

The Impact and Process of the ESG Peer Effect on Heavy-Polluting Companies' Green Innovation. Case of companies in the United Kingdom

Adel Necib¹, Mohamed Haddad Ben Mabrouk², Anis Jarboui³

¹University of Sfax; LARIGE Laboratory, University Of Gafsa, Gafsa, Tunisia, ORCID: <https://orcid.org/0000-0001-6818-772X>

²ISGG, University of Gabes, Gabès, Tunisia

³University of Sfax, Sfax, Tunisia, ORCID: <https://orcid.org/0000-0002-4811-6729>

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Abstract. Environmental innovation has become increasingly important for heavy-polluting companies because environmental pollution, climate change, and carbon reduction targets require firms to strengthen ecological responsibility and improve green technology innovation. ESG disclosure provides non-financial information to the market and may influence corporate green innovation not only directly, but also through the behaviour of peer companies operating in the same industry. This study examines the impact of the ESG peer effect on green innovation in heavy-polluting companies in the United Kingdom and investigates the mechanisms through which peer ESG disclosure promotes ecological innovation. The study uses data from heavy-polluting companies observed during 2018-2024. The ESG peer effect is measured as the average ESG score of other firms in the same industry, excluding the target company. Green innovation is measured by the natural logarithm of green patent applications plus one. The empirical analysis applies fixed-effects regression models, robustness tests, mediation mechanism tests, and heterogeneity analysis. Financing constraints, information asymmetry, and green awareness are examined as mediating mechanisms. The findings show that the ESG peer effect has a positive and statistically significant influence on green innovation. The baseline regression results indicate that ESG peer disclosure promotes ecological innovation among target companies, and the results remain valid after robustness checks, including Tobit regression, shorter sample period, lagged explanatory variables, and propensity score matching. The mediation analysis shows that the ESG peer effect promotes green innovation by reducing financing constraints, lowering information asymmetry, and strengthening corporate green awareness. Heterogeneity analysis reveals stronger effects among state-owned enterprises, large firms, and firms located in central and eastern regions. ESG peer disclosure encourages heavy-polluting companies to improve green innovation through competitive pressure, learning effects, and information signalling. Future studies should expand the sample to other industries and countries and examine additional mechanisms linking ESG performance, innovation strategy, and environmental transformation.

Keywords: ESG; peer effect; green innovation; heavy-polluting companies; ESG disclosure; green technology innovation; financing constraints; information asymmetry; green awareness; fixed-effects model; environmental responsibility; corporate sustainability.

JEL Classification: M14; Q55; Q56; O32; G32; C23

Formulas: 4; **fig.:** 0; **tabl.:** 6; **bibl.:** 32

Introduction. Environmental pollution, climate change, and other issues have become major concerns for nations worldwide in recent years (Berrached, 2024). Carbon reduction and carbon neutrality have become important strategic directions for pollution control and environmental preservation while promoting an ecological approach, conservation, and sustainable development with reduced carbon emissions.

Environmental, social, and governance, or ESG, encompasses economic and social benefits, aims for ecological sustainability, emits little carbon dioxide, and focuses on businesses' ability to make environmental, social, and governance-related decisions. In order to achieve carbon reduction goals, highly polluting businesses must undergo an ecological transition by improving their capacity to replace materials with more sustainable ones (Kafi & Elbayed, 2021). Even while ESG has become a crucial criterion for evaluating an organization's non-financial aspects, several studies have demonstrated that the quality of technological innovation within businesses is also influenced by ESG performance.

The main themes of research on the effects of information sharing between peers are the evolution of business behaviour in relation to social responsibility among peers (Nguyen, 2020) and information on product quality among peers (Gosselin, 2021). However, there is a lack of research on the effects of ESG disclosure by peers on business innovation, and this study adds to the current field by examining this relationship. Taking into account the research gaps mentioned above, this study investigates whether the impact of ESG peer integration influences environment-conscious innovation of selected companies and reveals the mechanism underlying this effect.

Based on theories of dynamic competition, market competition, and social comparison, this study examines in detail the effects of ESG disclosure by peers on technological innovation in the environmental sector of businesses. As the study's sample, it gathers relevant data from companies in the United Kingdom that were identified as highly polluting between 2018 and 2024, analyses them empirically using a fixed-effects model, and uses robustness tests to ensure the scientific validity of the research findings.

The remainder of the article is organized as follows. The literature review examines existing theories and previous empirical studies. The next section presents the aim, objectives, and research hypotheses. The methodology section discusses the research design, data sources, sample selection, main variables, models, and mediation mechanism tests. The results section presents descriptive statistics, baseline regression, robustness tests, mechanism testing, and heterogeneity analysis. The discussion section interprets the findings, while the conclusion summarizes the results and provides recommendations.

Literature Review. Recent articles focus mostly on the economic factors and effects of an organization's ESG performance. The main factors

influencing an organization's ESG disclosure are its own characteristics and the macroeconomic environment. Macroeconomic research has examined the effects of national economic development (Leroux, 2025), financial policy uncertainty (Blot et al., 2025), international trade (Cachard, 2018), global trade, and capital markets (Fenet & Waquet, 2024) on the ESG performance of businesses. The company's size (Gherib & M'hissen, 2010), internal governance structure (Ziani, 2019), share price (Lantin, 2009), leadership traits (Necib, 2023), and institutional investor involvement (Bughin et al., 2011) have all been found to have a significant impact on the company's ESG performance.

Three topics are primarily distinguished in papers on economic outcomes of ESG disclosure: innovation, financial risk, and entrepreneurial value. According to Gasmi (2021) and Caublot (2024), proactive ESG measures help businesses develop differentiation strategies, which in turn help them increase their value.

The phrase “peer effect” refers to how an organization's actions are influenced by both its own characteristics and the initiatives of other businesses operating in the same industry. Ferry (2018) and Ziane (2023) established a theoretical framework aimed at evaluating the imitation behaviour of businesses by distinguishing two fundamental themes for imitation: information-based imitation and competition-based imitation. Researchers have noted that actions such as mergers and acquisitions (Aslanoff, 2013; Habib et al., 2024), business governance (Pigé, 2002), green innovation (Bari & Azegagh, 2022), investment (Rigot et al., 2016), and shareholder rights (Kostruba, 2025), among others, demonstrate peer effects.

Additionally, researchers have observed the influence of peers on financial decisions based on empirical experiences. After analysing these findings, they concluded that competition in product markets, education, and internal capital markets are the main causes of peer effects in the financial sector.

A significant portion of studies on ESG in business examines how an organization's ESG performance affects its value, risk, innovation, and other behaviours, viewing businesses as separate dynamic entities and ignoring peer relationships. However, in order to reduce the risks and expenses associated with making decisions, businesses monitor and learn from the actions of their peers. Less research has been done on how ESG peer effects influence ecological innovation. In order to fill this research gap, this paper uses peer effects to examine the relationship between the environmental innovation of target businesses and the ESG performance of other businesses in the same industry.

Aims. The aim of this study is to examine the impact and mechanism of the ESG peer effect on green innovation in heavy-polluting companies in the United Kingdom during the period 2018-2024.

The objectives of the study are to investigate whether ESG disclosure by peer companies stimulates green innovation in target enterprises; to analyse how ESG peer disclosure affects green technology innovation through financing constraints, information asymmetry, and green awareness; to test the robustness of the relationship between ESG peer effects and green innovation using alternative empirical approaches; and to examine whether the impact of ESG peer effects differs according to property rights, company size, and region.

The study is based on the following research hypotheses:

H1: Environmental innovation within the targeted company will be stimulated by ESG performance in the same industry.

H2: By lowering the financial burden on the targeted companies, the impact of ESG peer effect may encourage the development of environmentally conscious innovations.

H3: By lowering the level of information asymmetry, the effect of ESG peer effect may raise the level of green innovation inside the targeted companies.

H4: The impact of ESG peer effect may increase the environmentally conscious nature of the targeted companies, hence promoting green innovation.

Methodology. This study examines how ESG peer effects influence green innovation using fixed-effects regression models. It also applies mediation mechanism tests to analyse whether financing constraints, information asymmetry, and green awareness explain the relationship between ESG peer effects and green innovation.

Data Sources and Sample Selection. This study focuses on highly polluting businesses in the United Kingdom surveyed as a group of businesses between 2018 and 2024. Since the ESG metrics discussed in this article are based on the FTSE100's ESG ratings, 2018 was chosen as the starting point of the study. To ensure the validity and scientific integrity of the study, the sample was processed by eliminating companies with a significant amount of inconsistent data and by applying a 1% winsorization on the continuous variables. This resulted in 700 firm-year observations.

The ESG index used in this study is based on published ratings. The AAA-C indicators were replaced with values ranging from 9 to 1, with higher scores indicating better ratings. The explanatory variable, green innovation level, as well as the control and mediation mechanism variables, were obtained from relevant databases.

Main Variables. The dependent variable is green innovation, denoted as Green. Research and business development include interest in green technological innovation, which includes a wide range of technological advancements with an emphasis on environmental conservation and energy efficiency. Among other indicators, the total number of green patent applications is used as a measure of an organization's ability to advance technologically. The study uses the number of green patent applications

combined with a logarithmic process as a variable indicator to measure the level of ecological innovation.

The core independent variable is the ESG peer effect, denoted as *ESG_peer*. According to Beaupré et al. (2008), ESG assessments are required to measure an organization's environmental protection, social responsibility, and long-term growth. Therefore, this study uses ESG ratings provided by the information platform to assess ESG effectiveness. The ESG peer effect is measured as the average ESG score for the industry, excluding the current company.

The mediating mechanism variables are financing constraints, information asymmetry, and green awareness. Financing constraints are measured using the SA index. The current literature uses the WW, SA, and KZ indices to assess financial constraints. However, in order to ensure the reliability of the SA index, Hadlock and Pierce (2010) developed it by relying on exogenous variables such as the size and age of the enterprise. This method helps prevent endogenous disturbances and strengthens the credibility of the index. The formula used to determine the SA index is:

$$SA_{i,t} = -0.737 \times Size_{i,t} + 0.043 \times Size^2_{i,t} - 0.04 \times Age_{i,t} \quad (1)$$

Age is the length of time the business has been in operation, whereas Size is the total amount of activity expressed in millions of dollars and then treated logarithmically. A higher SA index indicates that the company faces fewer financing constraints.

Information asymmetry is measured using transaction-related indicators from traded companies. The study identifies the main component among the liquidity ratio, the illiquidity indicator, and the Pastor and Stambaugh return reversal indicator. The Asy index is used as the information asymmetry indicator. A higher Asy index indicates a higher degree of information asymmetry.

Green awareness is measured by whether the company disclosed environmental information in its annual social responsibility report. If the company disclosed such information, the value is 1; otherwise, it is 0.

The control variables include company size, operating cash flow, growth capacity, ratio of independent directors, executive team size, profitability, asset-liability ratio, shareholding concentration, and age of business.

Table 1. Definition of Variables

Variable Category	Variable Name	Symbol	Variable Explanations
Dependent variable	Green innovation	Green	The natural logarithm of the number of green patent applications filed by businesses plus one is used to calculate the level of green innovation.
Independent variable	ESG Peer Effect	ESG_peer	The performance of the current year is not included in the average ESG ranking of other companies in the same industry.
Intermediary variable	Financing constraints	SA	Index of financial restrictions. The firm is subject to fewer financing constraints the greater the index.
Intermediary variable	Information asymmetry	Asy	The degree of information asymmetry for the return reversal indicator GAM, the liquidity indicator LR, and the illiquidity indicator ILL is ascertained by extracting the first principal components.
Intermediary variable	Green awareness	CSRReport	CSRReport = 1 if the company included environmental information in its yearly social responsibility report; if not, it is 0.
Grouping variable	Nature of property rights	Soe	Whether the actual controlling shareholder is a state-owned enterprise: 1 = yes, 0 = no.
Grouping variable	Company size	Size_big	Size_big = 1 if the firm size exceeds the sample median; if not, 0.
Grouping variable	District	District	The business is located in the eastern, central, or western region. East = 1 indicates that the business is located in the eastern region, Middle = 1 indicates that it is located in the central area, and East = 0 and Middle = 0 indicates that it is located in the western area.
Control variable	Company Size	Size	Natural logarithm of total company assets.
Control variable	Operating cash flow	Cash	Company's net cash flows from operations divided by total assets.
Control variable	Growth capacity	Growth	Revenue growth rate.
Control variable	Ratio of independent directors	Indirect	Number of independent directors divided by number of board directors.
Control variable	Executive Team Size	Tmtsize	The natural logarithm of the number of executives plus one.
Control variable	Profitability	Roa	Net profit divided by total assets.
Control variable	Asset-liability ratio	Lev	Total liabilities divided by total assets.
Control variable	Shareholding concentration	Top10	The proportion of the top ten shareholders' shares.
Control variable	Age of business	LnAge	Natural logarithm of age of business.

Source: systematized by the authors

Baseline Regression Model. This study examines how the ESG peer effect affects innovation development using a fixed-effects model. The regression model is specified as follows:

$$\text{Green}_{it} = \alpha_1 + \beta_1 \text{ESG_peer}_{it} + \sum_j \beta_j \text{Controls}_{it} + \lambda_i + \mu_t + \varepsilon_{it} \quad (2)$$

In the equation, Green represents the degree of green innovation that businesses possess, ESG_peer refers to the impact of ESG peer integration, and Controls represents company size, profitability, and other control

variables. λ_i is the individual fixed effect, μ_t is the time fixed effect, and ε_{it} is the random error term. If the coefficient β_1 corresponding to ESG_peer is significantly positive, this suggests that raising the sectoral average ESG score could encourage ecological innovation within the targeted industry.

Mediating Mechanism Test Model. The research methodology is used to investigate the effects of the ESG peer effect on reducing financial constraints, reducing information asymmetry, and expanding the company's ecological consciousness, thereby promoting green innovation. The regression model is developed in two steps using equation (2):

$$MV_{it} = \alpha_2 + \beta_2 ESG_peer_{it} + \sum_j \beta_j Controls_{it} + \lambda_i + \mu_t + \varepsilon_{it} \quad (3)$$

$$Green_{it} = \alpha_3 + \beta_3 ESG_peer_{it} + \gamma MV_{it} + \sum_j \beta_j Controls_{it} + \lambda_i + \mu_t + \varepsilon_{it} \quad (4)$$

The three intermediary variables SA, Asy, and CSRReport are identified by MV in model (3). The equation shows the regression model of the ESG peer effect on each intermediary variable. If the net value of β_2 is positive, it means that the ESG peer effect has a positive effect on the mediating variable. The second step of the two-phase regression method includes model (4), and coefficient β_3 shows how the ESG peer effect affects green innovation. If β_1 , β_2 , and γ are significant, this suggests that some mechanism factors influence the indirect impact of the ESG peer effect on green innovation.

Results. Table 2 presents descriptive statistics for the main variables discussed in this article. It is evident that highly polluting businesses have ESG scores ranging from C to AA, with a mean score of 4.06557 and a standard deviation of 1.223481.

Table 2. Descriptive Statistics

Variable	N	Mean	SD	Minimum	Maximum
ESG	700	4.06557	1.223481	1	9
ESG_peer	700	4.062656	0.4201563	3.015485	8.76
Green	700	0.8192225	1.065776	0	7.931574
Size	700	24.30602	1.47394	18.15485	30.63758
Cash	700	0.0683079	0.0880643	-1.686397	3.221623
Growth	700	7.944298	604.9358	-4.491824	64461.64
Indirect	700	0.4009859	0.0632697	0.1667	0.8154
Tmtsize	700	2.005333	0.388582	0.6931472	3.122054
Roa	700	0.0495337	0.2356492	-3.199499	8.545085
Lev	700	0.4582024	0.3127323	0.007321	4.371887
Top10	700	61.44867	17.63297	1.3103	97.5894
Lnage	700	3.946079	0.410877	0.7231572	7.928652

Source: developed by the authors

This indicates that the ESG scores of businesses are generally low and show limited variance among them. The ESG peer effect, also known as ESG_peer, has a limited range in highly polluting businesses, with a mean

of 4.062656, a minimum value of 3.015485, a maximum value of 8.76, and a standard deviation of 0.4201563.

Basic Regression Test. The results of the basic regression are shown in Table 3. The results of the test aimed at determining whether highly polluting businesses are affected by ESG peer effects are shown in column (1). When individual and annual effects are taken into account, the ESG peer effect is evident, as demonstrated by the ESG_peer coefficient of 0.492 at the 1% level.

Column (2) does not contain control variables, while column (3) contains control variables. After accounting for individual and temporal effects, the coefficients ESG_peer pertaining to the impact of peer ESG on the level of green innovation are 0.182 and 0.197, respectively. These two coefficients are statistically significant at the 1% level, suggesting that ESG disclosure by peers promotes ecological innovation in corporate entities. Thus, the hypothesis of this study is valid.

Table 3. Basic Regression Results

Variable	(1) ESG	(2) Green	(3) Green
ESG_peer	0.492*** (9.82)	0.182*** (5.16)	0.197*** (5.45)
Size	0.314*** (16.92)		0.377*** (21.13)
Cash	-0.199** (-1.94)		0.0718 (0.73)
Growth	-0.0000384*** (-2.94)		0.00000392 (0.35)
Indirect	1.357*** (6.22)		0.537** (3.18)
Tmtsize	0.0569 (1.22)		0.00897 (0.33)
ROA	0.0618 (0.83)		0.0347 (0.51)
Lev	-0.773*** (-10.41)		0.00523 (0.09)
Top10	0.000714 (0.73)		0.00229** (3.11)
Lnage	-0.298*** (-2.74)		-0.195*** (-2.90)
Observations	700	700	700
Firm Effect	Yes	Yes	Yes
Year Effect	Yes	Yes	Yes
Adj. R-squared	0.2118	0.216	0.226

Note: *t* statistics in parentheses. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

Source: developed by the authors

Robustness Tests. Several robustness tests were conducted. First, the Tobit model was used to obtain a more accurate estimate due to the significance of zeros in commercial patent demands. The Tobit model test is shown in Table 4, column (1), and the ESG_peer coefficient of 0.443 is significant at the 1% level. This shows that, despite the regression model's

revision, ESG disclosures by peers continue to play a significant role in promoting ecological innovation projects within targeted businesses.

Second, a shorter sample period was used. This article includes post-2020 data in order to analyse the impact of external shocks on business innovation in the technology sector. The results of the regression are shown in column (2) of Table 4, and the coefficient ESG_peer is 0.412. The result remains consistently positive at the 1% level, supporting the claim that the ESG peer effect fosters green innovation.

Third, first-order and second-order lag terms for explanatory variables were used. The omission of some unmeasured factors and the potential for an inverse causal relationship between ESG peer effects and green innovation are the root causes of the endogeneity problem. Therefore, in this study, the first- and second-order lag terms of ESG_peer are used as instrumental variables for endogenous tests. The test results are shown in columns (3) and (4) of Table 4. The first-order lag, L.ESG_peer, and second-order lag, L2.ESG_peer, show positive and significant coefficients at the 1% level, confirming the regression results and validating the study's conclusions.

Fourth, propensity score matching was applied. Businesses in a particular industry may share characteristics, which could introduce bias in the sampling process and influence the study's conclusions. The article uses the propensity score matching method to modify the control variables as covariates with a ratio close to 1:1 in order to optimize the comparison between experimental and control groups. The regression results are shown in Table 4, column (5), and the fact that the coefficients of the main independent variables remain positive indicates that the article's conclusions are correct.

Table 4. Check for Robustness

Variable	Changing the regression model	Shorter sample periods	First-order lag of explanatory variables	Second-order lag of explanatory variables	Propensity score matching
	(1) Green	(2) Green	(3) Green	(4) Green	(5) Green
ESG_peer	0.443***	0.412***			0.338***
	(4.13)	(5.77)			(5.34)
L.ESG_peer			0.445***		
			(7.36)		
L2.ESG_peer				0.338***	
				(6.66)	
Control variable	Yes	Yes	Yes	Yes	Yes
Observations	700	700	700	700	700
Firm Effect	Yes	Yes	Yes	Yes	Yes
Year Effect	Yes	Yes	Yes	Yes	Yes
Adj. R-squared		0.4538	0.5369	0.5125	0.5365

Note: *t* statistics in parentheses. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

Source: developed by the authors

Mechanism Testing. The results of the financing constraint mechanism tests are shown in Table 5, columns (1) and (2). The regression results on the impact of ESG peer effects on financial constraints are shown in column (1). The ESG_peer coefficient is consistently positive, indicating that ESG information disclosure by peer companies may help mitigate financial constraints on target companies. The model then considers both financial constraints and ESG peer effects. These two coefficients are significantly positive, as shown in column (2). This illustrates how financial constraints affect green innovation and the ESG peer effect, and H2 is validated.

The results of the investigation into the mechanism causing information asymmetry are presented in Table 5, columns (3) and (4). Column (3) shows that the ESG peer effect reduces information asymmetry, while column (4) shows that the ESG_peer index has a positive coefficient when both information asymmetry and ESG peer effects are included in the model. Conversely, Asy has a negative value. This result supports the mechanism of information asymmetry in the effect of ESG peer disclosure on ecological innovation and validates H3.

The test results for green awareness are displayed in Table 5, columns (5) and (6). The ESG_peer coefficient of 0.0517 in column (5) is positive, indicating that the ESG peer effect has a positive impact on the company's ecological sensitivity and therefore supports its green innovation efforts. The sixth column shows how the regression model considers environmental consciousness and the ESG peer effect to assess the influence on ecological innovation in businesses. In terms of significance and orientation, the coefficients show that green awareness plays an intermediary role in the effect of ESG peer disclosure on green innovation. This outcome validates hypothesis H4.

Table 5. Results of the ESG Peer Effect Mediation Mechanism Test

Variable	Financing constraints	Financing constraints	Information asymmetry	Information asymmetry	Green awareness	Green awareness
	(1) SA	(2) Green	(3) Asy	(4) Green	(5) CSRReport	(6) Green
SA		1.645*** (11.24)				
Asy				-0.2089*** (-9.98)		
CSRReport						0.0656*** (4.44)
ESG_peer	0.0134*** (3.83)	0.024*** (6.61)	-0.0298*** (-6.05)	0.2145*** (4.74)	0.0517*** (3.18)	0.2145*** (9.97)
Control variable	Yes	Yes	Yes	Yes	Yes	Yes
Observations	700	700	700	700	700	700
Firm Effect	Yes	Yes	Yes	Yes	Yes	Yes
Year Effect	Yes	Yes	Yes	Yes	Yes	Yes
Adj. R-squared	0.2140	0.2168	0.1314	0.1050	0.1967	0.2095

Note: *t* statistics in parentheses. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

Source: developed by the authors

Heterogeneity Analysis. This study distinguishes between businesses that are state-owned and those that are not, and it modifies the regression model based on groupings. The study's results are shown in Table 6, columns (1) and (2), where the coefficients of the main explanatory variables show positive significance for both state-owned and non-state-owned businesses. However, the coefficients of the state-owned enterprise group are more significant. This may be related to the role of state-owned businesses in the economy and the greater social attention directed toward them.

The study also divides the sample into large and small businesses. The statistical results are shown in Table 6, columns (3) and (4). From a statistical perspective, the coefficients are negative but not statistically significant for the group of small businesses and positive for the group of large businesses. This suggests that the influence of ESG peer disclosure on green innovation is more pronounced for large businesses and has no discernible effect on small businesses.

Due to differences in economic growth, political resource allocation, and public consciousness between regions, businesses established in these regions may adopt varying levels of investment in ESG and ecological practices in response to the ESG disclosures of their counterparts. In order to create a group regression, this study divides the area where businesses are located into three zones: eastern, central, and western. The results, as shown in Table 6, columns (5), (6), and (7), show that the coefficients of ESG peer effects are generally positive in the central and eastern zones. Conversely, the coefficients of the western population are not significant.

Table 6. Heterogeneity Analysis Results

Variable	Nature of property rights		Company size		District		
	(1) State-owned enterprise	(2) Non-state-owned enterprise	(3) Big corporation	(4) Small corporation	(5) Eastern region	(6) Central region	(7) Western region
ESG peer	0.202*** (3.33)	0.103** (2.25)	0.316*** (4.98)	-0.023 (-0.47)	0.1456** (2.67)	0.3128*** (3.74)	0.2645 (1.54)
Control variable	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	700	700	700	700	700	700	700
Firm Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj. R-squared	0.1165	0.0654	0.0663	0.0308	0.0435	0.0903	0.0874

Note: *t* statistics in parentheses. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

Source: developed by the authors

Discussion. The findings of this study provide empirical evidence that ESG peer effects significantly influence green innovation in heavy-polluting companies. The baseline regression results show that the ESG_peer coefficient is positive and statistically significant, indicating that when ESG disclosure among competitors increases, target companies respond by

strengthening green innovation. This result supports the idea that firms are not isolated decision-making units. Instead, they observe, compare, and react to the ESG performance of other companies in the same industry.

The positive impact of ESG peer effects may be explained through dynamic competition, social comparison, and signalling mechanisms. When peer firms improve ESG disclosure, target companies may face increased competitive pressure and reputational pressure. They may also interpret peer ESG performance as a signal of future market expectations, investor preferences, and regulatory trends. As a result, target companies become more likely to invest in green patent applications and ecological innovation.

The robustness tests further confirm the stability of the main findings. The Tobit model, shorter sample period, lagged explanatory variables, and propensity score matching all support the conclusion that ESG peer effects promote green innovation. This strengthens confidence in the validity of the empirical results and reduces concerns about model specification, sample selection bias, and potential endogeneity.

The mediation mechanism tests reveal that the ESG peer effect influences green innovation through three channels: financing constraints, information asymmetry, and green awareness. First, ESG disclosure by peer companies may help ease financing constraints by improving market confidence and encouraging investors to support companies with stronger ESG orientation. Second, ESG peer disclosure can reduce information asymmetry by increasing transparency and signalling long-term development potential. Third, ESG peer effects can strengthen green awareness by encouraging companies to pay more attention to environmental responsibility and to integrate ecological consciousness into their strategies and operations.

The heterogeneity analysis shows that the ESG peer effect is stronger among state-owned enterprises, large companies, and firms located in more developed regions. This suggests that companies with stronger resources, higher visibility, and greater institutional pressure are more responsive to peer ESG disclosure. Large firms may have more financial and organizational capacity to translate ESG pressure into green innovation, while firms in more developed regions may benefit from better institutional support, stronger environmental awareness, and more advanced innovation infrastructure.

Overall, the study demonstrates that ESG peer disclosure is not only a transparency mechanism but also a behavioural and strategic driver of green innovation. For heavy-polluting companies, ESG performance by peer firms can create a competitive and informational environment that encourages ecological innovation, improves environmental responsibility, and supports long-term sustainability transformation.

Conclusions. In order to deepen the understanding of the relationship between ecological innovation and ESG effects, this study examines the

impact and mechanism of ESG peer effects on green innovation by applying theories of competition, market theory, and signal theory. It focuses on major polluting companies based in the United Kingdom from 2018 to 2024 as research subjects.

First, according to regression-based results, when the level of ESG disclosure among competitors increases, the targeted companies take action to improve their ESG performance due to competition and comparative trends. In other words, the ESG peer effect increases green innovation. The spillover effect associated with ESG disclosure by peers is still present in the robustness tests.

Second, according to the results of the intermediary mechanism test, improving the ESG performance of peer businesses encourages ecological innovation in targeted businesses by addressing financial constraints, reducing information asymmetry, and strengthening environmental consciousness.

Additionally, according to heterogeneity analysis, the effect of ESG performance on green innovation is particularly noticeable among state-owned enterprises, large corporations, and those located in more developed regions.

The study provides several policy recommendations. First, governments and regulatory authorities should refine the ESG disclosure process as well as systems of penalties and rewards. They could provide financial incentives, tax breaks, credit support, and other benefits to businesses that participate actively in ESG while monitoring and analysing those that have subpar results. Second, sector management teams should take active steps to improve the industry environment, create a business-friendly atmosphere, strengthen the informational context, and promote healthy competition among businesses. Third, businesses should develop ESG strategies and incorporate environmental consciousness into their business goals, management systems, and daily operations.

This research has a number of limitations. First, the sample is not sufficiently representative because the study only examines businesses that have been identified as highly polluting. Other industries are not taken into account, which may limit the generalisability of the findings. Second, the study's conclusions are based on a specific institutional and market environment, and it is important to assess whether similar effects occur in other countries. In the future, researchers should continue to investigate innovative practices and expand research in this field.

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