Exploring the Causal Links between ESG, R&D, and Firm Performance: Evidence from the US Technology and Food Companies

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Abstract

This study examines the causal relationships between ESG (Environmental, Social, and Governance) compliance, R&D expenditures, and financial performance in the technology and food sectors in the US. A panel dataset from 2012 – 2021 from the Thomson Reuters database was analysed for 12 food and 18 technology companies. The findings show that there are different causal relationships between sectors. While R&D investments in the technology sector positively affect firm performance by increasing ESG compliance, firm performance in the food sector directs ESG compliance, encouraging R&D investments. The study emphasizes that sectoral differences should be considered in sustainability and R&D strategies and guides policymakers and managers to develop approaches appropriate to the dynamics of the sector.

Keywords: *ESG criteria, firm performance, R&D, food industry, technology sector, causality*

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Introduction

It is a scientific fact that businesses exist to make a profit. Therefore, companies must maintain their financial performance by engaging in high-income/low-cost activities to survive. A strong financial performance is of great importance for both the sustainability of individual businesses and the economic welfare of societies. However, considering that natural resources are limited, meeting the needs of future generations with the current economic system based only on financial performance is problematic. To achieve a sustainable world, businesses must adopt a broader goal perspective beyond the financial mindset.

Economists have expressed concerns that the current production and consumption structure is not sustainable for many years, as an important criticism of capitalism. However, with the Brundtland Report published by the United Nations in 1987, the issue of sustainability began to be accepted as a global problem at the level of states. This report discussed sustainable development with its economic, environmental, and social dimensions, and solution proposals that all countries should implement were presented (Brundtland, 1987). Businesses and governments have taken increasing sustainability initiatives to achieve a more sustainable world. In addition to the regulations in the form of mandatory environmental taxes imposed on companies by governments, businesses have also started to make many initiatives.

Initiatives taken by businesses address sustainability with its economic, environmental, and social dimensions. It is hoped that these initiatives will create a more sustainable world. However, an issue that needs to be considered here is that the steps taken for sustainability create costs for companies, thus affecting the financial performance of companies. In this context, it is a controversial issue how the steps taken by companies within the scope of sustainability will affect their financial performance. Although these activities are often seen as a cost element for companies at first glance, many investors or credit providers have started considering companies' Environmental, Social, and Governance (ESG) policies in investing in companies or transferring funds. Ignorance of ESG criteria by the firms is seen as a non-financial risk factor in companies. Therefore, sustainability departments have started to be established in companies, and processes have started to be made visible to all stakeholders with sustainability reports. In addition, since the early 2000s, institutions such as Bloomberg, Thomson Reuters, the Carbon Disclosure Project (CDP), and Morgan Stanley have started measuring ESG scores with their methodologies to make ESG risks more measurable and objective for all stakeholders.

Since the companies and governments intensified the steps, they have taken in the field of ESG, the subject has become of increasing interest to researchers.

Estimating the financial effects of ESG by econometric methods will give clues for the future in terms of the financial sustainability of companies. It will provide an important road map for businesses investing in this field. Previous studies point to significant relationships between firm performance and ESG. High performance expectation impels companies to comply with ESG criteria in many sectors (Ruan and Liu, 2021; Ting et al., 2020; Mohammad and Wasiuzzaman, 2021). Especially in the technology sector, since compliance with the ESG criteria has the potential to contribute to the market value of the companies, the companies can approach the ESG criteria positively.

On the other hand, the factor that enables the firm to gain its performance and competitive advantage is its innovation capability. Interest in R&D investments as a precursor to innovation capability is high. R&D investments can increase the efficiency of natural resources and reduce environmentally harmful waste. R&D investments can thus increase positive trends toward the firm's ESG criteria (Guerrero-Villegas et al., 2018). However, due to the high risk and long-term results of innovative activities (Lv et al., 2021), a firm's willingness to choose an innovation program may depend on the firm's performance expectations and stakeholder pressures (Zheng et al., 2022). Empirical results support positive relationships between R&D investments, firm performance, and ESG (Lin et al., 2021; Dicuonzo et al., 2022; E-Vahdati and Binesh, 2022; Guerrero-Villegas et al., 2018; Li et al., 2023; Lv et al., 2021).

However, only some of the studies have sectoral distinctions. Also, the direction of causality between ESG, R&D, and firm performance has rarely been examined. Revealing the existence and direction of the relationship between sustainability indicators and financial performance will also inform investment decisions in enterprises, which are the locomotive of economies. Additionally, emerging findings may be useful in guiding government policies.

Initial research investigating the relationship between sustainability indicators and financial performance focused on corporate social responsibility (CSR) indicators (Giffin and Mahon, 1997). Since this initial research, the literature has developed that the concept of sustainability requires a much broader perspective has made it necessary to consider the issue not only with its social dimension but also with environmental and institutional dimensions.

Since the beginning of the 2000s, many studies have emerged exploring the relationship between ESG and financial performance. Although there are studies in the literature investigating the effects of sector-specific ESG indicators such as real estate sector, real estate investment partnership, banking sector, capital goods, commercial and professional services, and transportation on financial performance in Europe, Asia, and America (Almeyda and Darmansyah, 2019; Dragomir et al., 2022; Erol et al., 2021; El Khoury et al., 2021; Dicuonzo et al. 2022), we did not find any studies investigating the interaction between these variables for technology companies in the United States.

According to the report of KPMG (2021), 83% of US technology companies use sustainability reporting and 70% low carbon reporting. Technology companies are at the top of the ESG rankings published recently. Operating in the technology field, NVIDIA shows that innovation and technology can be essential tools for a more sustainable world. The company, which has started to demand carbon reporting from its suppliers, plans to measure the possible effects of climate change, which is one of the leading global problems, using the artificial intelligence-based applications it has developed. On the other hand, the company collaborates with the Lockheed Martin AI center to work on forest fire prediction with machine learning-based systems. Therefore, technology companies play a leading role in establishing a more sustainable world, compared to other sectors, with their innovation capabilities and the new technologies they have developed.

Research has often been designed as related to the efficiency or financial performance of the company, and then research is carried out within the framework of these assumptions. However, sectoral dynamics can significantly affect compliance with ESG criteria. For example, technology companies in global markets see CSR applications as a factor in maximizing firm value and seek to increase firm performance by complying with ESG criteria. In contrast, the food sector faces unique challenges in balancing productivity with sustainability. As Sandberg et al. (2023) noted, the food sector often prioritizes efficiency and productivity, sometimes at the expense of environmental and social responsibility. For instance, using chemicals to increase agricultural productivity can lead to environmental degradation, and the sector's focus on cost-efficiency may result in ESG practices being overlooked. This efficiency-oriented approach creates a tension between short-term productivity gains and long-term sustainability goals, making the food sector an interesting contrast to the technology sector. By examining these two sectors, we can better understand how different industry dynamics shape the relationship between ESG, R&D, and financial performance.

Researching the financial performance of companies in the technology and food sectors in the USA, with a focus on the interaction between ESG compliance and R&D investments, will fill an important gap in the literature. This study does not claim to analyze the effects of technology on food companies directly but rather aims to explore how sectoral dynamics shape ESG and financial performance within these two distinct industries. Considering the significant economic contributions of these sectors, the findings are expected to provide valuable insights into ESG policy implications and offer a practical framework for sustainability practices.

Additionally, the literature lacks studies investigating the causal relationships between ESG, R&D, and financial performance in a sector-specific manner. While many existing studies have identified relationships between these variables, the directionality of these relationships remains underexplored.

The main reason for selecting food and technology companies in this study is their different dynamics in ESG compliance and their importance in economic contributions. The technology sector plays a leading role in adopting ESG criteria by exhibiting an innovation-based structure. Particularly in the US, technology companies lead by example in environmental sustainability and social responsibility. Companies like NVIDIA turn ESG compliance into a strategic advantage by offering artificial intelligence-based environmental solutions. On the other hand, the food sector faces different challenges in terms of intensive use of natural resources and sustainability. This sector may put environmental and social responsibility practices on the back burner in pursuit of high productivity. However, the broad economic impact of the food sector makes the social implications of such policies even more critical.

While previous research has explored the relationship between ESG compliance, R&D investments, and financial performance, this study makes several distinct contributions to the literature. First, it employs panel causality analysis to examine the direction of causality between these variables, addressing a significant gap in the existing literature, which has largely focused on correlations rather than causal relationships. Second, the study provides a sector-specific analysis by comparing the technology and food sectors, two industries with distinct operational and sustainability challenges. This comparative approach offers nuanced insights into how ESG and R&D dynamics vary across sectors, which is critical for developing tailored policies and strategies. Third, the study focuses on the US context during 2012 – 2021, a timeframe marked by significant ESG policy implementation and innovation-driven growth. Doing so contributes to the limited body of empirical research on ESG and R&D in the US, particularly in the technology and food sectors. These contributions advance academic understanding and provide practical insights for policymakers and corporate leaders seeking to align sustainability initiatives with financial performance.

1. Literature Review

In recent years, mainly the level of compliance with ESG criteria has been used in determining the corporate social responsibilities of companies (Paolone et al., 2022; Carnini-Pulino et al., 2022;). The ESG overall score has three main dimensions with sub-categories: the environmental dimension, which includes innovation, emissions, and resource use; the governance dimension, which includes management, strategy, and shareholders; and the social dimension, which includes human rights, workforce, and product responsibilities (Cvelbar and Dwyer, 2013, p. 491). The ESG score is critically important for governments, companies, investors, and households. Today, ESG scores have become a tool used to measure the sustainability performance of companies. As a result of the calculation of the data compiled from different sources according to specific parameters, the ESG scores of the companies are reported both in letters (D-, A+) and numerically (0 – 100) (Refinitiv, 2022). When the literature examines the relationship between ESG score and firm performance is reviewed, it is seen that complementary data is needed since the traditional criteria alone do not yield meaningful results (Supriyadi and Terbuka, 2021, pp. 220 – 222).

Many studies have focused on the relationship of ESG with firm performance (Khan, 2022; Huang, 2021). Results on the effect/relationship of compliance with ESG criteria on firm performance can be grouped into three categories. Some of the studies show positive effects of ESG on firm performance (Ting et al., 2020; Mohammad and Wasiuzzaman, 2021; Rodriguez-Fernandez et al., 2019; Aydoğmuş et al., 2022; Maji and Lohia, 2023; Cho, 2022). On the other hand, some studies have found that compliance with ESG criteria negatively affects firm performance (Ruan and Liu, 2021; Wasiuzzaman et al., 2022; Chen et al., 2021). According to some studies, compliance with ESG criteria is unrelated to firm performance (La Torre et al., 2020; Aydoğmuş et al., 2022; Cho, 2022). Emphasizing that compliance with ESG criteria has different significant effects on companies, Ashwin Kumar et al. (2016) revealed that compliance with these criteria also reduces the volatility in the share values of companies. The effect of compliance with ESG criteria on firm performance varies according to the development level of the countries. For example, compliance of companies operating in emerging markets with ESG criteria can significantly increase their performance (Ting et al., 2020; Bahadori et al., 2021; Cho, 2022; Pu, 2022).

At the same time, the findings vary based on the sectors and financial variables (Garcia et al., 2020). It has also been supported by some studies that ESG has significant negative effects on firm profitability in some sectors. (Chen et al., 2021; Ruan and Liu, 2021; Wasiuzzamana et al., 2022;). As can be seen, the relationship between the total ESG score and firm profitability still needs to be clarified. The results of the studies are full of paradoxes (Khan, 2022). The paradox might be due to the development levels and sectoral differences of the countries where the examined companies are located. The differences in the resources allocated to social responsibility in developed and developing countries also impact companies' perspectives on ESG. Making sectoral comparisons in research can be a helpful method in terms of clearly showing the effect of ESG criteria on firm performance (Ruan and Liu, 2021). For this reason, it becomes vital to determine the relationship between ESG and firm performance. Firms can increase corporate value by making it an intangible asset due to the correct evaluation of ESG criteria, enabling the firm to create a new differentiated competitive advantage (Lin et al., 2021).

Despite the increasing research on the relationship between ESG (Environmental, Social, and Governance) compliance, R&D (Research and Development) investments, and financial performance, several critical gaps remain. First, while many studies have explored the correlation between these variables, few have investigated the direction of causality, particularly within specific sectors. This is a significant limitation, as understanding causality is essential for developing targeted policies and strategies. Second, most existing research focuses on individual sectors or aggregates data across industries, which overlooks the unique dynamics present in different sectors. For example, the technology sector, characterized by its innovation-driven structure, may exhibit different ESG and R&D dynamics compared to the food sector, which faces challenges related to resource efficiency and sustainability. Lastly, there is a lack of empirical studies that explore these relationships within the US context, especially during significant periods of ESG policy implementation, such as the timeframe from 2012 to 2021 covered in this study.

2. Methodology

The primary purpose of this study is to investigate the directional relationships between ESG compliance, R&D investments, and financial performance. For this reason, panel causality analysis has been chosen as the most appropriate method to explore the proposed links. While correlation analysis can reveal the strength and existence of relationships, it is limited in this study's context because it cannot capture the cause-and-effect dynamics between variables. For instance, a high correlation between ESG compliance and financial performance does not indicate whether ESG compliance leads to improved financial performance or if financially successful companies are more likely to adopt ESG practices. In contrast, causality analysis provides critical insights by identifying the direction of the relationship. This method allows us to determine whether changes in ESG compliance or R&D investments lead to changes in financial performance or vice versa. Understanding these directional links is particularly valuable for developing targeted policy recommendations and strategic business decisions, as it reveals the underlying mechanisms driving these interactions.

Moreover, causality analysis is better suited to this study's objectives because it accounts for sectoral and temporal variations, crucial in understanding the distinct dynamics of the food and technology industries. By employing panel causality analysis, this study can provide a nuanced understanding of how ESG compliance and R&D investments interact with financial performance over time and across different sectors. To support this objective, the panel causality analysis employed in this study examines sectoral dynamics and temporal variations across the food and technology industries in the USA. The methods used are detailed below to further explain their relevance and applicability.

2.1. Panel Causality Analysis

In panel causality analysis, it is essential to control the homogeneity of the units in the data set and to determine the technique to be used. If the relevant units are homogeneous, panel Granger causality analysis is appropriate; if heterogeneous, Dumitrescu and Hurlin's (2012) panel Granger causality analysis is correct (Tatoğlu, 2017, pp. 151 – 154). The Swamy (1970) *S* test is widely used to examine the homogeneity of the units that make up the panel. In the test, unit size *N* is expected to be smaller than the time dimension *T*. For this reason, the test statistics to be used in the study are given in Equation 3 (Pesaran and Yamagata, 2008, pp. 93 – 95).

$$\hat{S} = \sum_{i=1}^{N} \left(\hat{\beta}_i - \hat{\beta}_{WFE}\right) \frac{X_i^{'} \mu_\tau X_i}{\hat{\sigma}_i^2} \left(\hat{\beta}_i - \hat{\beta}_{WFE}\right) \tag{1}$$

Here $\hat{\beta}_i$ represents the least squares estimator obtained for individual units: σ_i^2 refers to the estimator associated with $\hat{\beta}_i$, and $\hat{\beta}_{WFE}$ denotes the weighted pooled estimator that accounts for variations across units.

$$\hat{\beta}_{WFE} = \left(\sum_{i=1}^{N} \frac{X_i^{'} \mu_\tau X_i}{\widehat{\sigma}_i^2} \right)^{-1} \sum_{i=1}^{N} \frac{X_i^{'} \mu_\tau y_i}{\widehat{\sigma}_i^2} \tag{2}$$

The test follows a chi-squared $\left(\chi^2\right)$ distribution with $K(N-1)$ degrees of freedom, where the primary hypothesis assumes that the parameters are homogeneous. However, due to the heterogeneity of the panel data set used in this study, the causality test proposed by Dumitrescu and Hurlin (2012) has been selected as the most suitable approach. Dumitrescu and Hurlin's panel Granger causality test offers significant advantages, as it can provide reliable estimators in cases where N > T or N < T, and it is applicable to both balanced and unbalanced panel data (Dumitrescu and Hurlin, 2012, p. 1457).

$$y_{i,t} = \alpha_i + \sum_{k=1}^{K} \gamma_i^{(k)} y_{i,t-k} + \sum_{k=1}^{K} \beta_i^{(k)} x_{i,t-k} + \varepsilon_{i,t} \tag{3}$$

$$x_{i,t} = \alpha_i + \sum_{l=1}^{L} v_i^{(l)} x_{i,t-l} + \sum_{l=1}^{L} \varphi_i^{(l)} y_{i,t-l} + u_{i,t} \tag{4}$$

Here, x and y represent two static variables observed in the T period for N cross-sections. In equation 4, where the causality relationship of x on y is examined, the parameters $\gamma_i^{(k)}$, representing the autoregressive parameter, and $\beta_i^{(k)}$, the slope coefficients, differ for cross-section i. The lag lengths K in the model are the same for all cross sections. The primary hypothesis of the test is that there is no causality relationship in the whole panel. In contrast, the alternative theory states a causal relationship exists in at least one horizontal section (Dumitrescu and Hurlin, 2012, p. 4). The interrelationships between two variables in panel data are determined by PVAR models, widely used to detect dynamic interactions. With PVAR models, a system of simultaneous equations, interactions specific to each unit can also be shown separately in heterogeneous panels.

Dumitrescu and Hurlin (2012) calculated Wald statistics for cross-section units to test the main and alternative hypotheses, and by taking the average of these statistics, the Wald statistics of the panel $\left(W_{N,T}^{HNC} = 1/N \sum_{i=1}^{N} W_{i,T} \right)$ have been obtained.

$$Z_{N,T}^{HNC} = \sqrt{\frac{N}{2K}} \left(W_{N,T}^{HNC} - K \right) \underset{N \to \infty}{\overset{d}{\to}} N(0,1) \tag{5}$$

$$Z_{N}^{HNC} = \frac{N^{1/2} \left[W_{N,T}^{HNC} - N^{-1} \sum_{i=1}^{N} E\left(W_{i,T}\right) \right]}{\sqrt{N^{-1} \sum_{i=1}^{N} Var\left(W_{i,T}\right)}} \underset{N \to \infty}{\overset{d}{\to}} N(0,1) \tag{6}$$

Dumitrescu and Hurlin (2012) suggested a statistic with asymptotic distribution when the time dimension is larger than the unit dimension *(equation 5)*, and a different statistic if the unit dimension is larger than the time dimension *(equation 6).*

2.2. Cross-Sectional Dependence in Panel-Data

The fact that all units are affected at the same level in response to the shock occurring in any of the cross-section units that make up the panel data set means that the units are independent of each other. To avoid affecting the results obtained because of the technique used, the cross-section dependence in the examined series should be tested. This study used the Pesaran cross-section dependency test because the unit dimension N is larger than the time dimension T (Pesaran, 2004, p. 4).

$$CD = \sqrt{\frac{2T}{N(N-1)}} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \hat{\rho}_{ij} \tag{7}$$

Here $\hat{\rho}_{ij}$, *i*. and *j*. it shows the instant correlation between units. It is based on the sum of the correlation coefficients between cross-section residuals. Under the primary hypothesis, which states that there is no relationship between cross-sections, the test statistics show a standard normal distribution (Pesaran, 2004, p. 9). If cross-section dependency is detected, second-generation panel unit root tests are used; if not, first-generation panel unit root tests are used (Baltagi, 2008, p. 284).

2.3. Panel Unit Root Tests

In the case of cross-sectional dependence, second-generation unit root tests (Pesaran, 2007; Hadri and Kurozumi, 2012; Bai and Ng, 2004) are used, while in the absence of cross-sectional dependence, first-generation unit root tests (Breitung, 2000; Im et al., 2003; Levin et al., 2002) are used. Since the series with and without cross-section dependence were determined because of the analyses, Levin-Lin-Chu (2002), one of the first-generation unit root tests, and Pesaran (2007) test, one of the second-generation unit root tests, were used in the study.

The CADF unit root test can be used for $T > N$ and $N > T$, developed by Pesaran (2007), which considers the cross-sectional dependence (Pesaran, 2007, pp. 269 – 271).

$$\Delta y_{it} = \alpha_i + b_i y_{i,t-1} + c_i \overline{y}_{t-1} + d_i \Delta \overline{y}_t + e_{it} \tag{8}$$
$$\left(i = 1,\ 2,\ \ldots,\ N, \quad t = 1,\ 2,\ \ldots,\ T\right)$$

If the primary hypothesis $\left(H_0 : b_i = 0\right)$ is rejected, it is concluded that the studied series is stationary. The $\left(H_a : b_i < 0\right)$ test equation developed by Levin-Lin-Chu (2002), which does not consider the cross-sectional dependence, is shared.

$$\Delta y_{it} = \alpha\, y_{it-1} + \sum_{j=1}^{p_i} b_{ij} \Delta y_{it-j} + X_{it}^{'} \delta + e_{it} \tag{9}$$

Here, the estimation of α is made using the variables Δy_{it} and y_{it}, free of autocorrelation and deterministic features. If the primary hypothesis $\left(H_0 : \alpha = 0\right)$ is rejected, it is concluded that the studied series is stationary $\left(H_a : \alpha < 0\right)$.

Panel causality equations are created after determining whether the series has a unit root and ensuring their stationarity with the necessary transformations. Levin, Lin and Chu test was prepared for the situation where there is a range of 10 to 250 units *(N:*10 – 250*)* and 25 to 250 *(T:*25 – 250*)* observations in each unit (Tatoğlu, 2013, p. 202).

3. Analysis and Findings

The study examined the relationship between ESG criteria, financial indicators, and firm performance. In this context, the data of companies in two sectors, food, and technology, were accessed from the Thomson Reuters database from 2012 – 2021. Twelve companies in the food sector and eighteen in the technology sector were considered. Information on the variables examined and their definitions are given in Table.1.

T a b l e 1

Variable Definitions

Variable	Description
Operation	Operating income
Roa	Return on assets – total (%)
Roe	Return on equity – total (%)
Net	Net sales or revenues
Emp	Employees
Profit	Operating profit margin
Asset	Total asset turnover
Value	Market value to book
Total	Total liabilities
Market	Market capitalization
RD	Research & Development
Quick	Quick ratio
Current	Current ratio
Day	Accounts receivables days
ESG	ESG Score – Measurement or evaluation of a given company, fund, or security's performance with respect to Environmental, Social, and Governance (ESG) issues

Source: Compiled by the authors.

T a b l e 2

Descriptive Statistics

Sector	Food				Technology			
Variable	*Mean*	*Std. dev.*	*Min.*	*Max*	*Mean*	*Std. dev.*	*Min.*	*Max*
Operation	14.495	1.966	10.316	17.412	19.180	0.410	18.919	20.870
Roa	8.697	5.542	–10.110	42.880	5.487	0.040	5.319	5.637
Roe	27.860	24.192	–37.400	108.810	10.168	0.101	10.120	11.513
Net	16.369	1.964	12.347	19.850	18.477	2.693	13.634	22.920
Emp	10.020	1.501	7.422	12.734	10.775	1.276	8.407	12.712
Profit	2.731	0.470	1.765	3.767	6.235	0.024	6.186	6.289
Asset	–0.373	0.461	–1.966	0.336	–0.184	0.504	–1.273	0.765
Value	1.422	0.782	–0.105	3.335	4.044	0.361	0.000	5.058
Total	16.164	1.965	11.733	18.248	18.082	2.704	13.400	23.745
Market	17.119	1.998	12.455	20.094	18.717	2.323	14.273	23.388
RD	11.691	1.639	8.575	14.448	16.006	2.297	11.527	20.079
Quick	–0.318	0.599	–1.427	1.338	0.583	0.511	–0.274	2.083
Current	0.203	0.522	–0.713	1.449	0.314	0.592	–0.799	1.982
Day	3.879	0.295	3.178	4.779	4.103	0.345	3.135	4.956
ESG	4.006	0.541	1.760	4.520	3.989	0.289	2.664	4.522

Source: Compiled by the authors.

Before starting the panel data analysis, logarithmic transformation was applied to the related variables to ensure stationarity in the variance, and the descriptive statistics are given in Table 2.

The cross-section dependence and stationarity of the variables whose descriptive statistics were given were examined. The results of the cross-section dependence test results of the variables to which the logarithmic transformation was applied due to the stationarity of the variance are given in Table.3.

Table 3

Cross-Section Dependency Results in Variables

H_0 : *No cross-section dependency*

H_a : *There is a cross-section dependency*

Sector / **Variable**	**Food**		**Technology**	
	Statistics	*p-value*	*Statistics*	*p-value*
***L**Operation*	7.42	0.000	4.87	0.000
Roa	0.34	0.737	1.32	0.186
Roe	0.44	0.661	1.80	0.072
***L**Net*	6.23	0.000	2.31	0.021
***L**Emp*	0.74	0.460	1.75	0.081
***L**Profit*	3.39	0.001	1.56	0.118
***L**Asset*	6.00	0.000	2.41	0.016
***L**Value*	3.03	0.002	1.76	0.079
***L**Total*	10.59	0.000	0.94	0.346
***L**Market*	7.65	0.000	11.84	0.000
***L**RD*	2.87	0.004	5.36	0.000
***L**Quick*	0.09	0.925	2.05	0.041
***L**Current*	0.10	0.923	1.63	0.103
***L**Day*	1.64	0.101	0.44	0.662
LESG	0.46	0.647	1.93	0.053

Note: Statistical significance at the 5% level was checked.

Source: Compiled by the authors.

In Table 3, the Pesaran CD test was used because the number of observations was higher than the number of units in the panel data set used to evaluate the cross-sectional dependence on a variable basis *(N > T).* Looking at the results in the technology sector operation, net, asset, market, RD, and quick variables, In the food sector, it is seen that there is a cross-section dependency in the variables of operation, net, profit, asset, value, total, market, and RD.

Therefore, the stationarity of the related variables was examined using the Karavias and Tzavalis (2014) panel unit root test, which is designed to handle structural breaks and cross-sectional dependence. The null hypothesis (H0) of this test states that all panel time series are unit root processes, while the alternative hypothesis $\left(H_0\right)$ that some or all the panel time series are stationary processes.

The results of the Karavias and Tzavalis (2014) test, provided in Table 4, indicate that the null hypothesis was rejected at the 5% significance level for all variables across the food and technology sectors. This suggests that all variables are stationary at levels $I(0)$, meaning they do not contain unit roots and are suitable for further analysis without differencing.

T a b l e 4

Second Generation Unit Root Test Results (with constant and trend)

H_0 *: The panel has a unit root* ***H_a*** *: There is no panel unit root*								
Sector	**Food**				**Technology**			
Variable	*Z[t-bar]*	*p-value*		*Decision*	*Z[t-bar]*	*p-value*		*Decision*
L*Operation*	–2.527	0.006		$I(0)$	.511	0.000		$I(0)$
L*Net*	–2.755	0.003		$I(0)$	–5.450	0.000		$I(0)$
L*Asset*	–4.006	0.000		$I(0)$	–4.638	0.000		$I(0)$
L*Market*	–2.045	0.020		$I(0)$	–1.827	0.034		$I(0)$
L*RD*	–2.625	0.004		$I(0)$	–4.634	0.000		$I(0)$
L*Quick*					–3.213	0.001		$I(0)$
L*Profit*	–5.150	0.000		$I(0)$				
L*Value*	–2.955	0.002		$I(0)$				
L*Total*	–5.168	0.000		$I(0)$				
Karavias and Tzavalis unit root								
Sector	**Food**				**Technology**			
Variable	*Z-stat*	*p-value*	*The year of breaking*	*Decision*	*Z-stat*	*p-value*	*The year of breaking*	*Decision*
L*Operation*	–5.527	0.000	2019	$I(0)$	–7.932	0.000	2019	$I(0)$
L*Net*	–3.251	0.000	2015	$I(0)$	–10.260	0.000	2014	$I(0)$
L*Asset*	–0.763	0.030	2015	$I(0)$	–2.831	0.010	2018	$I(0)$
L*Market*	–3.813	0.010	2013	$I(0)$	–0.134	0.000	2013	$I(0)$
L*RD*	–4.618	0.000	2013	$I(0)$	–4.760	0.000	2019	$I(0)$
L*Quick*					–4.848	0.000	2019	$I(0)$
L*Profit*	–6.120	0.000	2018	$I(0)$				
L*Value*	–0.599	0.040	2019	$I(0)$				
L*Total*	–4.215	0.000	2018	$I(0)$				

Note: Statistical significance at the 5% level was checked.

Source: Compiled by the authors.

Additionally, the second-generation Pesaran (2007) test was employed for robustness, particularly to account for cross-sectional dependence, and results are provided in Table 5. Similarly, these test results confirm the stationarity of all variables, reinforcing the robustness of the dataset for subsequent econometric analysis. Given that the dataset includes the period from 2019, covering the COVID-19 pandemic, these tests were specifically chosen to ensure that potential structural breaks or anomalies due to the pandemic were properly addressed. By combining these approaches, the study ensures a rigorous validation of stationarity while effectively accounting for sectoral dynamics and the impact of the pandemic.

Table 4 shows that the variables are stationary at their level states, indicating that they do not contain unit roots. This finding implies that the food and technology sectors exhibited stable patterns during the examined period without evidence of stochastic trends or probabilistic processes. Furthermore, including the 2019 – 2021 period, encompassing the COVID-19 pandemic, did not lead to significant structural breaks that could disrupt the stationarity of the variables. This result provides confidence in the robustness of the dataset and supports the validity of the subsequent econometric analyses. The results of the Levin-Lin-Chu first-generation unit root test applied for the variables without cross-sectional dependence are also given in Table 5.

T a b l e 5

First Generation Unit Root Test Results (with constant and trend)

H_0 *: The panel has a unit root*

H_a *: There is no panel unit root*

Sector / Variable	Food			Technology		
	t-statistic	*p-value*	*Decision*	*t-statistic*	*p-value*	*Decision*
Roa	–5.3676	0.000	$I(0)$	–11.6498	0.000	$I(0)$
Roe	–4.9748	0.000	$I(0)$	–10.4265	0.000	$I(0)$
***L**Emp*	–12.5691	0.000	$I(0)$	–6.6689	0.000	$I(0)$
***L**Current*	–5.8126	0.000	$I(0)$	–10.2039	0.000	$I(0)$
***L**Day*	–11.8808	0.000	$I(0)$	–6.3820	0.000	$I(0)$
***L**ESG*	–7.7415	0.000	$I(0)$	–5.1075	0.000	$I(0)$
***L**Profit*				–5.2053	0.000	$I(0)$
***L**Value*				–7.1276	0.000	$I(0)$
***L**Total*				–5.4036	0.000	$I(0)$
***L**Quick*	–9.7364	0.000	$I(0)$			

Note: Statistical significance at the 5% level was checked.

Source: Compiled by the authors.

Looking at Table 5, it is seen that the examined variables are stationary with their level states. The stationary states of the variables are included in the equations created for the panel causality analysis. To determine the appropriate panel causality analysis method, it is necessary to determine the homogeneity of the parameters in the model.

As a result of Swamy's *S* (1970) homogeneity test, the appropriate lag length was determined according to the MBIC criterion. The results for the sectors are given in Table 6.

Table 6

Homogeneity Tests' Results

Sector / **Test**	**Food**		**Technology**	
	Test statistics	*p-value*	*Test statistics*	*p-value*
$\tilde{\Delta}_{adj.}$	2.161	0.031	7.484	0.000
$\tilde{\Delta}$	2.447	0.014	5.287	0.000

Source: Compiled by the authors.

The optimal lag length was determined as 2 for both the food and technology sectors, and it was seen that the parameters of the models created because of the rejection of the basic hypothesis were heterogeneous. Dumitrescu and Hurlin's (2012) panel causality test was applied to the stationary series, and the results are presented in Table 7.

Since the time dimension is smaller than the cross-section dimension in the study, the directions of the causality relationships between the series were decided based on the results of the ZNHNC test statistics suggested by Dumitrescu and Hurlin (2012).

Considering the findings obtained for the food sector, it is seen that the variables in which a causal relationship is determined towards ESG are Roa, Roe, Market, Operation, Net, Profit, Quick, Current, and Day. It has been determined that there is a causal relationship between ESG to Market, Total, Net, Emp, Asset, RD, Quick, and Day variables.

Therefore, ESG and Market, Net, Quick, and Day variables have a bidirectional causality relationship. Considering the findings for the technology sector, it is seen that the variables for which a causal relationship is determined towards ESG are Total, Value, Operation, Net, Emp, Profit, Value, Total, and RD. It has been determined that there is a causal relationship between ESG to Roa, Roe, Total, Net, Asset, Quick, and Current variables. Therefore, there is a bidirectional causality between the ESG and Total variables.

T a b l e 7

Dumitrescu and Hurlin Panel Causality Analysis Results

H_0 *Non-Granger-causes*

H_a *Granger-causes*

(Due to rejecting the basic hypothesis, causality relations are determined.)

Sector / Aspect of relationship	Food $W_{N,T}^{HNC}$	Food $Z_{N,T}^{HNC}$	Food *p-value*	Sector / Aspect of relationship	Technology $W_{N,T}^{HNC}$	Technology $Z_{N,T}^{HNC}$	Technology *p-value*
ROA → LESG	2.0893	2.5547	0.0106	*LESG → ROA*	2.4140	4.2419	0.0000
ROE → LESG	2.5874	3.7228	0.0000	*LESG → ROE*	2.0658	3.1974	0.0014
LMARKET → LESG	4.7276	8.7420	0.0004	*LESG → LTOTAL*	2.6919	5.0757	0.0000
LESG → LMARKET	4.6615	8.5870	0.0000	*LTOTAL → LESG*	2.0039	3.0118	0.0026
LESG → LTOTAL	2.9964	4.6821	0.0000	*LVALUE → LESG*	2.2399	3.7197	0.0002
LOPERATION → LESG	2.5562	3.6495	0.0003	*LOPERATION → LESG*	3.2737	6.8212	0.0000
LESG → LNET	2.9080	4.4746	0.0000	*LESG → LNET*	2.2909	3.8728	0.0001
LNET → LESG	2.7079	4.0054	0.0001	*LNET → LESG*	2.3975	4.1926	0.0000
LESG → LEMP	2.2140	2.8741	0.0044	*LEMP → LESG*	2.4307	4.2922	0.0000
LPROFIT → LESG	3.5739	6.0363	0.0000	*LPROFIT → LESG*	2.9323	5.7969	0.0000
LESG → LASSET	2.6716	3.9203	0.0001	*LESG → LASSET*	1.7818	2.3455	0.0190
LESG → LRD	2.7288	4.0543	0.0001	*LRD → LESG*	2.5475	4.6425	0.0000
LQUICK → LESG	2.3186	3.0924	0.0020	*LESG → LQUICK*	3.7292	8.1877	0.0000
LESG → LQUICK	2.5771	3.6986	0.0002	*LESG → LCURRENT*	3.0453	6.1359	0.0000
LCURRENT → LESG	3.2854	5.3597	0.0000				
LESG → LDAY	6.9897	14.0471	0.0000				
LDAY → LESG	2.6318	3.8270	0.0001				

Source: Compiled by the authors.

4. Findings and Discussion

Environmental, social, and governance (ESG) factors are gaining increasing prominence among national and international firms, and it is becoming abundantly clear that merely adhering to traditional profit maximization strategies is no longer sufficient. It is imperative for companies to consider their societal and environmental impact, particularly regarding human capital development and corporate governance practices. The integration of environmental sustainability criteria into investment decisions is paramount for achieving sustainable finance outcomes (Galletta et al., 2022). From this point of view, it is aimed to examine the relationship between ESG factors and work efficiency values in different sectors. As a result of the analysis made for this purpose, the effect of ESGs on firm productivity is different according to the sectors. Empirical evidence is provided to support the creation of efficient and sustainable portfolios due to mapping differences by industry. When the findings are evaluated in general, the sound financial structure of technology and food companies encourages companies to comply with ESG criteria. In addition, compliance with the ESG criteria ensures that the activities of the companies are efficient. The literature shows that many studies examine the relationship between ESG and financial performance. However, few studies examine more than one sector (Pacelli et al., 2022; Ruan and Liu, 2021; Ting et al., 2020; Mohammad and Wasiuzzaman, 2021; Yavuz et al., 2025).

The findings of this study reveal distinct causal dynamics among ESG compliance, R&D investments, and financial performance within the technology and food sectors. In the technology sector, a positive causal relationship from R&D to ESG compliance indicates that innovation-driven firms are more inclined to adopt sustainable practices. This relationship holds considerable economic significance, as it suggests that investments in R&D not only drive technological advancements but also promote environmental and social responsibility. Companies within this sector are likely to leverage their innovative capabilities to create sustainable technologies, leading to long-term competitive advantages and market differentiation. For instance, firms such as NVIDIA make substantial investments in R&D, enabling them to develop AI-driven solutions for environmental challenges, including carbon reporting and forest fire prediction. This trend aligns with the broader economic movement, wherein technological innovation is increasingly recognized as a key driver of sustainability.

In the food sector, the relationship between firm performance and ESG (Environmental, Social, and Governance) compliance shows that financially stable companies are more likely to invest in sustainability initiatives. This trend is particularly evident in agriculture, a highly resource-intensive industry that faces significant pressure to balance productivity with environmental sustainability.

Financially strong firms in this sector are better equipped to absorb the initial costs associated with ESG compliance, such as implementing sustainable farming practices or reducing carbon emissions. However, the absence of a direct causal link from ESG compliance to improved firm performance suggests that sustainability initiatives may not lead to immediate financial benefits. This disconnect can be attributed to the industry's emphasis on short-term productivity and efficiency, which often takes precedence over long-term sustainability goals. Previous research has indicated that the current food sector, especially in agriculture, prioritizes high efficiency and frequently overlooks environmental issues (Sandberg et al., 2023). As a result, practices related to sustainability and social responsibility are often relegated to a secondary status in comparison to efficiency. Consequently, the research findings support the idea that "the effects from firm performance to ESG compliance" are consistent.

Previous research by Ruan and Liu (2021), Ting et al. (2020), and Mohammad and Wasiuzzaman (2021) has shown that companies are more inclined to adhere to ESG criteria when their financial performance is robust. This correlation is understandable, as companies typically prioritize financial success. Given that ESG compliance entails certain responsibilities, it is essential for companies to first strengthen their financial performance. Our findings indicate that adherence to ESG criteria tends to increase total liabilities, supporting the notion that ESG compliance incurs additional costs. This evidence aligns with existing studies and underscores the significance of financial stability in fostering ESG compliance.

Conclusion

This study examined the causal relationships between ESG compliance, R&D investments, and financial performance in the technology and food sectors in the USA. Using panel causality analysis, we found distinct sectoral dynamics that highlight the importance of tailoring ESG and R&D strategies to each industry's unique characteristics.

In the technology sector, R&D investments were found to promote ESG compliance, enhancing firm performance. This suggests that innovation-driven firms are more likely to adopt sustainable practices, leveraging their technological capabilities to address environmental and social challenges. For example, companies like NVIDIA have integrated ESG compliance into their innovation strategies, developing AI-based solutions for carbon reporting and climate change mitigation. This aligns with the broader economic trend, where technological innovation is increasingly seen as a key driver of sustainability.

In contrast, in the food sector, firm performance drives ESG compliance and encourages R&D investments. These findings suggest that financially stable firms are in a better position to invest in sustainability initiatives such as sustainable agricultural practices or reducing their carbon footprint. However, the lack of a direct causal effect of ESG on firm performance indicates that sustainability initiatives in the food sector may not immediately translate into financial gains. One possible reason for this could be that the sector generally prioritizes short-term efficiency and productivity over long-term sustainability goals.

The findings have important policy implications. For the technology sector, policymakers should take measures to encourage R&D investments, such as providing tax breaks or grants in the field of sustainable technology development. These incentives could motivate firms to develop innovative solutions that support environmental sustainability. For the food sector, policies should be developed to increase the financial stability of SMEs. In this context, subsidies or low-interest loans can support firms in investing in sustainable practices without jeopardizing their short-term profitability. Additionally, developing standard ESG reporting frameworks across sectors will enable companies to benchmark their performance and investors to assess their sustainability efforts more easily.

However, this study has some limitations. First, the subjectivity of ESG scoring methods may affect the comparability of results across firms and sectors. Additionally, the study focuses on the US and may be difficult to generalize to regions with different regulatory environments and market dynamics. Future research can address these limitations by examining the causal relationships between ESG, R&D, and financial performance across countries and sectors. Future research should also explore the impact of external factors, such as regulatory changes or market shocks, on these relationships. The findings in this study are based on causality analyses conducted within the scope of the panel data set. Additionally, the period covered by the study, between 2012 and 2021, especially 2020 and 2021, indicates a period in which extraordinary economic and operational effects were experienced in both the technology and food sectors due to the COVID-19 pandemic. Although the data from the pandemic period were included in the analysis, the effects specific to this period were not separately controlled in the model. Therefore, it is evaluated that caution should be exercised in interpreting the findings related to these two years.

References

ALMEYDA, R. – DARMANSYA, A. (2019): The Influence of Environmental, Social, and Governance (ESG) Disclosure on Firm Financial Performance. IPTEK Journal of Proceedings Series, *5*, pp. 278 – 290. DOI: <http://dx.doi.org/10.12962%2Fj23546026.y2019i5.6340>.

ASHWIN KUMAR, N. C. – SMITH, C. – BADIS, L. – WANG, N. – AMBROSY, P. – TAVARES, R. (2016): ESG Factors and Risk-Adjusted Performance: A New Quantitative Model. Journal of Sustainable Finance & Investment, *6,* No. 4, pp. 292 – 300. DOI: <https://doi.org/10.1080/20430795.2016.1234909>.

AYDOĞMUŞ, M. – GÜLAY, G. – ERGUN, K. (2022): Impact of ESG Performance on Firm Value and Profitability. Borsa Istanbul Review. DOI: <https://doi.org/10.1016/j.bir.2022.11.006>.

BAHADORI, N. – KAYMAK, T. – SERAJ, M. (2021): Environmental, Social, and Governance Factors in Emerging Markets: The Impact on Firm Performance. Bus Strat Dev, *4*, pp. 411 – 422. DOI: <https://doi.org/10.1002/bsd2.167>.

BAI, J. – NG, S. (2004): A Panic Attack on Unit Roots and Cointegration. Econometrica, *72,* No. 4, pp. 1127 – 1177. Available at: <https://www.jstor.org/stable/3598781>.

BALTAGI, B. H. (2008): Econometric Analysis of Panel Data. 4th edition. Chichester: John Wiley & Sons. ISBN 978-0-470-74403-1.

BREITUNG, J. (2000): The Local Power of Some Unit Root Tests for Panel Data. In: BALTAGI, B. H. (ed.): Advances in Econometrics. Vol. 15: Nonstationarity Panels, and Dynamic Panels. JAI Press, pp. 161 – 177. DOI: <https://doi.org/10.1016/S0731-9053(00)15006-6>.

BRUNDTLAND, G. H. (1987): Our Common Future-Call for Action. Environmental Conservation, *14,* No. 4, pp. 291–294. Available at: <https://www.jstor.org/stable/44518052>.

CARNINI, P. S. – CIABURRI, M. – MAGNANELLI, B. S. – NASTA, L. (2022): Does ESG Disclosure Influence Firm Performance? Sustainability, *14*, No. 13, 7595. DOI: <https://doi.org/10.3390/su14137595>.

CHEN, L. – YUAN, T. – CEBULA, R. J. – SHUANGJIN, W. – FOLEY, M. (2021): Fulfillment of ESG Responsibilities and Firm Performance: A Zero-Sum Game or Mutually Beneficial. Sustainability, *13*, No. 19, 10954. DOI: <https://doi.org/10.3390/su131910954>.

CHO, Y. (2022): ESG and Firm Performance: Focusing on the Environmental Strategy. Sustainability, *14*, No. 13, 7857. DOI: <https://doi.org/10.3390/su14137857>.

CVELBAR, L. K. – DWYER, L. (2013): An Importance-Performance Analysis of Sustainability Factors for Long-Term Strategy Planning in Slovenian Hotels. Journal of Sustainable Tourism, *21*, No. 3, pp. 487 – 504. DOI: <https://doi.org/10.1080/09669582.2012.713965>.

DICUONZO, G. – DONOFRIO, F. – RANALDO, S. – DELL'ATTI, V. (2022): The Effect of Innovation on Environmental, Social and Governance (ESG) Practices. Meditari Accountancy Research, *30*, No. 4, pp. 1191 – 1209. DOI: <https://doi.org/10.1108/MEDAR-12-2020-1120>.

DRAGOMIR, V. D. – BĂTAE, O. M. – IONESCU, B. Ș. – IONESCU-FELEAGĂ, L. (2022): The Influence of ESG Factors on Financial Performance in the Banking Sector During the Covid-19 Pandemic. Economic Computation & Economic Cybernetics Studies & Research, *56*, No. 4, pp. 71 – 88. DOI: <https://doi.org/10.24818/18423264/56.4.22.05>.

DUMITRESCU, E. I. – HURLIN, C. (2012): Testing for Granger Non-Causality in Heterogeneous Panels. Economic Modelling, *29*, No. 4, pp. 1450 – 1460. DOI: <https://doi.org/10.1016/j.econmod.2012.02.014>.

EL KHOURY, R. – NAIMY, V. – ISKANDAR, S. (2021): ESG Versus Corporate Financial Performance: Evidence from East Asian Firms in the Industrials Sector. Studies of Applied Economics, *39*, No. 3, pp. 1 – 24. DOI: <https://doi.org/10.25115/eea.v39i3.4457>.

EROL, I. – UNAL, U. – COSKUN, Y. (2021): ESG Investing and the Financial Performance: A Panel Data Analysis of Developed REIT Markets. [MAGKS Joint Discussion Paper Series in Economics, No. 23-2021.] DOI: <https://doi.org/10.21203/rs.3.rs-2528521/v1>.

E-VAHDATI, S. – BINESH, F. (2022): The Impact of CEO's Attributes on R&D Intensity and ESG Practices. Spanish Journal of Finance and Accounting/Revista Española de Financiación y Contabilidad, *51*, No. 3, pp. 326 – 349. DOI: <https://doi.org/10.1080/02102412.2021.1944459>.

GALLETTA, S. – MAZZÙ, S. – NACITI, V. (2022): A Bibliometric Analysis of ESG Performance in the Banking Industry: From the Current Status to Future Directions. Research in International Business and Finance, *62*, 101684. DOI: <https://doi.org/10.1016/j.ribaf.2022.101684>.

GARCÍA, F. – GONZÁLEZ-BUENO, J. – GUIJARRO, F. – OLIVER, J. (2020): Forecasting the Environmental, Social, and Governance Rating of Firms by Using Corporate Financial Performance Variables: A Rough Set Approach. Sustainability, *12*, 3324. DOI: <https://doi.org/10.3390/su12083324>.

GRIFFIN, J. J. – MAHON, J. F. (1997): The Corporate Social Performance and Corporate Financial Performance Debate. Business & Society, *36*, No. 1, pp. 5 – 31. DOI: <https://doi.org/10.1177/000765039703600102>.

GUERRERO-VILLEGAS, J. – SIERRA-GARCÍA, L. – PALACIOS-FLORENCIO, B. (2018): The Role of Sustainable Development and Innovation on Firm Performance. Corporate Social Responsibility and Environmental Management, *25*, No. 6, pp. 1350 – 1362. DOI: 10.1002/csr.1644.

HADRI, K. – KUROZUMI, E. (2012): A Simple Panel Stationarity Test in the Presence of Serial Correlation and a Common Factor. Economics Letter, *115*, pp. 31 – 34. DOI: <https://doi.org/10.1016/j.econlet.2011.11.036>.

HUANG, D. Z. (2021): Environmental, Social and Governance (ESG) Activity and Firm Performance: A Review and Consolidation. Accounting & Finance, *61*, No. 1, pp. 335 – 360. DOI: <https://doi.org/10.1111/acfi.12569>.

IM, K. S. – PESARAN, M. H. – SHIN, Y. (2003): Testing for Unit Roots in Heterogeneous Panels. Journal of Econometrics, *115*, No. 1, pp. 53 – 74. DOI: <https://doi.org/10.1016/S0304-4076(03)00092-7>.

KARAVIAS, Y. – TZAVALIS, E. (2014): Testing for Unit Roots in Short Panels Allowing for a Structural Break. Computational Statistics & Data Analysis, *76*, pp. 391 – 407. DOI: 10.1016/j.csda.2012.10.014.

KHAN, M. A. (2022): ESG Disclosure and Firm Performance: A Bibliometric and Meta-Analysis. Research in International Business and Finance, 101668. DOI: <https://doi.org/10.1016/j.ribaf.2022.101668>.

KPMG (2021): Survey of Sustainability Reporting at Technology Companies. Available at: <https://assets.kpmg.com/content/dam/kpmg/cr/pdf/tl-survey-of-sustainability-reporting-at-technology-companies.pdf>, April 2021.

LA TORRE, M. – MANGO, F. – CAFARO, A. – LEO, S. (2020): Does the ESG Index Affect Stock Return? Evidence from the Eurostoxx50. Sustainability, *12*, 6387. DOI: <https://doi.org/10.3390/su12166387>.

LEVIN, A. – LIN, C. F. – CHU, C. S. J. (2002): Unit Root Tests in Panel Data: Asymptotic and Finite-Sample Properties. Journal of Econometrics, *108*, No. 1, pp. 1 – 24. DOI: <https://doi.org/10.1016/S0304-4076(01)00098-7>.

LI, C. – BA, S. – MA, K. – XU, Y. – HUANG, W. – HUANG, N. (2023): ESG Rating Events, Financial Investment Behavior and Corporate Innovation. Economic Analysis and Policy, *77*, pp. 372 – 387. DOI: <https://doi.org/10.1016/j.eap.2022.11.013>.

LIN, S. L. – WU, S. C. – LI, Q. (2021): Do R&D and ESG Affect the Corporate Value? Evidence from China Fin-Tech Industry. Journal of Accounting, Finance & Management Strategy, *16*, No. 2, pp. 159 – 205. DOI: <https://doi.org/10.3390/su142114507>.

LV, C. – SHAO, C. – LEE, C. C. (2021): Green Technology Innovation and Financial Development: Do Environmental Regulation and Innovation Output Matter? Energy Economics, *98*, 105237. DOI: <https://doi.org/10.1016/j.eneco.2021.105237>.

MAJI, S. G. – LOHIA, P. (2023): Environmental, Social and Governance (ESG) Performance and Firm Performance in India. Society and Business Review, *18*, No. 1, pp. 175 – 194. DOI: <https://doi.org/10.1108/SBR-06-2022-0162>.

MOHAMMAD, W. M. W. – WASIUZZAMAN, S. (2021): Environmental, Social and Governance (ESG) Disclosure, Competitive Advantage and Performance of Firms in Malaysia. Cleaner Environmental Systems, *2*, 100015. DOI: <https://doi.org/10.1016/j.cesys.2021.100015>.

PACELLI, V. – PAMPURINI, F. – QUARANTA, A. G. (2022): Environmental, Social and Governance Investing: Does Rating Matter? Business Strategy and the Environment, *32*, pp. 30 – 41. DOI: <https://doi.org/10.1002/bse.3116>.

PAOLONE, F. – CUCARI, N. – WU, J. – TISCINI, R. (2022): How do ESG Pillars Impact Firms' Marketing Performance? A Configurational Analysis in the Pharmaceutical Sector. Journal of Business & Industrial Marketing, *37*, No. 8, pp. 1594 – 1606. DOI: 10.1108/JBIM-07-2020-0356.

PESARAN, M. H. – YAMAGATA, T. (2008): Testing Slope Homogeneity in Large Panels. Journal of Econometrics, *142*, pp. 50 – 93. DOI: <https://doi.org/10.1016/j.jeconom.2007.05.010>.

PESARAN, M. H. (2004): General Diagnostic Tests for Cross Section Dependence in Panels. Cambridge Working Papers in Economics, *435*, pp. 1 – 42.

PU, G. (2023): A Non-Linear Assessment of ESG and Firm Performance Relationship: Evidence from China. Economic Research-Ekonomska Istraživanja, *36*, No. 1, pp. 1 – 17. DOI: <https://doi.org/10.1080/1331677X.2022.2113336>.

REFINITIVE (2022): Environmental, Social and Governance (ESG) Scores from Refinitiv. Refinitiv. Available at: <https://www.refinitiv.com/content/dam/marketing/en_us/documents/methodology/refinitiv-esg-scores-methodology.pdf>.

RODRÍGUEZ-FERNÁNDEZ, M. – SÁNCHEZ-TEBA, E. M. – LÓPEZ-TORO, A. A. – BORREGO-DOMÍNGUEZ, S. (2019): Influence of ESGC Indicators on Financial Performance of Listed Travel and Leisure Companies. Sustainability, *11*, No. 199, 5529. DOI: <https://doi.org/10.3390/su11195529>.

RUAN, L. – LIU, H. (2021): Environmental, Social, Governance Activities and Firm Performance: Evidence from China. Sustainability, *13*, No. 2, 767. DOI: <https://doi.org/10.3390/su13020767>.

SANDBERG, H. – ALNOOR, A. – TIBERIUS, V. (2023): Environmental, Social, and Governance Ratings and Financial Performance: Evidence from the European Food Industry. Business Strategy and the Environment, *32,* No. 4, pp. 2471 – 2489. DOI: <https://doi.org/10.1002/bse.3259>.

SUPRIYADI, T. – TERBUKA, U. (2021): Effect of Return on Assets (ROA), Return on Equity (ROE), and Net Profit Margin (NPM) on the Company's Value in Manufacturing Companies Listed on the Exchange Indonesia Securities Year 2016 – 2019. International Journal of Economics, Business and Management Research, *5*, No. 4, pp. 219 – 228. ISSN 2456-7760.

SWAMY, P. A. V. B. (1970): Efficient Inference in a Random Coefficient Regression Model. Econometrica, *38*, No. 2, 311. DOI: <https://doi.org/10.2307/1913012>.

TATOĞLU, F. (2013): İleri Panel Veri Analizi: Stata Uygulamalı. İstanbul: Beta Publications. ISBN 978-6052425947.

TING, I. W. K. – AZIZAN, N. A. – BHASKARAN, R. K. – SUKUMARAN, S. K. (2019): Corporate Social Performance and Firm Performance: Comparative Study Among Developed and Emerging Market Firms. Sustainability, *12*, No. 1, p. 26. DOI: <https://doi.org/10.3390/su12010026>.

WASIUZZAMAN, S. – IBRAHIM, S. A. – KAWI, F. (2022): Environmental, Social and Governance (ESG) Disclosure and Firm Performance: Does National Culture Matter? Meditari Accountancy Research, ahead-of-print. DOI: <https://doi.org/10.1108/MEDAR-06-2021-1356>.

YAVUZ, M. S. – TATLI, H. S. – BOZKURT, G. – ÖNGEL, G. (2025). Does ESG Performance Have an Impact on Financial Performance? Evidence from Turkey. Journal of Entrepreneurship, Management and Innovation, *21*, No. 1, pp. 24 – 42. DOI: <https://doi.org/10.7341/20252112>.

ZHENG, M. – FENG, G.-F. – JIANG, R.-A. – CHANG, C.-P. (2022): Does Environmental, Social, and Governance Performance Move Together with Corporate Green Innovation in China? Business Strategy and the Environment, pp. 1 – 10. DOI: <https://doi.org/10.1002/bse.3211>.