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Factors Affecting the Sustainability of Corporates in Polluting Sectors

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Abstract: Corporate sustainability performance is gaining ever greater importance. The negative impact of climate change is manifested through heavy air, water and soil pollution. Polluting sectors, as the major players, are characterized by large amounts of emissions, waste and consumption of resources, and therefore have a larger negative impact on the environment. Companies operating in polluting sectors are recognized globally as the main sources of greenhouse gas emissions; thus, their performance is widely debated. Despite their character, such companies strive for higher profitability, better financial performance and operational efficiency. However, higher financial resources create the potential for innovation investments in companies. It is widely accepted that research and experimental development (R&D) expenditures enable new business ideas, models, products, services, and processes. However, while pursuing sustainability targets, financial results could be directed towards sustainability performance. The purpose of this paper is to analyze how the financial and innovation results of companies in polluting sectors interact with sustainability performance scores. For it, we have identified three essential pillars of sustainability: environmental, governance, and social. Using ordinary least squares (OLS) regressions, models were developed for each pillar of sustainability, including corporate financial performance indicators and R&D expenditures. The obtained results provide the insights that a company operating in polluting sector size and turnover significantly interacts with all pillars of sustainability. However, we also found that the corporate debt ratio, earnings ratio, and current liquidity have a significant relation only with environmental and social sustainability indicators.

Keywords: polluting sectors; corporate financial results; R&D expenditure; ESG scores

Citation: Vaitiekuniene, R.; Sutiene, K.; Krusinskas, R. Factors Affecting the Sustainability of Corporates in Polluting Sectors. *Sustainability* **2024**, *16*, 8970. https://doi.org/10.3390/su16208970

Academic Editor: Gaetano della Corte

Received: 16 September 2024
Revised: 28 September 2024
Accepted: 14 October 2024
Published: 16 October 2024

1. Introduction

Industries that emit pollutants and waste use significant resources and degrade the environment, which are polluting sectors. Manufacturing, mining, transportation, construction and agriculture, and forestry and fishing are the polluting sectors. These sectors emit large amounts of greenhouse gases. Environmentally harmful gases (carbon dioxide (CO_2), nitrogen oxide (N_2O), and methane (CH_4)) impact negatively on climate change. Polluting sectors negatively affect public health and air quality, as industrial enterprises emit dangerous pollutants: nitrogen oxides (NOx), sulfur dioxide (SO_2), and particulate matter. Climate-sensitive sectors use large amounts of fossil fuels and water in their production processes, resulting in rapidly increasing carbon footprints, water scarcity, and pollution from wastewater discharges. Industrial enterprises that are polluting must aim to reduce emissions, environmentally harmful waste, and pollutants and improve resource use efficiency in their production activities. New or significantly improved products, services, processes, methods, and ideas represent the concept of innovation. Research and experimental development enable innovation. Innovations based on research and

experimental development in business operations can improve sustainability and financial performance [1] (Xu et al., 2020). Innovations aimed at improving sustainability are particularly important for companies in polluting sectors, as this type of company emits large amounts of environmentally harmful gases. This can be a key factor in polluting companies, leading to pollution reduction, resource saving, and more efficient energy use. Sustainable innovations in the activities of companies can be a complex solution for increasing market value, improving reputation, and protecting the environment [2] (Fosu et al., 2024), especially in polluting sectors. The use of renewable energy (solar, wind) in production processes, the use of electric vehicles in the transport sector, waste recycling, and water treatment can be essential sustainability steps in polluting companies. The expenditure allocated by these polluting companies for scientific research and experimental development can enable the realization of the goal of environmentally friendly production output. Innovative technologies and environmentally friendly processes can be one of the solutions in the polluting sector. First is the adaptation and improvement of solar, wind, water, and geothermal energy in polluting companies; second is replacing all fossil fuel vehicles with electric and hybrid vehicles; third is precise machining, lean production, and development of environmentally friendly chemicals and processes in polluting sectors; fourth is replacing traditional farming with organic farms. Finally, sustainable building materials should be integrated into construction processes, and construction waste should be recycled into new, durable parts through reuse. Polluting companies could achieve more environmentally friendly results by increasing research and experimental development expenditure for more sustainable solutions. This would enable better ESG (Environmental, Social, and Governance) scores. The environmental score measures a company's impact on the environment and evaluates the effectiveness of its environmental risk management [3]. The governance score reflects the quality of the company's management, structure, and shareholder rights. The social score assesses the effectiveness of a company's management relationships with employees, suppliers, customers, and communities [4]. Higher sustainability scores indicate a company's greater responsibility towards the environment, employees, suppliers, customers, communities, the board, shareholders, and investors. Therefore, companies aim for higher sustainability scores. However, risk factors hinder achieving the highest sustainability scores. Financial risk factors can be significant risks that need to be controlled. For example, stocks of companies with low sustainability (ESG scores) are significantly more sensitive to environmental, governance, and social composite changes [5]. Businesses' ability to generate sales and attract loyal customers depends on revenue streams. Effective cost management depends on managing raw materials, labor, and general and administrative costs. This determines the net income, which affects the company's development opportunities and the volume of assets. The acquisition of more sustainable assets requires considerable capital. Equity depends on the net income earned by the company. Excessive borrowed capital can cause additional risks to the company's operations. All this is a complex mechanism that requires more profound and more detailed scientific research. Therefore, the main objective of this research is to investigate how companies' financial and innovation results interact with sustainability scores (environmental, governance, and social) in companies in polluting sectors using ordinary least squares (OLS) regression models.

2. Literature Review

A set of environmental, social, and governance criteria is short for ESG. A set of ESG criteria helps to better assess the sustainability practices of each company, especially in polluting sectors. Companies have an interest in improving ESG indicators for competition, financial performance, and reputation. A firm's long-term competitiveness may depend on ESG indicators [6] (He et al., 2024). A company's market value in the long term may depend on ESG indicators as well [7] (Jo and Harjoto, 2011). Not only the companies themselves are interested in consistently monitoring changes in ESG indicators, but also investors, customers, creditors, and regulators [8] (Luo and Ye, 2024). Each pillar of sustainability

(environmental, social, and governance) is measured by scores. A company declares higher sustainability practices with higher sustainability scores. The environmental score evaluates aspects mainly related to the company's greenhouse gas emissions, waste management, use of resources, and use of renewable energy [9] (Kartal et al., 2024). The assessment and management of this aspect of the environment is particularly important for polluting sectors, as companies in this sector emit a lot of greenhouse gases and waste, and intensively use natural resources. The social sustainability score assesses how and to what extent the company is socially responsible towards customers, employees, creditors, regulators, and suppliers. The governance sustainability score assesses the company's governance policies, including honesty and transparency. Evaluating and managing these social and governance aspects is important for every company.

The issue of sustainability is no longer a new topic, but it is as relevant as ever since millennials, as a new generation, are particularly interested in ESG topics [10]. Pollution emissions are influenced by various factors [11], such as the use of technology or energy consumption [12]. The issue of sustainability involves many problem areas. However, it is not just about protecting the environment. This issue affects social well-being, economic benefits, and corporate and global responsibility. As the demands for green economic growth increase, companies need to adapt their business models and development strategies, and public authorities must also dedicate more attention to the ecological environment [13]. Environmental, Governance, and Social (ESG) scores measure the sustainability performance of companies. The implementation of reducing greenhouse gas emissions includes an environmental dimension. The governance score comprises the independent board of shareholders of the company, implementation of the corruption prevention mechanism, and transparency of financial and sustainability reporting. A significant positive impact of the company's activities on the community, transparent marketing, and responsibility towards employees and their protection means a social score. Different criteria comprise the methodology for calculating companies' sustainability scores. Depending on the specifics of the agencies (Global Reporting Initiative (GRI), Task Force on Climate-related Financial Disclosures (TCFD), and Carbon Disclosure Project (CDP)), this methodology may differ. However, the essential criteria are the same, so analysts' ESG experience is significant when interpreting the information provided in companies' ESG reports [14,15]. The essential criteria can be the amount of emissions, the intensity of emissions, energy and water consumption, the management system's efficiency, and the board's activities and implementation of social initiatives. Sustainability assessment models are important tools that enable the evaluation of a company's sustainability indicators, showing the company's weaknesses and strengths in order to improve its sustainability practices. There are various sustainability assessment models. One of the sustainability assessment models is the Sustainability Balanced Scorecard [16] (Chehimi and Naro, 2024). This model enables us to combine the assessment of the company's sustainability goals and business strategy. Also, the Corporate Sustainability Reporting and ESG systems as an integrated sustainability assessment model can be applied in corporate activities [17,18] (Ortiz-Martínez et al., 2023; Sun et al., 2024). This model includes a comprehensive assessment of the company's sustainability reports and ESG indicators. Multi-criteria decision analysis can be applied as a sustainability assessment model [19] (Elavarasan et al., 2024). This model can combine different sustainability, financial, and strategic business indicators, giving different weights between the variables. ESG sustainability scoring as a sustainability assessment model was applied in this research. Many entities interested in monitoring the performance of companies (creditors, investors, suppliers, customers, potential employees, regulatory authorities) use sustainability scores as an evaluation and comparison tool. Joint stock companies increasingly disclose financial statements and sustainability results [20]. However, companies are more interested in publishing sustainability reports in different countries when they are under more pressure [21]. On the other hand, this requires strict scrutiny and regulation of corporate social responsibility contracting, especially where there is weaker investor protection and less transparency in disclosure [22]. Process control as a

policy influencer tool has a greater impact on environmental aspects [23]. Therefore, policy recommendations and guidelines on environmental issues (especially the policy of greener innovations and the complex system of environmental taxes) are significant for companies to make decisions [24,25]. As the authors [26] aptly stated, ESG scores are a "soft power" that shapes the image of a company's brand, but at the same time, these scores are "hard criteria" that promote the company's long-term promotion. Policymakers should guide better sustainability reporting to avoid corporate bias and information manipulation [18]. Higher sustainability scores are an aspiration for companies. Innovation can improve these environmental, governance, and social scores [27,28]. A significant positive relationship exists between the firm's technological innovation [29]. The output of scientific research and experimental activities can reflect the benefits of innovation. Research and testing on integrating better sustainability practices regarding reducing resource consumption, recycling materials, and using renewable resources in companies' operations can improve the results of sustainability activities. Companies in polluting sectors need measures to increase sustainability by implementing scientific research and experimental development to create cleaner and more sustainable innovations. The most polluting sectors can be classified as Manufacturing, Mining, Transportation, Construction and Agriculture, Forestry, and Fishing companies, as these firms emit the most greenhouse gases, pollute the air, water, and soil, and emit pollutants, thus harming the environment and society. Various measures are being tried in polluting sectors, promoting a more intensive transition towards sustainability, such as greener harvesting practices in the agricultural sector or using renewable energy in the transport sector [30]. Green transport based on renewable energy could be an excellent tool for achieving carbon neutrality [31]. The authors [32] distinguish that it is difficult to combine sustainability goals and efficiency results in the agricultural sector, which makes this sector vulnerable. Industrial intelligence, as the application of advanced technologies and data analysis in the activities of companies, can be a new way to move towards sustainability and promote transformation in industrial sectors [33]. The environmental performance of companies in manufacturing sectors can be improved by integrating transformational leadership into their operations. Integrating a green organizational culture can be an effective tool [34]. Investments in environmental protection have a significant impact on the productivity of companies [35]. To achieve higher sustainability results, companies face risk factors [36], such as financial risk [37–39]. Financial risk refers to financial opportunities or constraints to develop research and experimental development for more sustainable and green innovations. Financial constraints hinder the development of innovative activities, although companies' strategic goals are to achieve the highest sustainability scores. Wasting financial resources and taking the wrong sustainability path can lead to problems with the company's stability [40]. The issue of environmental protection has been of particular concern recently due to many aspects, such as excessive negative climate change and its catastrophic consequences. Economic and financial issues are relevant at all times, as companies must survive, compete, and adapt to rapidly changing market conditions. For these reasons, research may analyze economic and environmental issues more than social ones. Honest company operations and the full disclosure of performance results mean corporate transparency. Performance disclosure primarily involves providing transparent financial statements to all stakeholders equally; regardless of whether they are owners, employees, creditors, suppliers, customers or regulators, they are interested in the balance sheet, profit (loss) or cash flow statement. The existence of independent committees can significantly contribute to the transparency and disclosure of operational information of companies [41] (DeBoskey et al., 2018). However, not only the disclosure of information on the financial condition, but also the transparent opening of sustainability reports should be an obvious strategic decision. Independent auditors, professionalism, and procedural transparency improve disclosure [42] (Wang and Zeng, 2024). Sustainable and clean innovation costs the company. This requires the company to use itss own as well as borrowed funds. Implementation of innovations is also a risky activity, and not necessarily profitable. During the innovation implementation stage, the company may face

financial problems. Financial problems can lead to non-transparency of information in the financial statements. A company's desire to appear more sustainable and green can also lead to non-transparent information in sustainability reports. Therefore, complex and transparent disclosure of performance results is particularly significant in the activities of companies.

3. Methodology

The aim is to investigate how companies' financial and innovation results interact with ESG scores in polluting sector companies. This aim is formed based on the research questions according to the conducted literature review.

H1: *Financial activities have a significant impact on environmental, governance, and social sustainability scores (ESG pillar scores) of polluting companies.*

H2: *Innovation activities have a significant impact on polluting companies' environmental, governance, and social sustainability scores (ESG pillar scores).*

H3: *Financial activities, interacting with innovation activities, have a more significant impact on polluting companies' environmental, governance, and social sustainability scores (ESG pillar scores).*

In total, we collected 28,001 observations from 2790 joint stock companies in polluting sectors (Manufacturing (64.5%), Mining (15.5%), Transportation (13.0%), Construction (6.0%), and Agriculture, Forestry, and Fishing (1.0%)) over the past 12 years before the start of the pandemic from Bloomberg, Orbis, and Thomson Reuters databases. Depletion of natural resources, emissions of greenhouse gases, and negative climate change distinguish polluting sectors from other sectors of the economy. The manufacturing and industrial sector is one of the sectors of the economy that consumes the most energy and emits harmful gases and industrial waste in production processes. The mining sector is classified as a polluting sector, as it negatively affects water sources and soils, and negatively changes the earth's ecosystem. The transport sector uses a particularly large amount of petrol, diesel, and gas, which leads to large sources of emissions. The construction sector consumes a lot of water, energy, and wood in construction processes and leaves a lot of waste. The agriculture, forestry, and fishing sector is also polluting, as agriculture uses fertilizers and pesticides, and forestry and fishing contribute to unnatural climate change. The strong negative impact on the environment led to these sectors being classified as polluting sectors in this study. Data were collected from the continents of America (43%), Europe (24%), Asia (23%), Oceania (8%), and Africa (2%). Financial ratios and research and development expenditures are independent variables. Sustainability pillar scores (environmental, governance, and social) are dependent variables. Descriptions of these indicators, along with formulas, are in Table 1. The independent and dependent variables were selected based on the research's systematic findings and recommendations. By developing ordinary least squares regression models, we aim to answer the central question of how the financial indicators of companies in polluting sectors, together with the expenditure of scientific research and experimental development, interact with the scores of the sustainability pillars. Ordinary Least Squares (OLS) regression models are applied to estimate coefficients in linear regression equations in research on the interaction between financial results and sustainability pillar scores.

The financial results of the companies' activities are evaluated in different aspects. The evaluation approach depends on interest. Corporate shareholders seek regularly growing dividends. Company managers are interested in business development. Company employees seek rising wages. Creditors care about the creditworthiness of companies. Customers are interested in quality products at an attractive price. Regulators are concerned with the transparency of financial reporting. In order to reconcile different interests and to depict the financial condition as fully as possible, seven financial indicators were included in this study (size, debt ratio, return on equity, earnings ratio, current liquidity, turnover, and Tobin q ratio). On the other hand, research and experimental development is also an important

goal to be achieved in the activities of companies. This forms the basis for innovation. New products, processes, and services based on scientific research and experimental development can enable companies to develop and maintain competitiveness, and increase value. Measures of innovation performance can include return on investment, idea creation rate, time to market, customer satisfaction index, and research and experimental development. In order to reveal how much research and experimental development is spent on one unit of assets, the CRD indicator was chosen (the company's research and experimental development expenses divided by total assets). Only one indicator of innovative activity was included, so it can be a limitation of this research, encouraging the inclusion of more indicators from innovative activity in other studies.

Table 1. Description of the variables [based on [40,43,44]].

Corporate Pillars of Activities	Ratios	Formulas
Financial activity	Corporate size (CS)	ln (total assets)
	Corporate debt ratio (CDR)	((total long-term debt + total short-term debt)/total assets)
	Corporate return on equity (CRE)	(total net income/total common equity)
	Corporate earnings ratio (CER)	(total returned earnings/total assets)
	Corporate current liquidity ratio (CCL)	(total current assets/total current liabilities)
	Corporate turnover (CT)	(total sales/total assets)
	Corporate Tobin q ratio (CTR)	((total assets + (market capitalization × 1000) – total common equity))/total assets
Innovation activity	Research and development expenditures (CRD)	Corporate R&D expenditures/total assets
Environmental activity *	Environmental pillar score (CEPS)	a relative sum of the category of environmental protection weights
Governance activity *	Governance pillar score (CGPS)	a relative sum of the category of corporate governance weights
Social activity *	Social pillar score (CSPS)	a relative sum of the category of social responsibility weights

* dependent variable.

Ordinary Least Squares (OLS) regression models are created using the formulas below (see Formulas (1)–(6)). The developed regression models evaluate the interaction of financial ratios and the research and experimental development expenditure of companies in polluting sectors with the scores of the sustainability pillars (environmental, governance, and social). We created two regression models for each pillar of sustainability, a total of six regression models.

Model 1 evaluates the interaction of financial ratios with each pillar of sustainability (first with the environmental pillar score ($CEPS_{it(M1)}$), second with the governance pillar score ($CGPS_{it(M1)}$), and third with the social pillar score ($CSPS_{it(M1)}$)) in polluting sector companies. In contrast to Model 1, Model 2 estimates the interaction of financial ratios, research, and experimental development expenditure with the identical sustainability pillar scores of companies in polluting sectors (for environmental pillar score ($CEPS_{it(M2)}$), for governance pillar score ($CGPS_{it(M2)}$), for social pillar score ($CSPS_{it(M2)}$)).

$$CEPS_{it(M1)} = a + \beta_1 CS_{it} + \beta_2 CDR_{it} + \beta_3 CRE_{it} + \beta_4 CER_{it} + \beta_5 CCL_{it} + \beta_6 CT_{it} + \beta_7 CTR_{it} + \sum Country\ F.E. + \sum Industry\ F.E. + \sum Year\ F.E. + u_{it} \quad (1)$$

$$CEPS_{it(M2)} = a + \beta_1 CS_{it} + \beta_2 CDR_{it} + \beta_3 CRE_{it} + \beta_4 CER_{it} + \beta_5 CCL_{it} + \beta_6 CT_{it} + \beta_7 CTR_{it} + \beta_8 CRD_{it} + \sum Country\ F.E. + \sum Industry\ F.E. + \sum Year\ F.E. + u_{it} \quad (2)$$

$$CGPS_{it(M1)} = a + \beta_1 CS_{it} + \beta_2 CDR_{it} + \beta_3 CRE_{it} + \beta_4 CER_{it} + \beta_5 CCL_{it} + \beta_6 CT_{it} + \beta_7 CTR_{it} + \sum Country\ F.E. + \sum Industry\ F.E. + \sum Year\ F.E. + u_{it} \quad (3)$$

$$CGPS_{it(M2)} = a + \beta_1 CS_{it} + \beta_2 CDR_{it} + \beta_3 CRE_{it} + \beta_4 CER_{it} + \beta_5 CCL_{it} + \beta_6 CT_{it} + \beta_7 CTR_{it} + \beta_8 CRD_{it} + \sum Country\ F.E. + \sum Industry\ F.E. + \sum Year\ F.E. + u_{it} \quad (4)$$

$$CSPS_{it(M1)} = a + \beta_1 CS_{it} + \beta_2 CDR_{it} + \beta_3 CRE_{it} + \beta_4 CER_{it} + \beta_5 CCL_{it} + \beta_6 CT_{it} + \beta_7 CTR_{it} + \sum Country\ F.E. + \sum Industry\ F.E. + \sum Year\ F.E. + u_{it} \quad (5)$$

$$CSPS_{it(M2)} = a + \beta_1 CS_{it} + \beta_2 CDR_{it} + \beta_3 CRE_{it} + \beta_4 CER_{it} + \beta_5 CCL_{it} + \beta_6 CT_{it} + \beta_7 CTR_{it} + \beta_8 CRD_{it} + \sum Country\ F.E. + \sum Industry\ F.E. + \sum Year\ F.E. + u_{it} \quad (6)$$

where:

- CS is the corporate size;
- CDR is the corporate debt ratio;
- CRE is the corporate return on equity;
- CER is the corporate earnings ratio;
- CCL is the corporate current liquidity ratio;
- CT is the corporate turnover;
- CTR is the corporate Tobin q ratio;
- CRD is the research and development expenditures ratio;
- CEPS is the environmental pillar score;
- CGPS is the governance pillar score;
- CSPS is a social pillar score.

Here, '*i*' indicates selected countries, '*t*' indicates the period, and 'u_{it}' is a random disturbance term assumed to have zero means, homoscedastic and mutually uncorrelated at a time 't'.

A statistical description of all variables is provided (see Table 2).

Table 2. Statistical description.

Variable	N	Mean	p50	Standard Deviation	Min	Max
Corporate size	28,001	37.53	36.35	28.50	0.00	98.25
Corporate debt ratio	28,001	49.46	49.60	22.50	0.10	98.74
Corporate return on equity	28,001	44.30	41.96	24.22	0.19	98.94
Corporate earnings ratio	28,001	14.96	15.00	1.69	9.22	18.66
Corporate current liquidity ratio	28,001	0.25	0.24	0.18	0.00	0.94
Corporate turnover	28,001	0.14	0.16	0.49	−2.49	2.41
Corporate Tobin q ratio	28,001	0.05	0.23	0.94	−7.31	0.97
Corporate research and development	28,001	2.39	1.66	2.69	0.27	22.29
Environment pillar score	28,001	0.77	0.71	0.48	0.00	2.66
Governance pillar score	28,001	1.91	1.42	1.53	0.51	10.78
Social pillar score	28,001	0.03	0.00	0.07	0.00	1.00

A Breusch–Pagan/Cook–Weisberg test and a Hausman test were evaluated in this research. The null hypothesis of the Breusch–Pagan/Cook–Weisberg test was rejected (the chi-square test statistic was statistically significant at the 1 percentage level). All regression models created include standard errors of the estimated regression coefficients in parentheses. Standard errors are robust to heteroscedasticity. These errors are clustered at the corporate level. The null hypothesis of the Hausman test was rejected. This Hausman test proved that fixed effects are necessary for regression models. The developed regression models included state, year, and industry fixed effects (see Formulas (1)–(6)). Year fixed effects were included, as variation in sustainability scores may be small across years.

4. Results

The obtained results (see Table 3) based on ordinary least squares regression models allowed us to answer the main research question of how the financial results in polluting sectors are compatible with sustainability challenges. According to the research results, the financial ratios of companies in polluting sectors interact with sustainability scores. However, not all selected financial ratios have a significant relationship with es-

sential sustainability scores. Corporate size and turnover significantly positively affect all three sustainability pillar scores: environmental, governance, and social (see Model 1a,c,e). Otherwise, corporate size and turnover interact with research and development expenditure to have a more significant positive effect on all three pillars of sustainability (see Model 2b,d,f). Traditional assets of companies in polluting sectors include buildings, machinery, equipment, vehicles, land, inventory, intellectual property, brand reputation, cash, investments, and financial instruments. The growth of these assets (for example, cash and cash equivalents or returns on financial instruments) and revenue give the company more significant financial opportunities in implementing sustainability. Financial resources, together with the output of scientific research and experimental development, can become significant results in implementing sustainability. The more intensive integration of wind turbines, geothermal systems, and solar collectors in the activities of companies in polluting sectors enables a higher environmental pillar score. Improving the well-being and productivity of employees as well as a fair wage system and safe working conditions enable the growth of the social pillar score. More transparent disclosure of financial and non-financial information, a more diverse and independent board, and more effective asset management in polluting sectors enable a higher score on the corporate governance pillar. Implementation of these sustainability practices requires financial resources, research, and experimental development. Therefore, corporate size, turnover, and research and experimental development expenditures improve scores on environmental, governance, and social sustainability pillars.

Table 3. Fitted ordinary least squares (OLS) models by sustainability pillars scores.

	Environment Pillar Score ****		**Governance Pillar Score ******		**Social Pillar Score ******	
	Model 1a	**Model 2b**	**Model 1c**	**Model 2d**	**Model 1e**	**Model 2f**
Corporate size	11.692 *** [0.250]	11.693 *** [0.250]	5.940 *** [0.251]	5.941 *** [0.251]	9.739 *** [0.215]	9.743 *** [0.215]
Corporate debt ratio	−5.464 *** [1.750]	−5.067 *** [1.766]	−3.296 * [1.750]	−2.944 * [1.766]	−5.774 *** [1.604]	−4.395 *** [1.622]
Corporate return on equity	1.007 ** [0.399]	1.075 *** [0.402]	−0.089 [0.385]	−0.029 [0.386]	0.420 [0.349]	0.655 * [0.351]
Corporate earnings ratio	−2.146 *** [0.300]	−1.884 *** [0.346]	−0.076 [0.328]	0.157 [0.387]	−2.684 *** [0.291]	−1.773 *** [0.331]
Corporate current liquidity ratio	−0.299 *** [0.102]	−0.293 *** [0.102]	−0.047 [0.115]	−0.042 [0.115]	−0.119 [0.088]	−0.100 [0.088]
Corporate turnover	7.151 *** [0.779]	7.261 *** [0.786]	4.910 *** [0.763]	5.008 *** [0.769]	4.501 *** [0.677]	4.883 *** [0.681]
Corporate Tobin q ratio	0.766 *** [0.190]	0.700 *** [0.194]	0.076 [0.195]	0.018 [0.197]	1.174 *** [0.189]	0.945 *** [0.193]
Corporate research and development		7.146 * [3.966]		6.343 [4.537]		24.830 *** [4.290]
Constant	−144.886 *** [7.328]	−145.127 *** [7.336]	−50.551 *** [6.658]	−50.765 *** [6.658]	−123.462 *** [6.550]	−124.300 *** [6.548]
Adjusted R-squared	0.542	0.542	0.172	0.172	0.479	0.482
Observations	28,001	28,001	28,001	28,001	28,001	28,001

Standard errors reported in brackets under the estimated coefficients are robust for heteroscedasticity and clustered at the corporate level. *** Estimated probability p is less than a significance level of 0.01 (1%); ** Estimated probability p is less than a significance level of 0.05 (5%); * Estimated probability p is less than a significance level of 0.1 (10%). **** dependent variable.

Growing corporate size, return on common equity, and the Tobin q indicator in interaction with research and experimental development expenditure significantly increase the environmental sustainability score of companies in polluting sectors. The governance sustainability score increases depending on corporate size and turnover in interaction with research and experimental development expenditure. A higher social sustainability score depends on growing corporate size, turnover, Tobin q ratio, and research and experimental development expenditure. The results showed no significant relationship between the

return on equity and the governance score. Again, no relationship was found between the earnings ratio and the same governance score. Regarding current liquidity, Tobin's q ratio did not interact with the governance pillar. The explanation may be that improving governance sustainability requires qualitative soft corporate solutions.

5. Discussion

The problem of sustainability covers many areas: waste of resources, damage to ecosystems, pollution of air, water, and soil, much non-recyclable waste, economic imbalance, and the consequent deterioration in human health. Humans, corporations, and governments are responsible for solving sustainability issues. The European Commission has decided to act on more ambitious plans than ever. Its goal is to make the entire European continent climate-neutral by 2050. However, the world will not become climate-neutral if other continents do not pursue the same goals. In the pursuit of these goals, the functioning of corporations plays an important role. There is an increased focus on those corporations that contribute the most to adverse climate change. Now more than ever, it is essential for companies in polluting sectors to include strategic sustainability goals. The pursuit of profit must be balanced with sustainability goals. However, poor financial results of corporates will prevent the implementation of long-term sustainability goals.

On the other hand, poor sustainability indicators may prevent better financial results. This discussion question—whether financial performance significantly impacts sustainability indicators or vice versa—affects the endogeneity problem [18], an essential challenging issue. Considering the problematic issue, the endogeneity problem, and the systematized scientific literature, like other authors [18] we provide international evidence from the polluting sector (Manufacturing, Mining, Transportation, Construction and Agriculture, Forestry and Fishing) corporations operating in the continents of Europe, America, Asia, and Oceania. Based on the developed ordinary least squares (OLS) regression models, we provide reliable international evidence that the financial results of polluting corporations significantly affect the sustainability pillar scores. We also indicate that financial results combined with innovation indicators have a more substantial impact on sustainability scores. Companies strive to survive in a competitive, rapidly changing environment. This requires thoughtful strategic decisions in the long term. Strategic decisions lead to changes based on innovation. Innovation should be the output of research and experimental development. Scientific research and experimental development require the company's own and borrowed financial resources. In the process of implementing innovations, the company faces many risk factors and the end result is not always successful. However, proper risk management can lead to great results. Successfully implemented sustainability innovations can also lead to better financial results. Financial performance is crucial for every company. Sustainability results should be important for every company, especially in polluting sectors due to dangerous climate change. Therefore, particularly polluting companies must strive to balance financial performance and clean innovation activities to contribute to increasing sustainability.

6. Conclusions

The research questions raised were answered. Financial and innovative activities have a significant impact on the environmental, management, and social sustainability scores of polluting companies. The interaction between financial and innovative activities has a more significant influence on the sustainability pillar scores in polluting companies. The obtained results confirmed the conclusions of other authors. Companies in polluting sectors must definitely aim to contribute to the preservation of nature, as the effects of production harm the environment and the climate. Polluting sectors emit large amounts of carbon dioxide, hazardous pollutants, and toxic waste, damaging the environment and harming society and human health. Among the most polluting sectors are Manufacturing, Mining, Transportation, Construction and Agriculture, and Forestry and Fishing corporations, which are the most harmful to the environment and human health. Companies in these sectors

most need transformation towards more sustainable and greener operations. However, transformation requires changes in the company and is associated with many risk factors. On the other hand, it is an inevitable process on the way to sustainability. Therefore, the results of this research, based on collected data from polluting sector corporations from the continents of the world and created regression models, indicate that financial results, innovation activities, and sustainability scores interact with each other. Corporation size and corporate turnover positively affect all pillars of sustainability. Combined with research and experimental expenditure, these financial results can give polluting companies the best of all three sustainability scores. A corporate Tobin q can significantly positively affect environmental and social scores. A corporate return on equity also has a positive and significant effect on the environmental and social scores, especially the environmental score. In interaction with the output of innovative activities, this financial indicator can have the most significant positive impact on environmental and social scores. Irresponsible corporate borrowing can harm sustainability scores, primarily environmental and social. An unbalanced corporate current liquidity can hurt the environmental score. An unbalanced corporate earnings-to-assets ratio can harm environmental and social scores. The innovative activity of the corporation without financial indicators does not have such a significant impact when combined with financial results. Based on the final results, the interaction between the financial results, innovative activities, and sustainability scores in polluting corporations is complex and affected by endogeneity. However, those companies that combine size, turnover, and return, take risks due to research and experimentation, and measure debt and liquidity will achieve the best sustainability scores. A combination of indicators in the polluting sectors is essential to improve environmental and social scores, as these areas require more significant financial resources and, at the same time, cause additional risks. Directing their own and borrowed financial resources to more sustainable and cleaner innovations based on scientific research and experimental development could be one of the solutions in the polluting sectors.

7. Limitations and Future Research Directions

This research on the interaction of financial indicators and innovative performance of joint stock companies in polluting sectors with sustainability pillar scores has limitations. One of the most significant limitations is the research sample. A total of 28,001 observations were collected and included in the regression models using the Bloomberg, Orbis, and Thomson Reuters databases. The second limitation of the research is the identification of polluting sectors. We distinguished and included in the study five polluting sectors: Manufacturing, Mining, Transportation, Construction and Agriculture, Forestry, and Fishing. A third limitation of the study is the selection of variables. We included seven financial indicators and one innovation performance indicator as independent variables. We examined sustainability (environmental, governance, and social) scores as dependent variables, according to the results obtained and the existing limitations of the research. Considering the endogeneity problem, we recommend further research by including more detailed company indicators showing the change in sustainability pillars (environmental, governance, and social) and in the regression models. We also recommend that companies include financial, innovation, and sustainability indicators in their strategic goals. However, we further recommend that companies remember to evaluate the weights of individual indicators to achieve the highest efficiency of the company's operations by harmonizing financial aspirations and sustainability goals.

Author Contributions: Conceptualization, R.V., K.S. and R.K.; methodology, R.V., K.S. and R.K.; software, R.V., K.S. and R.K.; validation, R.V., K.S. and R.K.; formal analysis, R.V., K.S. and R.K.; investigation, R.V., K.S. and R.K.; resources, R.V., K.S. and R.K.; data curation, R.V., K.S. and R.K.; writing—original draft preparation, R.V., K.S. and R.K.; writing—review and editing, R.V., K.S. and R.K.; visualization, R.V., K.S. and R.K.; supervision, R.V., K.S. and R.K.; project administration, R.V., K.S. and R.K.; funding acquisition, R.V., K.S. and R.K. All authors have read and agreed to the published version of the manuscript.

Funding: This research received funding from the Research Council of Lithuania (LMTLT), agreement No S-PD-22-23.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The original contributions presented in the study are included in the article, further inquiries can be directed to the corresponding author.

Conflicts of Interest: The authors declare no conflicts of interest.

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