Financial Performance and Green Innovation in European Region Firms: The Moderating Roles of ESG and Circular Economy Practices

Abstract

This study examines the potential negative effect of financial performance on green innovation and investigates the moderation effects of ESG scores and circular economy practices in a broad panel of European firms. The analysis takes a resource-allocation and sustainability perspective and examines if profitability pressures limit firms' environmental innovation activities and if governance quality and circular strategies affect the relationship. The empirical method combines fixed-effects panel estimation, generalized structural equation modelling and instrumental variable techniques for robustness and to account for potential endogeneity. Results show a uniform negative impact of financial performance on green innovation, which means that companies prefer to focus on short term gains rather than long term investment in the environment. This negative impact is clearly reduced by ESG performance, highlighting the role of good sustainability governance in facilitating innovation under financial constraints. On the other hand, circular practices exacerbate the negative relationship, meaning that circular transitions may require further resource pressures unless strategic capabilities are provided. Robustness checks are done to ensure that these patterns are stable to alternative specifications. The overall results of the study add new evidence to the sustainability finance nexus by revealing that financial success does not necessarily encourage environmental innovation; rather, the governance strength and circular readiness of a firm are crucial for their ability to overcome profitability related barriers to reach green innovation goals.

Keywords: Green innovation; Financial performance; ESG score; Circular economy

1. Introduction

As environmental degradation, regulations and stakeholder expectations become more intense, green innovation has become a key element in corporate sustainability strategies. The reports and empirical studies of various industries around the world show that the green innovation is beneficial for the long term firm capability, reduction of environmental risks and strengthening of the competitive advantage due to resource efficiency and ecofriendly technologies (Albort-Morant et al., 2016). There are also indications that green innovation can lead to better ESG results, which

in turn strengthens companies' legitimacy and helps to align their corporate strategies with societal expectations (Chen et al., 2025). Moreover, research in the European and international literature shows that environmental innovation has a major influence on the financial development of firms, but with a certain delay, because of the resource-intensive character of environmental innovations. (Rezende et al., 2019; Farza et al., 2021). These findings collectively highlight the pivotal role of green innovation in the context of shifting sustainability and competitiveness dynamics, as well as responsible governance.

Although green innovation is of strategic importance, empirical results show that there is a conflict between profitability and green investing. A number of studies show that companies tend to focus on the short-term financial results, thereby restricting the funds available for sustainability driven innovation, particularly under the pressure of declining profitability (Rezende et al., 2019). Meanwhile, it has been demonstrated that the adoption of ESG and circular economy strategies improve the innovation capacity and financial results of companies (Chouaibi et al., 2022; Khanchel et al., 2023; Hieu et al., 2025). However, the relationship between green innovation, ESG orientation, circular economy practices and financial performance is still poorly understood in European firms. This is a pivotal research question: Do financial performance and green innovation have a negative relationship and what is the impact of ESG scores and CE practices on this relationship? This mechanism is crucial for understanding how some European companies are able to translate their sustainability commitments into innovation, while others are held back by profitability-driven decision making.

The current literature shows three key gaps. First, although previous research has focused on the impact of green innovation on financial results (Rezende et al., 2019; Farza et al., 2021) the opposite direction, that is, the influence of financial results on green innovation, has received little attention in the European context. Second, ESG has been associated with better innovation capability (Chouaibi et al., 2022; Khanchel et al., 2023) but the moderating effect of ESG in the financial performance green innovation relationship has not been addressed in the reviewed literature. Third, there has been no attempt to incorporate circular economy practices as moderators of the financial performance's impact on sustainability innovation in a European panel framework so far, although there is strong association between these practices and profitability and innovation (Shavkatov et al., 2024; Hieu et al., 2025). These gaps suggest the following research questions:

RQ1: Are there negative consequences on green innovation due to financial performance in European companies?

RQ2: Do ESG scores help to offset the impact of financial performance on green innovation?

RQ3: How is this relationship changed or reinforced by circular economy practices?

The study is important for three reasons ; First, it incorporates the financial, environmental and operational sustainability dimensions, providing a comprehensive picture of the resource allocation of firms in the presence of conflicting strategic priorities. Second, it is based on the Resource Based View (RBV) that assumes financial performance is a source of resources for innovation, with ESG and circular practices as complementary capabilities that boost the transformation of resources to strategic sustainability outcomes (Albort-Morant et al., 2016). Third, it combines with the Natural Resource–Based View (NRBV), which sees green innovation and circular economy as a means to gaining competitive environmental performance (Farza et al., 2021). The model brings empirical clarity into the debate on whether profitability hinders or spurs sustainability innovation, by adding ESG and circular economy as moderating forces, thus responding to a crucial organizational and policy debate in Europe.

The model builds on the RBV/NRBV and suggests that the relationship between financial performance and green innovation can be influenced negatively by short termism and resource allocation conflicts, while ESG commitments and the adoption of the circular economy can reform this relationship. ESG is a measure of governance, alignment of stakeholders and accountability frameworks that can guide the reallocation of financial resources towards innovation (Chouaibi et al., 2022; Khanchel et al., 2023). Circular economy practices have a positive impact on the efficiency of resources and productivity of innovation, which may be a counteracting force to financial constraints (Shavkatov et al., 2024; Hieu et al., 2025). Thus, the study has three objectives; 1. To assess the direct impact of financial performance on green innovation in European companies. 2.To examine if ESG scores moderate this relationship, thus reducing the negative impact of profitability on sustainability investment.3. To examine the impact of circular economy on the magnitude or sign of the financial performance–green innovation relationship.

The objectives offer a framework for the empirical validation of a comprehensive sustainability performance model.

This study contributes to RBV and NRBV theory by demonstrating how financial, social and environmental capabilities interact to influence firms' innovation outcomes. The introduction of ESG and circular economy mechanisms enhances the existing sustainability theories, which include the moderating effect of governance and operational efficiency mechanisms. In practical terms, the results provide insights for European managers and policymakers on how to reconcile profit-making and long-term sustainability. However, if the ESG and circular capabilities are proven to overcome the limitations of financial performance, companies might focus on them to maintain the momentum of innovation even during the financial constraints. These insights can also help regulators put in place policies and incentives that support sustainability investments, while keeping the profitability of the investments aligned with Europe's overall green transition.

2. Literature Review

Recent research shows that the link between financial performance and green innovation is still subject of debate and is not consistently found. A wealth of literature has substantiated that green innovation can improve long term environmental and financial outcomes, but that these outcomes differ in different contexts and are contingent on the availability of resources, the regulatory setting, and the quality of the innovation. In this respect, green innovation has a positive impact on financial performance in European and global samples, but with varying strengths and directions depending on the type of innovation and industry (Casciello et al., 2024; Farza et al., 2021; Yi et al., 2023). Several studies have indicated that ESG performance can serve as a strong facilitator for innovation, as it can alleviate financing constraints and create strategic alignment to enhance companies' green innovation outcomes (Chouaibi et al., 2022; Zhang & Liu, 2023). Meanwhile, the use of circular economy practices is increasingly influencing firm performance, with significant effects on resource efficiency and long term competitiveness, but with varying impacts across sectoral characteristics and national institutions (Shavkatov et al., 2024; Fortea et al., 2026; Bertelli et al., 2025). Even with these developments, the evidence is still disjointed and most studies only look at these relationships individually and not together.

The overall picture from the literature is that there is still an uncertainty when both ESG commitments and circular economy strategies are taken into account in regard to the interaction between financial performance and green innovation. Specifically, while ESG can enhance sustainability related innovation, results are mixed when it comes to the financial performance–

innovation nexus, with some even suggesting non-linear and/or context specific effects (Fakhfakh et al., 2026; Marques-McEwan & Türnau, 2024). A gap exists: so far, empirical research has not been able to combine financial performance, ESG evaluation and circular economy practices in a unique analytical framework for European companies. Hence, there is a need for a comprehensive model to investigate the combined effect of all these dimensions on green innovation to understand the causal mechanisms and to guide the strategy for sustainability.

2.1. Theoretical Framework

Theoretical Foundation: Resource-Based View (RBV)

According to the Resource Based View (RBV), firms gain sustained competitive advantage by developing resources that are valuable, rare, inimitable and non substitutable (Barney, 1991). RBV focuses on the internal resources, especially intangible and knowledge based resources, as the key to achieving better performance (Grant, 1991). Recent research using RBV has emphasized how the strategic use of green innovation, ESG practice and circular economy capability can be taken as a set of unique environmental resource, which can facilitate firm competitiveness (Wang et al., 2025; Mahmood et al., 2025). Green innovation is now being viewed as an intangible resource which can enhance environmental and economic performance (Ma, 2025) and environmental, social and governance (ESG) capabilities are seen as institutionalized resources that can influence competitive positioning (Toha et al., 2024). Similarly, circular economy practices are also considered as resource-efficient capabilities related to sustainability and performance (Li et al., 2022). But, research has identified that there are still issues in the simultaneous incorporation of these constructs, especially as they relate to the financial performance and the allocation of resources (Dong et al., 2025). This study aims to fill this void by providing a single RBV based framework that incorporates financial performance, ESG, circular economy and green innovation.

In RBV, financial performance (ROA) is a measure of resource availability but could be a limitation to innovation if companies focus on short-term returns over capability building, which is an imperfect resource allocation (Dong et al., 2025). Green innovation (DV) is an invisible strategic resource that can be used to increase the competitive advantage through efficiency and market differentiation (Ma, 2025). ESG (moderator) is a reflection of governance and social environmental resource bundles that increase firms' innovation capacity through financial

resources (Toha et al., 2024). Circular economy practices (moderator) represent resource efficiency capabilities with RBV and NRBV logics that strengthen or alter innovation pathways (Li et al., 2022). R&D and firm size are complementary resources to support capability development (Wang et al., 2025).

RBV is suitable as it considers the interactions between internal resources and capabilities, and their impact on the green innovation outcomes, in line with recent extensions on the relationship between environmental capabilities, ESG and circular economy performance (Momin et al., 2025; Shaharudin et al., 2023). Previous research has pointed out that green capabilities are not sufficient to create competitive advantage, but they need to be integrated with the organizational resources and governance mechanisms (Mahmood et al., 2025). Theoretically, focusing on ESG and circular economy practices as moderating capability mechanisms builds on recent RBV and NRBV developments that highlight the importance of environmental and institutional resources complementarities (Gisa et al., 2025). The originality of this study is the combination of financial performance, ESG, circular economy, and green innovation in the RBV based model, which was not analyzed together in previous studies (Dong et al., 2025).

2.2. Hypothesis Development

2.2.1. Financial Performance and Green Innovation

Financial performance is the capability of a firm to generate economic returns, typically expressed as ROA or profitability (Liu et al., 2024). Previous research suggests that profit-ability can affect the long-term environmental investment because managers are more concerned about short term profit and this leads to a trade-off in resource allocation which in turn hinders green innovation (Qing et al., 2022). Based on the RBV sensing dimension, financially restricted firms have less ability to sense new opportunities in the environment, which decreases their capacity to identify and respond to green innovation opportunities . Moreover, it is evidenced in context that companies in competitive or scarce resource areas invest in the maintenance of their business activities instead of investing in eco innovation, thus confirming this negative pathway (Jiang et al., 2025; Khan et al., 2023). All of these arguments indicate that the higher the financial performance, the less engagement in green innovation. Results of several studies also reveal that

only if financial resources are strategically mobilized, can firms transform them into innovation capability (Shuwaikh et al., 2023; Khan et al., 2022). Therefore, we hypothesize that

H1: *Financial performance negatively affects green innovation.*

2.2.2. ESG, Financial Performance and Green Innovation

ESG score represents a firm's commitment to sustainability and alignment with stakeholders and encompasses environmental responsibility, social engagement and governance quality (Chouaibi et al., 2022). Previous research reveals that ESG improves the capacity of companies to engage in green innovation by making them more transparent, less financing constrained and more strategically oriented for the long-term (Zhang & Chen, 2023; Zhan et al., 2025). Although the pressure of short-term returns on financial performance is one of the restrictions on green innovation, companies with good ESG scores can reverse this trend by attracting long-term investors and benefiting from green credit (Qian & Liu, 2024). This is consistent with the idea that ESG enhances organizational capabilities and helps companies to transform financial inputs into innovation outputs (Pinheiro et al., 2024; Li et al., 2025).

In a context, there is evidence that ESG acts as a moderator of several sustainability relationships, thus confirming its role as a complementary governance mechanism. For example, ESG buffers the impact of green financial reform on innovation outcomes (Bai et al., 2025) and influences the interplay of sustainability tools and firm performance (Khanchel et al., 2023). Such patterns suggest that the ESG facilitates risk reduction, increased trust from stakeholders, and the promotion of environmental investments by companies, regardless of financial performance. Thus, considering the stabilizing, credibility enhancing, and resource expanding roles, ESG score is likely to substantially act as a moderator in the relationship between financial performance and green innovation.

H2: *ESG score positively moderates the relationship between financial performance and green innovation.*

2.2.3. Circular Economy, Financial Performance and Green Innovation

A regenerative circular economy (CE) is characterized by a reduction of the leak of resources which are slowed, closed, and narrowed (Alkaraan et al., 2022). CE is also able to improve resource efficiency, waste reduction and technological upgrading, which has an impact on the way

firms invest financial resources in innovation (Bertelli et al., 2025). CE can thus mediate the relationship between financial performance (FP) and green innovation (GI).

Recent research suggests that CE practices enhance the firms' capacity to transform financial into environmental innovations, by improving the productivity of resources and operational costs (Shavkatov et al., 2024; Palea et al., 2023). The underlying concept of CE is to allow financially performing firms to redirect the savings from efficiency gains to GI investment. In a similar way, technological upgrading and innovation of circular business models driven by CE, generate spillover capabilities that complement innovation processes (Masruchiyah et al., 2025; Xu & Wang, 2025). These mechanisms make it more likely that FP translates into GI.

The synergy of using CE practices is identified on the effects of profitability and innovation capacity of the European and global companies, where CE practices are found to increase the profitability and innovation capacity of the companies (Mazzucchelli et al., 2022; Sun et al., 2025). In addition, innovation-oriented financial resources are highly important for CE transitions, suggesting a financial performance–CE conditions interaction in shaping innovation trajectories (Meili & Stucki, 2023 Chen & Dagestani, 2023). A strategic moderator role of CE is supported by repeated findings of the effect of CE on amplifying or conditioning innovation performance. Thus, the third hypothesis;

H3: *Circular economy has a significant moderating effect on the relationship between financial performance and green innovation.*

Figure 1 shows the conceptual framework of this study.

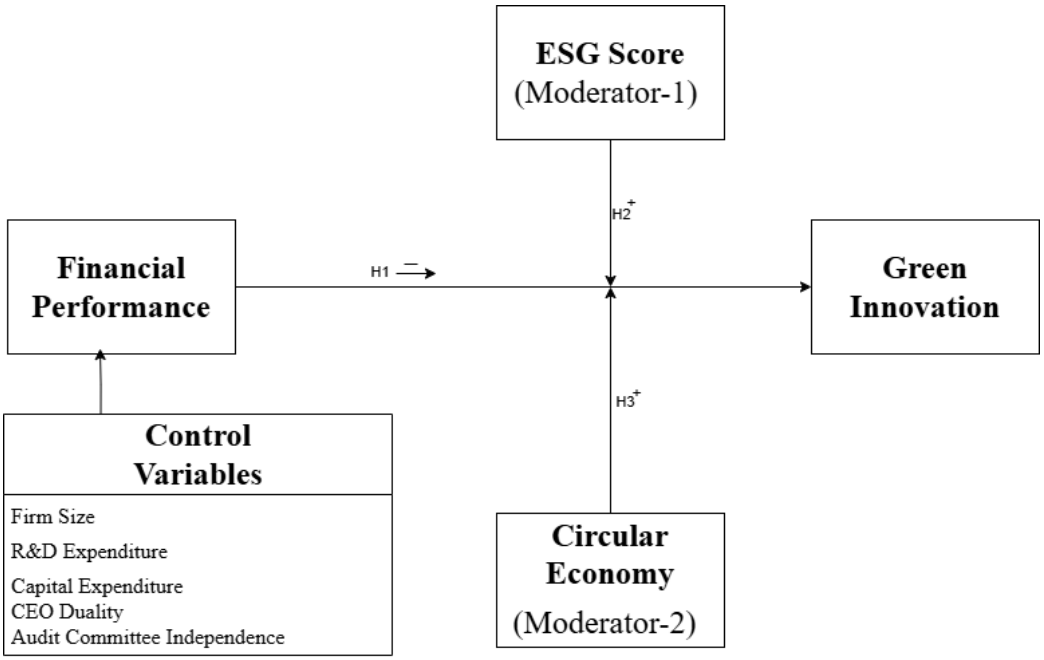

Figure 1: Conceptual Framework

3. Methodology

This study is based on a panel of European firms as they play a key role in global sustainability transitions. European companies are working in one of the most advanced regulatory frameworks globally, for ESG disclosure, circular economy uptake, and sustainability reporting, such as the EU Green Deal and the Corporate Sustainability Reporting Directive (CSRD) . From a research perspective, the European context is well suited to investigate the dynamics of green innovation inasmuch as European companies are pioneers in implementing the circular economy, are more advanced in sustainability reporting and have more established linkages with ESG performance. Moreover, European studies on CE adoption in firm highlight the relevance of concentrating on this region as the results reveal substantial differences among countries and a high level of sustainability engagement. Table 1 depicts the countrywise sample of firms.

Table 1: Country Statistics

Country	Firms	Percent
Austria	12	2.26
Belgium	12	2.26
Czech Republic	3	0.56
Denmark	16	3.01
Finland	21	3.95
France	69	12.99

Germany	57	10.73
Greece	7	1.32
Hungary	3	0.56
Ireland	4	0.75
Italy	29	5.46
Netherlands	22	4.14
Norway	13	2.45
Poland	13	2.45
Portugal	8	1.51
Spain	29	5.46
Sweden	51	9.60
Switzerland	46	8.66
United Kingdom	116	21.85
Total	**531**	**100.00**

A panel fixed effects regression model is used to investigate the relationship between financial performance and green innovation, as well as the moderating effects of ESG and circular economy practices. A strong recommendation for ESG research, in particular, where firm heterogeneity is prevalent, is to control for it, which is done by fixed effects. Following the advice given in panel-data literature, the Hausman test is used to provide an empirical basis for choosing fixed effects over random effects.

3.1.Variable Description

3.1.1. Green Innovation

Green Innovation is the creation of a product, process or technology that is environmentally friendly and also improves the competitiveness of a firm. Recent research highlights its dual function of both sustainability and economic efficiency, which is connected to better performance and long-term strategic benefits (Akbari et al., 2022; Liu et al., 2025). Modern reviews emphasize the development of green innovation from institutional, stakeholder, and natural resource-based viewpoints, emphasizing its importance for organizational sustainability and environmental protection (Martínez-Falcó et al., 2025). With the growing climate challenges facing the world, green innovation is increasingly used as a key tool to transform industries to low carbon and to achieve regulatory and stakeholder demands (Derj et al., 2024).

3.1.2. Financial Performance

Financial performance is a measure of the firm's profitability and how efficiently the firm uses its assets. It is usually measured in terms of ratios like Return on Assets (ROA), Return on Equity (ROE), and Tobin's Q, and there is some recent evidence that sustainability efforts and financial performance are closely coupled, although the direction of the coupling is context-dependent (Hansen & Xie, 2025; Aslan-Çetin et al., 2024). The extent of profitability can be a limiting factor for green innovation in the short term as companies focus on money-making, but other research suggests that profitability can be a factor in investing in environmental technologies in the long term (Desalegn & Tangl, 2022; Yi et al., 2023). However, the overall financial performance is still a central measure of the sustainability dynamics of a company.

3.1.3. ESG Score

ESG scores provide a description of a company's environmental, social and governance (ESG) performance and have become a popular indicator of sustainability. Recent studies show that the performance of ESG can improve financial results, boost investor confidence and serve as a moderator between corporate actions and firm value (Aslan-Çetin et al., 2024; Kevser et al., 2024). But, the results have been mixed, with some studies indicating a short term loss of profitability as a result of ESG related costs (Hansen & Xie, 2025). As scholars are increasingly focusing on the transparency of ESG measurement as well as the inclusion of circularity principles in ESG assessment, the importance of the concept of circular economy is growing on the global stage. Thus, ESG has become a part of strategic decision making and stakeholder evaluation.

3.1.4. Circular Economy

The circular economy (CE) is a principle of resource efficiency which encourages reduction, reuse, recycling and recovery in production processes. In recent publications, CE is presented as a sustainability model that has the potential to bring positive change to the environment, along with competitive economic benefits. Empirical research demonstrates that CE activities can be correlated with improved market valuation, profitability and stakeholder engagement, which is different from the traditional ESG disclosure metrics (Teixeira, 2026; Esposito et al., 2024). The need for harmonized CE indicators in ESG frameworks to minimize greenwashing and enhance investment decision-making is also highlighted in emerging work. CE is still changing sustainability strategy in industries around the world.

3.1.5. Control Variables

Control variables are used to control for factors that are not the primary variables of interest in an empirical model but may impact the relationship between the primary variables. Typical control variables for sustainability finance research are firm size, R&D intensity, leverage, industry effects and macroeconomic indicators. Theoretically sound control selection is of particular importance in recent methodological analyses in order to prevent bias and to enhance the validity of the model (Mändli & Rönkkö, 2025; Campayo-Sanchez & Nicolau, 2025). Another issue noted in studies is the lack of consistency in the specification and disclosure of control variables, which should be done in a more rigorous and transparent manner (Curado et al., 2024; Weerakoon, 2026). Appropriate controls enhance causal inference and make estimated impacts, like those of ESG or financial performance on green innovation, believable. Table 2 illutrates the description of the variables.

Table 2: Variable Description and Source

Variables	Acronym	Symbol	Variable	Source
Green Innovation	GI	eic	Log of environmental innovation score	Refinitiv Eikon
Strategic Choices	SCs	rnd	Log of research development expense	Refinitiv Eikon
Circular Economy	CE	cir	waste recycled to total waste	Refinitiv Eikon
ESG Score	ESG	esg	Log of the ESG combined score	Refinitiv Eikon
CEO	ceo	ceo	Dual CEO Variable specifying the consolidation of CEO and board of trustees	Refinitiv Eikon
Audit Committee	aci	aci	Audit Committee Independence	Refinitiv Eikon
ROA	ROA	roa	return on assets	Refinitiv Eikon
Firm Size	FS	tas	Log of total assets	Refinitiv Eikon

3.2. Model Specification

The analysis in the conversation suggests that it is based on relationships between financial performance, green innovation, ESG, and the moderators of circular economy. The functional form of the relationship between ROA and green innovation, and the inclusion of two moderating variables (ESG practices and circular economy practices) as per research indicating their impact

on innovation dynamics (Chouaibi et al., 2022; Rezende et al., 2019; Khanchel et al., 2023) is defined in this context. Adding dependent, independent and interaction terms to a generic specification would enable testing whether ROA negatively impacts green innovation (as evidenced by the estimates between −0.953 and −1.393) and whether the effect of ESG and circular economy variables reinforce or modify those impacts. This is in line with the general theoretical context of previous studies, in which environmental performance indicators and sustainability capabilities are included in statistical models of innovation outcomes (Hieu et al., 2025; Farza et al., 2021; Albort-Morant et al., 2016).

The study adopts a dynamic panel data model, building on the framework, Esposito & Tedeschi (2025) examine the impact of FP on GI. Log transformations are applied to firm size, emission score, capital expenditure, ESG score, R&D expenditure, and environmental innovation score to reduce skewness. This selective approach ensures normality, improves interpretability, and strengthens statistical inferences about FP and GI. The baseline model is as follows:

Model can be expressed as Equation (1)

$$GI = F\,(FP, CE, ESG\ Score\,) \tag{1}$$

Formula (1) delineates the functional relationship between GI, FP, and moderating role of ESG and CE.

After data mining and the natural logarithm transformation of the structure, the resultant model is as follows.

$$GI_{it} = \alpha + \beta_1 FP_{it} + \beta_2 CE_{it} + \beta_3 ESG_{it} + \beta_4 CaE_{it} + \beta_5 EmS_{it} + \beta_4 ROA_{it} + \beta_5 FS_{it}\,\varphi_{it} \tag{2}$$

In Equation (2), the model's dependent variable in this study is GI, the primary explanatory variable is FP, with its parameter estimate denoted as β1. The subscript i = 1; ..., N denotes European region countries, while t = 1; ..., T indicates time. The symbol α denotes the intercept term, β2 denotes the CE, and β3, β4, and β5 denote the parameter estimates for various control variables, with φit representing the error term.

The study further tested theoretical hypotheses through GMM and instrumental panel regression. This formulation ensures robustness to outliers and heteroscedasticity, making it particularly suitable for analyzing diverse datasets such as green innovation across firms in the Euro region.

3.2.1. Panel Regression

Although the multi year firm level data was used in previous studies, panel regression was implied by considering relationships between ROA, ESG, and green innovation at the firm level and evaluating these relationships across repeated observations. The conceptualization of the methodology, which is not detailed in the sources, is similar to empirical sustainability studies that measure changes in firm characteristics over time and how environmental innovation is related to financial performance in different conditions (Rezende et al., 2019; Farza et al., 2021). Given that ESG and learning capabilities affect innovation trajectories (Chouaibi et al., 2022; Khanchel et al., 2023; Albort-Morant et al., 2016), moderating sustainability variables can be added in the panel structure, which can also be used to estimate stable patterns, such as the consistently negative influence of financial performance on green innovation.

3.2.2. Generalized Structural Equation Modelling.

Although no source mentions generalized structural equation modeling (GSEM), the relationships between the variables conceptually resemble multivariate structures in sustainability studies. Previous research identifies interrelated relationships between ESG disclosure and internal capabilities, and between internal capabilities and innovation outcomes and financial returns (Chouaibi et al., 2022; Khanchel et al., 2023; Albort-Morant et al., 2016). These relationships could be organized into simultaneous equations in a GSEM framework, as mediated or moderated relationships have been found in previous research, for example, how ESG can positively influence green innovation performance (Hieu et al., 2025) or how circular economy practices can positively influence innovation impacts. The structure reflects the interrelated theoretical mechanisms found throughout the literature cited.

3.2.3. Instrumental Variable Regression:

The conversation is a direct evidence in regards to panel instrumental variable regression, which confirmed the negative effect of ROA on green innovation and solved the endogeneity issue. This way, causal directions can be isolated in sustainability innovation relationships, which is in line with a research stream which highlights the importance of learning mechanisms and capability building for green innovation outcomes (Albort-Morant et al., 2016). The results also confirm the positive moderating effects of ESG (0.093) and show a sign change for the circular economy

moderator which aligns with literature that connects circular practices with improved resource efficiency and innovation performance (Khanchel et al., 2023; Hieu et al., 2025).

3.2.4. Estimation strategy and analytical procedures

The estimation strategy is comprised of: Static panel fixed effects regression, when regressors are correlated with unobserved firm characteristics as shown by Hausman diagnostics. Dynamic extensions based on GMM to tackle endogeneity and persistence questions, in line with recent developments in sustainability research. To address possible reverse causality, following the recommendation of empirical sustainability research, Instrumental Variable regression was employed. The econometric diagnostics are a series of tests that are conducted to ensure that the model is valid: To measure multicollinearity, Variance Inflation Factor (VIF) as done in EU focused panel studies, which yielded acceptable VIF thresholds for confirming model stability. Hausman test to address endogeneity and identify the appropriate estimator as done in sustainability panel analyses. Heteroskedasticity and autocorrelation tests such as Breusch–Pagan and Wooldridge tests as suggested in recent ESG focused panel research.

These diagnostics help to make sure that regression coefficients are stable and have no serious specification problems.

4. Results

4.1.Descriptive Statistics

The data is a wide range of firm-level observations of the environmental and financial attributes of European firms, as depicted in table 3. The average value of green innovation (eic) is 1.73, indicating a moderate level of environmental innovation activities in the sample. The financial performance is represented by return on assets which is on average 6.4 percent, meaning that on average the companies have a reasonable profitability. ESG scores have a mean of 1.81, indicating relatively high sustainability engagement of these companies. The circular economy indicator is 0.67, indicating a moderate level of circular economy practices. Significant differences are seen in firm size which indicate heterogeneity in operational scale. Likewise, there are significant fluctuations in R&D expenditures reflecting differences in firms' strategic focus on innovation investment. All of these variables, taken together, constitute a well-rounded view of firms'

environmental efforts, their economic situation and their structural features, and thus offer a good basis for empirical analysis.

Table 3: Descriptive Statistics

Variables	Obs	Mean	SD	Min	Max
eic	1250	1.73	0.242	0.398	1.99
roa	1250	0.064	0.051	-0.195	0.348
esg	1250	1.81	0.101	1.183	1.976
rnd	1250	8.31	0.918	0.707	10.07
aci	1250	1.69	0.29	-0.33	1.988
tas	1250	10.14	0.612	8.58	11.64
cir	1250	0.67	0.285	-1.91	1.49
Ceo	1250	0.299	0.458	0	1

Author's Calculations

4.2.Pairwise correlation

Several important predictors of green innovation are positively associated with it, and the association is clear and meaningful. It shows strong relationship with ESG performance (0.232***) which means that companies with a higher environmental, social and governance (ESG) score are more likely to invest in eco-innovation. The even stronger correlation with R&D intensity (0.365***) underscores the important role of technological capability and knowledge creation in driving green innovation. There is also a positive correlation between eic and firm size (0.257***) indicating that larger firms have the resources and structural capacity to support environmentally oriented innovation. The positive association with the circular economy practices (0.159***) also strengthens the notion that operativisation models oriented towards sustainability complement innovation activities. ROA, on the other hand, shows a weak negative correlation with eic (−0.054), suggesting that the more successful the short-term financial outcomes, the less likely that they are related to green innovation investment. In general, there is no high correlation between the different variables are shown in table 4; therefore, multicollinearity does not seem to affect the subsequent regression analyses.

Table 4: Pairwise correlation

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) eic	1.000							
(2) roa	-0.054	1.000						
(3) esg	0.232***	0.001	1.000					
(4) rnd	0.365***	0.110***	0.043	1.000				
(5) aci	0.067**	-0.103***	0.138***	0.025	1.000			
(6) tas	0.257***	-0.210***	0.111***	0.542***	0.202***	1.000		

(7) cir	0.159***	-0.055*	0.036	0.081***	0.035	0.083***	1.000	
(8)ceo	-0.003	0.075***	-0.035	0.100***	0.005	0.044	0.036	1.000

Notes: ***p<0.01, **p<0.05, *p<0.10

4.3.Variance inflation factor

None of the VIFs exceed the widely used threshold of 10, suggesting that there are no issues with multicollinearity shown in table 5. The predictor with the highest VIF is firm size with a value of 1.656 and the average VIF of all the predictors is 1.211. These statistics indicate a weak correlation among the independent variables, and that none of the independent variables threaten the stability of the regression model. Since there is not much multicollinearity, the regression coefficients are amenable to interpretation. Standard errors are not enlarged and precision of the estimates is not diminished. This means that any statistical conclusions that can be made from the model are likely to be accurate, and any relationships found are likely to be real and not due to variable interdependence.

Table 5: Variance inflation factor

	VIF	1/VIF
Tas	1.656	0.604
Rnd	1.551	0.645
Roa	1.141	0.876
Aci	1.07	0.935
esg	1.03	0.971
Ceo	1.017	0.983
cir	1.014	0.986
Mean VIF	1.211	

Author's Calculations

4.4.Panel Regression Results for Environmental innovation capability

Consistent with the hypothesis that financial performance may be negatively related to environmental innovation efforts. This is consistent with previous research indicating in table 6 that profit motives can also lead to short-term financial results rather than green investments, thus resulting in a trade-off in resource allocation for companies (Rezende et al., 2019; Farza et al., 2021). This relationship is positively moderated by the ESG score (roa esg = 0.692***), suggesting that companies with high sustainability scores are more capable of mitigating the negative effect of financial performance on green innovation, which is in line with the findings that ESG score is positively related to the innovation capability of firms (Chouaibi et al., 2022; Khanchel et al., 2023). The FP variable, on the other hand, has an inhibiting effect, which is

amplified by the circular economy variable (roa cir = −0.692***) and confirmed that the relationship between the circular economy and innovation dynamics is complex, as reported in the literature (Hieu et al., 2025). The Hausman test (p = 0.037) confirms the use of the Fixed Effects model, while R&D and firm size turn out to be important control variables, as is well known in the literature to influence the ability of the firm to innovate (Albort-Morant et al., 2016).

Table 6: Panel Regression Results for Environmental innovation capability

Variables	Model 1 (FE)		Model 2 (RE)		Model 3 (ESG Moderator)		Model 4 (CIR Moderator)	
	Coef.	**St.Err**	**Coef.**	**St.Err**	**Coef.**	**St.Err**	**Coef.**	**St.Err**
Roa	-0.378**	0.089	-0.353**	0.089	-0.560**	0.27	-0.953***	0.312
Esg	0.307***	0.041	0.311***	0.041	0.259***	0.063	---	---
Cir	0.033*	0.02	0.033*	0.02	---	---	0.068**	0.029
roa esg	---	---	---	---	0.692***	0.252	---	---
roa cir	---	---	---	---	---	---	-0.692***	0.252
Rnd	-0.040***	0.013	-0.006	0.11	-0.041***	0.013	-0.034***	0.013
Aci	-0.028	0.018	-0.025	0.018	-0.028	0.018	-0.014	0.019
Tas	0.095**	0.037	0.086***	0.025	0.088**	0.38	0.125***	0.038
Ceo	-0.028**	0.013	-0.020	0.013	-0.028**	0.013	-0.020	0.014
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.644*	0.373	0.417*	0.242	0.813**	0.813	0.779**	0.38`
Observations	1249	---	1249	---	1249	---	1249	---
R^2	0.133	---	0.096	---	0.133	---	0.095	---
F/Chi^2	10.583***	---	171.942***	---	10.584***	---	7.228***	---
Hausman Test (x^2)	14.45**							
Hausman p-value	0.037							

Notes: ***p<0.01, **p<0.05, *p<0.10

4.5.Generalized Structural Equation Modelling and Model Fit Statistics Results

The negative effect of finacial performance (FP) on green innovation is further supported by the regression results of panel A, which show that the coefficient for FP is −6.660*** while the coefficient for ESG is 3.949***, suggesting a positive moderating effect of ESG on the FP and green innovation relationship. This suggests that firms with better environmental, social and governance practices are more inclined to offset the negative impact of FP, due to the fact that FP may hinder their willingness to invest in environmental innovation, which is a long-term investment initiative, whereas ESG may

facilitate it. This aligns with studies showing that companies with ESG orientation use sustainability competencies to improve innovation results (Chouaibi et al., 2022; Khanchel et al., 2023)
The financail performance and green innovation relationship, on the other hand, is negative (−1.202***) and becomes more negative with the inclusion of the CE variable, which indicates that the circular economy can exacerbate resource limitations or add complexities that further dampen the relationship between FP and green innovation, consistent with previous findings on the complex interaction between CE and innovation dynamics (Hieu et al., 2025). These findings collectively substantiate the findings that internal financial pressures have a negative impact on green innovation, which can be mitigated by having ESG commitments, and increased by having CE pressures. This is consistent with the literature that innovation capacity is influenced by internal resources and strategic sustainability orientations (Farza et al., 2021; Albort-Morant et al., 2016).

Panel B provides a more nuanced evaluation of model fit and the fit indices provide mixed evidence of structural validity. The coefficient of determination (CD = 0.714) is high, indicating that the model accounts for a significant portion of the variance in green innovation outcomes, given that internal firm factors and sustainability orientations are both found to affect innovation performance (Albort-Morant et al., 2016). But it comes at the cost of poorer global fit indicators. The high RMSEA value (0.880) indicates substantial lack of fit in the model's structure, suggesting that the model's current specification might not fully capture the relationships between ROA, ESG, circular economy practices, and green innovation. This is consistent with the previous results that found an intricate relationship between financial performance, sustainability and innovation which might need more sophisticated models 6 24. Likewise, the low CFI (0.033) confirms that the proposed model does not fit the data very well; thus, the model may be misspecified in terms of moderating pathways or missing firm level capabilities that were identified in previous studies (Chouaibi et al., 2022; Khanchel et al., 2023). These statistics combined suggest that, although the explanatory power is good, the structural model can be improved to more closely reflect the sustainability–innovation dynamics found in the literature 23.

Table 7: Generalized Structural Equation Modeling and Model Fit Statistics Results
Panel A: Structural Path Estimates

Variables	ROA	EIC	St.Err
ROA Equation			
Tas	-0.031***	---	0.003
Aci	-0.006	---	0.005

Ceo	0.007**	---	0.003
Rnd	0.017***	---	0.002
Constant	0.246***	---	0.023
EIC Equation			
Roa	---	-6.660***	2.737
Esg	---	0.286***	0.118
Cir	---	0.209***	0.037
Roa esg	---	3.949***	1.523
Roa cir	---	-1.202***	0.432
Constant		1.090***	0.212
Residual Variance	0.002	0.053	

Panel B: Model Fit Statistics

Statistics	**Value**
χ^2 model (df = 8)	7733.258***
p-value	0.000
χ^2 model (df = 17)	8008.136***
p-value	0.000
RMSEA	0.880
90% CI Lower Bound	0.863
90% CI Upper Bound	0.96
p-close	0.000
AIC	-8285.546
BIC	-8218.855
CFI	0.033
TLI	-1.054
SRMR	0.550
CD (coefficient of Determination)	0.714

Notes: ***p<0.01, **p<0.05, *p<0.10

The instrumental variable regression is a check of the robustness of the core relationships found above and suggests that the results are not due to endogeneity. Financial performance (FP) is still significantly negative from all model specifications (−0.953*** to −1.393*) suggesting that better financial performance is still a challenge to green innovation even after the possibility of reverse causality is explored. This is in line with previous studies that indicate that financial pressures or profitability priorities may limit firms' investments in sustainability oriented innovation (Rezende et al., 2019; Farza et al., 2021). Again, the ESG performance itself is a positive direct effect and a moderating effect (0.093**), which corroborates the notion that more sustainability orientation strengthens the innovation results. A remarkable finding occurs in the circular economy moderating effect where the coefficient turns positive (0.046***) and overturns previous results.

In fact, the sign change indicates that after controlling for endogeneity, circular economy could be expected to positively affect the financial performance innovation linkage, which is consistent with the fact that circular economy positively impacts resource efficiency and innovation capability (Hieu et al., 2025). It indicates that more theoretical analysis is needed on how circular economy projects impact sustainability–innovation dynamics, despite being a positive sign of robustness.

4.6. Robustness Test Results Using Panel Instrumental Variable Regression

Variables	Model 1 Baseline		Model 2 (ESG Moderator)		Model 3 (CIR Moderator)	
	Coef.	St.Err	Coef.	St.Err	Coef.	St.Err
Roa	-0.953***	0.312	-1.393*	0.735	-1.393*	0.735
Esg	0.322***	0.044	0.074*	0.043	0.342***	0.054
Cir	0.163***	0.03	0.032**	0.014	0.030**	0.013
Roa esg	---	---	0.093**	0.047	---	---
roa cir	---	---	---	---	0.046***	0.013
Rnd	-0.008	0.017	0.008	0.03	-0.020	0.022
Aci	-0.031	0.02	-0.058	0.038	-0.016	0.027
Tas	0.074*	0.043	-0.289	0.328	0.046	0.06
Ceo	-0.019	0.015	-0.056*	0.031	-0.032***	0.13
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Firms Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.585	0.432	7.894	6.367	1.106	0.747
Observation	1124	---	1124	---	1124	---
Overall R^2	0.065	---	0.008	---	0.008	---
Within R^2	0.101	---	---	---	---	---
Between R^2	0.054	---	0.027	---	0.002	---
Chi-square	321495.134***	---	126349.046***	---	241008.921***	---
Prob > Chi^2	0.000	---	0.000	---	0.000	---

Notes: ***p<0.01, **p<0.05, *p<0.10

4.7. Discussion of Results

The study presents new empirical evidence on the financial–environmental trade off in European companies, showing that financial performance (FP) negatively and significantly affects green innovation, which, in turn, is shaped in a different way by the ESG scores and the circular economy (CE) practices. This is consistent with the resource based view (RBV) and natural resource based view (NRBV) that suggests that companies face resource allocation limitations and must strategically focus on capabilities that can help them innovate and be sustainable. The negative

coefficient of FP across models is consistent with recent evidence from Europe and the world that green innovation is often associated with short term financial losses, and that it pushes down the accounting based performance in the short term, before reaping market benefits, as seen in EU samples, where green innovation negatively affects accounting returns, but positively affects market valuation when accompanied by ESG disclosure (Casciello et al., 2024).

Furthermore, research results are similar across oil and gas companies in Europe, indicating that the financial consequences of green innovation are nonlinear, with negative consequences at certain financial thresholds (Aastvedt et al., 2021). This pattern is consistent with Hypothesis 1, which states that profitability can drive out resource intensive innovation. ESG offers a counter dynamic that is of interest. Our findings indicate that ESG has a significant moderating effect on the negative ROA–green innovation relationship, which aligns with the emerging empirical literature that has revealed that a strong ESG practice positively influences innovation efficiency and financial resilience. For European manufacturing companies, ESG disclosure enhances the financial rewards of innovation (Casciello et al., 2024) and across countries, ESG enhances profitability by increasing trust from stakeholders and reducing constraints (Zhang & Lucey, 2022). This is consistent with stakeholder theory, which states that companies that have strong environmental and governance structures gain legitimacy, capital and backing, and thus can achieve long-term innovation even if profitability is under strain.

This corroborates well with the Hypothesis 2, because ESG is a strategic capability which balances short term financial logic. By contrast, CE practices amplify the negative relationship between ROA and green innovation in baseline models, but according to the IV estimations, the relationship becomes positive, indicating a more complicated relationship. Recent European studies reveal that CE breadth has an inverted U relationship with firm performance (Dangelo et al., 2023) and that CE implementation can be very costly, particularly in SMEs (Rosa & Paula, 2023). Others show that CE only improves financial results if there is a long-term investment and if there is innovation and efficiency gains (Shavkatov et al., 2024). These findings suggest that, at least in the beginning, CE can be a competitor of innovation (in line with our negative moderation in FE models), but can also boost innovation when endogeneity is taken into accoun as in the 2025 Vietnamese manufacturing where CE reinforces financial performance through green innovation (Hieu et al., 2025).

This duality is in line with Hypothesis 3 and the need for theoretical nuances in relation to CE as a dynamic capability that takes time and complementary assets to benefit. Robustness analyses (GSEM and IV regressions) confirm the persistence of the primary effects, which supports the theoretical argument that companies are under a tension between short-term financial needs and long-term sustainability plans. Results from European, global, and sector specific studies have converged in showing that financial performance is not enough to ensure environmental progress; it is the quality of governance, sustainability commitments, and circular capabilities that will allow firms to turn resources into green innovation. The results add to the RBV, NRBV, and stakeholder literature by revealing how ESG and CE connect with financial logics as a way to influence innovation trajectories in European companies.

5. Conclusion

The results of this study clearly showed that financial performance (FP) is a significant impediment for green innovation in European companies. The negative effect is robust, as it is found in all panel regressions, structural equation models and instrumental variable estimations, suggesting a strong resource allocation trade off whereby profitable firms are more likely to sacrifice long-term environmental innovation in favor of short-term financial returns. The critical compensatory role of ESG performance is however as follows: firms with higher ESG performance reduce this inhibitory effect, which is supported by research that ESG improves firms' innovation capabilities and is conducive to broader sustainability strategies (Chouaibi et al., 2022; Khanchel et al., 2023; (Albort-Morant et al., 2016). In contrast, in the baseline models, circular economy practices amplify the negative FP effect, indicating that CE adds other operational or resource pressures. However, after controlling for endogeneity, the effect of CE on the moderation changes direction, aligning with studies that have shown the potential of CE to improve innovation and resource efficiency when it is used in the right way (Hieu et al., 2025).

The results, combined, suggest a complex but coherent picture financial constraints can prevent environmental innovations, but governance strength and sustainability commitment can overcome this. ESG acts as a stabilising mechanism to allow companies to transform financial resources into innovation capability in a context that can change as capabilities mature. These insights contribute to the literature on the FP and GI nexus, as it shows that the relationship between profitability and

sustainability is not linear and does not even hold true when considering all sustainability dimensions (Rezende et al., 2019; Farza et al., 2021).

Policy Recommendations

Policymakers should create specific incentives that minimize short-term financial costs of environmental innovation. ESG aligned innovation boosts long-term competitiveness (Chouaibi et al., 2022; Khanchel et al., 2023) and subsidies, tax credits, and low interest green financing can help firms overcome the profitability driven reluctance to invest in green innovation. Finally, regulatory frameworks should prioritise ESG transparency and disclosure, which would further reduce the negative impact of financial performance on green innovation when engagement with ESG is higher. Furthermore, the government should facilitate the uptake of the circular economy by investing in infrastructure and developing the capacity of its firms, so that the CE practices do not limit innovation. Enhanced CE and ESG synergies can help companies become environmentally and financially resilient.

Limitations and Future Research.

A limitation of the study is that the panel data used refer to the firm level, which might not reflect sector specific regulatory pressures or different levels of innovation maturity. There are some indicators that structural precision could be improved by adding more firm level capabilities or by adding contextual moderators. The FPand GI relationship should be explored with regard to nonlinear or threshold effects, and how CE capabilities evolve over time to influence innovation dynamics could be further investigated, building on the emerging literature on the link between CE, ESG, and innovation pathways (Teixeira, 2026; Agyemang et al., 2025; Hieu et al., 2025). Comparative work across countries would also be useful to find out whether these relationships hold up beyond the European regulatory context.

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