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Environmental Certifications as Strategic Assets? Evidence from Italian Chemical and Pharmaceutical Firms

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Abstract

Environmental sustainability reporting is increasingly adopted by firms, yet its actual impact on economic performance remains unclear, raising the question of whether such disclosures represent genuine strategic resources or merely symbolic practices. This study examines the relationship between environmental disclosure and economic performance, in the Italian chemical and pharmaceutical industries. Adopting the Resource-Based View (RBV), we evaluate the effectiveness of certified environmental practices as strategic assets that can enhance firm performance. We utilized an AI-based content analysis of financial reports from non-listed, non-SME Italian chemical and pharmaceutical companies between 2012 and 2020 to determine the level of firms' generic environmental disclosures (without third-party verification) and on specific environmental certifications. We then examine the relationship between economic performance and the type of environmental disclosure observed. Using financial data at the firm level as moderators, we found that generic environmental disclosures have no significant impact on economic performance. In contrast, disclosures on environmental certifications are positively associated with higher economic performance in the chemical sector. Certifications may provide a competitive advantage in environmentally intensive sectors but appear to be less relevant in innovation-driven sectors such as the pharmaceutical industry. Our findings emphasize the strategic value of reliable, externally validated environmental practices, and highlight the limitations of symbolic disclosure.

Keywords: environmental disclosure; pharmaceutical industry; chemical industry; sustainability reporting; AI-based content analysis; environmental certifications

JEL Classification: M14; M41; Q56

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1. Introduction

As the effects of climate change, resource depletion, and ecosystem degradation intensify, stakeholders are pressuring companies to take proactive steps to mitigate their environmental footprint (Shrivastava, 1995; Szabo & Webster, 2021). In this regard, firms are engaging in environmental disclosure practices to demonstrate their commitment to sustainability and build trust with their stakeholders (Brown et al., 2009; Morrow & Rondinelli, 2002).

Originally, non-financial disclosure was voluntary in both its application and reporting methods. However, regulators are increasingly mandating that companies provide transparent and comparable data concerning their initiatives to curb carbon emissions (Venturelli

et al., 2019; Lombardi et al., 2021; Wang et al., 2024). In particular, the lack of standardized methods for sustainability reporting has been recently addressed with changes at both the regulatory level (e.g., European Directive 2022/2464) and the accounting level (e.g., IFRS Sustainability Disclosure Standards).

Environmental reporting is therefore becoming one of the relevant duties that firms must fulfill, as they can be held accountable for their environmental impacts in front of their stakeholders. However, current disclosure practices are widely recognized as inadequate and inconsistent (Darnall et al., 2022; Korca et al., 2021), and their effectiveness and strategic value are still being debated, particularly across different industrial settings. The reliability of ESG ratings (Berg et al., 2022; Dimson et al., 2020) and the quality of ESG reporting (Arvidsson & Dumay, 2022) are currently a matter of concern, hampering trust toward the sustainable transformation aimed to foster a safer environment for future generations.

In such circumstances, using the interpretive lenses of the Resource-Based View (Barney, 1991), voluntary environmental certifications currently represent pragmatic means that not only convey sustainability efforts, but also indicate the development of strategic resources coherent with stakeholders' expectations. Environmental certifications—such as ISO 14001 and EMAS—can indeed be interpreted as valuable organizational resources helping firms to achieve a competitive advantage. In other words, by integrating sustainability into their operational practices, firms are likely to enhance their capabilities and differentiate themselves in increasingly environmentally-conscious markets. This is expected to improve firms' economic performances.

In this study, we assess whether certified companies perform better economically compared to their non-certified peers in the Italian chemical and pharmaceutical industries. Results indicate that environmental certifications are associated to enhanced economic performance in the chemical sector, however, this correlation is not evident in the pharmaceutical industry. Following the RBV, this outcome can be interpreted as evidence that the efficacy of sustainability certifications as strategical assets is context-dependent. Specifically, the relationship between environmental certification and economic performance might vary according to sector-specific characteristics (e.g., production processes, regulatory pressures and consumers' expectations). For example, environmental certification might be a more valuable asset for companies operating in sector where innovation is less disruptive.

In the next section, we discuss the conceptual framework behind our research questions. In the Section 3, we outline the empirical strategy followed, which consisted of two phases: (a) an AI-based content analysis was conducted to measure the level of environmental disclosure in the financial reports of each of the firms under observation; (b) multivariate regression models aimed to test if the degree of environmental sustainability disclosure is associated with firms' profitability. Section 4 shows the results of the two mentioned phases, Section 5 provides a brief discussion of results and Section 6 concludes the article suggesting future research avenues.

2. Literature Review

2.1. ESG Disclosure and Business Performance

The academic interest in ESG (Environmental, Social, and Governance) disclosure has recently intensified, and researchers are often investigating on non-financial information for evaluating corporate performance and accountability (Dimes & Molinari, 2024). In particular, this article focuses on the Environmental pillar of the ESG framework.

A broad stream of literature has explored how financial variables, such as firm turnover/size and profitability, influence the extent of CSR and ESG disclosure practices. For instance, while larger companies may be better equipped to handle stakeholder pressure (Meznar & Nigh, 1995), most studies in this field have found a positive relationship

between firm size and voluntary CSR/ESG disclosure (Eilbirt & Parket, 1973; Wallace & Naser, 1995; Gao et al., 2005; Chiu & Wang, 2015; Duran & Rodrigo, 2018; Abdul Rahman & Alsayegh, 2021). Regarding profitability, high-performing firms are generally expected to engage more actively in sustainability disclosure, since management might want to justify financial results and support higher compensation schemes. Moreover, political process theory suggests that firms with higher profits seek social legitimacy by disclosing more non-financial information (Inchausti, 1997). Consistently, numerous studies identified a positive correlation between profitability and the extent of ESG disclosure (Lapinskienė & Tvaronavičienė, 2012; Tarmuji et al., 2016; Sharma et al., 2020).

Our study investigates the relationship between environmental disclosure and corporate profitability, expecting a positive one. This interpretive approach relies on the notion of strategic value of sustainability actions. Drawing on the RBV (Barney, 1991), we explore the idea that environmental sustainability can represent a strategic resource. According to the RBV (Barney, 1991), firms achieve superior performance by developing and leveraging valuable, rare, inimitable, and non-substitutable resources. Indeed, Lev (2017) argued that necessary condition for an organization's commitment to ESG/sustainability is to achieve competitive advantage, enabling the firm to survive and create value in a competitive environment.

However, we adopted a pragmatic distinction between the generic notion of "environmental disclosure" and the one regarding certifications based on internationally recognized environmental norms. The former concerns any form of disclosure about environmental information regarding the business, while the latter regards disclosures on specific aspects the business that external authoritative institutions consider "evidence" of relevant practice oriented toward environmental sustainability. The distinction is intended to discriminate suspected facade responses to stakeholders' pressure from (likely) true actions regarding business operations. The distinction is important because, aligned with Bari et al. (2022) and Bataineh et al. (2024), we argue that integrating sustainability into operational practices likely enhances firms' capabilities, support differentiation, and contributes to a sustained competitive advantage.

Therefore, we interpreted environmental certifications such as ISO 14001 or EMAS as strategic resources, as they can enhance both internal capabilities (e.g., process efficiency), and external legitimacy (e.g., stakeholder trust). According to the RBV, we expect that firms conforming their business processes to environmental certifications show better financial performances.

2.2. Research Gap

Despite the growing literature on ESG disclosure and corporate performance, relatively little attention has been devoted to distinguishing between generic environmental reporting and externally validated certifications. Recent studies emphasize concerns about disclosure credibility and potential greenwashing (Free et al., 2024; Battisti et al., 2025), yet evidence on whether certifications function as substantive strategic resources remains limited. Moreover, few works (e.g., Hervas-Oliver et al., 2024; Lajmi & Shiri, 2025) have analyzed this distinction within environmentally intensive industries such as chemicals, or compared it to innovation-driven contexts such as pharmaceuticals. This study addresses these gaps by employing AI-based content analysis of corporate reports and assessing how certifications and generic disclosures are associated with firm performance in two contrasting industrial settings.

Hypothesis 1. *Firms with environmental certifications outperform their non-certified counterparts in terms of economic performance.*

2.3. Industry Focus: Chemical and Pharmaceutical Context

The benefits of a strategic asset may vary across sector-specific contexts and regulatory environments. Therefore, we focused on a relatively uniform group of firms: (a) non-listed companies and non-SMEs; (b) businesses based on chemical operations. The first inclusion criterion aims to select firms subject to the same financial reporting rules. The second criterion aims to consider business substantially similar for types of production processes; in particular, we selected the chemical and the pharmaceutical industry. The similarity of production processes is associated with a similarity in environmental risks, but the two industries differ significantly in terms of targeted markets, customer sensitivity and political/social salience. In this section, we provide a brief overview of the environmental challenges and regulatory responses of the two industries analyzed.

The chemical industry supplies essential materials and solutions across numerous sectors, from agriculture and manufacturing to consumer goods and energy. However, since chemical production is often energy-intensive, reliant on fossil-based inputs, and associated with the emission of hazardous substances and the generation of persistent waste, increasing attention is being paid to its environmental impacts (OECD, 2019).

The European Union has long established legislative frameworks such as Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH—Regulation (EC) No 1907/2006) and the Industrial Emissions Directive (IED—Directive 2010/75/EU), aimed at controlling chemical risks and pollution. These regulations promote transparency and safety in the production and use of chemical substances.

The pharmaceutical industry is an evolution of the chemical industry (Malerba & Orsenigo, 2015). While the pharmaceuticals companies are major actors in the healthcare sector, essential to improving human health and the overall quality of life, there is growing awareness of the significant environmental impacts they generate (Belkhir & Elmeligi, 2019). Compared to other chemical companies, pharmaceutical manufacturing is particularly known for its substantial generation of waste and by-products and its relatively poor efficiency in managing carbon emissions (Cue & Zhang, 2009). Furthermore, the environmental impacts of pharmaceutical activities extend throughout the life cycle of pharmaceuticals, with residues contaminating water bodies after consumption (Kümmerer, 2010).

EU legislation has been in place for several years, covering various stages of the pharmaceutical life cycle, particularly manufacturing and disposal. These norms, such as REACH and Good Manufacturing Practices (GMP—Directive 2003/94/EC), aim to address concerns related to the production and use of pharmaceuticals throughout their life cycle. The BIO Intelligence Service (2013), a report that laid the foundation for the European Commission's strategic approach to environmental sustainability, proposed several actions to tackle environmental issues. Suggestions to encourage greener industrial practices include regulatory reforms and incentives (e.g., patent protection extensions and fee reductions) to support the development of greener medicines.

The EU regulatory perspective is similar, but the two sectors differ in terms of environmental challenge: we argue that such difference is mostly market driven. Since their higher political/social salience may have hidden their negative environmental impact from stakeholders, pharmaceutical companies may have perceived less pressure on sustainability practices and reporting. Additionally, in the pharmaceutical industry, competitive advantages are more likely driven by patents and regulatory approvals related to clinical effectiveness and patient safety (Yeoh & Roth, 1999; Gassmann et al., 2008). Finally, chemical companies have been under scrutiny for longer (Gillet, 1952), also due to the number of major accidents reported over time, and thus may be more accustomed to sustainability practices (Calciolari et al., 2024). Therefore, certifications are more likely to represent a

strategic asset, in terms of risk reduction, cost savings, and market access for the chemical sector rather than the pharmaceutical one.

Hypothesis 2. *The strength of the relationship between environmental certifications and economic performance is greater in the chemical sector than in the pharmaceutical sector.*

3. Data and Methods

We adopt a two-step analytical strategy to investigate the proposed hypotheses. First, we perform an AI-based content analysis to assess the extent to which companies voluntarily disclose information on environmental sustainability and environmental certifications in their financial reports. Second, we employ a multivariate panel regression analysis to examine the relationship between these disclosures and firms' economic performance, using multiple model specifications and alternative samples to foster the robustness of our findings.

3.1. AI-Based Content Analysis

The sample selection identified a homogeneous group of companies not legally obliged to disclose information on environmental issues, large enough to capture the attention of a relevant number of stakeholders. We selected a single country, Italy, to simplify the comparison of contents included in financial reports, particularly within the same accounting standards and to avoid the complexity arising from documents drafted in different languages.

The sample consists of all Italian non-SME and non-listed pharmaceutical and chemical companies observed over nine years (2012–2020). As previously mentioned, this selection allowed us to compare the results of the analysis of the pharmaceutical sector with those of an industry similar in terms of production processes but with a lower political/social salience in the society at large. The final sample includes 1748 observations distributed across the two sectors (51.2% pharmaceutical companies). The source of financial data (extracted as a single Excel file) and financial reports (downloaded as separate PDF files) is the AIDA Bureau van Dijk database.

The first phase of our study comprises a content analysis performed on the retrieved financial reports. Content analysis consists of "*codifying qualitative information in anecdotal and literary form into categories in order to derive quantitative scales of varying levels of complexity*" (Abbott & Monsen, 1979, p. 504). The technique is commonly used in social and environmental reporting studies (Gray et al., 1995; Parker, 2005, 2011) and relies on the axiom that the amount of information within each conceptual category reflects its importance level (Unerman, 2000). Therefore, we used the technique to obtain metrics useful to assess the priority of disclosed information to derive quantitative scales of varying levels of complexity (Abbott & Monsen, 1979). However, considering the large number of documents, the analysis relied on Artificial Intelligence (AI) algorithms developed to retrieve information traceable to specific categories of information, as in Calciolari et al. (2024). For more information, see Appendix A.

Our content analysis identified two categories of information in the retrieved annual reports:

- Generic environmental disclosure, such as the presence of a dedicated section specifically addressing environmental reporting, sentences regarding water discharge management practices or statements on adherence to environmental norms, and environmental certifications (*Disclosures*)

➢ Specific disclosure of environmental certifications formally obtained by the company (*Certifications*).

Notably, occurrences falling in the second category are also included in the first one. Both variables (*Disclosures* and *Certifications*) are generated as dichotomous indicators, coded as "1" if the corresponding information is present in the report, and "0" otherwise.

3.2. Multivariate Analysis

The second phase of our study used different multivariate regression models to test if the degree of environmental sustainability disclosure influences the firms' financial performance. We run five models, according to alternative financial performance proxies: logarithmically transformed Total Sales (model 1); logarithmically transformed EBITDA (model 2); EBITDA/Sales (model 3); EBITDA/Assets (model 4); ROE (model 5).

We perform a longitudinal multivariate regression analysis, including financial indicators as control variables: logarithmically transformed Total Assets (Ln_Assets) as a proxy for firm size, Sales to Assets ratio (Efficiency) to control for efficiency, and Debt to Equity ratio (Debt_to_Equity) as a financial risk indicator. Our panel data is unbalanced because some companies entered or exited the market during the observation period (2012–2020). We first performed the estimation process separately on the full sample of pharmaceutical companies and chemical firms. Equation (1) formalises the fixed effects model used for our estimation.

$$Performance_{it} = \alpha + \beta\ Disclosure_{it} \times\ Certifications_{it} + CONTROLS_{it} + \epsilon_{it} \quad (1)$$

The subscripts' "i" and "t" indicate the firm and the year of observation, respectively. *Performance* is a vector representing firms' economic performance in different model specification (alternatively, Total Sales, EBITDA, EBITDA/Sales, EBITDA/Assets, and ROE. The interaction between *Disclosure* and *Certifications* allows us to disentangle the effect of being environmentally certified or generically disclosing environmental themes. *CONTROLS* is a matrix of financial metrics measured at the firm level (i) each year (t) of the observation period, and they include a binary variable indicating whether the company is pharmaceutical (1) or chemical (0); finally, ε_{it} is the error term clustered at the company level. Finally, β and γ are estimated coefficients, and α is a constant term. After performing the multivariate analysis on the whole sample, including both chemical and pharmaceutical companies, we split the sample by sector and replicate the analysis with each industry at a time.

We acknowledge potential endogeneity concerns, in particular the possibility that better-performing firms are more likely to adopt environmental certifications. To partially mitigate this risk, our empirical design incorporates firm fixed effects and industry-year controls, which help account for time-invariant unobservables and sectoral shocks. Nonetheless, causality should be interpreted with caution, as the associations reported cannot fully rule out reverse causality.

We generate the descriptive statistics of our data and performed the regression analyses using the statistical software package Stata (version 18.0).

4. Results

4.1. Content Analysis Results

Table 1 summarizes the findings obtained through the AI-based tool applied to the financial reports of the selected companies. The variable *Certifications* represents the percentage of companies disclosing environmental certifications in their financial reports. The variable *Disclosure* measures the presence of any environmental theme (including certifications) in a report. Results indicate an increase in the level of environmental information disclosed in the annual reports of pharmaceutical companies, showing a growth of 10.8%

over the 2012–2020 period (+32.2% firms disclosing certifications). Chemical companies have consistently shown higher levels of disclosure since the beginning of the observation period. However, this difference has diminished over time, resulting in a thin difference across the two sectors in 2020.

Table 1. Environmental Certifications and Disclosure Rates in Pharmaceutical and Chemical Firms (2012–2020).

	Pharmaceutical Firms		Chemical Firms	
Year	**Certifications**	**Disclosure**	**Certifications**	**Disclosure**
2012	0.347	0.589	0.427	0.629
2013	0.426	0.585	0.429	0.615
2014	0.414	0.606	0.484	0.674
2015	0.420	0.610	0.464	0.680
2016	0.394	0.586	0.479	0.698
2017	0.400	0.620	0.510	0.670
2018	0.394	0.566	0.459	0.633
2019	0.439	0.643	0.470	0.670
2020	0.459	0.653	0.460	0.660
average	**0.410**	**0.607**	**0.465**	**0.659**

4.2. Multivariate Analyses Results

4.2.1. Descriptive Statistics

Table 2 reports the summary statistics for the full sample, while Appendix B provides the corresponding statistics for each sector (chemical and pharmaceutical). Assets, Sales, and EBITDA are continuous variables that capture firm size and operational performance. ROE and Debt_to_Equity are ratio variables reflecting firm profitability and capital structure. Disclosure and Certifications are the binary indicators described in the previous section. Finally, Geographical_Clusters is a categorical variable representing the spatial distribution of firms across different the four areas of Italy: North-West (1—66.48% of the sample), North-East (2—10.70%), Centre (3—20.31%), South and Islands (4—2.52%).

Table 2. Descriptive statistics of the whole sample. Source: Aida BvD.

Variable	Obs	Mean/Prop	Std. Dev.	Min	Max	Variable Type
Assets	1728	261,864	385,185	9825	3,696,000	Cont. (EUR th.)
Sales	1743	250,389	404,567	0	5,317,564	Cont. (EUR th.)
EBITDA	1742	17,817	51,761	−649,664	362,704	Cont. (EUR th.)
ROE	1726	12.43	21.10	−149.25	92.86	Ratio
Debt_to_Equity	1726	1.76	2.72	−0.29	38.59	Ratio
Disclosure	1748	0.63	0.48	0	1	Binary
Certifications	1748	0.44	0.50	0	1	Binary
Geographical_Clu	1748	1.59	0.89	1	4	Categorical

4.2.2. Full Sample

This section presents the empirical findings of our regression analysis investigating the relationship between environmental disclosure and the presence of environmental certifications on firm-level economic performance in the full sample (Table 3). In order to assess the influence of the quality and credibility of disclosed environmental information on key productivity and profitability indicators, we differentiate between firms that disclose environmental information with certifications (*Certification* × *Disclosure* = 1;1) and without (*Certification* × *Disclosure* = 0;1). Firms that do not engage in any environmental

disclosure serve as the reference group in our analysis (*Certification* × *Disclosure* = 0;0), while the category of firms engaging in environmental disclosure without certifications (*Certification* × *Disclosure* = 0;1) is empty by data structure. The models account for sectoral and geographical fixed effects, as well as firm-level control variables such as size (*Ln_Assets*), efficiency (*Efficiency*), and capital structure (*Debt_to_Equity*).

Table 3. Regression Estimates for Chemical and Pharmaceutical Firms: The Role of Environmental Certifications.

	(1)	(2)	(3)	(4)	(5)
Variables	**Ln Sales**	**Ln EBITDA**	**EBITDA/Sales**	**EBITDA/Assets**	**ROE**
Certifications × *Disclosure* (0;1)	0.005	0.063	0.003	0.003	0.070
	(0.036)	(0.075)	(0.012)	(0.008)	(1.710)
Certifications × *Disclosure* (1;1)	0.125 ***	0.129	0.020	0.013	−0.895
	(0.036)	(0.080)	(0.012)	(0.009)	(1.736)
Ln_Assets	0.173 ***	0.130 *	0.003	−0.001	0.276
	(0.031)	(0.067)	(0.010)	(0.009)	(1.473)
Efficiency	0.001 ***	0.001	0.000	0.069 ***	0.001
	(0.000)	(0.001)	(0.000)	(0.004)	(0.023)
Debt_to_Equity	−0.062 ***	0.039 ***	−0.013 ***	0.003 **	0.151
	(0.006)	(0.014)	(0.002)	(0.001)	(0.266)
Controlled by Sector and Geographical cluster	YES	YES	YES	YES	YES
Constant	9.862 ***	7.552 ***	0.054	0.010	9.342
	(0.369)	(0.800)	(0.125)	(0.106)	(17.600)
Observations	1710	1549	1710	1711	1696
R-squared	0.085	0.012	0.029	0.195	0.000
Number of companies	198	196	198	198	198

Notes: Standard errors in parentheses and clustered at the firm level. All models include year fixed effects; sector/geographical fixed effects are included where indicated. *Certifications* × *Disclosure* = (1;1) for firms that both disclose environmental information and explicitly report third-party environmental certifications (e.g., ISO 14001, EMAS) *Certifications* × *Disclosure* = (0;1) for firms that disclose environmental information but do not explicitly report third-party environmental certifications. *Ln_Assets* is the natural logarithm of Total Assets (EUR th.). Significance levels: * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$.

Our results show that disclosures not accompanied by environmental certifications (*Certification* × *Disclosure* = 0;1), does not influence significantly performance-related variables. In contrast, firms that include environmental certifications in their disclosures (*Certification* × *Disclosure* = 1;1) are linked to a positive and statistically significant coefficient in Model 1 (*Ln Sales*)). However, no significant effects emerge in the other models, although the direction of the coefficients is positive except for Model 5 (*ROE*), suggesting no clear link between certification and this metric of profitability.

The empirical results from the full sample of firms provide support for the hypothesis that environmental certifications are associated with improved economic performance in one model. The lack of statistical significance across all outcome variables for this group suggests that generic disclosure, without certified environmental practices, does not generate appreciable economic advantages.

4.2.3. Split Sample

The second hypothesis suggests that the positive correlation between environmental certifications and economic performance is stronger in the chemical industry than in the pharmaceutical industry. Indeed, such certifications are expected to generate greater economic value in industries where environmental pressure is intense and the lack of political/social salience does not help overshadowing their negative environmental impact in the stakeholders' eyes.

Empirical findings partially support this hypothesis. In the chemical sub-sample, environmental certifications show a significant positive association with two economic performance indicators (Table 4). Certified firms demonstrate a higher production value (*Ln Sales*) and gross operating profitability (EBITDA/Sales), both of which are significant at the 99% level. In contrast, the pharmaceutical sub-sample exhibits no statistically significant relationship between certifications and any of the considered performance metrics (Table 5), thus supporting Hypothesis 2.

Table 4. Regression Estimates for Chemical Firms: The Role of Environmental Certifications.

	(1)	(2)	(3)	(4)	(5)
Variables	**Ln Sales**	**Ln EBITDA**	**EBITDA/Sales**	**EBITDA/Assets**	**ROE**
Certifications × *Disclosure* (0;1)	0.003	−0.032	0.006	−0.005	−0.570
	(0.055)	(0.120)	(0.012)	(0.016)	(2.668)
Certifications × *Disclosure* (1;1)	0.222 ***	0.150	0.044 ***	0.013	−1.273
	(0.057)	(0.132)	(0.012)	(0.016)	(2.708)
Ln_Assets	−0.557 ***	−0.714 ***	−0.024 **	−0.033	−2.768
	(0.048)	(0.108)	(0.010)	(0.020)	(2.292)
Efficiency	−0.003 ***	−0.004 ***	−0.000	0.055 ***	−0.019
	(0.001)	(0.001)	(0.000)	(0.007)	(0.025)
Debt_to_Equity	−0.118 ***	0.042	−0.018 ***	0.008 ***	0.577
	(0.010)	(0.027)	(0.002)	(0.003)	(0.484)
Controlled by Geographical Cluster	YES	YES	YES	YES	YES
Constant	18.634 ***	17.454 ***	0.353 ***	0.389	42.633
	(0.572)	(1.301)	(0.123)	(0.250)	(27.591)
Observations	835	738	835	834	822
R-squared	0.281	0.074	0.104	0.223	0.004
Number of companies	98	96	98	98	98

Notes: Standard errors in parentheses and clustered at the firm level. All models include year fixed effects; sector/geographical fixed effects are included where indicated. *Certifications* × *Disclosure* = (1;1) for firms that both disclose environmental information and explicitly report third-party environmental certifications (e.g., ISO 14001, EMAS) *Certifications* × *Disclosure* = (0;1) for firms that disclose environmental information but do not explicitly report third-party environmental certifications. *Ln_Assets* is the natural logarithm of Total Assets (EUR th.). Significance levels: * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$.

Table 5. Regression Estimates for Pharmaceutical Firms: The Role of Environmental Certifications.

	(1)	(2)	(3)	(4)	(5)
Variables	**Ln Sales**	**Ln EBITDA**	**EBITDA/Sales**	**EBITDA/Assets**	**ROE**
Certifications × *Disclosure* (0;1)	−0.012	0.099	0.003	0.011	1.615
	(0.022)	(0.083)	(0.020)	(0.008)	(2.167)
Certifications × *Disclosure* (1;1)	−0.011	0.046	−0.001	0.010	−1.585
	(0.022)	(0.086)	(0.020)	(0.008)	(2.194)
Ln_Assets	0.941 ***	1.152 ***	0.051 ***	0.024 ***	9.128 ***
	(0.021)	(0.085)	(0.019)	(0.008)	(2.054)
Efficiency	0.902 ***	1.223 ***	0.099 ***	0.138 ***	21.781 ***
	(0.028)	(0.113)	(0.025)	(0.010)	(2.747)
Debt_to_Equity	−0.040 ***	0.021	−0.010 ***	0.002 *	0.472
	(0.003)	(0.014)	(0.003)	(0.001)	(0.321)
Controlled by Geographical Cluster	YES	YES	YES	YES	YES
Constant	−0.232	−5.728 ***	−0.600 **	−0.343 ***	−116.994 ***
	(0.262)	(1.081)	(0.237)	(0.098)	(25.804)
Observations	875	811	875	877	874
R-squared	0.753	0.233	0.037	0.196	0.078
Number of companies	100	100	100	100	100

Notes: Standard errors in parentheses and clustered at the firm level. All models include year fixed effects; sector/geographical fixed effects are included where indicated. *Certifications* × *Disclosure* = (1;1) for firms that both disclose environmental information and explicitly report third-party environmental certifications (e.g., ISO 14001, EMAS) *Certifications* × *Disclosure* = (0;1) for firms that disclose environmental information but do not explicitly report third-party environmental certifications. *Ln_Assets* is the natural logarithm of Total Assets (EUR th.). Significance levels: * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$.

The data (visually summarized in Figure 1) reveal a clear divergence in the behavior of the two sectors, yet they share a common trait: generic disclosure of environmental topics, without certifications, is never associated with superior financial performance. When considering the whole sample, our models can only identify one effect due to the noise associated to the pharmaceutical sub-sample, but the results of the split samples show that any influence of environmental certifications on performance belong to the chemical companies.

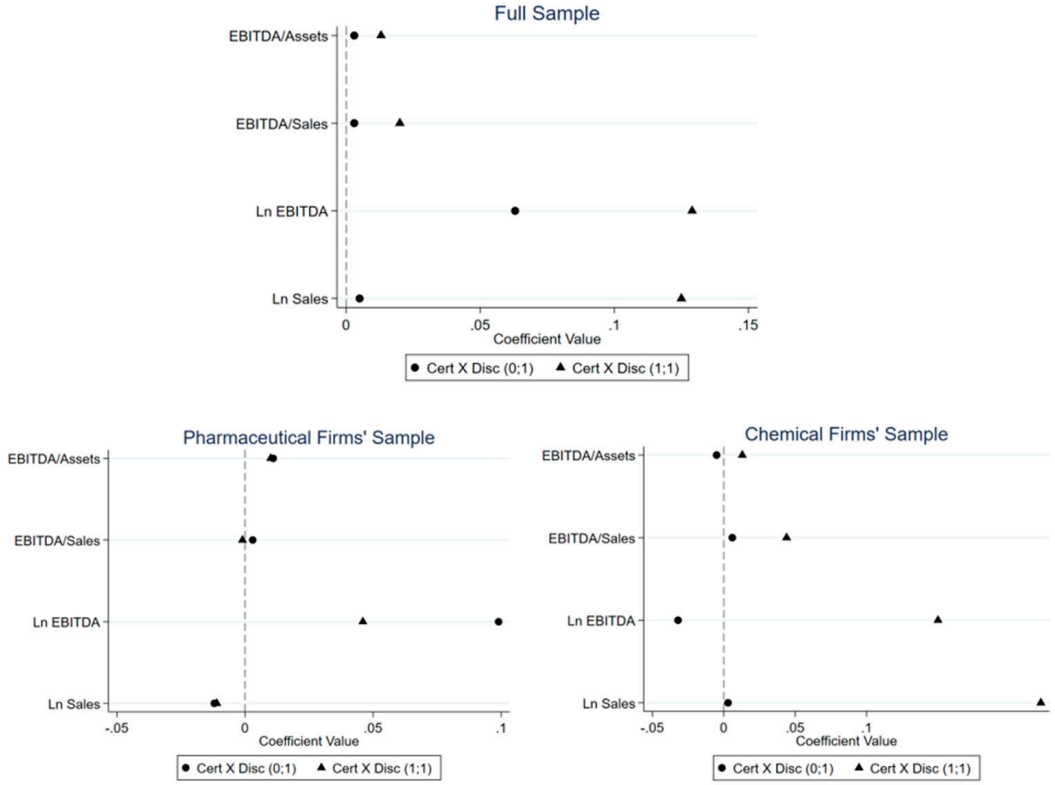

Figure 1. Environmental Certification Effects on Firm Performance by Sector. Coefficient plots.

5. Discussion

This study examined the relationship between environmental disclosure, environmental certifications, and economic performance in the Italian chemical and pharmaceutical industries. These results document robust associations; although we use longitudinal data and fixed effects, reverse causality cannot be entirely ruled out—financially stronger firms may be more likely to obtain certifications. Therefore, we interpret our findings as evidence of an association consistent with RBV, rather than definitive causal proof. The results suggest that environmental certifications constitute a strategic asset, though their impact is context-dependent. Firms holding these certifications, particularly in the chemical sector, exhibited superior economic outcomes compared to non-certified peers, indicating that certifications are not merely symbolic but reflect a deeper integration of environmental sustainability into operational processes, potentially enhancing efficiency and market legitimacy.

A sharp distinction emerged between generic environmental disclosure and the disclosure of environmental certifications. While generic disclosure alone was not significantly associated with economic benefits, certification-based disclosure showed a positive influence on firm performance. This finding is particularly relevant in the context of increasing concerns about greenwashing (Darnall et al., 2022; Korca et al., 2021). In line with Lev (2017) argument, certifications may serve as credible, rare, and difficult-to-imitate intangible

assets that signal long-term commitment to sustainability. If environmental practices are to contribute to sustainable competitive advantage, they must be clearly recognized as strategic, not symbolic, and be properly integrated within corporate reporting systems.

The industry-level analysis revealed that the positive influence of environmental certifications on financial performance is limited to the chemical sector. This is consistent with the higher regulatory exposure and environmental risk inherent in the industry. Certifications likely function as competitive levers, reinforcing compliance while also creating differentiation and reputational gains. Conversely, the pharmaceutical industry showed no significant influence of environmental certifications on financial performance. This finding aligns with Syed's (2024) view that pharmaceutical innovation hinges primarily on two strategic assets: compound knowledge and clinical trial data, usually "capitalized" in patents. In this sector, currently, ESG practices may have reputational value but are unlikely to drive profitability in the same way as patents do. This trade-off between environmental investments and core innovation priorities may explain the weaker link between certifications and economic returns for pharmaceutical firms.

The results also resonate with the broader literature on ESG trade-offs. As shown by Yusifzada et al. (2025) and Ait Sidhoum et al. (2022), the relationship between sustainability performance and economic outcomes is neither linear nor universal. The value of ESG initiatives (particularly the environmental pillar) depends significantly on the sectoral context in which firms operate. Indeed, efforts to enhance environmental sustainability may conflict with other strategic priorities more often or more acutely in certain industrial contexts compared to others; or in some circumstances, such efforts may excessively come at the cost of technical or economic efficiency.

These findings suggest that policymakers should avoid blanket regulations and instead tailor incentives to specific industries, offering support to sectors like chemicals where certifications are effective. Finally, for managers, the key takeaway is to focus on obtaining certifications only if they are relevant and material to their specific industry and operations, ensuring they translate into real value rather than just being a box-ticking exercise. These dynamics reinforce the notion that ESG initiatives must be strategically designed and tailored to industry-specific priorities, rather than implemented through a one-size-fits-all approach.

6. Conclusions

Overall, this study contributes to the ongoing debate on the credibility and effectiveness of sustainability practices by distinguishing between generic environmental disclosure and certification-linked disclosure, and by showing how their economic implications vary across industries. However, some limitations must be taken into consideration. The analysis focused on Italian firms, which may reduce the generalizability of the findings to other regulatory environments. Additionally, despite the longitudinal nature of our analysis, we cannot definitely rule out whether certifications drive better performance or more successful firms are more likely to seek certifications. However, the identified relationships between environmental certifications and performance are robust. Our study also does not account for the qualitative aspects of disclosure or potential confounding factors such as corporate culture, managerial capabilities, or market positioning.

Further research may investigate whether there are other relevant industrial heterogeneities regarding the relationship between ESG and financial performance: enhanced knowledge about differences may help the decision maker to better calibrate the sustainability regulation. In addition, refining our knowledge about the evidence of "genuine ESG practices" and their impact on financial performance might help to design effective incentives to improve sustainability.

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Appendix A AI Content Analysis Pipeline

We downloaded the financial reports from the AIDA (Bureau van Dijk) database and processed them with an author-developed AI pipeline to extract references to environmental sustainability certifications (e.g., ISO 14001) and to regulatory provisions related to environmental matters (e.g., Legislative Decree 152/06). The pipeline consists of two main modules:

1. an OCR-based text-extraction module, implemented with the Tesseract library, which converts PDF pages (including scanned images within PDFs) into machine-readable text;
2. a topic-detection module, which applies a combination of rule-based routines and supervised classifiers to the extracted text in order to identify passages that discuss environmental disclosure, third-party certifications, emissions trading, and related subjects.

Below we summarise the implementation and validation procedures for these two components.

OCR and text extraction. Although many financial statement PDFs contain embedded vector text, a non-negligible portion of relevant information (tables, scanned pages, annexes) is stored as images. For robust coverage we therefore adopted Tesseract OCR (LSTM-based) to recover textual content from all pages. Preprocessing steps included header/footer removal, normalization (lowercasing, removal of non-alphabetic characters), tokenization and n-gram preservation up to trigram length to retain contextual phrases (for example, "ISO 14001", "environmental certification", "Legislative Decree 152/06"). We validated OCR output by randomly sampling extracted passages and comparing them with the original PDFs. The recovered text was highly consistent with source documents, with only sporadic minor typographical errors.

Topic detection: rule-based and machine-learning classifiers. To locate relevant passages within the extracted text we developed both rule-based filters and supervised machine-learning classifiers. Rule-based filters consist of human-curated patterns and keyword rules (for example, if a sentence contains "ISO 14001" or "environmental certification" then flag as certification-related). Supervised classifiers were trained on a manually annotated, stratified sample of sentences/documents (labels: no environmental disclosure; generic disclosure; certification-linked disclosure). Training used standard NLP pipelines implemented in Python 3.10 and scikit-learn; we experimented with different algorithms and used cross-validation to tune hyperparameters. Because rule-based systems are transparent and quick to implement, we used them as baseline checks; ML classifiers, while often less interpretable, can capture broader linguistic variability. In our setting—characterised by a limited, domain-specific vocabulary and a training set on the order of hundreds of

labelled examples—rule-based and ML approaches produced highly similar outputs. This convergence increases our confidence in the reliability of the extracted indicators.

Output and downstream use. The topic-detection module outputs a structured spreadsheet that summarizes, for each firm-year, the topics detected and the corresponding text excerpts that triggered the classification. This spreadsheet is the starting point for the construction of the firm-level disclosure indicators used in the econometric analysis. To assess residual error and to support robustness checks, we also (i) inspected a hold-out manual validation sample, (ii) produced confusion matrices for the classifiers, and (iii) tested alternative rule sets and classifier specifications.

Computational resources, performance and reproducibility. Processing approximately 500 full financial statements required roughly 48 h on a Linux workstation (Intel i7, 32 GB RAM). The entire pipeline was implemented in Python with ad-hoc scripts for preprocessing, OCR, and classification. Raw, full-text documents cannot be publicly released for confidentiality reasons; nevertheless, a redacted sample of annotated records is included to enable independent verification.

Future availability. The tool remains under active development and will be released in an open-source (or otherwise publicly accessible) form at the conclusion of the project to allow other researchers to adapt and extend the pipeline for the automated analysis of financial documents.

Appendix B Descriptive Statistics by Sector

Table A1. Descriptive statistics for the sample of chemical firms. Source: Aida BvD.

Variable	Obs	Mean/Prop.	Std. Dev.	Min	Max	Variable Type
Assets	846	241,195	356,028	9825	3,696,000	Cont. (EUR th.)
Sales	861	261,410	474,458	0.00	5,317,564	Cont. (EUR th.)
EBITDA	860	12,831	61,035	−649,664	323,484	Cont. (EUR th.)
ROE	847	9.67	21.94	−149.25	92.86	Ratio
Debt_to_Equity	849	1.56	2.04	0.00	20.45	Ratio
Disclosure	862	0.66	0.47	0	1	Binary
Certifications	862	0.48	0.50	0	1	Binary
Geograhical_Clus	862	1.40	0.76	1	4	Categorical

Table A2. Descriptive statistics for the sample of pharmaceutical firms. Source: Aida BvD.

Variable	Obs	Mean/Prop	Std. Dev.	Min	Max	Variable Type
Assets	882	281,689	410,440	5,224,772	3,635,235	Cont. (EUR th.)
Sales	882	239,630	321,955	0	1,796,530	Cont. (EUR th.)
EBITDA	882	22,678	40,180	−74,680	362,704	Cont. (EUR th.)
ROE	879	15.08	19.91	−123.5	86.06	Ratio
Debt_to_Equity	877	1.96	3.23	0.02	38.59	Ratio
Disclosure	882	0.61	0.49	0	1	Binary
Certifications	882	0.41	0.49	0	1	Binary
Geograhical_Clus	882	1.77	0.97	1	4	Categorical

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