



# ESG Practices and Firm Productivity in the Belt and Road Initiative Evidence of a Short-Term Trade-off and the Moderating Roles of Cost of Debt and Overseas Revenue

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**Abstract.** This paper uses A-share listed firms in China's Belt and Road sector for 2008-2024 as the sample, applies the widely used Levinsohn-Petrin (LP) method to estimate firms' Total Factor Productivity (TFP), and empirically examines the potential effect of Environmental, Social, and Governance (ESG) performance on TFP and its underlying mechanisms. The results indicate that ESG performance among firms along the Belt and Road exerts a statistically significant negative effect on TFP, consistent with the compliance cost hypothesis. Heterogeneity analysis shows that this negative effect is concentrated in non-heavy-polluting industries. Moderation tests reveal that higher cost of debt and overseas market expansion could mitigate the adverse impact of ESG on TFP. The paper thereby uncovers efficiency losses and external constraints faced by Belt and Road firms during the initial stages of green transformation, providing valuable microlevel evidence relevant to the design of green finance policies and to guiding firms' high-quality internationalization.

**Keywords:** Belt and Road Firms, ESG Performance, Total Factor Productivity, Cost of Debt, Proportion of Overseas Revenue.

## 1 Introduction

As the global concept of sustainable development deepens, environmental, social, and governance (ESG) factors have become a key benchmark for firms' comprehensive competitiveness [1]. While increasingly integrated into global value chains, the Chinese economy faces intensified resource and environmental constraints and rising pressure for green transformation. In particular, the ongoing promotion of the Belt and Road Initiative (BRI) not only expands opportunities for Chinese firms to enter international markets and engage in cross-border production cooperation, but also raises the requirements for firms' environmental compliance and sustainable development capabilities [2]. Total factor productivity (TFP), as a core indicator of technological progress and

resource allocation efficiency, directly determines firms' long run competitive advantage [3]. With the adoption of "dual carbon" targets and the tightening of international green standards, firms participating in the BRI confront a more complex compliance environment and greater transformation costs. Yet scholars have not reached a consensus on whether ESG investment functions as an efficiency enhancer or as a resource drain in the short run. This question is particularly salient for the BRI context, which combines capital intensive characteristics with institutional heterogeneity; investigating the productivity effects of ESG investment in this setting has important theoretical and practical implications for understanding the microcosts of green transformation and for optimizing firms' resource allocation decisions.

The extant literature has produced mixed evidence on the relationship between ESG and corporate performance. From Stakeholder Theory and the Resource-Based View, some studies argue that ESG practices promote productivity by enhancing reputational capital, alleviating financing constraints, and stimulating innovation [4]. Other studies contend that ESG investment can lead to overinvestment or managerial self-interest, crowding out resources devoted to core productive activities [5]. Most of these studies focus on mature markets or on pooled samples, and relatively few examine the specific conditions of Belt and Road firms. Moreover, prior research has paid limited attention to the boundary conditions of the ESG-TFP relationship, leaving the moderating roles of key contextual factors underexplored.

This paper employs ESG rating data from *SynTao Green Finance*, combines firm-level ESG performance with the macro context of the BRI, and examines the relationship between ESG performance and firms' TFP and its mechanisms. Empirical results indicate that ESG performance exerts a significant negative effect on TFP for BRI firms; however, this adverse impact is mitigated among enterprises with higher costs of debt and greater overseas revenue shares. The study makes three contributions. First, from a theoretical perspective, it moves beyond a single narrative of ESG as purely promotive and, drawing on Organizational Slack Theory and Financial Flexibility Theory, documents a crowding out effect of ESG investment on productive resources in the Belt and Road setting, thus offering a novel explanation for the short run cost attributes of ESG. Second, with respect to mechanisms, the paper systematically investigates the dual moderating roles of cost of debt and the share of overseas revenue, identifying two channels: a financing constraint screening mechanism and an international learning mechanism, thereby extending the contingency framework for ESG investment efficiency. Third, in terms of policy relevance, the analysis shows that non heavy polluting industries incur more pronounced productivity losses from ESG. This counterintuitive finding challenges a one-size-fits-all approach to ESG promotion and supports the design of differentiated green transformation policies by industry.

## **2 Theoretical Basis and Research Hypotheses**

### **2.1 The Relationship between Firm's ESG Performance and TFP**

Organizational Slack Theory offers a useful perspective for understanding the productivity implications of ESG investment. Bourgeois defined organizational slack as a

stock of resources in excess of those required to sustain current operations, including unused capacity, redundant funds, and redeployable human capital [6]. The theory suggests that moderate slack facilitates innovation, whereas excessive slack can induce inefficient investment and managerial laxity. When firms face external ESG compliance pressures and lack sufficient slack to absorb additional costs, management may effectively confront a zero-sum tradeoff between ESG expenditures and productive investment. This concern is salient for listed firms participating in the BRI, many of which operate in capital-intensive sectors such as energy, infrastructure, and manufacturing, characterized by high asset specificity and substantial adjustment costs. In such contexts, ESG investment is more likely to disrupt existing production processes than to complement technological collaboration. Consequently, improvements in ESG performance may divert limited resources from core production activities toward environmental compliance and social responsibilities, producing a short-term inhibitory effect on TFP. Accordingly, this paper proposes the following Hypothesis 1.

H1: For firms in the Belt and Road sector, ESG performance has a negative effect on their TFP.

## 2.2 The Moderating Role of Cost of Debt

Financial Flexibility Theory emphasizes that preserving financial flexibility enables firms to manage uncertainty and seize investment opportunities, while the erosion of flexibility undermines strategic adaptability [7]. High cost of debt reduces firms' financial flexibility, prompting management to adopt stricter real-options reasoning in investment decisions, i.e., projects are undertaken only if expected marginal returns exceed the opportunity cost of capital. Under such discipline, ESG expenditures face a more rigorous efficiency assessment; ESG initiatives that do not yield measurable short-term cost savings or revenue gains are more likely to be curtailed or deferred. This intensified financial discipline can thereby constrain the crowding-out effect of ESG investment on productive investment, attenuating the negative ESG-TFP relationship. Therefore, a Hypothesis 2 is proposed.

H2: Higher cost of debt financing mitigates the negative relationship between ESG performance and TFP.

## 2.3 The Moderating Role of Overseas Revenue Share

Institutional Distance Theory highlights that differences in regulation, norms, and cognitions between home and host countries constitute core challenges for multinational firms [8]. For firms operating along the Belt and Road, host-country requirements on environmental standards, labor protection, and business ethics are often more stringent than those in China. Such institutional distance compels firms to develop forward-looking ESG capabilities during internationalization to avoid institutional conflict and legitimacy risks in overseas operations. Firms with greater international exposure can recast ESG expenditures from pure compliance costs into capability-enhancing investments, thereby weakening the short-term negative impact of ESG on productivity. Therefore, a Hypothesis 3 is proposed.

H3: A higher share of overseas revenue attenuates the negative relationship between ESG performance and TFP.

### 3 Data and Methodology

#### 3.1 Sample Selection and Data Sources

The sample comprises annual observations of A-share listed firms in the Belt and Road sector on the Shanghai, Shenzhen and Beijing exchanges for 2008–2024. Financial and ESG data are sourced from the *Choice* financial terminal and the official *SynTao Green Finance* website. Industry classification follows the “2012 China Securities Regulatory Commission Standard”. To ensure data reliability, the initial sample would be screened as follows: (1) exclude observations with missing values on key variables; (2) exclude financial firms; and (3) exclude firms subject to special treatment (ST or \*ST) during the sample period. After screening, the final sample comprises 1,578 firm-year observations.

#### 3.2 Variable Definition and Measurement

**Explained Variable – ESG Rating Score (ESG).** This study employs the *SynTao Green Finance* ESG rating to measure firms’ environmental, social, and governance performance. *SynTao Green Finance* is a leading Chinese ESG rating agency whose system was launched in 2015 and was the first domestic ESG dataset adopted by *Bloomberg* [9]. The rating is widely used in top Chinese journals. Coverage includes all A-share listed firms and evaluates three dimensions across 14 secondary topics and more than 200 tertiary indicators. Final ratings range from A+ to D and are based on firms’ public disclosures and authoritative government data, ensuring objectivity, continuity, and comparability.

Since *SynTao Green Finance* reports annual ratings, the year-end rating for each firm is used as the main explanatory variable. To mitigate potential endogeneity, lagged ESG ratings are used in robustness checks. Letter grades are converted to numeric scores following prior practice: A+ = 10, A = 9, A- = 8, B+ = 7, B = 6, B- = 5, C+ = 4, C = 3, C- = 2, D = 1. Higher values indicate better ESG performance.

**Explanatory Variable – Total Factor Productivity (LnTFP).** TFP captures firm output efficiency net of factor inputs and reflects multidimensional contributions such as technological progress, managerial improvement, and resource allocation efficiency [3]. Compared with single financial indicators, TFP better represents firms’ long-run growth potential and sustainable performance as it is less affected by short-term price movements or accounting choices. This study measures firm-level TFP using the semi-parametric Levinsohn-Petrin (LP) method. The production function is specified as equation (1).

$$\text{Ln}Y_{i,t} = \alpha_0 + \alpha_k \text{Ln}K_{i,t} + \alpha_l \text{Ln}L_{i,t} + \alpha_m \text{Ln}M_{i,t} + \omega_{i,t} + \varepsilon_{i,t} \quad (1)$$

Here,  $LnY_{i,t}$  denotes firm  $i$ 's output in year  $t$ ;  $LnK_{i,t}$  represents capital input;  $LnL_{i,t}$  means the labor input;  $LnM_{i,t}$  is intermediate input;  $\omega_{i,t}$  characterizes an unobserved productivity shock, and  $\varepsilon_{i,t}$  an error term. Following the LP procedure, a control function is constructed, and a third-order polynomial approximation in capital and intermediate inputs  $\Phi_{i,t}$  is used to estimate, year by year, the labor and intermediate input output elasticities ( $\widehat{\alpha}_l$  and  $\widehat{\alpha}_m$ ). The capital elasticity  $\widehat{\alpha}_k$  is recovered using moment conditions and solved via nonlinear optimization to satisfy the identifying conditions. Once factor output elasticities are obtained, firm TFP is computed as the equation (2).

$$TFP_{i,t} = \exp(LnY_{i,t} - \widehat{\alpha}_k LnK_{i,t} - \widehat{\alpha}_l LnL_{i,t} - \widehat{\alpha}_m LnM_{i,t}) \quad (2)$$

For empirical analysis, the natural logarithm of TFP is used ( $LnTFP$ ).  $LnTFP$  greater than zero indicates that a firm's productivity exceeds the sample average, while  $LnTFP$  less than zero indicates productivity below the sample average.

**Moderator Variables.** ① Cost of debt (*Cost*): Following Mei & Zhang (2023), the cost of debt financing is proxied by the ratio of financial expenses to total liabilities [10]. A higher ratio indicates a higher effective debt financing cost. ② Proportion of overseas revenue (*OR*): Following Chen et al. (2025), *OR* is measured as the ratio of a firm's overseas revenue to total revenue [11]. A higher value indicates greater internationalization and higher dependence on overseas markets; a lower value indicates greater reliance on the domestic market.

**Control Variables.** The study follows prior literature on determinants of firm TFP and includes a set of control variables that may affect TFP, including firm size (natural logarithm of total assets, *Size*), leverage ratio (*LEV*), fixed asset intensity (*FA*), return on assets (*ROA*), book-to-market ratio (*BM*), year-on-year growth rate of operating revenue (*Growth*), and firm age (*Age*).

### 3.3 Empirical Models

To test Hypothesis 1, the following baseline panel regression is estimated in equation (3).

$$LnTFP_{i,t} = \mu_0 + \mu_1 ESG_{i,t-1} + \mu_2 \mathbf{Controls}'_{i,t-1} + \sum Industry + \sum Year + \varepsilon_{i,t} \quad (3)$$

Here,  $\sum Industry$  denotes industry dummy variables and  $\sum Year$  denotes year dummy variables, and  $\varepsilon_{i,t}$  is the random error term. Notably, the moderator variables (*Cost* and *OR*) are included as control variables in this specification.

To examine the moderating role of cost of debt (Hypothesis 2), the specification is extended to include an interaction term, as shown in equation (4).

$$LnTFP_{i,t} = \beta_0 + \beta_1 ESG_{i,t-1} + \beta_2 Cost_{i,t-1} + \beta_3 (ESG_{i,t-1} \times Cost_{i,t-1}) + \beta_4 \mathbf{Controls}'_{i,t-1} + \sum Industry + \sum Year + \varepsilon_{i,t} \quad (4)$$

The coefficient  $\beta_3$  captures the moderating effect of cost of debt on the ESG-TFP relationship.

Similarly, to test Hypothesis 3 regarding the moderating effect of the share of overseas revenue (*OR*), the model is specified as the following equation (5).

$$\ln TFP_{it} = \mu_0 + \mu_1 ESG_{it-1} + \mu_2 OR_{it-1} + \mu_3 (ESG_{it-1} \times OR_{it-1}) + \mu_4 Controls'_{it-1} + \sum Industry + \sum Year + \varepsilon_{it} \quad (5)$$

The coefficient  $\mu_3$  measures how the *OR* moderates the effect of ESG on TFP. Statistical significance of the interaction terms indicates the presence of moderation.

## 4 Research Results and Analysis

### 4.1 Descriptive Analysis

Table 1 reports descriptive statistics for the variables. The mean of *LnTFP* is -6.7913 with a standard deviation of 0.6307, suggesting that sample firms exhibit generally low TFP with moderate dispersion. The proximity of the mean and median indicates an approximately symmetric distribution without pronounced right skew. The sample mean ESG score is 6.0456 with a standard deviation of 1.2209, implying a concentrated distribution and generally medium to high ESG performance, albeit with room for improvement. The average cost of debt financing is 0.75%, with a standard deviation of 1.36% and a minimum of -4.85%, which may reflect occurrences of interest income exceeding interest expense or government subsidies. Overall, costs of debt in the sample are low. The mean share of overseas revenue is 19.83% with a standard deviation of 21.77%, indicating substantial heterogeneity in firms' participation in foreign markets. Other variables display distributions within acceptable ranges.

**Table 1.** Descriptive statistical results.

Variable	Count	Mean	Standard deviation	Minimum	Median	Maximum
<i>LnTFP</i>	1578	-6.7913	0.6307	-8.6488	-6.7553	-4.9297
<i>ESG</i>	1578	6.0456	1.2209	4.0000	6.0000	9.0000
<i>Cost</i>	1578	0.0075	0.0136	-0.0485	0.0081	0.0366
<i>OR</i>	1578	19.8289	21.7711	0.0120	11.7936	95.6293
<i>Size</i>	1578	23.4314	1.8222	19.9762	23.2911	27.6874
<i>LEV</i>	1578	0.5529	0.1680	0.1405	0.5720	0.8810
<i>FA</i>	1578	0.2121	0.1670	0.0108	0.1654	0.7406
<i>ROA</i>	1578	0.0409	0.0481	-0.1267	0.0366	0.2059
<i>BM</i>	1578	0.6776	0.3724	0.0882	0.5820	1.7990
<i>Growth</i>	1578	0.0834	0.2318	-0.5231	0.0656	0.9485
<i>Age</i>	1578	22.6572	6.5915	8.0000	23.0000	42.0000

### 4.2 Multicollinearity Test

Assessing multicollinearity is necessary to ensure the validity of regression inference. High linear correlation among explanatory variables inflates standard errors, which can

reduce t-statistics, compromise significance tests, and potentially produce unstable or sign-reversed coefficient estimates. This study employs the variance inflation factor as the diagnostic metric, using a threshold of 10. VIF values below this threshold for core explanatory and control variables indicate that multicollinearity is not severe and that estimation results are reliable. The VIF results show that all explanatory and control variables are well below the critical value. Firm size has the highest VIF at 2.4766 and firm age has the lowest at 1.0933; the mean VIF is 1.5820. Since all VIF values are below 2.5, the regression estimates are robust, supporting retention of all variables.

### 4.3 Panel Regression Analysis

**Results of Hypothesis 1.** Based on the foregoing hypotheses, the analysis is conducted on listed firms participating in BRI. Table 2 presents the main regression results for Hypothesis 1. The full sample column reports that the coefficient on ESG is -0.0596 and is significant at the 5 percent level. This implies that a one-unit increase in the ESG score is associated with a 0.0596 decline in the log mean TFP. Translating this effect, a one standard deviation increase in ESG corresponds to an approximate 7.02 percent reduction in TFP. Although the coefficient is negative, the magnitude is moderate, indicating that the short-run cost effect of ESG is nontrivial but has not produced a severe productivity collapse. This finding is consistent with the compliance cost hypothesis. For energy, infrastructure, and manufacturing firms in the Belt and Road sample, ESG expenditures are often concentrated in end-of-pipe treatment (for example, purchases of environmental protection equipment and compliance spending) rather than in process or technological innovation. In the short run such expenditures can crowd out productive investment and reduce TFP. Moreover, firms expanding overseas confront diversified institutional and cultural environments and, under tightening global sustainability standards, face higher short-term costs for environmental inputs, labor protection, and compliance in host countries. These costs can initially weaken operational efficiency and further suppress TFP, supporting Hypothesis 1.

Heterogeneity tests follow the approach of Li et al. (2021) [12]. Heavy polluting industries are defined as 18 sectors (including coal mining, petroleum processing, textiles, pharmaceutical manufacturing, etc.) using the 2012 CSRC industry classification and the Ministry of Environmental Protection's environmental verification catalogue; remaining sectors are classified as non-heavy polluting. Regression results differ significantly across subsamples. In the heavy polluting subsample, the ESG coefficient is not significant, whereas in the non-heavy polluting subsample, the ESG coefficient is negative and significant at the 1% level. Thus, the overall negative ESG-TFP relationship is driven primarily by non-heavy polluting firms. A plausible interpretation is that heavy polluting firms face stronger and more persistent environmental regulation; their ESG-related expenditures have become internalized as ongoing operating costs and are more likely to be accompanied by investments in environmental technology and process reengineering, which attenuate the crowding out of productive investment. By contrast, non-heavy polluting firms face lower marginal compliance costs and ESG spending is more likely to appear as new expenditures rather than technological substitution, producing larger short-term productivity losses.

**Table 2.** Regression results of Hypothesis 1-3.

	Hypothesis 1			Hypothesis 2	Hypothesis 3
	Full sample	Heavy polluting firms	Non-heavy polluting firms		
<i>ESG</i>	-0.0596**	0.0282	-0.0761***	-0.0689***	-0.0822***
<i>Cost</i>	-0.0094	-9.1392**	-1.3567	-7.4718*	/
<i>ESG × Cost</i>	/	/	/	1.2741*	/
<i>OR</i>	0.0005	0.0007	0.0010	/	-0.0057***
<i>ESG × OR</i>	/	/	/	/	0.0010***
<i>Size</i>	-0.1591***	-0.1277*	-0.1717***	-0.1586***	-0.1572***
<i>LEV</i>	-0.3007	0.4209	-0.1353	-0.3083***	-0.3138***
<i>FA</i>	-0.0681	-1.1075*	-0.2855	-0.0990	-0.0632
<i>ROA</i>	2.1773***	2.6315**	2.3036***	2.1877***	2.1450***
<i>BM</i>	-0.2868***	-0.0405	-0.3967***	-0.2893***	-0.2896***
<i>Growth</i>	-0.0007	-0.6059***	0.0471	-0.0096	0.0009
<i>Age</i>	-0.0028	-0.0331***	0.0013	-0.0030*	-0.0028*
<i>Industry FE</i>	Yes	Yes	Yes	Yes	Yes
<i>Year FE</i>	Yes	Yes	Yes	Yes	Yes
<i>R-squared</i>	0.6375	0.6316	0.6899	0.6386	0.6394
<i>N</i>	1578	209	1369	1578	1578

Note: The data in the table are regression coefficient of each variable, and \*\*\*, \*\*, and \* are significant at the significance level of 1%, 5% and 10% respectively.

**Results of Hypothesis 2 & 3.** Regarding Hypothesis 2, the interaction between ESG and cost of debt ( $ESG \times Cost$ ) is positive and significant at the 10% level ( $p = 0.0754$ ). This suggests that higher costs of debt financing mitigate the negative effect of ESG on TFP. Hypothesis 2 is supported. One interpretation is that tighter external financing constraints and stronger oversight compel firms with higher debt costs to allocate funds more prudently, thereby reducing the crowding out of productive investment by ESG expenditures and lowering the productivity drag. This result highlights how the financing environment can influence the efficiency of ESG investment.

Finally, the last column reports the moderating effect of *OR*. The interaction coefficient between ESG and *OR* ( $ESG \times OR$ ) is positive and significant at the 1% level. This finding confirms Hypothesis 3, indicating that greater overseas revenue attenuates the negative ESG-TFP relationship. As firms increase their overseas revenue share, they may move beyond an initial compliance adjustment period toward deeper internationalization and organizational learning. Firms can then reorient ESG investment from end-of-pipe measures toward green process transformation. Process improvements can generate cost savings, raw material efficiency, product premiums, and technological learning that partially offset initial costs and ultimately feed back into productivity. Consequently, higher internationalization weakens the substitution between ESG and productive investment and can strengthen complementarity, reducing TFP losses.

#### 4.4 Robustness Test

To assess the robustness of the baseline findings, the benchmark regression's clustered robust standard error is replaced by heteroskedasticity-robust standard errors. Given the relatively limited sample size, focusing on heteroskedasticity-consistent inference helps ensure that estimates remain reliable even if the error variance is nonconstant across observations. Under this alternative specification, the ESG coefficient remains  $-0.0596$  and is significant at the 1% level ( $p = 0.0000$ ), consistent with the baseline result and supporting the robustness of the main conclusion.

## 5 Conclusion

Based on an empirical analysis of listed firms in the Belt and Road sector over 2008–2024, this paper reexamines the short-term economic consequences of ESG investment from the perspective of firm productivity, providing new microlevel evidence on the costs of sustainable transformation.

First, a productivity paradox associated with ESG exists in specific contexts. Contrary to studies emphasizing long-run value creation from ESG, the results indicate that ESG investment by Belt and Road firms has crowded out productive resources in the short term. This finding does not deny the long-term benefits of ESG but highlights transitional frictions, that is, when environmental compliance requirements are imposed exogenously and firms' absorptive capacity and organizational adjustments lag, efficiency losses are likely. Second, industry heterogeneity reveals a threshold effect of environmental regulation. Uniform ESG promotion may induce efficiency losses in some sectors, whereas industry differentiated regulatory approaches are more appropriate. Third, the moderating roles of financing constraints and internationalization identify important boundary conditions for ESG investment efficiency. Firms with higher financing costs tend to screen ESG projects more rigorously, avoiding inefficient compliance for appearance only. Increased overseas revenue share, through market expansion and organizational learning, provides firms with channels to absorb ESG costs and convert ESG spending into productive capability.

Drawing on these findings, the paper offers policy recommendations. First, governments should adopt differentiated support measures and establish long-term compensation mechanisms for ESG investment. For capital-intensive energy and infrastructure firms participating in Belt and Road projects, instruments such as tax relief, preferential green credit, and research and development subsidies can lower short-term compliance costs and encourage a shift from end-of-pipe treatment to process technology innovation, thereby mitigating the crowding-out effect on productive investment and aligning environmental protection with production efficiency. Second, given that moderate financing constraints can improve the allocation efficiency of ESG resources, financial institutions should link financing conditions to ESG performance and implement differentiated credit policies. For firms with strong ESG records but high borrowing costs, lenders could consider appropriate rate concessions or facilitation of green bond issuance, balancing supervisory incentives with support for sustainable investment. Third, since greater internationalization helps alleviate the negative productivity effects of

ESG, policymakers should strengthen support for firms' overseas operations. Enhancing services for overseas investment, establishing overseas risk monitoring and environmental compliance guidance, and promoting international cooperation platforms for green technology can help firms navigate the initial compliance period abroad, promote the shift of ESG spending toward productive process improvements, and foster a dynamic complementarity between ESG performance and TFP.

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