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Investigating the Nexus Between Energy Transition Reporting Practices and Corporate Efficiency in the European Agri-Food Sector

Serhiy Zabolotnyy

Department of Finance, Institute of Economics and Finance, Warsaw University of Life Sciences-SGGW, Nowoursynowska 166, 02-787 Warsaw, Poland; serhiy_zabolotnyy@sggw.edu.pl

Abstract: The research paper investigates the nexus between energy transition reporting practices and corporate efficiency of listed European companies from the agri-food sector. The study relies on key energy-related and financial indicators and logistic regression analysis conducted on 219 EU business entities publishing their financial and non-financial reports between 2004 and 2023. Based on the distribution of financial metrics in the sample, we assumed that entities reporting data on energy transition, either partially or fully, could achieve higher profitability and simultaneously have lower liquidity than non-reporting companies. The panel data model indicated a strong relationship between the reporting status of a business entity, its revenue, and the time variable, demonstrating that the likelihood of providing information on energy transition was associated with the size of a company and increased systemically over time. However, further regression analysis revealed a lack of a persistent, significant relationship between the key financial indicators and the entities' energy transition reporting status. Considering the substantial changes in the EU regulatory environment associated with introducing CSRD, we conclude that with increasing legal pressure over time, companies will gradually shift towards standardized industry-related reporting practices, resulting in more consistent and transparent evidence of their energy transition strategies.

Keywords: energy transition; CSRD; ESRS; efficiency; agri-food sector

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1. Introduction

The ongoing debate over the scope of the ESG reporting standards, with a focus on climate change and energy transition, drives the particular attention of investors, business managers, policymakers, researchers, and NGO representatives globally [1–3]. From an academic perspective, ESG reporting aims to mirror the company's strategy towards sustainability, including reduction in carbon emissions and energy consumption, and reflect the non-financial impact of business on the broad circle of end users of corporate information [4,5].

The evolution from traditional financial standards towards sustainable corporate reporting was primarily accelerated by the European energy transition strategy aiming at combating climate change and promoting sustainable development. In response to rising environmental concerns and due to international commitments, such as the Paris Agreement, European countries have set ambitious targets for reducing greenhouse gas emissions and achieving climate neutrality [6].

Corporate ESG reporting practices emerged from a voluntary activity and gradually acquired more significance in business strategy planning and financial decision making. This shift grew from various factors, including the regulatory pressure for sustainability and greater transparency, the influence of investors recognizing energy management strategy as a critical component for a competitive edge, and managers' acknowledgment of the long-term economic benefits associated with sustainable energy-related practices [7–10]. Notably, the new EU's CSRD directive significantly enlarged the circle of reporting entities,

simultaneously posing new reporting obligations to standardize the scope of public corporate non-financial information and ensure better communication with stakeholders [11]. In this context, the increasing capacity and quality of a firm's ESG and energy-related disclosures became a basis for various investors' indices and models, evaluating businesses according to sustainable policies and articulating their relevance to shareholders' wealth [12,13]. Therefore, ESG reporting policies on energy transition gradually created a prerequisite and a hallmark for perceiving companies as more sustainable and competitive in highly regulated business environments [14,15]. Information about carbon emissions, energy consumption, and strategies toward renewable sources became a significant part of these non-financial reporting frameworks [16].

The energy transition poses both challenges and opportunities for businesses. On one hand, companies recognize the benefits of introducing sustainable practices as they foster technological change and operational efficiency. On the other hand, regulatory pressure imposes strict compliance requirements, which can constrain business innovativeness in pursuing novel approaches toward sustainability. Therefore, effectively navigating these dual targets—higher efficiency and regulatory accountability—has become essential for maintaining a competitive edge and following the principles of corporate sustainability.

In resource-oriented industries, particularly agri-business, that are intensively interacting with the environment and local communities, the energy management strategy should additionally consider the complexity of ecosystem and social dynamics as well as the vast relations of a business with its supply chain as a crucial matter defining the products' traceability [17–19]. Hence, for entities operating in the agri-food sector, reporting on energy transition acquires even greater importance, as the accountability and consistency of the related information may directly impact the customer's perception of product quality and associated health risks. Through this channel, parallel to the investor's perspective, corporate energy reporting practices can affect the efficiency and value of an agri-food business entity.

The objective of the research is to identify the trends in reporting practices on energy transition and investigate the relationship between reported corporate energy management policies and the efficiency of business entities from the agri-food sector operating in the EU. By utilizing a sample of 219 listed European companies from the agri-food supply chains observed from 2004–2023, we explore their current reporting statuses on energy transition in the scope of ESRS 1E and clarify whether performance might correspond to the capacity of the relevant non-financial information. With this aim, we apply a set of key financial metrics such as profitability, liquidity, leverage, and productivity to elaborate on a unique mindset for investigating the possible multidimensional effects of business performance and confront it with a company's reporting practices on energy transition. As part of the original contribution, the subsequent step of the research involves employing a logistic regression model to measure the strength of relationships among specific variables that indicate the degree of corporate energy transition and business efficiency characterized by these financial metrics.

Our findings suggest a strong relationship between the capacity of the information on energy transition, firm size, and a time variable. Moreover, we noticed a divergence in financial ratios among companies with different reporting statuses. However, according to designed panel data models, there is no statistically significant evidence that corporate performance might motivate managers to implement more consistent and transparent reporting practices on energy transition. Therefore, the strict regulatory environment seems to be the primary factor forcing companies to impose more sophisticated energy management policies. With regard to this fact, we assume that adopting bottom-up mechanisms, such as compensation plans linked to energy performance targets or introducing ESG-driven corporate codes of conduct, could further stimulate energy-related initiatives and help overcome natural managerial resistance towards the associated investments in energy transition with comparatively longer payback periods.

The paper contributes to the broader debate on the significance of energy management policies for firms' business efficiency in light of the trade-off between long-term competitive advantage and short-term cash earnings. Notably, it addresses the gap in the existing research on the degree of adoption of environmental standards and the relationship between energy transition reporting practices and corporate performance in the EU's agri-food sector. Based on empirical findings, the study advocates that disclosures on energy transition can successfully convey a corporation's long-term competitive edge to its stakeholders. From this perspective, the research results might be significant for both regulators and business decision-makers from the agri-food sector, revealing the trends in corporate reporting on climate change and energy transition and its possible linkage to firm-level performance.

The paper is organized as follows. We first present a literature review on the emergence of ESG standards, focusing on climate change, carbon emissions, and energy transition reporting practices, their importance for business entities from the agri-food sector, and possible stakeholders' motives for introducing the non-financial reporting mechanisms. Then, we describe the research methods, characterize the sample, and analyze the data using financial ratio analysis and statistical panel data modeling. We conclude with a discussion and a summary of the findings.

2. Literature Review

The evolution of the ESG corporate reporting initiative was the broad socio-economic response to accelerated climate change, as emphasized by the Paris Agreement, which gradually evolved into consequent sustainability reporting frameworks globally [20,21] and regionally in Europe [22]. It is worth noting that the European energy market reveals significant discrepancies among EU countries regarding their progress toward energy transition targets, and the EU policies strive to integrate the European energy systems through innovation, transparency, and enhanced legislative initiatives [23,24]. While the earlier regulations remained fragmentary and lacked consistency, the European authorities put significant effort into developing the comprehensive NFRD directive that required large corporations to communicate their ESG impact, including carbon emission and energy use, as a part of their non-financial annual reports [25,26]. Despite this step, the proposed measures left room for misinterpretation and allowed companies to potentially obscure significant impacts beyond their financial statements [27]. Moreover, the absence of external attestation for these non-financial reports meant that compliance with the NFRD directive often depended on managerial behavior and decisions rather than mandatory standards [28]. Adopting the subsequent CSRD directive enhanced the existing set of ESG reporting requirements and extended their enforceability to a broader group of entities. In addition, it initiated external audits for mandatory attesting to the non-financial information as a part of the annual report [29].

The CSRD directive introduced the ESRS reporting standards that comprise a coherent set of rules beginning from general requirements and disclosures on the context and scope of the reporting, progressing through various aspects of ESG performance, and culminating with detailed industry-specific regulations [30,31]. The core distinction of the ESRS standards is their comprehensive nature and a high degree of standardization. For example, following the standards' scope, the environmental dimension requires detailed and unified data points reporting on such issues as climate change, pollution, water and marine resources, biodiversity, and ecosystems [32]. In the energy transition context, the ESRS E1 standard included the indicators on CO2 equivalent emissions, emission trading and reductions, energy consumption, and transformation toward renewable sources [33]. Concurrently, the subsequent industry-related standards aim to bring even more relevance and precision to the reported information and establish a foundation for comparing entities grouped according to unique risk factors operating in a specific environment [34]. At the same time, the new directive has faced criticism for excessive detail and the possible complexity associated with implementing and enforcing its integral standards into current business models, which is incredibly challenging for smaller companies [35,36].

Undoubtedly, the agri-food sector is closely related to the energy balance, directly affecting the environment through extensive resource usage, emissions, energy consumption, and influencing local communities [37,38]. At the same time, it remains pivotal in securing the sustainability and well-being of EU societies [39,40]. Holding the equilibrium between limiting the negative environmental impact of the agri-food sector and supporting its business viability remains one of the critical priorities of European policy [41]. The challenge increases dramatically as the specificity of agricultural supply chains is determined by their economic vulnerability and sensitivity to the negative impact of external shocks [42]. Consequently, despite the availability of numerous funding mechanisms and grants, agri-food businesses are subject to acute financial shortages and rapid turbulences in the downstream and upstream channels [43]. Regarding the environmental dimension, this comparatively low-risk resilience and lack of financial resources for agri-food entities may cause a reduction of energy-related investments and less transparent and consistent non-financial reporting practices. For example, small-scale operations and higher earnings volatility of an agricultural business can deteriorate green incentives and force managers to adopt a more conservative stance toward energy transition [44]. Given the existing fragility of the agri-food sector, regulators should implement effective initiatives, including the promotion of broad digital and sustainable transitions, to address the contradictions between productivity and competitiveness and to enforce more effective sustainable strategies among agri-food producers [45].

Considering these arguments, applying industry-specific reporting standards in agri-food entities, lying beyond the scope of interest of traditional corporate shareholders, is crucial for several reasons, including public health, food safety, and ecological issues. In this context, the new CSRD directive postulates the elaboration of sector standards addressing the abovementioned risks. For example, the draft ESRS SEC1 is the emerging classification standard that categorizes a business into a particular industry and explains the sector-related disclosure requirements [30]. The objective of this standard is to provide relevant information on specific business activities as required by ESRS 1 and assess the material influence following ESRS 4, considering sector-specific impacts, risks, and opportunities. Remarkably, the draft of an ESRS SEC1 standard clearly identifies the agriculture and farming, and food and beverages sectors, providing a non-limitative indication of sustainability matters to be considered by the classified entity when assessing material impacts, risks, and opportunities. These subject matters include, namely, energy consumption and mix, GHG emissions, financial exposure to risks, water-related performance management, resource flow, pollution of water and soil, working conditions, personal safety, and products and services. As an example, to illustrate the diversity of risk-related issues, the standard states the high energy intensiveness of the food and beverages sector as a significant matter in the energy consumption mix and a substantial exposure of agri-food producers to financial uncertainty due to price fluctuations, impacting the continuity of business in the long term [30].

Designing industry-tailored corporate reporting initiatives on energy transition can lead to measurable benefits for stakeholders, including better cost control and risk management in multiple dimensions [46]. From a managerial perspective, focusing on sustainable strategies can lead to multiple positive effects on the firm's business results. Developing environmental policies should reduce carbon emissions, waste, and energy consumption, directly impacting an entity's operating performance [47]. Maintaining high social standards in the work environment can help overcome the problem of energy overconsumption by the labor force and rural communities [48]. Additionally, enhancing more transparent governance practices enables companies to reduce the cost of capital and attract more investments to energy transition projects [49]. However, pursuing these measurable goals does not automatically transfer into consistent non-financial reporting practices on energy transition, and, moreover, their linkage with the overall business performance often remains ambiguous [50–52]. Therefore, the problem of causality in this nexus raises further concerns about whether sustainable companies with complex energy transition strategies

become more efficient or if their better performance leads to superior energy management and higher reporting culture [53].

In this context, growing pressure from various stakeholders and sharpening regulatory requirements supported by the rapid development of legal frameworks in recent years bring managers to the dilemma of balancing the benefits and costs of disclosing information on energy transition [54,55]. Theoretically, this fundamental question relates to the unresolved problem of a trade-off between value maximization and continuity throughout the company's lifetime [56]. According to a value-creation school, adopting the sustainability strategy, including energy transition, enhances the firm's potential for building a competitive edge in the long term and contributes to business viability [57,58]. However, based on a cost-concerned approach, in the short term, additional costs of green initiatives may substantially limit corporate earnings and decrease the value and, hence, the speculative attractiveness of the business [59]. The same arguments may solely apply to energy-related reporting practices, as more consistent and detailed reporting requires much more managerial effort, while omitting non-financial aspects may lead to significant time and cost savings in the short term [52]. Given this perspective and considering the business cycle horizon, we can generally assume that a stronger focus on short-term profit maximization may prompt managers to reduce initiatives on energy transition disclosures. Conversely, in the long run, a more sustainability-oriented behavior can lead to extensive energy-related reporting, aiming to secure strategic competitive advantage. Therefore, despite the short-term cost effect, focusing on business continuity and extensively communicating the energy management strategy in annual reports, managers can strive to increase the company's reputation, build upon the stakeholders' trust, and improve business profitability and value in the long term [60]. However, various endogenous factors, as well as industry and firm-level heterogeneity, can deteriorate the presented theoretical pattern [61].

The available research demonstrates the diverse effects of enhanced ESG practices and the transition strategies towards cleaner energy on corporate efficiency [62]. Some available sources report the positive impact of sustainable reporting practices on corporate performance, including profitability, market value, and productivity [63–66]. Other authors indicate the absence of a significant relationship between ESG reporting and key performance indicators, stressing the companies' heterogeneity and sector specificity as one of the main factors deteriorating the persistent patterns of business performance and sustainability [67,68]. However, there is also evidence suggesting a negative relation between sustainable reporting and overall business performance, which is widely explained by the higher cost of implementing sustainable solutions and complying with existing environmental standards [69].

Investigating the academic question of the relationship between business sustainability and performance in the context of the agri-food sector may help understand whether energy transition reporting practices follow the classical short-term value maximization versus continuity trade-off pattern or if their adoption correlates with higher profits and value to shareholders, thereby supporting a long-term view of corporate competitiveness and value creation.

Last, our research can provide additional hints to the regulator on the state and effectiveness of existing energy transition reporting practices among European businesses to further adjust the regulatory mechanisms on energy policies and reporting standards and elaborate on stakeholders' incentives towards more sustainable practices.

3. Materials and Methods

The research relied on a longitudinal dataset comprising 219 publicly listed EU companies operating in the agri-food sector from 2004 to 2023. Financial and ESG firm-level data originated from the Refinitiv Eikon database and were extracted based on The Refinitiv Business Classification (TRBC) criterion. Specifically, the sample encompassed companies from the agri-food supply chains classified within the Food and Beverages, Food and Drug Retailing, and Chemicals TRBC business sectors. Considering the bottom level of classifica-

tion, the TRBC industry, the dataset included entities categorized as Fishing and Farming (14.7% of firm-year observations), Food Processing (45.2%), Food Retail and Distribution (14.3%), Non-Alcoholic Beverages (2.1%), Distilleries and Wineries (11.7%), Brewers (7.4%), Tobacco (1.3%), and Agricultural Chemicals (3.2%). The sample demonstrated a fairly balanced geographical distribution, with the most significant jurisdictions, France and Germany, accounting for 13.2% and 11.1% of observations. Firm-year observations with a zero value for revenues or assets were excluded. There was no additional condition on the duration of the time series for the firms in the sample. Consequently, the panel dataset was unbalanced.

The data collection process started by accumulating financial and energy-related information from the companies. The firm financial data series included reported sales revenue, total assets, current assets, shareholders' equity, total liabilities, current liabilities, inventory, accounts receivable, cash and short-term investments, and accounts payable. Based on these companies' parameters, we calculated financial ratios used in further steps of the research, such as return on equity (ROE), current ratio (CR), cash conversion cycle (CCC), solvency ratio (SR), productivity of assets (PA). Table 1 presents the descriptive statistics of the financial metrics of the companies from the agri-food sector.

Table 1. Descriptive statistics of the financial metrics.

Parameter	Mean	Std. Dev.	Min	Max
ROE	0.083	0.14	−1.00	0.96
CR	1.79	1.17	0.30	10.25
CCC	94.6	124.7	−81.4	981.4
SR	0.542	0.17	0.09	0.96
PA	1.108	0.67	0.03	4.11

The energy-related information consisted of the data points in the scope of the ESRS E1 standard. It comprised a set of 25 metrics, including Targets Emissions, Policy Emissions, Total CO_2 Equivalent Emissions To Revenues, CO_2 Equivalent Emissions Total, CO_2 Equivalent Emissions Direct (Scope 1), CO_2 Equivalent Emissions Indirect (Scope 2), CO_2 Equivalent Emissions Indirect (Scope 3), Carbon Offsets/Credits, Estimated CO_2 Equivalent Emissions Total, CO_2 Estimation Method, Emissions Trading, Climate Change Commercial Risks Opportunities, Particulate Matter Emissions Reduction, Environmental Expenditures, Environmental Investments Initiatives, Self-Reported Environmental Fines, Environmental Partnerships, Energy Use Total, Energy Purchased Direct, Energy Produced Direct, Electricity Purchased, Electricity Produced, Renewable Energy Purchased, Renewable Energy Produced, and Renewable Energy Used.

These metrics are essential for assessing energy transition, offering a detailed picture of a company's emissions and energy consumption. They give insight into direct and indirect carbon footprints, helping businesses pinpoint areas for introducing more sustainable practices. Moreover, information on renewable energy generation, consumption, environmental investments, and expenditures underscores corporate dedication to sustainable practices. Collectively, these metrics enable monitoring progress toward energy transition objectives in line with the guidelines outlined in the ESRS E1 standard.

A detailed definition of all employed variables is stated in Table 2.

Table 2. Definitions of variables.

Variable	Description
Financial metrics	
Profitability (ROE)	The ratio of Net Income to Equity
Liquidity (CR)	The ratio of Current Assets to Current Liabilities
Oper. Efficiency (CCC)	The ratio of Cash Conversion Cycle = Days of Inventory Outstanding + Days Sales Outstanding − Days Payable Outstanding
Solvency (SR)	The ratio of Total Liabilities to Total Assets
Productivity (PA)	The ratio of Sales Revenue to Total Assets
Energy transition metrics	
Targets Emissions	Has the company set targets or objectives to be achieved on emission reduction (binary)
Policy Emissions	Does the company have a policy to improve emission reduction (binary)
Total CO_2 Equivalent Emissions To Revenues	Total CO_2 and CO_2 equivalents emission in tonnes divided by net sales or revenue
CO_2 Equivalent Emissions Total	Total CO_2 and CO_2 equivalent emission in tonnes
CO_2 Equivalent Emissions Direct (Scope 1)	Direct of CO_2 and CO_2 equivalent emission in tonnes
CO_2 Equivalent Emissions Indirect (Scope 2)	Indirect of CO_2 and CO_2 equivalent emission in tonnes
CO_2 Equivalent Emissions Indirect (Scope 3)	Total CO_2 and CO_2 Scope 3 equivalent emission in tonnes
Carbon Offsets/Credits	The equivalent of the CO_2 offsets, credits, and allowances, in tonnes purchased and/or produced by the company during the fiscal year
Estimated CO_2 Equivalents Emissions Total	The estimated total CO_2 and CO_2 Equivalents Emissions in tonnes
CO_2 Estimation Method	Carbon estimate method is structured around four models (reported, CO_2 model, energy model, median model)
Emissions Trading	Does the company report on its participation in any emissions trading initiative (binary)
Climate Change Commercial Risks Opportunities	Is the company aware that climate change can represent commercial risks and/or opportunities (binary)
Particulate Matter Emissions Reduction	Does the company report on initiatives to reduce, substitute, or phase out particulate matter less than ten microns in diameter? (binary)
Environmental Expenditures	Total amount of environmental expenditures
Environmental Investments Initiatives	Does the company report on making proactive environmental investments to reduce future risks or increase future opportunities? (binary)
Self-Reported Environmental Fines	Environmental fines as reported by the company
Environmental Partnerships	Does the company report on partnerships or initiatives focused on improving environmental issues? (binary)
Energy Use Total	Total direct and indirect energy consumption in gigajoules
Energy Purchased Direct	Direct energy purchased in gigajoules
Energy Produced Direct	Direct energy produced in gigajoules
Electricity Purchased	Electricity purchased in gigajoules
Electricity Produced	Electricity produced in gigajoules
Renewable Energy Purchased	Total primary renewable energy purchased in gigajoules
Renewable Energy Produced	Total energy produced from primary renewable energy sources in gigajoules
Renewable Energy Use	Does the company make use of renewable energy (binary)

The availability of the baseline energy-related information in annual reports determined the classification of entities according to the information volume criterion. Specifically, using this criterion, we divided the sample into three subsets, considering the presence of selected energy-related data. The first subset included business entities revealing more than 75% of data points (classified as 'Reporting'), the second consisted of companies reporting between 25% and 75% of information ('Partially Reporting'), and the third group included those firms submitting less than 25% of energy-related data ('Not Reporting'). Based on this classification and the distribution of key performance indicators within the

subsets, we identified trends in the reporting status and the average levels of corporate efficiency in defined groups. Next, we elaborated on theoretical assumptions for the relationship between the selected parameters to investigate possible statistically significant links. In the next step, we designed the panel data model to characterize the assumed nexus between the energy transition reporting status and corporate efficiency of agri-food companies. The conceptual specification of the model is as follows:

$$R.STATUS_{it} = \beta_0 + \beta_1 FIRM.PERFORM_{it} + \beta_2 FIRM.CONTROL_{it} + \beta_3 Year_i + \beta_4 Country_i + \epsilon_{i,t}$$

where $R.STATUS_{it}$ is an explanatory variable set for the energy transition reporting status of a business entity, $FIRM.PERFORM_{it}$—a vector of firm performance variables (financial ratios), $FIRM.CONTROL_{it}$—firm characteristics control variable. The model includes the time $Year_i$ and region $Country_i$ fixed effects to control for sample heterogeneity.

We recognize that heterogeneity across business entities may influence the proposed model due to differences in size, industry, and operational scope. However, further segmenting the sample would reduce the model's statistical robustness, given the number of observations. To partially mitigate the impact of heterogeneity, the model incorporates a firm control variable and fixed effects for time and region.

According to the research plan, further parametrization of the stated general model into logit required transforming the dependent variable of energy transition reporting status from categorical into binary. With this aim, based on the similar energy-related data availability criterion, we divided the panel data into two subsets, defining companies providing less than 25% of information as 'Not reporting' (group 1) and the remaining entities as 'Reporting' (group 2). To confirm the empirical findings, we applied the multinomial logit model using a categorical dependent variable based on three subsets according to the energy transition reporting status. The constructed models enabled the investigation of the possible relationship between the reporting status of entities from the agri-food sector and their profitability, liquidity, solvency, operating efficiency, and productivity.

4. Results

4.1. Trends in Energy Transition Reporting and Performance of the EU Companies from the Agri-Food Sector

Considering the structure of the sample, some industry patterns of financial performance of companies from the agri-food sector were identified (Table 3).

Table 3. Sample structure vs. financial metrics.

Industry Name	Share	Mean				
		ROE	CR	CCC	SR	PA
Agricult. Chemicals	3.2%	5.3%	1.64	81.5	0.51	0.81
Brewers	7.4%	13.7%	1.24	59.7	0.55	0.82
Distillers and Wineries	11.7%	6.2%	2.06	269.4	0.52	0.57
Fishing and Farming	14.7%	7.0%	2.04	126.1	0.55	1.05
Food Processing	45.2%	7.6%	1.79	73.4	0.52	1.10
Food Retail and Distribution	14.3%	12.1%	1.27	12.3	0.66	1.87
Non-Alcoholic Beverages	2.1%	13.6%	2.24	50.2	0.56	1.04
Tobacco	1.3%	11.2%	3.72	88.4	0.30	1.24
Total	100.0%	8.3%	1.79	94.6	0.54	1.11

Companies from the food processing industry constituted the majority of the research sample and could be treated as a benchmark in terms of financial performance, demonstrating average values of financial metrics such as profitability (ROE 7.6%), liquidity (CR 1.79), cash conversion cycle (CCC 73.4 days), solvency (SR 0.52), and assets' productivity (PA 1.10). In comparison to the benchmark, business entities from beverage-related industries

characterized by relatively fast-moving goods demonstrated higher earnings (ROE 13.6% for non-alcoholic beverages and 13.7% for brewers), average solvency (SR 0.56 and 0.55, respectively), and lower cash conversion cycles (CCC 50.2 and 59.7 days). However, these industries significantly differed in average liquidity ratios (CR 1.24 for brewers and 2.24 for non-alcoholic beverages). Conversely, firms from agriculture-related industries such as distillers and wineries and fishing and farming applied more conservative financial strategies. They had longer cash conversion cycles (CCC 269.4 days for distillers and wineries and 126.1 days for fishing and farming), demonstrated lower profitability (ROE 6.2% and 7.0%, respectively), significantly higher liquidity (CR 2.06 and 2.04), and average solvency (SR 0.52 and 0.55). Companies from the food retail and distribution industry signaled aggressive financial strategies supported by higher operating efficiency and significant financial risk. Probably due to the specificity of their business models, these entities were characterized by higher average profitability (ROE 12.1%), low liquidity (CR 1.27), a concise cash conversion cycle (CCC 12.3 days), high asset productivity (PA 1.87), and higher debt (SR 0.66). Agricultural chemicals had less favorable conditions in terms of their financial position, achieving low profitability (ROE 5.3%), lower liquidity (CR 1.64), and comparatively low asset productivity (PA 0.81). Contrary to this, the tobacco industry demonstrated relatively high equity margins (ROE 11.2%), average cash conversion cycles (CCC 88.4 days), higher assets' productivity (PA 1.24), and small debt ratios (SR 0.30). In general terms, the presented financial ratios indicated that various parts of the agri-food supply chains functioned within unique financial patterns shaped by their operational characteristics, market environments, financial potential, and strategic objectives.

Figure 1 shows that most business entities did not report energy-related information in compliance with the ESRS E1 standard, accounting for an average of 68.7% of firm observations between 2004 and 2023.

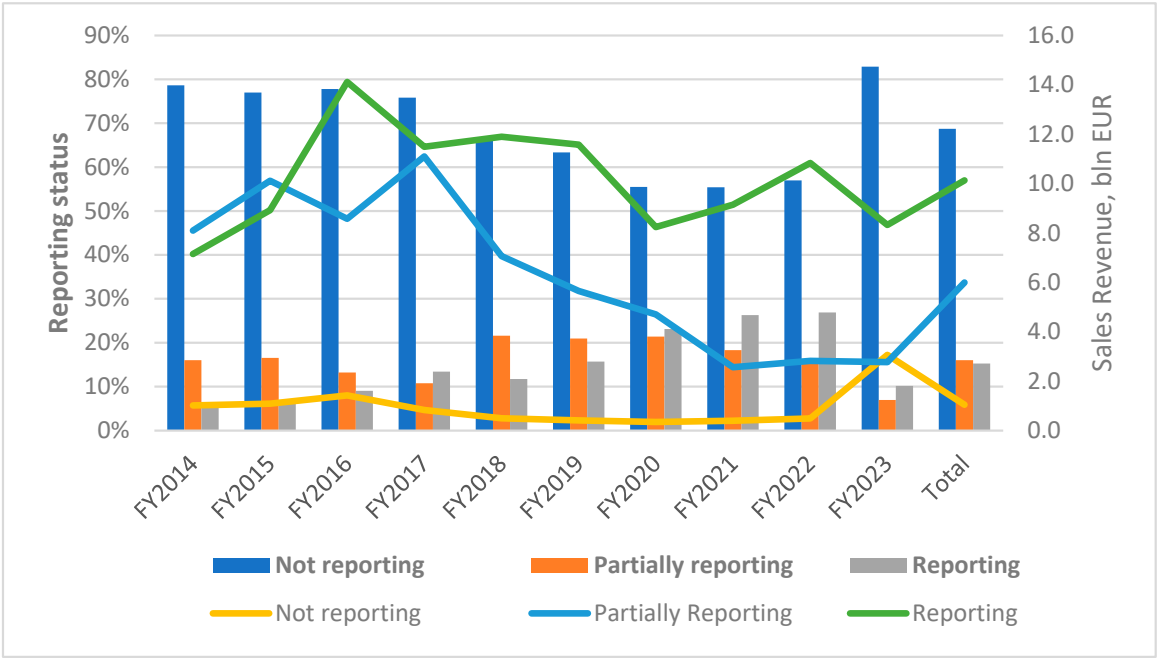


Figure 1. Energy Transition Reporting Status vs. Sales Revenue.

However, the share of the reporting entities in the sample increased over time from 5.3% in 2014 to 26.9% in 2022, while the number of non-reporting businesses fell from 78.6% to 57.0%. The increase in non-reporting entities in 2023 may be attributed to delays in accumulating relevant corporate energy transition data within the database. Considering the growing regulatory pressure in the EU, it can be anticipated that the trend of an increasing number of companies disclosing non-financial information will persist. On average, when comparing sales revenue, the reporting entities were characterized by a larger business

scale than their partially reporting and non-reporting counterparts. It could be associated with the focus of the EU regulations, primarily requiring larger corporations to comply with the requirement of disclosing ESG-related non-financial information. Moreover, a general trend of declining revenue among sample companies has been observed since 2016–2017, which could be partially attributed to crises such as the pandemic and the war in Ukraine in the later years.

Based on the profitability metrics, a discernible trend indicated that profitability decreased with a reduction in the volume of disclosed information (Figure 2).

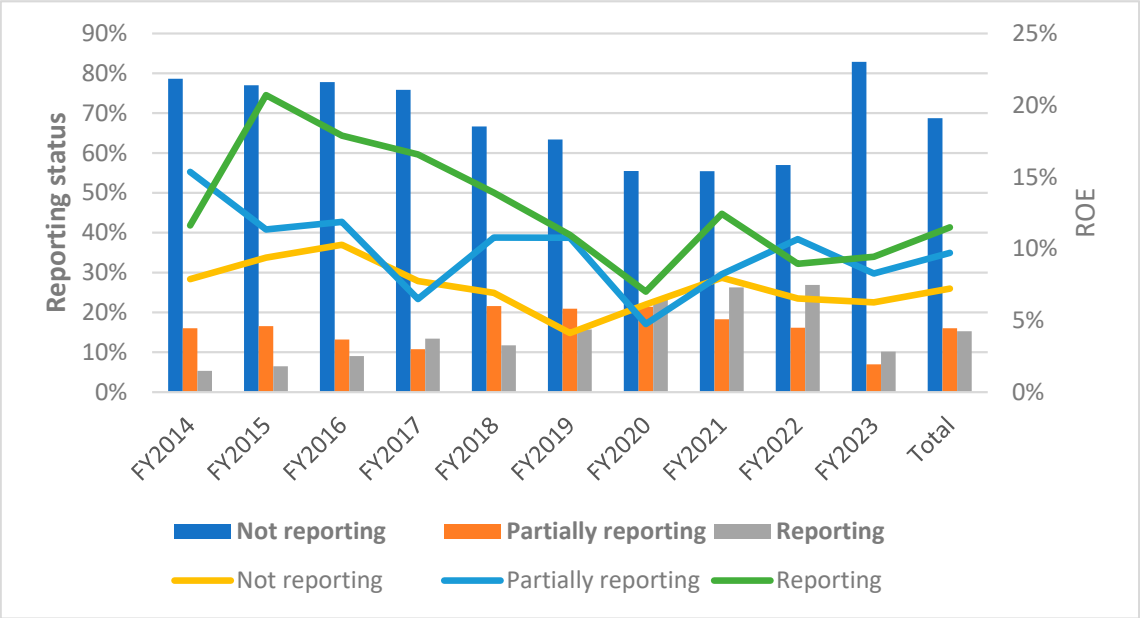


Figure 2. Energy Transition Reporting Status vs. Profitability.

For example, the highest average profitability was noticed in the 'Reporting' group of units (ROE 11.5%), while 'Partially reporting' and 'Not reporting' units demonstrated lower average ratios (ROE 9.7% and 7.2%, respectively). However, the analyzed sample revealed an overall decline in profitability indicators across all subsets of companies. Specifically, in the 'Reporting' group, ROE decreased from 20.7% in 2015 to 9.4% in 2024. The 'Partially reporting' group experienced a profitability decline from 11.3% to 8.3%, while the 'Not reporting' group reduced ROE from 9.4% to 6.3% in the same period. Adverse external economic conditions could impact these trends and simultaneously affect the ability and willingness of companies to comply with the reporting requirements on energy transition. Additionally, industry-specific and firm-specific factors might impact profitability, adding pressure to the extent and timeliness of energy-related disclosures. However, higher profitability among the 'Reporting' group supported the view of the long-term positive relationship between the energy transition strategy and business competitiveness.

In terms of liquidity, a contrasting trend within the research sample was observed as the highest liquidity ratios were associated with the group of 'Not reporting' entities (CR 1.92), whereas 'Partially reporting' and 'Reporting' companies exhibited lower ability to cover current liabilities (CR 1.58 and 1.41, respectively) (Figure 3).

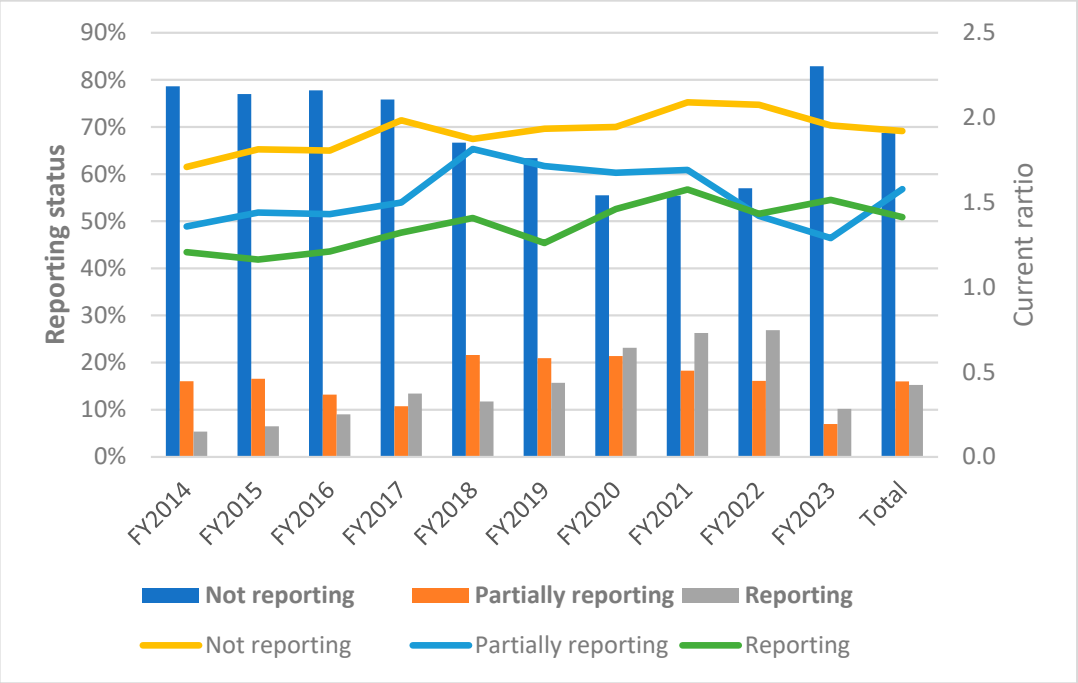


Figure 3. Energy Transition Reporting Status vs. Liquidity.

Furthermore, in the subset of 'Partially reporting' entities, a reduction in the current ratio from 1.82 in 2018 to 1.29 in 2023 could potentially signal a more widespread liquidity gap challenge within the sector. Considering the specific characteristics of agri-business enterprises, namely high seasonality, low inventory turnover, a long cash conversion cycle, and significant price volatility, low and declining liquidity ratios could threaten the continuity of ongoing operational activities in these entities. Moreover, the increasing economic turbulence caused by exogenous factors could result in adverse financial spillover effects in the interconnected supply chain. In a classic trade-off between value and continuity, higher liquidity is associated with lower risk for stakeholders and supports the assumption of more conservative financial strategies. From the energy transition perspective, increased liquidity in 'Not reporting' entities could signal a short-term cash surplus and advocate for the lack of managers' willingness to invest in long-term and less profitable energy incentives. Moreover, it could potentially increase the average cost of capital for financing operating activities. However, the reasons for fluctuating liquidity ratios could be beyond the scope of energy-related strategies.

In summary, the analysis revealed that the positive energy transition reporting status predominantly applied to entities with larger revenues, and there was a systematic increase in the share of reporting companies within the research sample. Additionally, a general trend illustrated that units with a higher capacity of reported energy-related information maintained higher profitability ratios. Conversely, companies characterized by a lower reporting level demonstrated higher liquidity ratios. In the broader context, the trends of declining profitability and persistently low liquidity should be regarded as adverse for European agri-business enterprises. Assuming the existence of significant relationships between corporate efficiency and energy transition reporting status, this phenomenon could negatively impact the energy transition strategies of European companies from the agri-food sector.

4.2. Modeling the Relationship Between the Energy Transition Reporting Practices and the Financial Performance of Agri-Food Companies

To examine and test the relationship between energy transition reporting practices and the financial condition of agri-food companies, we utilized a logistic regression model

designed for the sample panel data. In this model, the dependent variable was binary, indicating the reporting status across two subgroups of companies ('Reporting' or 'Not reporting'), while the explanatory variables comprised key financial metrics characterizing the companies' corporate efficiency. Table 4 presents the baseline logistic regression model (4), along with its variations that incorporate the impact of region (1), time (2), or both time and region (3) fixed effects (Table 4).

Table 4. Logit models for energy transition reporting status versus financial performance.

Model No	**(1)**	**(2)**	**(3)**	**(4)**
Explained variable: Reporting Status				
Explanatory variables:				
LRev	1.723 ***	3.047 ***	2.829 ***	1.898 ***
	(9.87)	(10.19)	(9.39)	(10.24)
ROE	−0.473	0.0721	−0.343	−0.278
	(−0.54)	(0.05)	(−0.24)	(−0.31)
CR	0.101	0.0219	−0.0351	0.0751
	(0.50)	(0.08)	(−0.11)	(0.40)
CCC	−0.00145	−0.00192	−0.0000369	−0.00283
	(−0.77)	(−0.63)	(−0.01)	(−1.36)
SR	0.167	−1.688	−2.081	0.0721
	(0.14)	(−0.93)	(−1.08)	(0.06)
PA	−1.126 ***	−1.051 *	−0.593	−1.449 ***
	(−3.54)	(−2.23)	(−1.30)	(−4.23)
_cons	−36.56 ***	−67.17 ***	−63.95 ***	−39.02 ***
	(−8.90)	(−10.31)	(−8.76)	(−10.28)
Log Likelihood	−476.48672	−348.57011	−326.58295	−494.36309
Wald chi2	121.97 ***	140.67 ***	131.17 ***	114.65 ***
Prob > chi2	0.000	0.000	0.000	0.000
Country Fixed Effects	Yes	No	Yes	No
Year Fixed Effects	No	Yes ***	Yes ***	No
N	1472	1618	1457	1638

Note: Significance of variables is denoted with asterisks: * $p < 0.1$, *** $p < 0.01$. t-values are reported in parentheses.

In general, logistic models were statistically significant, supporting the validity of the parameter estimates and the assumption of the appropriateness of the chosen specification. All models indicated a robust positive link between the scale of business, measured by sales revenue (LRev), and the likelihood of energy-related information disclosure. For example, the strongest effect of the revenue on the outcome was noticed in model (2) with a fixed time variable (OR 21.05) and model (3) with fixed time and country variables (OR 16.93).

Additionally, three out of four models revealed a robust negative relationship between asset productivity (PA) and the reporting status of agri-food companies. The most significant association of these variables was characterized by model (4) without time and country fixed effects (OR 0.24) and model (1) with defined country effect (OR 0.32). The observed inverse correlation could be explained in two ways. First, the rising asset productivity is often attributed to large, established firms facing the challenges of diseconomies of scale and complexity of organization structure that might decrease the efficiency of operations and the willingness to provide non-financial information. Second, the rapid increase in productivity can be observed in relatively smaller and innovative entities that do not fall under the non-financial regulatory burden due to their size.

Importantly, in the analyzed population, the time variable exhibited a robust positive association with reporting status, indicating that the likelihood of firms being classified as reporting increased significantly in the later years of the research period compared to the reference year. For example, model (3) identified yearly indicators, particularly from FY2014 (OR 5.17) onwards, as significant predictors of reporting status, with especially

strong effects observed from FY2020 (OR 1400.6) to FY2022 (OR 1789.9). This distinctive trend confirmed the substantial impact of adopting new regulations, including NFRD and CSRD, on the energy transition reporting practices of EU companies in the agri-food sector.

However, other explanatory variables such as profitability (ROE), liquidity (CR), operating efficiency (CCC), and solvency (SR) did not significantly impact the reporting status of agri-food companies. Their p-values were well above 0.05 in all models, indicating that these variables were not strong predictors. It supported the view of an ambiguity in the relation between corporate efficiency and energy transition reporting practices within the research sample.

To confirm the relationships observed in models (1–4) and acquire a deeper insight into the structure of the sample, we transformed a binary dependent variable (reporting status) into a categorical dependent variable, dividing the dataset into three subgroups: 'Not reporting' entities (provided up to 25% of energy-related information), 'Partially reporting' (25–75%), and 'Reporting' (>75%). Then, we applied a multinomial logit model for a designed categorical dependent variable (Table 5).

Table 5. Multinomial logit model for energy transition reporting status versus financial performance.

Group	Coefficient	Std. Err.	z	P > |z|	[95% Conf. Interval]	
Not_reporting	(base outcome)					
Partially_reporting						
LRevenue	1.597	0.176	9.080	0.000	1.252	1.942
ROE	−0.486	0.954	−0.510	0.610	−2.356	1.384
CR	0.263	0.194	1.350	0.176	−0.118	0.644
CCC	−0.003	0.003	−1.060	0.287	−0.008	0.002
SR	−0.574	1.326	−0.430	0.665	−3.173	2.026
PA	−0.653	0.329	−1.980	0.047	−1.297	−0.008
_cons	−34.683	3.719	−9.330	0.000	−41.971	−27.394
Reporting						
LRevenue	2.270	0.271	8.360	0.000	1.738	2.802
ROE	−0.481	1.152	−0.420	0.676	−2.738	1.776
CR	−0.241	0.274	−0.880	0.379	−0.777	0.295
CCC	−0.002	0.002	−0.760	0.446	−0.006	0.003
SR	−0.307	1.624	−0.190	0.850	−3.489	2.876
PA	−2.319	0.487	−4.760	0.000	−3.273	−1.364
_cons	−46.998	5.556	−8.460	0.000	−57.887	−36.108
var(u2)	5.970	1.567			3.569	9.986
var(u3)	8.383	2.492			4.681	15.010
Log Likelihood	−749.86306					
Wald chi2	137.20					
Prob > chi2	0.0000					

This approach added more detail to exploring how selected key performance indicators could contribute to the likelihood of gradual change in the reporting statuses from 'Not reporting' to 'Partially reporting' and 'Reporting'. Strictly, the model estimated the effects of explanatory variables on the probability of a firm being categorized as a Reporting or Partially reporting entity compared to a base non-reporting company.

In this comparison, sales revenue had a significant positive coefficient for both the 'Partially reporting' (1.60) and 'Reporting' (2.27) groups of entities. It indicated that compa-

nies with higher revenues were more likely to provide extended energy-related information than their smaller counterparts. Conversely, assets' productivity had a significant negative coefficient for Partially reporting (−0.65) and Reporting (−2.32) firms. The comparatively higher coefficients of significant explanatory variables for a 'Reporting' group of entities suggested that the capacity and quality of reported information could be susceptible to the company's size, confirming the assumption that regulatory pressure could be the primary driver for managers in reporting their energy transition strategies. Other financial variables such as profitability, liquidity, cash conversion cycle, and solvency did not demonstrate significant effects, as indicated by their p-values, suggesting that they did not strongly differentiate between 'Partially reporting' and 'Not reporting' status in this model. The model outcomes supported our earlier assumptions on the role of financial metrics associated with the energy transition reporting statuses of agri-food companies.

5. Discussion and Concluding Remarks

The efficiency of a business entity manifests in various dimensions, including its operational processes, financial position, marketing strategies, and environmental and energy policy [70,71]. Integrating these dimensions enables corporate governance to gain a competitive edge and improve financial results, thereby enhancing the value of a company. In light of the lasting debate over climate change and business responsibility, the corporate policy on energy transition introduces a new dimension to performance evaluation criteria [72,73].

The current body of literature addresses the nexus between energy transition strategy and corporate efficiency in various contexts [74,75]. In the broader academic research, there is a visible connection between energy-related reporting practices and the financial performance of business entities [76,77]. In the environmental and energy transition aspects, the benefits associated with adopting ESG practices include reducing waste, preserving natural resources, lowering carbon emissions, and limiting energy use to optimize available resources [78]. The social context means introducing more sustainable labor practices, equal employment policy, community engagement, and workforce diversity to enhance the company's reputation and brand value for the customer [79]. The governance aspect embraces sustainable managerial practices such as ethical conduct, independence, and transparency that should mitigate the risks of biased communication and improve the shareholders' trust, adding to the company's market value [80]. Therefore, both the social and governance dimensions can significantly contribute to pursuing energy-efficient policy and stimulate energy transition within a business entity. Furthermore, following the value creation school, in the long-term, the energy transition strategy can increase the company's overall financial performance through all these channels, supporting higher profitability, adequate debt levels, and improved operating efficiency [81].

From the investors' perspective, corporate non-financial reports might be the indicators of better corporate performance and associated with higher returns [82]. Numerous studies stress the importance of various energy-related rankings for evaluating the companies' growth potential and overall investment attractiveness [83]. However, some studies identified no significant links between ESG sustainable practices, particularly in carbon emissions and energy management, and value for shareholders, as well as diverse effects of reporting initiatives on investor behavior that question their usefulness as a guide for making investment decisions in a broader market [84–87].

From the managerial point of view, maintaining energy management strategies and enhancing energy transition reporting practices may result in numerous competitive bonuses, such as increased customer loyalty, better relations with suppliers, and lower cost of financing [88]. However, in the short term, energy-related disclosures may be associated with additional operating expenses, resulting from more labor effort for the reporting department and auditing function. Therefore, in light of a classic trade-off between value maximization and business continuity, a manager can choose between two strategic options: the immediate consumption of profits or the allocation of idle cash to long-term energy

incentives and energy transition reporting activities to enhance corporate competitiveness. However, the causality of the relationship between performance and energy-related policies is an ongoing debate among academics and business practitioners [89].

In our study, we explored the relationship between companies' energy transition reporting practices and the corporate efficiency of EU companies in the agri-food sector. The emerging expectations of more transparent and consistent energy transition disclosures and the growing importance of the ESG framework in the agri-food sector make this topic significant for different groups of stakeholders.

For research purposes, we utilized a set of energy-related data points from the scope of the ESRS 1E standard to identify the reporting status of entities from the EU agri-food sector. Then, we confronted the observed energy transition corporate practices with key financial metrics, characterizing business efficiency, including profitability, liquidity, solvency, operating efficiency, and productivity. First, our findings suggest that companies exhibited varying firm-level characteristics based on the reporting status classification. On average, the reporting entities operated on a larger scale than their non-reporting counterparts, demonstrating a strong correlation between corporate revenue and energy transition policies. We also noticed increasing reporting quality among agri-food companies over time. For example, the proportion of reporting and partially reporting companies grew from 2014 systematically, likely due to the rising regulatory pressure on listed companies to disclose energy-related data.

Using descriptive statistics and financial ratio analysis, we noticed that reporting companies, on average, could have higher profitability and productivity ratios, indicating higher efficiency. These findings partially endorsed our assumption of the long-term competitive advantage of energy transition reporting companies, contradicting the cost-based short-term view on a trade-off between value and continuity of business. Moreover, analyzing the trends in ratio distribution over time, we detected relatively higher liquidity and solvency in the group of non-reporting entities, supporting their more conservative stance over financial management strategies. Notably, a greater amount of net working capital and more equity in capital structure could lead to higher financing costs and decrease efficiency in the long term.

In further research, we applied a panel data regression analysis to evaluate the statistical significance of the observed trends. The panel data logit model, which explains energy transition reporting status based on firm key performance indicators, demonstrated a robust positive nexus between the company's size and energy transition disclosures, confirming our previous assumptions. However, the inverse relationship between energy transition reporting status and asset productivity suggested a more complex corporate pattern that could be influenced by diseconomies of scale.

Importantly, in our study, the energy transition reporting status did not show a statistically significant link with most financial metrics, such as profitability, liquidity, solvency, and operating efficiency of sample companies. On the one hand, this could signal the irrelevance or ambiguity of financial strategies in light of the companies' energy transition reporting practices, which was confirmed in some of the analyzed empirical studies. On the other hand, the absence of a statistically significant relationship could be explained by the limitations of our study, including the specificity of the sector-oriented data sample and rapid changes in the ESG-related regulatory environment. By extending the study to include longer periods with well-established and comparable ESG legislative frameworks and expanding the sample to additional geographic regions and industries, we can more comprehensively explore the relationship between energy transition reporting practices, efficiency, and firm value in future research. However, we believe that our study, in its current form, can be a valuable exploratory tool for practitioners, researchers, and policy decisionmakers.

In a managerial context, the research reveals how energy transition practices, including energy use optimization, the introduction of renewable energy sources, and the reduction of emissions, can align with key performance indicators, emphasizing the role of the energy

management strategy in enhancing a company's value. By allocating resources to these initiatives, managers can improve resource efficiency and create a strong connection between energy transition goals and sustainability objectives, ultimately improving profitability. This strategic shift in managerial approach aims to ensure compliance with regulations and enhance corporate resilience, particularly in the agri-food sector, which faces increased regulatory pressure and rapidly developing environmental risks.

From the academic perspective, our research can facilitate the broader scientific discussion on the relevance of energy-related reporting standards and the hierarchy of corporate motives for elaborating on energy transition strategies toward circular business models. In this context, our ultimate ambition is to contribute to developing the existing legislative framework on energy transition standards to support achieving the EU goals for energy transformation and sustainability in the agri-food sector.

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