher labor productivity than non-adopters. Atan et al. (2017), analyzing 54 Malaysian firms over 2010–2013, find that higher ESG scores are associated with a lower

4) ISO 14001 is an international standard issued by the International Organization for Standardization (ISO) that specifies requirements for an organization's environmental management system (EMS).

cost of capital, although the separate effects of the E, S, and G components are not statistically significant. Barrymore and Sampson (2021), using U.S. firms over 2008–2018, document that the ESG–labor productivity relationship varies by industry and is positive for larger firms. Kalantzis and Niczyporuk (2022), examining more than 15,000 firms across the EU-27 and the United Kingdom over 2018–2019, find that investments in within-firm energy efficiency increase labor productivity, potentially by improving the quality of machinery and equipment and enhancing working conditions. Finally, Deng et al. (2023), using 2,833 listed Chinese firms over 2016–2020, show that stronger ESG performance is associated with higher total factor productivity.

However, a number of studies report negative or mixed findings. Becker (2011), analyzing manufacturing plants in the United States, finds that higher environmental compliance costs are associated with lower labor productivity, although the effect is not statistically significant. Lannelongue et al. (2017), using a sample of 2,823 plants located in 23 European Economic Area (EEA) countries in 2014, document a negative relationship between environmental performance and labor productivity. They further examine moderating effects by interacting environmental performance with capital intensity and show that the negative association is stronger for more capital-intensive plants—that is, labor productivity declines more in plants with higher environmental performance (e.g., lower CO_2 emissions) when capital intensity is high. Ma et al. (2020), studying Chinese manufacturing firms in 2016, also report that environmental management is negatively related to labor productivity, and that quality management—proxied by adoption of ISO 9001[5)]—attenuates this negative relationship. More recently, Kim and Lee (2025) analyzed the relationship between ESG performance and corporate productivity for Korean listed firms over the period 2006–2021. The results show that neither the overall ESG composite score nor the individual E and S scores have statistically significant effects on total factor productivity. In contrast, the

5) ISO 9001 is an international standard for Quality Management Systems (QMS) that applies to all industry sectors, issued by the International Organization for Standardization (ISO).

E score has a statistically significant negative effect on labor productivity—measured as total revenue divided by labor costs—whereas the S score and the G score have statistically significant positive effects.

III. Data

To empirically examine the effect of firms' ES activities on labor productivity in the Korean manufacturing sector, we construct our dataset by merging two main databases. ES-related measures are obtained from firm-level environmental (E) and social (S) ratings and detailed assessment scores published annually by the Korea Corporate Governance Service (KCGS). Financial statements and other firm characteristics are drawn from DataGuide. Our analysis sample includes only firm-year observations that are available in both data sources.

KCGS has reported annual pillar ratings for E, S, and G as well as an overall ESG rating since 2011. The ratings take six ordered categories[6)]—A+ (excellent), A (very good), B+ (good), B (fair), C (weak), and D (very weak)—which we convert into a numeric scale from 1 to 6 (A+ = 6, A = 5, B+ = 4, B = 3, C = 2, D = 1). *ES_rating* is constructed as the simple average of the numeric E and S ratings. In addition to letter grades, KCGS computes detailed pillar scores on a 0–100 scale each year. Unlike the ratings, these scores are not publicly disclosed and are provided only on a restricted basis for research purposes. Specifically, *ES_rating* is a publicly disclosed ordinal measure that provides an intuitive benchmark for comparing firms' relative ES performance, whereas *ES_score* is an internally assessed continuous measure that can capture finer-grained variation that may not be reflected in the discrete rating scale. We therefore conduct analyses using both rating-based and score-based ES measures to assess the robustness of our findings regarding the ES–

6) KCGS ratings are classified into seven categories—S, A+, A, B+, B, C, and D. In manufacturing, however, there are no observations rated S in our sample. Accordingly, we exclude the S category and work with the remaining six rating grades in the empirical analysis.

productivity relationship. The sample period is set to 2015–2023, during which the ESG data exhibit greater stability and time-series consistency.

We include a standard set of firm-level financial controls that are commonly related to labor productivity, including firm size, capital intensity, firm age, labor costs, R&D, leverage, and profitability. The dependent variable is firm-level labor productivity. Following the literature, we measure labor productivity as the natural logarithm of value added per employee (Jensen et al., 2001; Zwick, 2004; Salis and Williams, 2010; Delmas and Pekovic, 2013; Kalantzis and Niczyporuk, 2022) and, alternatively, the natural logarithm of sales per employee (Ichniowski, 1990; Koch and McGrath, 1996; Fallahi et al., 2010; Lannelongue et al., 2017; Barrymore and Sampson, 2021). Sales are readily available, but they embed intermediate input costs (e.g., raw materials and intermediate goods), which can limit their ability to capture the firm's net economic contribution. To address this concern, we treat value added as our primary measure while also reporting results based on sales. Firm-level value added is constructed following the methodology of the Korea Productivity Center (KPC) and includes operating profit, labor income (including wages, retirement benefits, and employee welfare expenses), depreciation, allowance for doubtful accounts, and taxes and dues.[7] Ideally, the denominator would be hours worked at the firm level; however, due to data availability constraints, we use the number of employees.[8]

Labor productivity is more directly connected to environmental and social (E and S) dimensions—such as environmental efficiency, working conditions, and human resource management—whereas governance (G) is largely characterized by more indirect features, including internal control systems and

7) The value-added measure of Korea Productivity Center (KPC) is constructed using listed-firm financial statement data, and information from the manufacturing cost statement are not available, which limits our ability to estimate value added with full precision. To compensate for this, we also report results using an alternative labor productivity measure based on sales.

8) Both the OECD and the International Labour Organization (ILO) compile labor productivity statistics based on value added per unit of labor input. In Korea, the Korea Productivity Center (KPC) regularly produces official labor productivity indicators by sector and by industry, reporting both value added per labor input and an index of industrial labor productivity. (https://www.kpc.or.kr)

shareholder rights protection. Accordingly, following common practice in the literature, we use an ES measure that combines only environmental and social performance as our primary explanatory variable (Deng et al., 2013; Lins et al., 2017; Dyck et al., 2019; Choi and Jeong, 2025). This choice is intended to more clearly isolate the ESG components that are most directly relevant for labor productivity.[9)]

To appropriately account for firm characteristics that may affect labor productivity, we include a set of financial and structural factors. Firm size is a standard control variable in productivity studies, and prior research documents that larger firms tend to be more productive, potentially reflecting economies of scale (Koch and McGrath, 1996; Zwick, 2004; Laureti and Viviani, 2011; Ma et al., 2020). We proxy firm size by the natural logarithm of total assets and expect a positive coefficient. Capital intensity captures the amount of physical capital used per unit of labor input; higher capital intensity implies greater availability of machinery and equipment per worker and is therefore expected to be positively related to labor productivity. Following Fallahi et al. (2010), we measure capital intensity as the natural logarithm of tangible fixed assets per employee. For robustness checks, we also use an alternative measure that includes intangible assets, with similar results. Firm age may also influence productivity in either direction (Jensen et al., 2001; Ma et al., 2020). Older firms may benefit from accumulated experience and learning-by-doing, whereas younger firms can be more productive in industries with rapid technological change. We use the natural logarithm of firm age, and the expected sign can be positive or negative.

Wage levels paid to workers can materially affect firm productivity (Fallahi et al., 2010; Delmas and Pekovic, 2013). Higher average wages may reflect a more skilled workforce and can raise productivity by improving worker motivation and reducing turnover. Conversely, wage increases that exceed marginal productivity may impose additional cost burdens. To accommodate

9) For the main specifications, we also re-estimate the models using the overall ESG measure in place of ES. The results are reported in Table 3 and remain robust across additional specifications.

these competing effects, we use the natural logarithm of average wage per employee, and the expected sign is ambiguous. Innovation is another key determinant of production efficiency (Schumpeter, 1934; Kurt and Kurt, 2001). Following Ma et al. (2020), we measure the degree of innovation by an R&D ratio, defined as R&D expenses scaled by total assets. Because more active innovation is likely to enhance productive efficiency, we expect a positive coefficient. From the perspective of financial structure, leverage may have offsetting effects on productivity (Kalantzis and Niczyporuk, 2022; Deng et al., 2023; Lan et al., 2024; Kim and Lee, 2025). Moderate use of debt can support expansion and the realization of scale economies, whereas excessive leverage can reduce productivity through higher interest expenses and tighter financing constraints. Accordingly, the expected sign of leverage—measured as total liabilities divided by total equity—is not clear ex ante. Finally, profitability (ROA) can provide an important foundation for productivity improvements. More profitable firms may strengthen efficiency and productivity by expanding capital investment and increasing R&D spending. Following Laureti and Viviani (2011) and Lan et al. (2024), we proxy profitability using net income scaled by total assets and expect a positive sign.

Our final sample consists of firms in the manufacturing sector—defined as KSIC 2-digit industries with codes 10–34—for which ESG assessments are available. The resulting panel includes 4,138 firm-year observations. Table 1 reports summary statistics for the main variables.[10] The labor productivity measures and ESG-related variables exhibit reasonable distributions in the sample, and most financial variables fall within ranges comparable to those documented in prior studies. Labor productivity displays substantial cross-firm heterogeneity, and firm characteristics such as asset size, capital intensity, and profitability also show meaningful dispersion, supporting an empirical analysis of productivity determinants. Overall, the sample covers manufacturing firms with diverse scales and financial structures, providing sufficient variation to examine the relationship between ESG activities and productivity.

10) Definitions of the main variables are provided in Appendix A.1.

Table 1. Summary statistics

This table reports summary statistics for the main variables used in the empirical analysis. The table presents the number of observations, mean, median, standard deviation, minimum, and maximum for each variable. Variable definitions are provided in Appendix A.1.

Variables	Obs.	Mean	Median	Std.Dev.	Min	Max
LP_VA	4,138	11.49	11.42	1.21	5.27	17.22
LP_Sales	4,138	13.82	13.67	1.05	10.18	19.77
ES_rating	4,138	2.85	2.50	1.17	1.00	6.00
Size	4,138	20.19	19.95	1.45	16.47	26.85
CapIntensity	4,138	12.89	12.80	1.12	8.12	18.80
Age	4,138	3.52	3.76	0.71	0.69	4.84
Salary	4,138	10.97	10.95	0.29	9.34	12.22
R&D	4,138	0.01	0.00	0.02	0.00	0.32
Leverage	4,138	1.39	0.74	14.54	0.02	845.10
ROA	4,138	0.03	0.03	0.07	-0.58	1.30

IV. Empirical Results

1. Baseline Regression Analyses

This section examines the relationship between ES activities and labor productivity through a sequence of descriptive and regression analyses. Section 4.1.1 first illustrates how the ES–productivity relationship changes depending on whether firm size is controlled for. Sections 4.1.2 and 4.1.3 then assess whether this pattern remains consistent in the baseline ES regressions and in comparative specifications using alternative measures, including the E, S, and G pillar ratings as well as the integrated ESG ratings.

1.1. Univariate Test

To provide descriptive evidence on the relationship between labor productivity and ES measures, we first present a simple comparison without controlling for firm size (Figure 1). We then examine whether a similar pattern persists after removing the size component in advance (Figure 2). Because ES is typically strongly correlated with firm size, contrasting the size-unadjusted and size-adjusted comparisons is informative for isolating the underlying ES–productivity relationship.

Panel A of Figure 1 compares mean labor productivity across groups defined by the discrete ES rating. Firms are classified into three categories: Low ($ES\_Rating \leq 2$, corresponding to grades C and D), Middle ($ES\_Rating = 3$, grade B), and High ($ES\_Rating \geq 4$, grades B+, A, and A+). The number of observations in each group is 1,734 (Low), 1,610 (Middle), and 794 (High), indicating that the High group contains substantially fewer observations than the other two groups. The x-axis indicates the year, and the y-axis shows the group-specific mean of labor productivity measured by natural logarithm of value added per employee (LP_VA). The unconditional comparison shows that firms with higher ES ratings tend to exhibit higher labor productivity. Panel B constructs ES_score as the average of the environmental (E) and social (S) scores (0–100) and partitions firms into terciles based on this continuous measure. As a result, the three groups are approximately balanced, with about 1,380 observations per tercile. Consistent with Panel A, mean labor productivity increases with ES_score. However, these patterns do not take into account the strong correlation between ES and firm size. Given that high-ES firms are typically larger and have greater resource capacity, the relationship may differ once firm size is controlled for.

Figure 1. Trends in labor productivity across ES ratings and scores

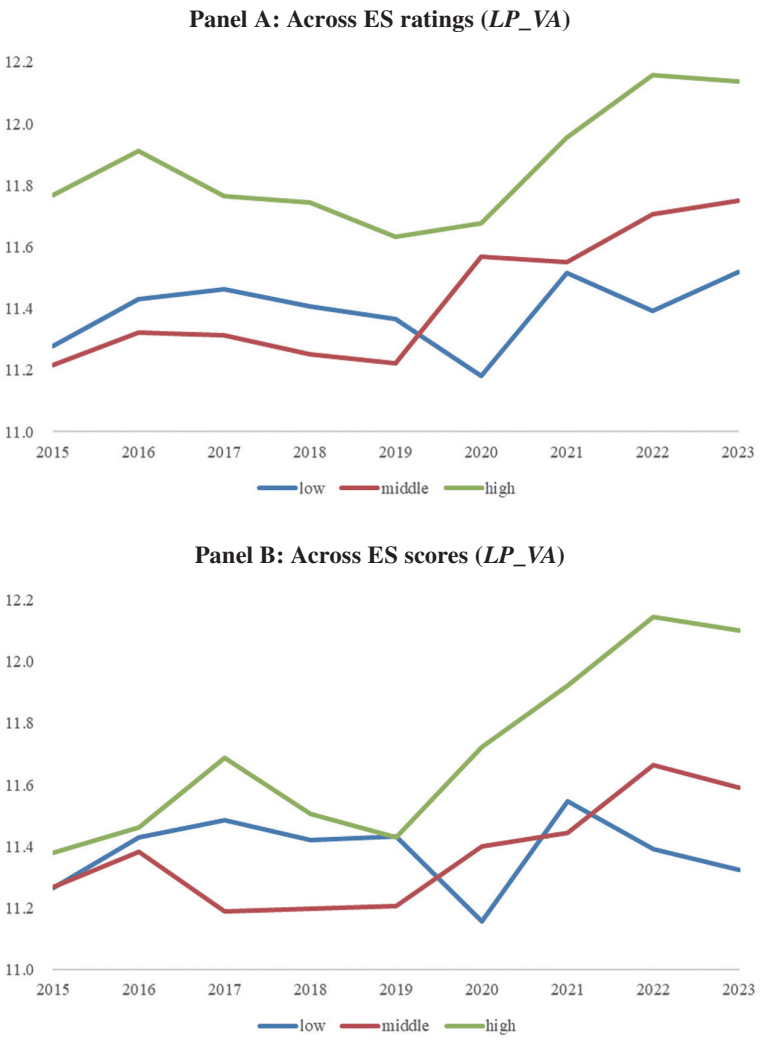
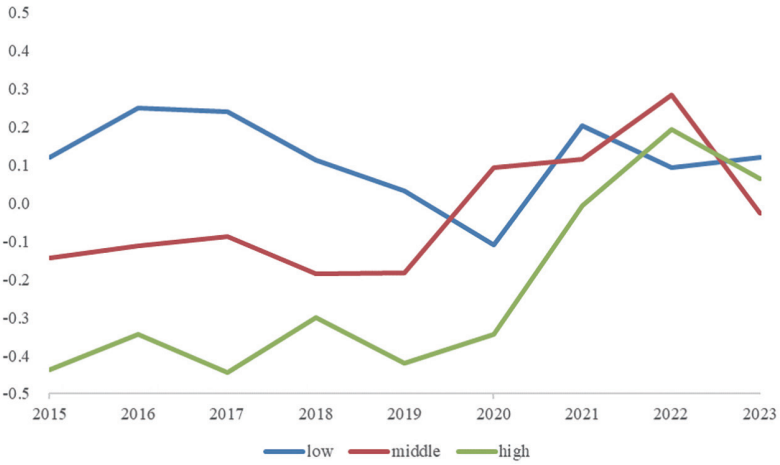


Figure 2 compares differences in the labor productivity across ES groups after purging the effect of firm size (*Size*) from labor productivity. Specifically, we regress labor productivity on firm size and compute the resulting residuals, which are then plotted by ES group. The size-adjusted patterns differ markedly from those in Figure 1. In Panel A, once the size component is removed, the high-ES group exhibits lower productivity on average, reversing the unconditional pattern shown in Panel A of Figure 1. Panel B yields a

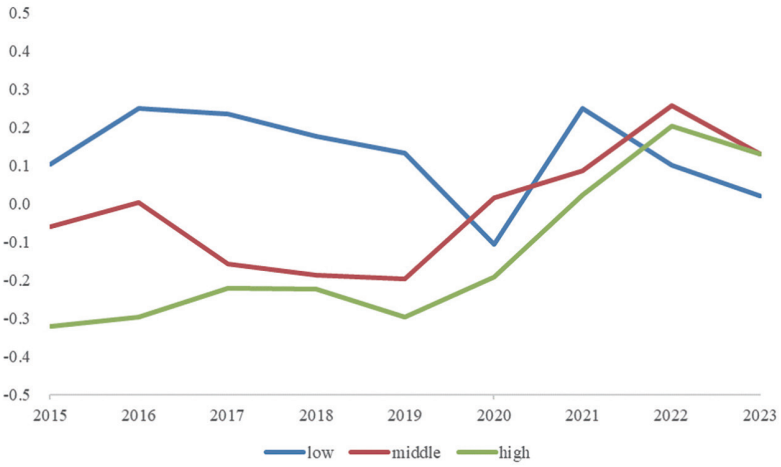
similar reversal when *ES_score* is used. These findings suggest that, after accounting for firm size, the relationship between ES and labor productivity may be weak or even negative. The fact that the simple comparisons produce opposite patterns before and after the size adjustment underscores the importance of more rigorous empirical strategies—controlling for firm size and incorporating fixed effects—in the subsequent regression analyses.

Figure 2. Trends in labor productivity after controlling for firm size

Panel A: Across ES ratings



Panel B: Across ES scores



1.2. Baseline Regression

To more rigorously assess the effect of ES activities on labor productivity, this section estimates panel regression models that include industry and year fixed effects. Our baseline specification is as follows.

$$LP\_VA_{i,t} = \beta\ ES\_rating_{i,t-1} + \gamma\ X_{i,t-1} + \alpha_{k(i)} + \tau_t + \varepsilon_{i,t}$$

Our primary dependent variable is labor productivity based on value added (LP_VA), and we additionally report results using sales-based labor productivity (LP_Sales) as a robustness check. The key explanatory variable captures the level of firms' ES activities. Throughout the main analyses, we use *ES_rating* and also present results based on the continuous assessment measure, *ES_score*. As control variables, we include the seven firm characteristics described in the data section: *Size*, *CapIntensity*, *Age*, *Salary*, *R&D*, *Leverage*, and *ROA*. To mitigate endogeneity concerns arising from contemporaneous correlations and potential reverse causality, we follow standard practice and use one-period lagged values (t−1) for the explanatory and control variables. We further include industry fixed effects, $\alpha_{k(i)}$, defined at the KSIC 2-digit level, and year fixed effects, τ_t. All statistical inferences are based on heteroskedasticity-robust standard errors clustered at the firm level.

Table 2 reports regression estimates of the effect of the ES rating on labor productivity. Columns (1) and (2) present results for manufacturing firms (KSIC 2-digit codes 10–34), whereas columns (3) and (4) report estimates for the broader sample excluding the financial sector. The dependent variable is value-added-based labor productivity (LP_VA) in columns (1) and (3) and sales-based labor productivity (LP_Sales) in columns (2) and (4).

In the manufacturing firm sample, the coefficient on *ES_rating* is −0.0623 in column (1) and −0.0650 in column (2), both statistically significant at the 5% and 1% levels, respectively. This implies that firms with higher ES ratings—i.e., those evaluated more favorably on environmental and social dimensions—exhibit lower labor productivity conditional on the included

controls and fixed effects. This finding contrasts with the unconditional patterns in Figure 1, where higher ES is associated with higher productivity, and it is broadly consistent with the size-adjusted evidence in Figure 2, which suggests an inverse relationship once the size component is removed. In other words, for manufacturing firms, the negative association between ES and productivity persists in the multivariate regressions. The estimated coefficients on the controls are also intuitive. In column (1), *Size*, *CapIntensity*, and *Salary* all enter with strongly positive coefficients, consistent with prior evidence that productivity tends to be higher in larger firms, in firms with greater physical capital per worker, and in firms paying higher wages. *R&D* and *ROA* are likewise positively and significantly associated with productivity, indicating that more innovative and more profitable firms tend to exhibit higher labor productivity.

The negative relationship remains when we expand the industry coverage from manufacturing firms to the broader sample of non-financial firms. In columns (3) and (4), the coefficient on *ES_rating* is −0.1290 and −0.1021, respectively, both statistically significant at the 1% level. Notably, the magnitudes are larger in absolute value than those in the manufacturing subsample, indicating that the inverse ES–productivity relationship is even more pronounced across a wider set of industries. While the simple mean comparisons in Figure 1 suggest higher productivity among high-ES firms—largely because such firms tend to be larger—once we control for key firm characteristics, including size, capital intensity, wage levels, and profitability, ES rating continues to exhibit a consistently negative association with labor productivity. This pattern is robust to expanding the sample beyond manufacturing firms.[11)]

11) Using the same empirical framework as in Table 2, we replace the ES rating with the continuous ES score (*ES_score*). The results are reported in Appendix A.2 and confirm that our findings are robust.

Table 2. ES ratings and labor productivity

This table presents the regression estimates of labor productivity on ES measures. The dependent variables are labor productivity estimated by value-added (column 1 and 3) or sales (column 2 and 4). The definitions of each variable are presented in the Appendix A.1. All regressions include industry and year fixed effects. The heteroscedasticity-consistent standard errors are clustered by firm level. Parenthetical values are the t-statistics. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Dependent Variable	*LP_VA*	*LP_Sales*	*LP_VA*	*LP_Sales*
	(1)	(2)	(3)	(4)
ES_rating	-0.0623**	-0.0650***	-0.1290***	-0.1021***
	(-2.332)	(-2.900)	(-5.524)	(-4.975)
Size	0.0653**	0.0362	0.1283***	0.0788***
	(2.442)	(1.560)	(5.428)	(3.827)
CapIntensity	0.6785***	0.6846***	0.5041***	0.5416***
	(15.927)	(17.773)	(18.114)	(20.871)
Age	-0.0314	0.0015	-0.1239***	-0.0684**
	(-0.942)	(0.049)	(-3.635)	(-2.186)
Salary	0.4779***	0.5313***	0.7810***	0.6872***
	(4.235)	(5.526)	(7.871)	(7.888)
R&D	2.2722**	0.9312	-1.0527	-1.4686
	(1.981)	(1.006)	(-0.952)	(-1.507)
Leverage	-0.0006**	-0.0002	-0.0003	0.0002
	(-2.233)	(-0.725)	(-0.727)	(0.449)
ROA	3.1963***	0.1316	1.5847***	-0.1629
	(7.478)	(0.586)	(4.205)	(-0.889)
Industry Fixed Effect	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
Observations	4,138	4,138	6,944	6,944
R-Squared	0.5028	0.6387	0.4816	0.5797

1.3. Comparisons of ESG and E, S, G components

Table 3 compares the effects of the overall ESG rating and its individual pillars—environment (E), social (S), and governance (G)—on labor productivity. Columns (1)–(8) sequentially include *ESG_rating*, *E_rating*, *S_rating*, and *G_rating*. All specifications control for firm characteristics and include industry and year fixed effects, allowing us to assess the association between each ESG component and productivity net of observable firm heterogeneity and common time- and industry-level shocks. In columns (1) and (5), where the overall ESG rating is used, we again find a consistently negative relationship between ESG and labor productivity. This mirrors the estimates based on ES in Table 2 and indicates that our main conclusion is unchanged when replacing the ES measure with the overall ESG rating.

In columns (2) and (6), where only the environmental (E) rating is included, the negative association becomes more pronounced. Among the ESG pillars, the E component shows the most consistent inverse relationship with labor productivity. One potential interpretation is that environmental efforts—such as compliance with regulations, emissions abatement, and improvements in energy efficiency—may entail higher costs in the short run, which can be reflected in lower measured productivity. In this sense, the negative ESG–productivity association appears to be driven primarily by the environmental pillar. As shown in columns (3) and (7), the social (S) rating is also negatively related to labor productivity, although the estimates are weaker in statistical significance than those for E. This may reflect the heterogeneous nature of social activities—covering areas such as employee welfare, working conditions, and diversity—whose productivity implications can vary across firms. By contrast, in columns (4) and (8), the governance (G) rating does not exhibit a clear relationship with labor productivity. Because governance largely captures more indirect and longer-term features such as risk management and internal controls, it may be less tightly linked to short-run productivity measures. Overall, the G pillar does not appear to be a primary driver of productivity variation in our setting.

In sum, the estimates in Table 3 (columns (1)–(8)) indicate that the ESG pillars are related to labor productivity in different ways. The overall ESG rating, as well as the environmental (E) and social (S) components, are consistently negatively associated with productivity after controlling for firm characteristics and fixed effects, whereas the governance (G) component exhibits limited and less systematic relationships. These results suggest that, for productivity analysis, it is more informative to move beyond a single aggregate ESG measure and to consider its underlying components separately. They also provide supporting justification for our focus on the ES measure in the main analysis.

Table 3. ESG components and labor productivity

This table presents the regression estimates of labor productivity on ESG components. The dependent variables are labor productivity estimated by value-added. All regressions include industry and year fixed effects. The heteroscedasticity-consistent standard errors are clustered by firm level. Parenthetical values are the t-statistics. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Dependent Variable	*LP_VA*	*LP_VA*	*LP_VA*	*LP_VA*	*LP_Sales*	*LP_Sales*	*LP_Sales*	*LP_Sales*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ESG_rating	-0.0444*				-0.0524***			
	(-1.866)				(-2.700)			
E_rating		-0.0731***				-0.0625***		
		(-3.101)				(-3.027)		
S_rating			-0.0155				-0.0302*	
			(-0.727)				(-1.780)	
G_rating				0.0038				-0.0138
				(0.176)				(-0.824)
Firm characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4,138	4,138	4,138	4,138	4,138	4,138	4,138	4,138
R-Squared	0.5021	0.5043	0.5014	0.5012	0.6379	0.6395	0.6369	0.6363

2. Channel Evidence

This section provides evidence on potential mechanisms through which the baseline negative ES–labor productivity relationship may arise. Specifically, Section 4.2.1 examines a firm-level cost mechanism based on firms' cost structure, while Section 4.2.2 investigates an ES activity-level mechanism by decomposing ES into its underlying subcomponents.

2.1. Firm-level cost channel: Total operating cost ratio

This subsection examines whether a cost-burden mechanism may help explain the negative association between ES activities and labor productivity. To capture firms' operating cost burden, we use the total operating cost ratio (*TOCR*), defined as (cost of goods sold plus selling, general and administrative expenses) divided by sales, i.e., (COGS + SG&A)/Sales. Because *TOCR* jointly reflects production costs (COGS) and operating/administrative costs (SG&A), it provides a useful summary measure for assessing whether ES activities are linked to firms' cost structure in ways that may translate into lower short-run productivity.

Panel A of Table 4 examines whether firms with stronger ES performance exhibit a higher operating cost burden. In column (1), *ES_rating* is positively and statistically significantly associated with *TOCR*, suggesting that firms with higher ES ratings may incur higher total operating costs relative to sales. A key consideration is that ROA is mechanically and accounting-wise closely related to TOCR, because profits are calculated after subtracting major cost components, including COGS and SG&A. Including such a performance measure in the TOCR equation can therefore constitute overcontrol by partialling out variation that is inherently tied to the cost structure through which ES activities may operate. Accordingly, we present the specification without *ROA* as the baseline. When *ROA* is additionally controlled for, the coefficient on *ES_rating* becomes smaller and loses statistical significance (column (2)), consistent with the notion that ROA absorbs a substantial portion of the variation in operating cost burden.

Panel B of Table 4 examines how the ES–productivity relationship changes when *TOCR* is added to the labor productivity regressions. *TOCR* is strongly negatively associated with labor productivity, indicating that firms with a higher operating cost burden tend to exhibit lower productivity (column (2)). Moreover, once *TOCR* is included, the estimated coefficient on *ES_rating* remains negative but its statistical significance weakens (column (3)). This pattern suggests that part of the negative ES–productivity relationship may be linked to firms' operating cost burden, providing indirect evidence consistent with the view that ES activities can entail higher costs in the short run.

Table 4. ES, total operating cost ratio and Labor Productivity

This table presents the regression estimates of the total operating cost ratio (*TOCR*) on *ES_rating* (Panel A) and labor productivity on *ES_rating*, controlling for *TOCR* (Panel B). The dependent variable in Panel A is TOCR, defined as (COGS + SG&A)/Sales, and the dependent variable in Panel B is labor productivity estimated by value-added. The definitions of each variable are presented in Appendix A.1. All regressions include industry and year fixed effects. The heteroscedasticity-consistent standard errors are clustered by firm level. Parenthetical values are the t-statistics. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Panel A: ES and total operating cost ratio

Dependent Variable	*TOCR*	*TOCR*
	(1)	(2)
ES_rating	0.0067**	0.0020
	(2.510)	(0.974)
Size	-0.0091***	-0.0056**
	(-3.388)	(-2.478)
CapIntensity	0.0030	-0.0003
	(1.218)	(-0.127)
Age	0.0130***	0.0101***
	(3.737)	(3.494)
Salary	-0.0322***	-0.0070
	(-2.593)	(-0.707)
R&D	0.1150	-0.0221
	(0.828)	(-0.183)
Leverage	0.0001	0.0000
	(1.158)	(-1.490)
ROA		-0.4476***
		(-8.403)
Industry Fixed Effect	Yes	Yes
Year Fixed Effect	Yes	Yes
Observations	4138	4138
R-Squared	0.5133	0.5272

Panel B: ES and labor productivity controlling for total operating cost ratio

Dependent Variable	*LP_VA*	*LP_VA*	*LP_VA*
	(1)	(2)	(3)
ES_rating	-0.0623**		-0.0442
	(-2.332)		(-1.597)
TOCR		-2.7690***	-2.7555***
		(-7.243)	(-7.241)
Firm characteristics	Yes	Yes	Yes
Industry Fixed Effect	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes
Observations	4138	4138	4138
R-Squared	0.5028	0.5451	0.5459

2.2. ES activity channel: Subcategory analysis

Section 4.2.1 shows that the negative ES–labor productivity relationship may be closely linked to firms' operating cost burden, as proxied by the total operating cost ratio (TOCR). However, TOCR is a broad cost measure that aggregates cost of goods sold and SG&A expenses. As such, evidence that ES is associated with higher overall costs does not, by itself, identify which types of ES activities are most directly connected to these cost increases and the accompanying productivity constraints. ES activities are not a single policy or investment item; rather, they comprise heterogeneous components—such as strategy formulation, internal governance and operational management systems, stakeholder engagement, and performance implementation. It is therefore plausible that the adverse ES–productivity association is not uniform across ES components, but instead is more tightly related to activities with higher coordination and managerial requirements, including operational management and stakeholder-facing efforts, which may bear more immediate resource and organizational burdens. Motivated by this view, we decompose the KCGS environmental (E) and social (S) measures into subcategories and reinterpret the ES–productivity relationship at the specific activity level.[12] Because subcategory information is available only as continuous scores rather than discrete ratings, we use *ES_score* (instead of *ES_rating*) to ensure comparability across the subcategory measures.[13]

Turning to the environmental (E) subcategories in Panel A of Table 5, the overall E score continues to be associated with labor productivity in a predominantly negative direction, consistent with the earlier results. When we decompose E into subcomponents, the negative association appears to

12) Descriptions of the environmental (E) and social (S) subcategories are provided in Appendix A.3.

13) The subcategory structure of the KCGS environmental (E) and social (S) measures has changed over time. For the E pillar, the framework shifted from five subcategories in 2011–2018 to three subcategories in 2019–2021, and was then reorganized into four subcategories from 2022 onward. The S pillar also underwent a revision: it consisted of four subcategories through 2021 but expanded to nine subcategories beginning in 2022. To maintain consistency in the number and definition of subcategories across our sample period, we conduct the subcategory analysis using the original framework—five E subcategories and four S subcategories.

be concentrated in subcategories with a more operational and managerial orientation. In particular, *E. Governance Structure*, *E. Management*, and *E. Stakeholder Engagement* display consistently negative relationships with labor productivity. This pattern is consistent with the idea that practical, implementation-oriented activities—such as establishing environmental governance systems, managing environmentally friendly production and supply chains, and engaging in stakeholder communication—may impose additional managerial and operational burdens in the short run that are linked to the negative labor productivity. By contrast, more structural and longer-horizon dimensions such as *E. Strategy* and *E. Performance* exhibit more limited and less systematic associations with labor productivity. This suggests that some environmental efforts may contribute to longer-term risk management or efficiency improvements, but may not translate immediately into short-run labor productivity measures.

Panel B, which reports results for the social (S) subcategories, also highlights meaningful heterogeneity within ES activities. While the overall S score retains a consistently negative sign, the subcategory-level estimates reveal divergent patterns. The coefficients on S. *Employees*, S. *Supply Chain* and S. *Market Relations*, and S. *Customer Relations* are not statistically significant, indicating no clear association with labor productivity for these dimensions. In contrast, S. *Community Engagement* stands out with a positive and statistically significant relationship. This finding is consistent with the possibility that efforts to strengthen ties with local communities and undertake social contribution initiatives may enhance firm reputation, customer trust, and internal cohesion, which can in turn be associated with higher labor productivity.

Overall, the subcategory decomposition suggests that the negative ES–labor productivity relationship is unlikely to reflect a uniform adverse effect of ES as a whole; rather, it may arise through specific types of activities. In particular, the consistently negative associations for operational, managerial, and stakeholder-facing environmental activities—such as governance structure, management, and stakeholder engagement—link naturally to the cost-burden

evidence in Section 4.2.1, in that these activities may raise coordination and managerial costs in the short run and thereby make the labor productivity worse. By contrast, the positive association for social-community engagement indicates that some ES activities may operate through compensating channels, such as strengthening trust, reputation, and relational capital, potentially buffering or offsetting short-run productivity deterioration. Taken together, the effects of ES activities on labor productivity appear heterogeneous across subcomponents, with cost-intensive operational efforts and relationship-building activities potentially operating simultaneously.

Table 5. ES Subcategories and labor productivity

This table presents the regression estimates of labor productivity on ES measures, controlling for detailed subcategories. The dependent variables are labor productivity estimated by value-added. All regressions include industry and year fixed effects. The heteroscedasticity-consistent standard errors are clustered by firm level. Parenthetical values are the t-statistics. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Panel A: Environmental subcategories

Dependent Variable	*LP_VA*	*LP_VA*	*LP_VA*	*LP_VA*	*LP_VA*	*LP_VA*
	(1)	(2)	(3)	(4)	(5)	(6)
ES_score	-0.0067***	-0.0081**	-0.0054	0.0052	-0.0076***	-0.0016
	(-3.176)	(-2.195)	(-1.404)	(1.437)	(-3.195)	(-0.772)
E. Strategy		-0.0010				
		(-0.865)				
E. Governance Structure			-0.0030*			
			(-1.955)			
E. Management				-0.0090***		
				(-3.843)		
E. Performance					0.0017	
					(0.866)	
E. Stakeholder Engagement						-0.0031***
						(-3.033)
Firm characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3,645	2,197	2,197	3,645	3,645	3,645
R-Squared	0.4977	0.4737	0.4751	0.5038	0.4978	0.5016

Panel B: Social subcategories

Dependent Variable	*LP_VA*	*LP_VA*	*LP_VA*	*LP_VA*	*LP_VA*
	(1)	(2)	(3)	(4)	(5)
ES_score	-0.0067***	-0.0088***	-0.0081***	-0.0079***	-0.0117***
	(-3.176)	(-3.178)	(-3.243)	(-3.389)	(-4.740)
S. Employees		-0.0059			
		(-1.305)			
S. Supply Chain and Market Relations			0.0015		
			(0.900)		
S. Customer Relations				0.0013	
				(1.450)	
S. Community Engagement					0.0057***
					(3.398)
Firm characteristics	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effect	Yes	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes
Observations	3,645	3,645	3,645	3,645	3,645
R-Squared	0.4977	0.4981	0.4980	0.4981	0.5012

3. Heterogeneity Analyses

The impacts of ES activities on labor productivity are unlikely to be uniform across firms. Accordingly, this section examines whether the ES–productivity relationship varies systematically with firm and industry characteristics by conducting heterogeneity analyses. Specifically, Section 4.3.1 introduces interaction terms between ES and key firm characteristics to assess differential effects across firms, and Section 4.3.2 estimates industry-specific regressions to evaluate cross-industry differences in the ES–labor productivity relationship.

3.1. Interaction Effects between ES and Firm Characteristics

Firms differ in capital structure, innovative capacity, and financial conditions, and such differences can shape how ES activities are implemented and incorporated into managerial decision-making. As a result, the ES–labor productivity relationship may exhibit heterogeneity, in the sense that the association can be amplified or attenuated depending on firm characteristics. To examine this possibility, we estimate regression models that include interaction terms between the ES rating and key firm attributes.

Table 6 reports the results from these interaction specifications. The interaction terms are constructed using capital intensity (*CapIntensity*), R&D ratio (*R&D*), leverage (*Leverage*), and profitability (*ROA*). All models include the full set of firm-level controls as well as industry and year fixed effects. Across specifications, the coefficient on *ES_rating* remains negative, indicating that the baseline pattern—higher ES is associated with lower labor productivity—persists even after allowing the relationship to vary with firm characteristics. In other words, our main finding is largely unchanged in the augmented models, providing additional evidence of robustness.

In column (2), which interacts ES with capital intensity, the baseline ES effect becomes substantially less statistically significant, suggesting that the ES–productivity relationship is not fully stable across different levels of capital intensity. Although the interaction term itself does not exhibit a clear or robust pattern, the attenuation of the main ES coefficient indicates that differences in firms' capital structure may partially dilute the measured ES–productivity association. In column (3), where we allow the ES effect to vary with R&D ratio, the statistical significance of the baseline ES coefficient similarly weakens, and the interaction term is not statistically significant. Taken together, these results imply that the ES–productivity relationship does not vary in a systematic way with firms' innovation level, and that R&D does not appear to be a consistent moderator that either amplifies or mitigates the effect.

By contrast, column (4), which introduces the interaction between ES and leverage, yields an interaction term that is weakly positive. This suggests that the negative association between ES activities and productivity may be attenuated among more highly levered firms. One possible interpretation is that, for firms facing tighter financial constraints, ESG-related efforts can play a complementary role in strengthening external stakeholder confidence and easing financing frictions, thereby partially offsetting the adverse productivity effect. In column (5), where ES is interacted with profitability (ROA), the interaction term is consistently positive. This implies that the negative ES–productivity association is substantially weaker for more profitable firms. Firms with stronger profitability may be better positioned to absorb the resource demands associated with environmental and social initiatives, so that any short-run increases in operating burdens are less likely to be passed on to labor productivity. Overall, these results indicate that financial conditions can meaningfully shape the extent to which ES activities are associated with labor productivity.

Overall, the interaction analysis indicates that our main finding—a negative association between ES ratings and labor productivity—largely persists in augmented specifications that allow the relationship to vary with firm characteristics. At the same time, leverage and profitability emerge as meaningful moderators: higher leverage and stronger profitability are associated with a weaker negative ES–productivity relationship. These results suggest that the economic implications of ESG-related activities should be interpreted in light of firms' financial structure and managerial capacity, and that the ES–productivity association can differ systematically across firms.

Table 6. Interaction between ES and firm characteristics and labor productivity

This table presents the regression estimates of labor productivity on ES measures, controlling for interaction terms. The dependent variables are labor productivity estimated by value-added. All regressions include industry and year fixed effects. The heteroscedasticity-consistent standard errors are clustered by firm level. Parenthetical values are the t-statistics. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Dependent Variable	*LP_VA*	*LP_VA*	*LP_VA*	*LP_VA*	*LP_VA*
	(1)	(2)	(3)	(4)	(5)
ES_rating	-0.0623**	-0.1960	-0.0509*	-0.0648**	-0.0912***
	(-2.332)	(-0.568)	(-1.758)	(-2.406)	(-3.096)
*ES_rating * CapIntensity*		0.0103			
		(0.383)			
*ES_rating * R&D*			-0.7948		
			(-1.197)		
*ES_rating * Leverage*				0.0021*	
				(1.704)	
*ES_rating * ROA*					0.8454***
					(2.868)
Firm characteristics	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effect	Yes	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes
Observations	4,138	4,138	4,138	4,138	4,138
R-Squared	0.5028	0.5030	0.5031	0.5030	0.5054

3.2. Industry-Level Analyses

The preceding analysis establishes the ES–labor productivity relationship in the full sample, but the average association may mask substantial heterogeneity across industries. Because industries differ markedly in production technologies, energy use, workforce composition, and regulatory environments, the costs and operational constraints associated with ES activities can vary by industry. To assess such cross-industry heterogeneity, we conduct industry-level analyses of the ES–productivity relationship. Detailed results for all manufacturing industries at the KSIC 2-digit level are reported in Appendix A.4. In the main text, we summarize the industries exhibiting statistically meaningful patterns and report the corresponding estimates in Table 7.

We first consider industries of particular national and policy relevance—namely, major export-oriented sectors[14] (column (1)) and high–greenhouse-gas-emitting industries[15] (column (2)). For these groups, ES ratings are, on average, negatively associated with labor productivity, but the estimates are not statistically significant. This may indicate that firms in these industries have already adapted to ES-related practices to some extent, or that the inherently high capital and technology intensity of these sectors makes the incremental operating burdens associated with ES activities less salient in measured productivity. Importantly, we do not find statistically significant evidence that ES activities reduce labor productivity in the major export-oriented industries. From a policy perspective, this is a relatively encouraging result, suggesting that strengthening ES practices need not necessarily undermine external competitiveness in these key sectors.

In contrast, a more disaggregated view across manufacturing industries reveals substantial cross-industry heterogeneity in the ES–productivity

14) We define major export-oriented industries as the seven KSIC 2-digit industries that correspond to Korea's 15 leading export items identified by the Ministry of Trade, Industry and Energy (2024): KSIC codes 20, 23, 24, 26, 28, 30, and 31.

15) High–greenhouse-gas-emitting industries are defined as the six KSIC 2-digit industries with the highest average emissions in Korea over 2018–2020, based on the OECD country–industry emissions dataset: KSIC codes 17, 18, 19, 20, 23, and 24.

relationship. In paper and pulp (KSIC 17), basic metals (KSIC 24), fabricated metal products (KSIC 25), electronic components and computers/communications equipment (KSIC 26), and furniture manufacturing (KSIC 32), ES ratings exhibit a pronounced negative association with labor productivity. These findings suggest that environmental and social initiatives may translate into more immediate operational burdens in these industries—through production-process adjustments, higher operating costs, or compliance-related expenditures. The adverse association may be particularly notable in sectors where environmental regulation or workplace safety and labor standards entail substantial implementation and monitoring costs.

Overall, the industry-level evidence indicates that the average negative ES–productivity association documented in the full sample does not apply uniformly across manufacturing industries. Instead, the relationship varies meaningfully with industry-specific technological conditions, capital intensity, and regulatory environments. This underscores the importance of interpreting the economic implications of ESG activities in an industry context and suggests that effective ESG-related policy design and corporate strategy should take such cross-industry differences into account.

Table 7. Industry-level analysis

This table presents the regression estimates of labor productivity on ES measures by industry. The dependent variables are labor productivity estimated by value-added. Column 1 reports the result for the core export industries (KSIC industry codes 20, 23, 24, 26, 28, 30, and 31). Column 2 reports the result for the high-emission industries (KSIC industry codes 17, 18, 19, 20, 23, and 24). Column 3 reports the results for the Manufacture of Pulp, Paper, and Paper Products (KSIC industry code 17). Column 4 reports the result for the Manufacture of Basic Metals (KSIC industry code 24). Column 5 reports the result for the Manufacture of Fabricated Metal Products Except Machinery and Furniture (KSIC industry code 25). Column 6 reports the result for the Manufacture of Electronic Components, Computers, Imaging, Audio, and Communication Equipment (KSIC industry code 26). Column 7 reports the result for the Manufacture of Furniture (KSIC industry code 32). The results for all industries are provided in the Appendix A.4. The heteroscedasticity-consistent standard errors are clustered by firm level. Parenthetical values are the t-statistics. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Dependent Variable	*LP_VA*	*LP_VA*	*LP_VA*	*LP_VA*	*LP_VA*	*LP_VA*	*LP_VA*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
ES_rating	-0.0557	-0.0540	-0.2582**	-0.2085**	-0.2990*	-0.1485*	-0.3632*
	(-1.326)	(-0.996)	(-2.850)	(-2.244)	(-2.078)	(-1.992)	(-2.316)
Firm characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effect	Yes	Yes	-	-	-	-	-
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,142	1,372	131	404	89	372	44
R-Squared	0.4797	0.5693	0.6456	0.6042	0.6168	0.3450	0.8184

V. Conclusion

This study empirically examines the relationship between firms' environmental (E) and social (S) performance—measured using KCGS indicators—and labor productivity. We construct a panel of listed firms over 2015–2023 and estimate panel regression models that include standard firm-level controls as well as industry and year fixed effects. Our empirical analyses encompass baseline specifications, mechanism-oriented evidence, and heterogeneity tests across firms and industries.

Empirically, we find that ES ratings and ES scores are significantly negatively associated with labor productivity in the full sample—an association that contrasts with simple, unconditional comparisons that do not account for firm size. The results indicate that once key firm characteristics such as size, wage levels, and capital intensity are controlled for, ES activities may be linked to lower, rather than higher, short-run productivity, potentially reflecting operating burdens or implementation frictions. The negative association is also observed when using the overall ESG rating and the individual E, S, and G ratings, supporting the robustness of the baseline finding. Mechanism-oriented analyses provide complementary evidence. Firms with higher ES performance exhibit a higher total operating cost ratio (TOCR), and the negative ES coefficient becomes statistically insignificant once TOCR is included, suggesting that the ES–productivity relationship may be closely related to firms' operating cost burden. Subcategory analyses further reveal meaningful heterogeneity within E and S activities. On the environmental side, subcomponents related to operational management and stakeholder engagement are consistently negatively associated with productivity, whereas on the social side, community engagement shows a positive association. Taken together, these findings are consistent with the coexistence of a cost-burden channel and a relational-capital channel within ES activities. We also document heterogeneity across firms and industries. In firm-level interaction specifications, the negative ES–productivity association is partially attenuated under certain financial conditions—most notably among firms with higher

leverage or stronger profitability—implying that the ES effect can vary with firms' financial capacity. Industry-level analyses likewise show that the negative association is pronounced in some manufacturing industries, while it is not statistically significant in major export-oriented sectors or high–greenhouse-gas-emitting industries.

These empirical findings suggest that the impacts of ES activities on labor productivity are not straightforward and yield several policy and managerial implications. First, ES initiatives should be interpreted through a long-horizon perspective of value creation and risk management rather than as instruments for immediate productivity improvement. Accordingly, relying solely on short-run productivity measures provides an incomplete assessment of the economic relevance of ES activities. Second, the mechanism-oriented evidence indicates that ES engagement can entail short-run operating burdens and that the effects on labor productivity may differ across activity types. This underscores the need to move beyond an exclusive focus on aggregate ES scores and to manage ES efforts with explicit attention to cost structures and the composition of activities. Third, because the ES–productivity relationship varies with firm characteristics and industry-specific cost and regulatory environments, uniform ES policies or regulatory approaches may be undesirable. Industry-tailored policies are particularly relevant where production processes and environmental regulatory frameworks differ substantially across sectors. Notably, we do not find statistically significant evidence of adverse effects in major export-oriented manufacturing industries, suggesting that strengthening ES practices need not necessarily undermine external competitiveness—an important consideration for future sustainability policy design.

Our analysis focuses on short-run labor productivity, whereas ES activities may exert their influence through longer-run outcomes such as innovation, resilience, and financial stability. In addition, our labor productivity measures are based on value added (or sales) per employee and therefore may not fully capture variation in hours worked or changes in labor quality. Future research could therefore incorporate longer horizons and a broader set of performance

measures, including productivity metrics that better reflect labor input intensity and quality. Moreover, macro-level conditions—such as industry technology regimes and regulatory institutions—may interact with ES engagement. A multi-layered framework that jointly considers firm behavior and the industry- and country-level institutional environment would be a fruitful direction for further work.

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Appendix

Appendix A.1. Definitions of variables

Variable	Description
E_rating	Numeric values converted from letter-graded ratings of a firm's environmental performance by KCGS (D = 1 to A+ = 6)
S_rating	Numeric values converted from letter-graded ratings of a firm's social performance by KCGS (D = 1 to A+ = 6)
G_rating	Numeric values converted from letter-graded ratings of a firm's governance performance by KCGS (D = 1 to A+ = 6)
ESG_rating	Numeric values converted from letter-graded ratings of a firm's ESG performance by KCGS (D = 1 to A+ = 6)
ES_rating	The arithmetic average between *E_rating* and *S_rating*
ES_score	The average of the environmental score (out of 100) and the social score (out of 100) provided by KCGS, which are non-public data
LP_VA	Natural logarithm of value-added per employee
LP_Sales	Natural logarithm of sales per employee
Size	Natural logarithm of total assets
CapIntensity	Natural logarithm of tangible assets per employee
Age	Natural logarithm of a firm’s age
Salary	Natural logarithm of salaries per employee
R&D	Ratio of R&D expenses to total assets
Leverage	Total liabilities divided by total equity
ROA	Return on Assets, measured as net income divided by total assets
TOCR	Total Operating Cost Ratio. (Cost of goods sold(COGS) + Selling, General &Administrative(SG&A))/ Sales

Appendix A.2. ES scores and labor productivity

This table presents the regression estimates of labor productivity on ES measures. The dependent variables are labor productivity estimated by value-added (column 1 and 3) or sales (column 2 and 4). The definitions of each variable are presented in the Appendix A.1. All regressions include industry and year fixed effects. The heteroscedasticity-consistent standard errors are clustered by firm level. Parenthetical values are the t-statistics. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Dependent Variable	*LP_VA*	*LP_Sales*	*LP_VA*	*LP_Sales*
	(1)	(2)	(3)	(4)
ES_score	-0.0051***	-0.0052***	-0.0093***	-0.0073***
	(-2.777)	(-3.411)	(-6.131)	(-5.606)
Size	0.0796***	0.0499**	0.1468***	0.0936***
	(2.826)	(2.072)	(5.996)	(4.361)
CapIntensity	0.6737***	0.6801***	0.5004***	0.5386***
	(15.858)	(17.789)	(18.111)	(20.886)
Age	-0.0322	0.0009	-0.1232***	-0.0678**
	(-0.968)	(0.030)	(-3.633)	(-2.176)
Salary	0.4956***	0.5476***	0.7914***	0.6955***
	(4.375)	(5.701)	(8.025)	(8.034)
R&D	2.3020**	0.9592	-0.9582	-1.3929
	(2.034)	(1.048)	(-0.882)	(-1.453)
Leverage	-0.0006**	-0.0002	-0.0003	0.0001
	(-2.315)	(-0.720)	(-0.821)	(0.388)
ROA	3.1651***	0.1021	1.5660***	-0.1779
	(7.439)	(0.458)	(4.190)	(-0.977)
Industry Fixed Effect	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes
Observations	4,138	4,138	6,944	6,944
R-Squared	0.5040	0.6403	0.4843	0.5818

Appendix A.3. Description of ES subcategories

Variable	Description
E. Strategy	Activities related to setting the overall direction of environmental management and establishing and operating environmental strategies/policies, as well as defining environmental goals and implementation plans.
E. Governance Structure	Activities related to building an environmentally oriented organizational structure for environmental management and clarifying environmental roles and responsibilities (organizational arrangements and systems).
E. Management	Activities related to implementing environmental management in day-to-day operations, including the establishment and execution of operational/management systems such as environmentally friendly production, climate-change response, environmentally responsible supply-chain management, and environmental risk management.
E.Performance	Activities related to the environmental performance evaluation system, including selecting performance indicators, measuring/analyzing/evaluating performance, and reporting and reviewing the results to support continuous improvement.
E. Stakeholder Engagement	Activities related to promoting stakeholder participation and interaction in environmental management, establishing communication channels, and collecting stakeholder feedback on disclosed environmental information and reflecting it in subsequent actions.
S. Employees	Activities related to protecting and respecting internationally recognized labor rights; ensuring quality of life through fair compensation, stable employment, and a healthy working environment; and providing opportunities for education, training, and capability development.
S. Supply Chain and Market Relations	Activities related to responsible transactions and management in supply-chain and market relationships, including fair treatment of suppliers, incorporating social responsibility into purchasing/procurement policies, and considering CSR-related issues such as human rights and labor practices among suppliers.
S. Customer Relations	Activities related to fair dealings with customers, ensuring product/service safety and health, collecting/using/managing personal data in a lawful and fair manner, and establishing communication mechanisms to gather and incorporate customer feedback into products/services.
S. Community Engagement	Activities related to contributing to local residents' quality of life (e.g., support for education, culture, and health), promoting local economic development through employment, purchasing, technical support, and infrastructure investment, and maintaining constructive relationships through active communication with local communities.

Source: KCGS (2010)

Appendix A.4. Industry-level regression results

This table presents the regression estimates of labor productivity on ES measures by industry. The dependent variables are labor productivity estimated by value-added. All regressions include firm, industry and year fixed effects. The heteroscedasticity-consistent standard errors are clustered by firm level. Parenthetical values are the t-statistics. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Industry Description	Ind. code	Coefficient	t-value	Observations
Core export industries (20, 23, 24, 26, 28, 30, 31)		-0.0557	(-1.326)	2142
High-emission industries (17, 18, 19, 20, 23, 24)		-0.0540	(-0.996)	1372
Manufacture of Food Products	10	-0.0054	(-0.089)	282
Manufacture of Beverages	11	0.0583	(0.535)	44
Manufacture of Tobacco Products	12	-	-	9
Manufacture of Textiles (Except Apparel)	13	0.1583	(0.583)	41
Manufacture of Wearing Apparel, Accessories, and Fur Products	14	-0.0888	(-0.931)	136
Manufacture of Leather, Bags, and Footwear	15	0.4232	(1.216)	37
Manufacture of Wood and Wood Products (Except Furniture)	16	-0.2123	(-1.185)	31
Manufacture of Pulp, Paper, and Paper Products	17	-0.2582**	(-2.850)	131
Printing and Reproduction of Recorded Media	18	-	-	0
Manufacture of Coke, Briquettes, and Refined Petroleum Products	19	-0.0377	(-0.277)	43
Manufacture of Chemicals and Chemical Products (Except Pharmaceuticals)	20	0.0063	(0.094)	604
Manufacture of Medical Substances and Pharmaceuticals	21	-0.0681	(-1.184)	496
Manufacture of Rubber and Plastics Products	22	0.1451	(1.253)	215
Manufacture of Non-metallic Mineral Products	23	-0.0977	(-1.324)	190
Manufacture of Basic Metals	24	-0.2085**	(-2.244)	404
Manufacture of Fabricated Metal Products (Except Machinery and Furniture)	25	-0.2990*	(-2.078)	89
Manufacture of Electronic Components, Computers, Imaging, Audio, and Communication Equipment	26	-0.1485*	(-1.992)	372
Manufacture of Medical, Precision, Optical Instruments and Watches	27	0.0565	(0.768)	74
Manufacture of Electrical Equipment	28	-0.0879	(-0.858)	157
Manufacture of Other Machinery and Equipment	29	-0.0980	(-1.109)	306
Manufacture of Motor Vehicles and Trailers	30	-0.0043	(-0.042)	369
Manufacture of Other Transport Equipment	31	0.0146	(0.093)	46
Manufacture of Furniture	32	-0.3632*	(-2.316)	44
Manufacture of Other Products	33	-	-	18
Repair of Industrial Machinery and Equipment	34	-	-	0

<Abstract in Korean>

ES 활동과 노동생산성: 한국 제조업 사례

정성준*, 유복근**

본 연구는 KCGS(Korea Corporate Governance Service)가 제공하는 환경(E) 및 사회(S) 지표를 활용하여 기업의 ES 활동이 노동생산성에 미치는 영향을 실증적으로 분석한다. 2015~2023년 상장기업 패널자료를 이용한 분석 결과, ES 등급과 ES 점수 모두 노동생산성과 유의한 음(−)의 관계를 보였으며, 이러한 결과는 ESG 종합등급이나 E · S 개별 등급을 사용한 경우에도 강건하게 유지되었다. 나아가 본 연구는 비용 부담 경로와 정합적인 채널 증거를 제시한다. ES 수준이 높은 기업일수록 총영업비용률(TOCR)이 높게 나타나, ES−생산성 관계가 운영비용 압박과 연관되어 있음을 시사한다. 하위지표 분석에서는 ES 내부의 이질적 경로가 확인된다. 환경(E) 부문에서는 운영 · 관리 및 커뮤니케이션 중심 활동이 노동생산성과 음(−)의 관계를 보여, 조정 및 관리 비용 증가와 부합하는 결과를 나타낸다. 반면 사회(S) 부문의 지역사회 참여는 노동생산성과 양(+)의 관계를 보이며, 신뢰, 평판, 관계자본을 통한 보완적 경로가 존재함을 시사한다. 마지막으로 기업 수준 및 산업 수준 분석은 ES−생산성 관계가 기업과 산업 간에 상당한 이질성을 보임을 보여준다. 종합하면, 본 연구는 비용 기반 채널 증거, 하위지표 분해, 이질성 분석을 결합함으로써 지속가능경영의 경제적 함의를 평가할 때 총합 ES/ESG 지표뿐 아니라 비용 구조, 활동 유형, 기업 및 산업 특성을 함께 고려할 필요가 있음을 강조한다.

핵심 주제어: ESG, ES 활동, 노동생산성, 제조 기업

JEL Classification: D24, E24, G30, Q50

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BOK 경제연구 발간목록

한국은행 경제연구원에서는 Working Paper인 『BOK 경제연구』를 수시로 발간하고 있습니다. 『BOK 경제연구』는 주요 경제 현상 및 정책 효과에 대한 직관적 설명 뿐 아니라 깊이 있는 이론 또는 실증 분석을 제공함으로써 엄밀한 논증에 초점을 두는 학술논문 형태의 연구이며 한국은행 직원 및 한국은행 연구용역사업의 연구 결과물이 수록되고 있습니다.
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