Study Project

Sustainability Reporting in the European Union: A Systematic Review of Regulatory Developments and Their Influence on Corporate Sustainability Strategies

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List of Abbreviations:

AI – Artificial Intelligence

CapEx – Capital Expenditure

CSDDD – Corporate Sustainability Due Diligence Directive

CSR – Corporate Social Responsibility

CSRD – Corporate Sustainability Reporting Directive

EC – European Commission

EFRAG – European Financial Reporting Advisory Group

EP – European Parliament

ERM – Enterprise Risk Management

ESG – Environmental, Social, and Governance

ESRS – European Sustainability Reporting Standards

EU – European Union

EVS – Environmental and Sustainability Standards

GAR – Green Asset Ratio

GHG – Greenhouse Gas

GHGP – Greenhouse Gas Protocol

GRI – Global Reporting Initiative

IME – Institute of Environmental Sciences and Environmental Technology

ISSB – International Sustainability Standards Board

NFRD – Non-Financial Reporting Directive

NLP – Natural Language Processing

OpEx – Operational Expenditure

SAP – Systems, Applications, and Products in Data Processing

SDGs – Sustainable Development Goals

SEPR – Sustainability and Environmental Performance Reporting

SFDR – Sustainable Finance Disclosure Regulation

SMEs – Small and Medium-sized Enterprises

TCFD – Task Force on Climate-related Financial Disclosures

XHTML – Extensible Hypertext Markup Language

Abstract

This thesis presents a systematic literature review that explores how the Corporate Sustainability Reporting Directive (CSRD) influences the design and implementation of Enterprise Risk Management (ERM) systems in EU-based corporations.

In response to the growing regulatory emphasis on environmental, social, and governance (ESG) transparency, the CSRD is reshaping corporate behavior by embedding sustainability considerations into formal risk management practices.

Using peer-reviewed academic sources and official publications post-2015, the study identifies how CSRD requirements contribute to a shift in risk taxonomies, strengthen internal control frameworks, and align ERM with stakeholder-oriented and long-term corporate sustainability strategies.

The analysis underscores the role of stakeholder theory and double materiality in driving this transformation, revealing how companies are now required to consider both the financial impact of sustainability risks and their broader social and environmental consequences.

To ground these findings in practice, case examples from TotalEnergies, Siemens, and Volkswagen are examined, illustrating how leading corporations are adapting their ERM frameworks to meet CSRD expectations and enhance strategic resilience.

These companies demonstrate differing levels of maturity in integrating sustainability risks into ERM, providing insights into the variability of implementation strategies across sectors.

The findings suggest that the CSRD acts as a regulatory catalyst, advancing the convergence between sustainability reporting and enterprise risk governance.

This review contributes to academic and managerial debates by clarifying the evolving role of non-financial disclosure regulations in shaping corporate risk cultures, while also identifying key gaps for future empirical research.

Keywords: Sustainability Reporting, Non-financial Reporting, Corporate sustainability Reporting, European Union

1 Introduction

1.1 Background and Context; A Brief overview

Sustainability reporting is essential for providing stakeholders with reliable and comparable information, especially as sustainability issues increasingly have become a central concern for investors, creditors, legislators, customers, and other key groups. By enabling transparency, sustainability reporting supports the direction of private capital towards funding the green and social transition, while also helping to draw more investments aimed at achieving sustainable economic objectives (Ruohonen & Kullas, 2024). Sustainability reporting has emerged as a key instrument in aligning corporate strategy with global environmental, social, and governance (ESG) goals (Opferkuch et al., 2023). By sustainability reporting, it is intended to provide stakeholders with consistent and objective information so that they can evaluate the company's approach or strategy for value creation, including both non-financial goals and performance in these areas (Opferkuch et al., 2023).

By disclosing environmental and social data, firms enhance their ability to assess, monitor, and manage non-financial performance, thereby identifying sustainability-related risks and fostering greater stakeholder trust (Posadas et al., 2023). Beyond transparency, sustainability reporting serves as a vehicle for aligning internal business strategies, corporate planning processes, and management control systems with sustainability principles. This strategic alignment empowers organizations to shape externally communicable, sustainability-oriented business models (Raucci & Tarquinio, 2020).

Over time, the evolving understanding of organizational behavior in the context of sustainability, has led to the institutionalization of both voluntary and mandatory disclosure frameworks, now formally recognized under European regulations as sustainability reporting. These mechanisms are designed to serve stakeholders across sectors and enable their use in various decision-making contexts (Fontaine et al., 2024). By releasing non-financial information, companies are able to manage their business risks better and more effectively, which in turn leads to greater financial success (Primec & Belak, 2022). The importance of sustainability reporting is also reflected in its ability to integrate and balance quantitative and qualitative dimensions of both financial and non-financial data, forming a central component of corporate annual and sustainability disclosures (Paun et al., 2020).

As mentioned before, sustainability reporting also strengthens collaboration between communities by the environmental, social, and governance (ESG) framework (Yébenes, 2024). Its role in advancing both corporate and global sustainability objectives is increasingly evident, given that stakeholders use disclosed information to determine how well a company aligns with ESG criteria. The availability of ESG data enhances transparency, offering a clearer understanding of how companies and investors contribute to the transition toward a carbon-neutral economy (Yébenes, 2024).

In recent years, a growing global awareness, driven by citizens and policymakers alike, has emphasized the critical importance of reexamining the structural dynamics underpinning the global economy (Principale & Pizzi, 2023). Unlike the past, the private sector has taken on a central role in integrating environmental, social, and governance concerns into core operational strategies. This shift has been accompanied by a rising stakeholder interest in ESG matters, which has intensified corporate focus on sustainability reporting as a means to demonstrate accountability and long-term responsibility (Nampoothiri et al., 2024).

Organizations now are key players in the implementation of sustainable business practices, that not only create value for investors but also serve the wider interests of society. Their contributions are central to mitigating climate change and fostering the transition toward a greener economy (Perevoznic & Dragomir, 2024). Accordingly, Stakeholders are increasingly encouraged to integrate non-financial information into their decision-making processes, prompting companies to revise business models and align them with ambitious policy objectives set by legislators (Pizzi et al., 2023). As a result, sustainability has emerged as a central concern not only for corporations but also for researchers and society at large. Prioritizing environmental and social dimensions in corporate strategy and decision making signifies a broader commitment to socially responsible behavior (Krasodomska et al., 2023).

Financial institutions, as primary channels of fundings, are pivotal in supporting the shift toward a sustainable and circular economy. This was reaffirmed by the EU Commission in its 2018 action plan, *Financing Sustainable Growth*, which emphasized the need to reorient private capital flows toward more sustainable investments (Siri & Zhu, 2019).

In this context, corporate disclosures contribute to the dissemination of long-term strategic objectives, support circular economy models, engage key stakeholders, and sustain public confidence. Non-financial reporting thus represents the initial regulatory step toward embedding socially responsible governance across European business landscapes (Primec & Belak, 2022). As awareness of responsible and ethical business conduct continues to rise, there has been a corresponding increase in the demand for both voluntary and mandatory sustainability disclosures, a trend evidenced by the global expansion of sustainability reporting frameworks and instruments (Ottenstein et al., 2022).

Sustainability has increasingly emerged as a fundamental driver of long-term corporate success, particularly in aligning business practices with the objectives set forth by the United Nations' Sustainable Development Goals (SDGs) (Velte, 2023). Over the past two decades, the European Union has systematically built one of the world's most comprehensive regulatory frameworks for sustainability. This began with the launch of the EU Sustainable Development Strategy in 2001, which was subsequently revised in 2006 and 2009 to intensify efforts across all ESG dimensions (Pacces, 2021).

The formulation of the Europe 2020 Strategy and the 2016 Commission Communication marked a significant advancement in the EU's strategic trajectory, explicitly integrating the United Nations Sustainable Development Goals into the policymaking framework (Pacces, 2021). Together, these initiatives have established the EU as a global front-runner in climate governance, with ambitious targets and substantial investments aimed at reshaping the European economy through the European Green Deal (Principale & Pizzi, 2023).

A significant milestone in this regulatory evolution was the adoption of Directive 2014/95/EU, the Non-Financial Reporting Directive (NFRD), which marked the EU's first legal requirement for large public-interest entities to disclose ESG-related information (Paun et al., 2020). As the foundation for harmonized sustainability reporting across Europe, the NFRD introduced the principle of mandatory non-financial disclosure, though its flexibility in implementation revealed several shortcomings, such as limited comparability and lack of coverage for SMEs (Stefanescu, 2022).

To address these challenges, the European Commission introduced the Corporate Sustainability Reporting Directive (CSRD), published in December 2022 and entering into force in early 2023. The CSRD dramatically expands reporting obligations, introduces mandatory third-party assurance, and enforces the application of the European Sustainability Reporting Standards (ESRS), thereby enhancing both the credibility and standardization of sustainability data across the EU (Ruohonen & Kullas, 2024 ; Opferkuch et al., 2023). Complementing these directives, the EU introduced a set of financial and due diligence regulations aimed at structuring capital flows and corporate accountability. The EU Taxonomy Regulation, effective since July 2020, serves as the EU's first unified classification system for sustainable economic activities (Tettamanzi et al., 2024 ; Fontaine et al., 2024). It links closely to the EU Action Plan on Financing Sustainable Growth and integrates with instruments such as the EU Green Bond Standard (Hoepner & Schneider, 2023). The Sustainable Finance Disclosure Regulation (SFDR) obligates financial institutions to incorporate sustainability considerations into investment strategies, positioning the EU as a global standard setter in ESG finance (Yébenes, 2024). Meanwhile, the Corporate Sustainability Due Diligence Directive (CSDDD) pushes beyond financial transparency, imposing mandatory human rights and environmental risk assessments across global value chains. It requires companies to adopt enforceable codes of conduct and obtain contractual assurances from partners, under the supervision of national authorities (Tettamanzi et al., 2024 ; Vandenbroucke, 2024). Nearly 80 percent of European multinationals have now implemented such due diligence protocols, marking a paradigm shift from voluntary corporate sustainability reporting (CSR) toward enforceable corporate accountability (Mieszkowska, 2024; Dempere et al., 2024). Despite persistent challenges including fragmented reporting frameworks, data inconsistency, and the risk of greenwashing the European Commission has continued refining its policy tools. Reforms such as the Omnibus Package aim to reduce administrative burdens, especially for SMEs, while reinforcing the EU's leadership in sustainable governance (Fiandrino et al., 2022; Pantazi, 2024).

At the heart of this framework is the concept of materiality, particularly *double materiality*, which is now embedded in both the NFRD and CSRD (Miettinen, 2024; Dragomir et al., 2024). It redefines how companies must interpret and disclose sustainability risks, balancing their financial impacts with broader societal and environmental consequences (Mezzanotte, 2023; Pozzoli et al., 2023). By operationalizing this concept through detailed ESRS requirements and digital reporting mechanisms, the EU has laid the groundwork for a transparent, accountable, and forward-looking corporate ecosystem. In this broader context, the EU's regulatory architecture has evolved from principle-based disclosure toward a binding, enforceable, and metrics-driven regime. This shift not only aligns corporate behavior with societal values but

also establishes a governance model in which sustainability reporting serves as both a compliance requirement and a strategic asset (Godt, 2023; Klimczak et al., 2023 ; Elamer & Boulhaga, 2024).

1.2 Research Significance

The increasingly dynamic and evolving nature of sustainability reporting legislation presents a significant challenge to researchers and practitioners alike (Hummel & Jobst, 2024). As regulatory instruments such as the Corporate Sustainability Reporting Directive (CSRD) continue to develop, uncertainties have emerged regarding their interpretation and implementation (Posadas et al., 2023). In particular, many companies remain unclear about how to operationalize new requirements in practice, due in part to the absence of comprehensive guidance from EU institutions at the national enforcement level (Fiechter et al., 2022).

A key concern is the lack of harmonized and clearly defined reporting standards, which contributes to inconsistencies, minimalist disclosure practices, and limited comparability between corporate sustainability reports (Villiers, 2022). Moreover, questions remain regarding the substantive impact of governance mechanisms such as sustainability-focused supervisory boards on corporate social responsibility (CSR) strategies. It is yet to be determined whether such boards function as symbolic structures or are genuinely motivated by long-term commitments to sustainable transformation (Velte, 2023). The CSRD, which applies to all companies listed on EU-regulated markets with exemptions for certain micro, small, and medium-sized enterprises (SMEs), introduces new and complex compliance obligations (Dimes & Molinari, 2024). These include third-party verification, digital formatting requirements, and extensive qualitative and quantitative ESG disclosures. Startups and SMEs are particularly vulnerable to the administrative and financial burdens introduced by these obligations, which may pose barriers to market entry and inhibit innovation (Dempere et al., 2024).

While standardized sustainability reporting frameworks such as the Global Reporting Initiative (GRI) offer a starting point, they are often disproportionately tailored to large corporations. As such, they may fail to account for the unique stakeholder dynamics, operational constraints, and reporting motivations of SMEs. This highlights the urgent need for a more flexible and proportionate reporting framework that is adapted to the specific characteristics and capacities of smaller firms (Nowak et al., 2024). Despite the existence of procedures for introducing sustainability in enterprises, such as the Global Reporting Initiative (GRI), these are primarily implemented by large corporations because it requires resources and capabilities that SMEs may not have. furthermore, the GRI procedure may not consider the specifics and needs of SMEs, such as their stakeholders, impacts, and motivations for sustainability reporting, indicating a need for a holistic, tailor-made approach for SMEs (Nowak et al., 2024).

In light of the evolving regulatory landscape, it is now pertinent to explore the current status of EU sustainability reporting frameworks and assess their strategic implications for corporate practice. The following section addresses these core questions.

1.3 Research Questions

What is the current status quo of EU sustainability reporting regulations?

The current regulatory landscape of sustainability reporting in the European Union reflects a significant departure from early voluntary disclosures toward a system of comprehensive, mandatory requirements. Since 2018, the Non-Financial Reporting Directive (NFRD) has required large EU public-interest entities, with more than 500 employees, to disclose key environmental and social information, thereby establishing a baseline for transparency and accountability in corporate sustainability practices (Dinh et al., 2023). Building on this foundation, the Corporate Sustainability Reporting Directive (CSRD) introduces a more expansive and prescriptive framework. Replacing the NFRD in full, the CSRD broadens the scope of reporting obligations to include all companies listed on EU-regulated markets, as well as large undertakings exceeding specific thresholds for net turnover, balance sheet total, or employee count. Insurance undertakings and credit institutions are also subject to these requirements (Dimes & Molinari, 2024).

In addition to mandating third-party assurance for disclosed information, the directive introduces digital formatting standards, requiring XHTML-tagged financial and management reports to facilitate machine-readability and comparability across the EU (Mezzanotte, 2023). Complementing the CSRD, two other key regulatory instruments shape the current status quo: the Sustainable Finance Disclosure Regulation (SFDR) and the EU Taxonomy. The SFDR, in force since March 2021, imposes binding transparency obligations on financial market participants and advisors, requiring them to disclose the sustainability characteristics of investment products (Partiti, 2024). Meanwhile, the EU Taxonomy offers a standardized classification scheme to identify environmentally sustainable economic activities, thereby providing investors with a consistent basis for decision-making (Dinh et al., 2023). Despite the increasingly mandatory nature of these frameworks, no single EU Member State prescribes a uniform reporting standard for compliance. This regulatory flexibility has introduced uncertainty among reporting firms, many of which must navigate a landscape of overlapping international frameworks while seeking alignment with the CSRD and ESRS (Dumay et al., 2019). While this flexibility enables firms to adapt the requirements to their specific operations, it also creates challenges in interpretation, especially for companies with little reporting experience or those moving from voluntary to mandatory disclosure. (Breijer et al., 2024).

Together, these instruments form the backbone of the EU's current sustainability reporting regime, an architecture designed to enhance transparency, facilitate responsible investment, and strengthen the integration of sustainability considerations across corporate and financial systems (García-Sánchez et al., 2023). *(Note: The legislative trajectory and historical evolution of these regulations are addressed in detail in the preceding section and are not repeated here.)*

How do these regulations influence corporate sustainable strategies?

The introduction and implementation of EU sustainability regulations have had far-reaching implications for corporate strategy, particularly in how companies position themselves competitively, manage risks, and structure internal governance. The EU Taxonomy reporting requirements have triggered strategic reflection among firms, prompting a re-evaluation of core activities against three key performance indicators: turnover, capital expenditure (CapEx), and operational expenditure (OpEx) related to environmentally sustainable activities (Hummel & Bauernhofer, 2024).

The Corporate Sustainability Reporting Directive (CSRD) further necessitates a rapid and comprehensive transformation of corporate structures and culture. In order to comply, businesses are required to adopt risk-oriented management tools that integrate sustainability across all functions and processes within the organization. This shift demands not only technical adaptation but also deep organizational change, as sustainability is embedded into enterprise-wide decision-making systems (Cavallaro et al., 2024). Nevertheless, the effectiveness of these regulatory frameworks may be compromised by certain structural weaknesses. Despite the consistent rollout of reporting directives, the absence of sufficiently robust enforcement mechanisms and sanctions may undermine their intended impact (Cavallaro et al., 2024). At the same time, companies must navigate rising operational costs and capital expenditures as they redesign business models to align with regulatory obligations, stakeholder expectations, and the broader goals of the European Green Deal (Burca et al., 2024). In practical terms, firms are now required to obtain contractual assurances from business partners and enforce codes of conduct that are aligned with evolving EU standards. This increased demand for accountability across the value chain has led many companies to restructure not only their immediate operations but also their long-term strategic outlook (Vandenbroucke, 2024). The Taxonomy Regulation has also catalyzed internal dialogue within firms, fostering competition around sustainability performance and encouraging alignment with regulatory benchmarks (Chrzan & Pott, 2024).

A defining feature of this new regulatory environment is the formal adoption of the double-materiality principle under the CSRD. This principle obliges companies to assess and report both how sustainability issues affect their financial health and how their activities impact the broader social and environmental context. Its implementation represents a fundamental shift in governance, demanding that businesses integrate sustainability factors into core strategic and reporting frameworks. However, critical perspectives suggest that not all firms may embrace these changes in good faith. There is a growing concern that some companies may engage in what has been termed “creative compliance”, a practice in which regulatory requirements are technically fulfilled while circumventing their underlying intent. This strategy may limit the transformative potential of sustainability regulations by focusing on formalistic box-ticking rather than substantive corporate change (Biondi et al., 2020).

2 Methodology

2.1 Research Design

This study adopts a systematic literature review (SLR) approach to examine the evolving regulatory landscape of sustainability reporting in the European Union and its implications on corporate strategy. The methodology follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines, ensuring a transparent, replicable, and unbiased review process. The research is guided by the following primary question:

"What is the current status quo of sustainability reporting regulations in European union and how it influences the corporate sustainable strategies?"

The main research question is then broken down to the following sub-questions**:**

- What is the current status quo of EU sustainability reporting regulations?

- How do these regulations influence corporate sustainable strategies??

As 2015 marks the adoption of major global frameworks like the Paris Agreement and UN Sustainable Development Goals (SDGs), which influenced EU policies on sustainability. This period captures the evolution of key EU regulations, including the Non-Financial Reporting Directive (NFRD) (2014/95/EU) and its successor, the Corporate Sustainability Reporting Directive (CSRD)(2021).

2.2 Data Sources and Search Strategy

To identify relevant literature, we searched two academic databases—Web of Science and Google Scholar—and complemented these with manual searches of official websites, including those of the European Commission, Siemens, and TotalEnergies, to access grey literature such as policy frameworks and corporate sustainability reports. We applied three main search strings in Web of Science, combining keywords related to sustainability reporting frameworks, European policy instruments, and corporate outcomes. Boolean operators and topic field tags (TS=) were used to structure the queries, such as:

(TS=("sustainability reporting" OR "non-financial reporting" OR "Integrated Reporting" OR "EU Taxonomy" OR "circular economy action plan" OR "sustainability policies") AND TS=("European Union" OR "European regulations" OR "EU") AND TS=("corporate" OR "corporate performance"))

(TS=("CSRD" OR "NFRD" OR "ESRS" OR "CSDDD" OR "EU ETS" OR "SFDR" OR "ESG" OR "RED") AND TS=("European Union" OR "European Regulations" OR "EU") AND TS=("corporate sustainability" OR "corporate strategies" OR "corporate performance"))

(TS=("sustainability directives" OR "sustainability frameworks" OR "sustainability reports") AND TS=("European Union" OR "European Regulations" OR "EU") AND TS=("corporate sustainability" OR "corporate strategies" OR "corporate performance"))

2.3 Inclusion and Exclusion Criteria

To ensure the relevance, quality, and academic rigor of this systematic literature review, a set of clear inclusion and exclusion criteria was developed. These criteria served as a guiding framework for selecting sources that meaningfully contribute to the research objectives, namely, understanding the evolution of sustainability reporting regulations within the European Union (EU) and their impact on corporate sustainability strategies. The selection process aimed to strike a balance between breadth and depth, capturing a comprehensive yet focused view of the regulatory landscape and its corporate implications.

The first inclusion criterion was geographic scope. Only studies that focus explicitly on the European Union regulatory context were considered. Given that the EU has played a leading role in shaping sustainability and ESG (Environmental, Social, and Governance) reporting standards, the regional specificity was essential to maintain consistency and comparability among the selected literature. This approach also reflects the thesis's primary interest in the EU's legal and policy frameworks, such as the Non-Financial Reporting Directive (NFRD) and the Corporate Sustainability Reporting Directive (CSRD).

Secondly, thematic relevance was a critical filter. Selected studies had to address topics directly related to sustainability reporting, ESG disclosure, or non-financial reporting. These areas are central to the thesis and represent key domains through which regulatory frameworks influence corporate behavior. Particular attention was paid to studies that connect reporting requirements with organizational responses, such as changes in corporate strategy, improvements in performance metrics, or enhanced compliance practices. This ensures that the analysis remains aligned with the research question and allows for a deeper exploration of the regulatory impact on business decision-making.

In terms of source quality, only peer-reviewed journal articles and high-quality official reports were included. Peer-reviewed publications guarantee a certain standard of academic reliability and methodological soundness. However, considering the evolving nature of EU regulation, some grey literature—specifically official reports and documents from recognized institutions such as the European Commission—was also included, provided it met standards of credibility and relevance.

Exclusion criteria were also carefully defined to eliminate studies that could potentially dilute the analytical focus or compromise the credibility of the review. First, non-English language publications were excluded due to language constraints and to ensure consistency in interpretation. Second, studies published before 2015 were omitted. This cutoff was chosen to focus on the most recent developments in sustainability reporting, especially in light of significant legislative changes in the past decade.

Moreover, papers that fell outside the EU context, even if related to sustainability reporting, were excluded to maintain regional specificity. Non-peer-reviewed materials, including blogs, opinion pieces, or unofficial reports, were also excluded unless they originated from verified and authoritative sources. Additionally, studies that, based on title and abstract screening, appeared to be irrelevant to the research topic were removed from consideration. Finally, studies that have never been cited were excluded due to concerns about their academic credibility and influence within the scholarly community. Overall, these inclusion and exclusion criteria were designed to ensure that the selected literature provides a robust and relevant foundation for the subsequent analysis. They help ensure that the review is methodologically sound and aligned with the objectives of understanding the intersection between regulation and corporate sustainability strategy in the EU.

2.4 Screening and Selection Process

The initial search yielded 428 records. After removing non-English records (10), duplicates (52), and non-peer-reviewed materials (27), 339 records remained for screening. After reviewing titles and abstracts, 156 were excluded for irrelevance or being outside the EU context. This left 156 full-text reports sought for retrieval, of which 8 could not be accessed, and 148 were assessed for eligibility. Of these, 48 were excluded, either due to credibility issues (10) or failing to meet the final inclusion criteria (38). Ultimately, 94 articles were included from database searches, with 33 additional sources from manual and grey literature searches, resulting in a final review sample of 127 documents. In Figure 1 PRISMA flow diagram illustrates the screening and selection process.

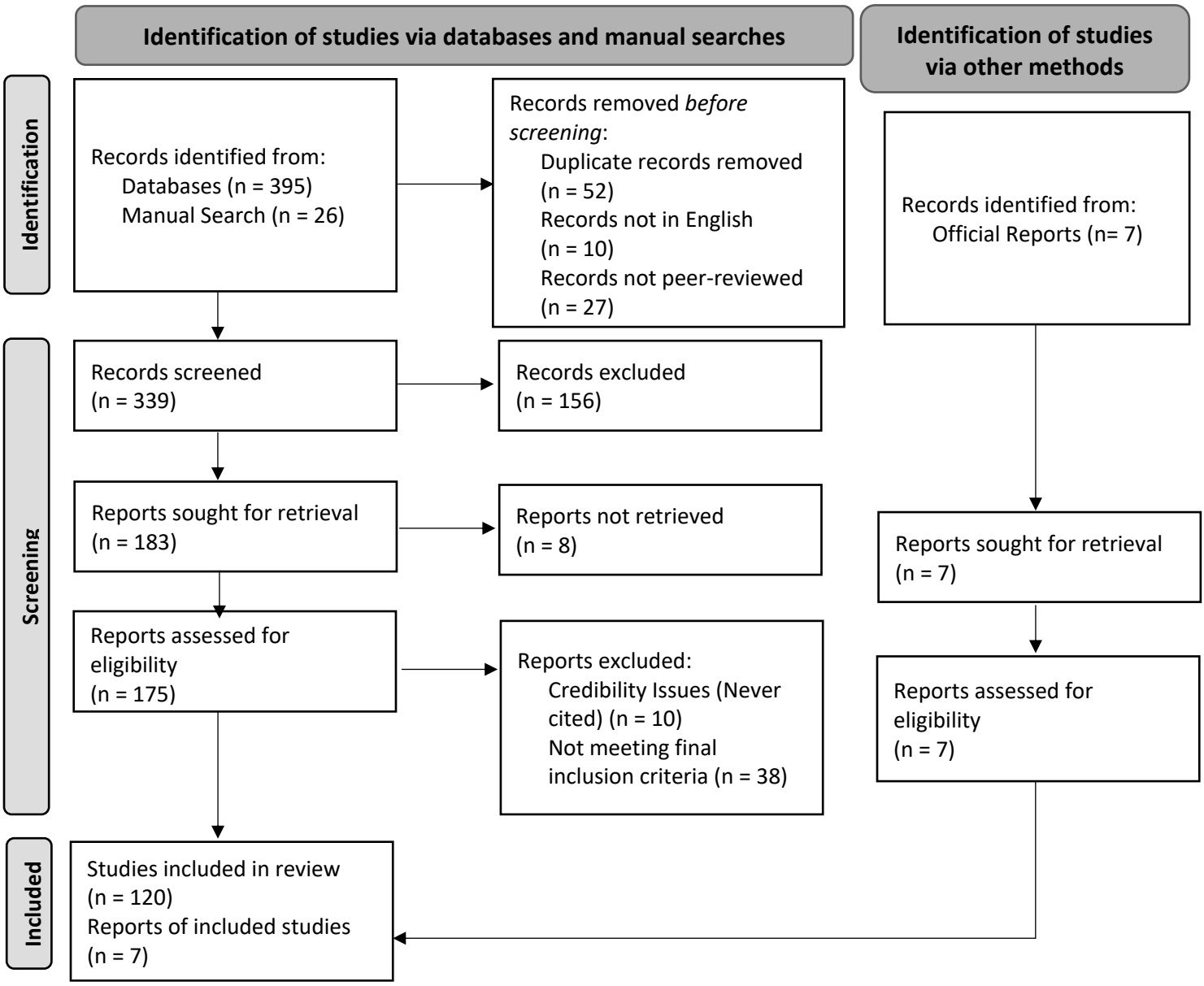

Figure 1: PRISMA 2020 Flow Diagram illustrating the screening and selection process

2.5 Data Analysis

A key focus of the study is the differentiated impact of these regulations on large firms versus SMEs. Initially, the NFRD targeted only large public-interest entities, effectively excluding SMEs despite their vital economic role within the EU (Fiandrino et al., 2022). The CSRD addresses this gap by extending mandatory reporting obligations to include listed SMEs and a broader range of large private companies. These new requirements are proportionately tailored to firm size and available resources, recognizing the structural and financial constraints that SMEs often face (European Commission, 2024).

Included literature was analyzed using qualitative content analysis. Key themes were recognized, focusing on how EU sustainability directives (e.g., CSRD, NFRD, EU Taxonomy) influence corporate sustainability strategy, reporting practices, and performance metrics. Particular attention was given to differences in corporate response across sectors and over time.

3 Historical Evolution of EU Sustainability Reporting Regulations (2014–2025)

The development of sustainability reporting regulations in the European Union over the past decade represents a transformative shift—from fragmented, voluntary disclosures toward a comprehensive and standardized legal framework (Hummel & Jobst, 2024). A chronological overview of key regulatory milestones from 2014 to 2025 is presented in Table 1, highlighting the EU's evolving approach to sustainability reporting. This chapter outlines the general trajectory from 2014 to 2025, marking the EU's progressive consolidation of non-financial reporting into a binding system that integrates corporate sustainability into strategic, financial, and governance structures.

The evolution began with the Non-Financial Reporting Directive (NFRD)**,** formally adopted as Directive 2014/95/EU. This was the EU's first major initiative to institutionalize ESG disclosures among large public-interest entities with more than 500 employees (Breijer et al., 2024). Although it created a foundation for non-financial reporting, its flexible implementation across Member States resulted in inconsistent practices and limited comparability (Fiandrino et al., 2022). A more detailed analysis of the NFRD is provided in Section 3.1.

In response to stakeholder feedback and growing demands for transparency, the European Commission launched a formal review process and consultation between 2019 and 2021. This led to the

proposal and eventual adoption of the Corporate Sustainability Reporting Directive (CSRD) in December 2022. The CSRD significantly expanded the number of companies subject to reporting requirements and introduced structural reforms such as double materiality, mandatory assurance, and machine-readable XHTML formatting (Dragomir et al., 2024 ;Mezzanotte, 2023; European Commission, 2024). The transition from the NFRD to the CSRD is addressed in detail in Section 3.2, while the implementation framework and innovations of the CSRD are explored in Section 3.3.

In parallel, the EU introduced complementary regulations such as the EU Taxonomy**,** the Sustainable Finance Disclosure Regulation (SFDR), and the forthcoming Corporate Sustainability Due Diligence Directive (CSDDD), each reinforcing the integration of ESG factors into corporate and investment decision-making. Collectively, these instruments demonstrate the EU's position as a global leader in embedding sustainability into corporate governance (Dempere et al., 2024; Hoepner & Schneider, 2023; Huq et al., 2024; Villiers, 2022).

By 2025, the regulatory environment continues to evolve with the introduction of reform proposals such as the Omnibus Package, reflecting the European Commission's intent to balance transparency and regulatory ambition with the need for administrative proportionality, particularly for smaller firms. These ongoing refinements highlight the EU's pragmatic approach to sustainable governance, one that recognizes the diverse capabilities of reporting entities while maintaining alignment with its long-term environmental and social objectives (Klimczak et al., 2023; Martínez-Torres, 2024; Miettinen, 2024; Villiers, 2022). (*Note: The Omnibus Package and its phased implementation, scope adjustments, and simplified standards are discussed in detail in the following chapter.)*

Table 1: Evolution of EU Sustainability Reporting Framework, European Commission

Year	Key Developments	Outcomes
2014	Adoption of Directive 2014/95/EU (NFRD)	Introduced mandatory non- financial reporting for large public-interest entities
2015	Stakeholder consultations, preparation of non-binding guidelines	Laid the groundwork for consistent implementation; alignment with global sustainability goals
2016	Transposition of NFRD into national laws	Legal foundation for sustainability reporting established across all Member States
2017	Publication of Non-binding Guidelines	Practical tool for companies to prepare relevant, comparable non-financial reports
2018	First NFRD-based reports published; Sustainable Finance Action Plan launched	Highlighted reporting inconsistencies and initiated deeper policy integration of sustainability disclosure
2019	European Commission launches formal review of NFRD	Identified weakness in comparability, reliability, and scope; began planning a revision of the directive
2020	Public consultation on NFRD revision; Taxonomy adopted	Identified major flaws in the NFRD; created momentum for a complete necessary change
2021	Proposal of the CSRD published	Introduced expanded scope, mandatory reporting standards, digitalization, and assurance requirements
2022	CSRD formally adopted as EU law (Directive 2022/2464)	Created a new mandatory sustainability reporting regime with phased implementation and assurance
2023	First set of ESRS adopted; SME and sectoral standards under development	Provided companies with detailed, binding reporting standards; began technical support for implementation
2024	Phased implementation of CSRD begins for companies already subject to NFRD	Companies start preparing reports under new ESRS; first experiences with mandatory digital reporting and assurance emerge
2025	Extension of CSRD reporting to large companies not previously covered under NFRD	Broader application of ESRS; external assurance and digital tagging become mainstream; more sector- specific standards adopted

Source: adopted by authors from European Commission

3.1 The Non-Financial Reporting Directive (NFRD) (2014–2018)

The Non-Financial Reporting Directive (NFRD), formally known as Directive 2014/95/EU, was adopted in October 2014 as an amendment to the EU Accounting Directive (Directive 2013/34/EU). It marked the EU's first legislative step toward integrating environmental, social, and governance (ESG) information into corporate disclosure frameworks (Ferrer et al., 2020). The directive aimed to strengthen

corporate accountability and transparency by mandating that large companies report on non-financial risks and impacts (Matuszak & Rózanska, 2021). It was conceived as part of the EU's post-financial crisis response, supporting responsible business conduct in alignment with broader societal values (Cavallaro et al., 2024).

According to the European Commission, the NFRD was designed to ensure that companies take responsibility for their social and environmental impacts while supporting the objectives of the European Green Deal. It also aimed to increase corporate visibility regarding climate-related and social risks (Aluchna et al., 2022; Fiechter et al., 2022). The directive applied specifically to public interest entities (PIEs) with over 500 employees. This included listed companies, banks, and insurance undertakings. Additional eligibility criteria required a balance sheet total exceeding €20 million or a net turnover above €40 million (Heichl & Hirsch, 2023; Martínez-Torres, 2024). Approximately 6,000 companies across the EU fell within its scope. While SMEs were excluded from mandatory reporting obligations, voluntary uptake was encouraged (Raith, 2023). The EU emphasized that the NFRD should apply to firms with significant societal and environmental impacts, particularly those with high visibility and systemic importance in financial markets (Cuomo et al., 2024; García-Benau et al., 2022)**.**

Substantively, the directive required disclosure on topics such as environmental policies, social and employee-related matters, human rights, anti-corruption, and board diversity (Pantazi, 2024) . The NFRD was principles-based, offering companies discretion in reporting format and depth, so long as they addressed relevant material issues. It was also an early legislative reference point for the double materiality concept encouraging companies to report both on financial impacts of ESG risks and their broader societal and environmental effects (Raith, 2023). However, due to the lack of clear definitions, this principle was inconsistently applied across countries (Pantazi, 2024).

The directive's flexibility, particularly its "comply or explain" model and absence of mandatory auditing, led to inconsistencies and limited comparability between firms (Velte, 2024). Despite these weaknesses, the NFRD laid essential groundwork for the EU's sustainability reporting architecture. It established ESG disclosure as a legal obligation and highlighted the need for harmonization ultimately paving the way for the CSRD and the development of standardized reporting frameworks under the European Sustainability Reporting Standards (ESRS) (Ottenstein et al., 2022).

3.2 Transition to CSRD (2019–2022): Addressing NFRD's Limitations

Following the implementation of the NFRD, numerous stakeholders including regulators, investors, and reporting entities voiced criticism about the directive's lack of clarity, standardization, and enforcement. Chief among the concerns were the absence of harmonized standards, limited comparability across disclosures, and the non-binding nature of reporting guidelines (Pantazi, 2024).

In 2020, the European Commission launched a public consultation to address these concerns. More than 80% of respondents supported the introduction of mandatory sustainability reporting standards, citing the need for credible and comparable disclosures to combat greenwashing and regulatory fragmentation (Pantazi, 2024; Primec & Belak, 2022). A key issue was the freedom granted to companies under the NFRD to use any preferred framework such as GRI, SASB, or IIRC or none at all, which resulted in highly inconsistent reporting practices (Heichl & Hirsch, 2023). Moreover, the absence of third-party assurance further reduced the reliability and perceived legitimacy of reported data (Ruohonen & Kullas, 2024).

In response, the European Commission proposed the Corporate Sustainability Reporting Directive (CSRD) on April 21, 2021. The proposal was part of the broader European Green Deal and the Sustainable Finance Action Plan, which aim to align capital flows with sustainable development objectives (Klimczak et al., 2023). The CSRD was explicitly designed to correct the shortcomings of the NFRD by introducing mandatory EU-wide reporting standards, expanding company coverage, and requiring that all reported sustainability data be digitally tagged and independently audited (Primec & Belak, 2022).

Importantly, the CSRD also reframed the terminology and conceptual scope of disclosure from "non-financial reporting" to "sustainability reporting." This shift reflects an acknowledgment of the financial relevance of ESG issues and the need for integrated, forward-looking disclosure across short-, medium-, and long-term horizons (Pantazi, 2024; Primec & Belak, 2022).

3.3 Corporate Sustainability Reporting Directive (CSRD) (2023–2024)

The CSRD**,** adopted in 2022 and entering into force in 2023, marks a significant expansion of the EU's sustainability reporting framework. It replaces the NFRD and extends reporting obligations to a much broader spectrum of companies, including large and publicly listed entities across the EU (Ruohonen &

Kullas, 2024). This expansion reflects a systemic policy effort to promote value chain transparency, particularly within high-impact sectors such as energy, finance, and manufacturing (Becchetti et al., 2024).

A central feature of the CSRD is the mandatory application of the European Sustainability Reporting Standards (ESRS)**.** Developed by the European Financial Reporting Advisory Group (EFRAG)**,** these standards define detailed disclosure requirements across environmental, social, and governance categories. They are legally binding marking a departure from the voluntary frameworks used under the NFRD (Primec & Belak, 2022). As of 2024, ESRS encompasses climate impacts, circular economy metrics, working conditions, human rights protections, ethical governance, and anti-corruption practices (Primec & Belak, 2022).

Another key element of the CSRD is the requirement for limited assurance of sustainability information by independent auditors, with a pathway toward more exact reasonable assurance over time. This reform aims to mitigate the prevalence of greenwashing and enhance the credibility of reported data (Klimczak et al., 2023; Pantazi, 2024). Additionally, all disclosures must be digitally tagged in XHTML format, enabling machine-readability and aligning sustainability disclosures with existing financial reporting practices (Lombardi et al., 2022). As demonstrated throughout the preceding chapters, the transformation of sustainability reporting within the European Union reflects a significant regulatory and strategic shift, from fragmented, voluntary disclosure frameworks to a unified, mandatory system centered on transparency, standardization, and accountability (Breijer et al., 2024).

This overview has focused primarily on developments up to the year 2024, laying the groundwork for understanding the initial rollout of the CSRD and related directives. Building on this foundation, the following chapters shift focus to the year 2025 and beyond, presenting empirical case studies and applied analyses that illustrate how these regulations, particularly the CSRD, ESRS, and the Omnibus Package are being interpreted and operationalized across sectors and firm sizes. These studies provide practical insight into corporate adaptations, governance strategies, and reporting challenges, providing a comprehensive picture of the current landscape and future outlook for sustainability reporting in the EU.

4 Current Status Quo of EU Sustainability Reporting Regulations (2025)

The European regulatory landscape for sustainability reporting has undergone a profound transformation over the past decade. In January 2023, the Corporate Sustainability Reporting Directive (CSRD) was enacted to replace the Non-Financial Reporting Directive (NFRD), expanding the reporting universe from 11,700 to nearly 50,000 firms (Stojanović-Blab & Blab, 2024). This expansion reflects the EU's determination to embed Environmental, Social, and Governance (ESG) considerations into mainstream financial analysis and corporate strategy. It aims to improve transparency, comparability, and accountability in corporate disclosures, a response to growing concerns among investors and society about climate change and social responsibility (European Commission, 2025a; Krasodomska et al., 2024). This comprehensive approach is designed to encourage long-term value creation that aligns corporate objectives with broader societal goals, necessitating that firms adopt more rigorous and standardized reporting practices (European Commission, 2025a).

At the same time, the EU Green Deal, launched in 2019, set ambitious targets to achieve climate neutrality by 2050 (Danila et al., 2022). This target further reinforces the need for comprehensive sustainability disclosures that integrate both financial and non-financial performance metrics. However, in the midst of economic pressures and market uncertainties, the regulatory framework was adjusted in February 2025 with the introduction of the Omnibus Package (European Commission, 2025a). This package seeks to reduce the compliance burden on companies while preserving the integrity of sustainability disclosures (Primec & Belak, 2022). The Omnibus Package attempts to balance regulatory stringency with economic pragmatism, aiming to foster more efficient and effective compliance practices that support the EU's overall sustainability goals (European Commission, 2025a).

4.1 CSRD Implementation Timeline and Scope Expansion

The CSRD is implemented in carefully planned phases designed to support a gradual transition and ensure uniform disclosure practices across Europe (Martinčević & Dorić, 2024). As the directive unfolds in FY2025, its phased approach from FY2024 to FY2028 serves not only as a timeline but also as a catalyst for companies like Siemens to rethink their sustainability commitments from the ground up (Becchetti et al., 2024). The implementation phases are structured to broaden the scope of sustainability reporting gradually, allowing companies to adapt their data collection and reporting processes while accommodating entities of varying sizes and operational scales (Hummel & Bauernhofer, 2024). The

CSRD's implementation is strategically structured across four distinct waves, each targeting different categories of companies based on size, listing status, and geographical location. This phased approach aims to ensure a gradual and manageable transition to the new reporting requirements, allowing companies time to adapt their systems and processes (Farbstein et al., 2024). The following sections will detail the specific criteria and timelines associated with each wave.

Wave 1: Beginning in FY2024, this phase targets large public-interest entities with over 500 employees already subject to Non-Financial Reporting Directive (NFRD) standards. These firms must submit their first reports under CSRD guidelines by FY2025, setting benchmarks for sustainability reporting across Europe (European Commission, 2025a; Krasodomska et al., 2024).

Wave 2: Extending to large companies meeting two out of three criteria (>250 employees, €40M turnover, €20M assets), this phase requires compliance beginning FY2025 for reports due in FY2026 (European Commission, 2025a; Krasodomska et al., 2024).

Wave 3: Covering listed SMEs starting FY2026 with reports due by FY2027, this phase addresses smaller entities while maintaining robust sustainability standards across diverse organizational structures (European Commission, 2025b; Hummel & Bauernhofer, 2024).

Wave 4: Targeting non-EU entities operating within Europe with substantial turnover (€150M net or €40M branch), this final phase begins in FY2028 for reports due by FY2029 (Becchetti et al., 2024; European Commission, 2025a).

This phased approach not only allows companies time to upgrade internal data systems and reporting processes but also fosters comparability of ESG information across diverse industries (Odobasa & Marosevic, 2023). The gradual ramp-up is particularly critical for firms that historically had limited experience in non-financial reporting, enabling them to adjust their internal controls and management practices (Doni et al., 2025).

The following sections and table 2 will detail the specific criteria and timelines associated with each wave.

Table 2: CSRD Implementation Phases

Wave	Start Year	Report Due	Scope	Approx. Number of Firms
1	FY2024	2025	Large public-interest entities	11,700
2	FY2025	2026	Other large firms	30,000
3	FY2026	2027	Listed SMEs, non-EU firms	8,000
4	FY2028	2029	Significant non-EU entities	500

Sources: Adopted by authors from (European Commission, 2025c; Stojanović-Blab & Blab, 2024)

By March 2025, early-adopter firms such as TotalEnergies have begun finalizing their initial CSRD reports, marking a significant advancement in corporate transparency and data integration (TotalEnergies, 2025). However, challenges persist and companies still face issues related to data collection, the integration of non-financial information into existing financial systems, and resource constraints that are especially pronounced for SMEs (Martinčević & Dorić, 2024; Primec & Belak, 2022). These challenges underscore the complexity of transitioning from legacy reporting systems to a comprehensive, standardized framework. Further research indicates that organizational readiness, internal capacity, and the availability of reliable data are key determinants of successful CSRD implementation (Doni et al., 2025).

4.2 European Sustainability Reporting Standards (ESRS) Framework

At the heart of the CSRD is the European Sustainability Reporting Standards (ESRS), developed by the European Financial Reporting Advisory Group (EFRAG) and adopted in July 2023 (European Financial Reporting Advisory Group, 2024). The ESRS framework comprises 12 sector-agnostic standards, including cross-cutting (ESRS 1–2) and topical (ESRS E1–G1) requirements, designed to enforce double materiality assessments and align with global reporting initiatives (Dragomir et al., 2024). These standards aim to provide a consistent and comparable basis for sustainability reporting across industries, promoting market transparency and fostering investor confidence. ESRS serves as a framework through which firms, such as TotalEnergies, can strategically communicate their commitment to environmental stewardship,

potentially enhancing their attractiveness to global investors. This perspective aligns with emerging research on the performative aspects of sustainability reporting and its influence on capital markets (Baumuller & Sopp, 2022; Martinčević & Dorić, 2024).

One of the most transformative features of the ESRS framework is its double materiality principle (Mezzanotte, 2023). This concept requires companies to assess their sustainability performance through two lenses: impact materiality, which evaluates how a company's operations affect society and the environment, and financial materiality, which examines how sustainability risks and opportunities impact the company's financial performance (Dragomir et al., 2024). By incorporating this dual perspective, ESRS ensures that sustainability reporting is both comprehensive and actionable, enabling stakeholders to gain a holistic understanding of corporate performance while aligning disclosures with global frameworks like ISSB and GRI (Baumuller & Sopp, 2022; Fontaine et al., 2024).

As ESRS reporting takes effect in 2025, businesses face significant opportunities to enhance their market positioning through compliance. The framework facilitates improved comparability across firms by standardizing key performance indicators and metrics, such as Scope 3 emissions tracking, labor practices, and governance structures (European Commission, 2025b). This consistency is particularly valuable for investors who increasingly view sustainability performance as a proxy for long-term corporate resilience. Moreover, compliance with ESRS opens access to the EU's €15 trillion market, positioning companies at the forefront of global sustainability trends while fostering trust among environmentally conscious consumers and stakeholders (European Commission, 2025a; Fontaine et al., 2024).

While sector-specific standards are slated for introduction in June 2026 under the Omnibus Package, the current set of ESRS provides a strong foundation for comprehensive ESG reporting (Bataleblu et al., 2024). By aligning with global frameworks such as the Task Force on Climate-related Financial Disclosures (TCFD), ESRS enhances cross-border comparability while reducing compliance burdens for multinational entities operating in multiple jurisdictions (European Commission, 2025a). This alignment ensures that European companies remain competitive in a global marketplace increasingly driven by sustainability considerations. While sector-specific standards are slated for introduction in June 2026 under the Omnibus Package, the current set of ESRS mention in table 3.

Table 3: Key ESRS Standards and Their Focus Areas

Standard	Focus Area	Key Metrics
ESRS E1	Climate Change	GHG emissions, climate-related risks
ESRS E2	Pollution	Pollutant management, waste metrics
ESRS E3	Water and Marine Resources	Water usage, impacts on marine systems
ESRS E4	Biodiversity and Ecosystems	Land use, conservation efforts
ESRS S1	Own Workforce	Labor practices, human rights
ESRS S2	Workers in Value Chain	Supply chain labor practices
ESRS S3	Affected Communities	Local community impacts
ESRS S4	Consumers and End-Users	Consumer protection measures
ESRS G1	Business Conduct	Ethical behavior, anti-corruption
ESRS G2	Governance	Board oversight, stakeholder engagement

Sources: Adopted by authors from (Baumuller & Sopp, 2022; Dragomir et al., 2024)

4.3 The Omnibus Package: Simplification Measures

In February 2025, the European Commission unveiled the Omnibus Package, a landmark initiative aimed at reducing the compliance burden for companies while maintaining the integrity of sustainability disclosures (European Commission, 2025a; Primec & Belak, 2022). The Omnibus Package, proposed in February 2025, introduces a complex dynamic to the CSRD implementation. While it may offer short-term regulatory relief for SMEs such as EcoWeave by easing immediate compliance burdens, the potential long-term implications for achieving ambitious sustainability targets across the European Union remain a subject of ongoing scholarly debate (European Commission, 2025b; Hummel & Bauernhofer, 2024). This raises critical questions about the balance between fostering economic growth and maintaining environmental integrity within the evolving regulatory landscape.

This package represents a strategic recalibration of the Corporate Sustainability Reporting Directive (CSRD) in response to mounting concerns over the administrative complexity of sustainability reporting requirements. A key measure within the Omnibus Package is the increase in the employee threshold for mandatory reporting to over 1,000 employees, coupled with additional financial criteria such as annual revenue exceeding €50 million or a balance sheet total above €25 million (European Commission, 2025b). This adjustment reduces the number of firms required to produce full-scale sustainability reports from approximately 50,000 to 10,000, concentrating compliance efforts on larger organizations with greater resources and environmental impacts. By narrowing the scope, smaller entities are afforded the opportunity to focus on their core operations while larger corporations remain accountable for their significant societal and environmental footprints (European Commission, 2025b).

Another pivotal feature of the Omnibus Package is the introduction of ESRS Lite, a simplified reporting framework tailored for small and medium-sized enterprises (SMEs) (European Commission, 2025b). ESRS Lite aims to strike a balance between regulatory compliance and administrative feasibility by reducing mandatory data points and streamlining disclosure requirements. This framework alleviates disproportionate financial and operational burdens on SMEs while ensuring they can still contribute meaningfully to sustainability goals. Additionally, reporting deadlines for Waves 2 and 3 companies have been postponed by two years—extending compliance deadlines to FY2027 and FY2028 (European Commission, 2025b). This delay provides companies with additional time to upgrade their internal systems and adapt to evolving regulatory demands (European Commission, 2025a). These measures reflect a pragmatic approach by policymakers to address criticisms that EU red tape hinders competitiveness while preserving alignment with the broader objectives of the Green Deal (European Commission, 2021).

Although these simplifications have been welcomed by many business leaders as a necessary step toward reducing administrative burdens, they have sparked concerns among environmental advocates who fear that easing requirements could dilute the regulatory framework's effectiveness in achieving long-term sustainability goals (Dicuonzo et al., 2022). For large corporations like TotalEnergies, this recalibration shifts strategic focus from peripheral value chain issues toward core operational impacts (Doni et al., 2025). This divergence in perspectives underscores an ongoing debate about finding an optimal balance between regulatory efficiency and environmental stewardship, a central theme in the evolving landscape of EU sustainability reporting (Ottenstein et al., 2022). As illustrated in Table 4, This

adjustment reduces the number of firms required to produce full-scalesustainability reports from approximately 50,000 to 10,000.

Table 4: Key Changes Under the Omnibus Package

Measure	Impact	Effective Date
Employee threshold > 1,000	Reduces reporting scope from 50,000 firms to 10,000	FY2025
Introduction of ESRS Lite	Simplifies compliance requirements for SMEs	FY2025
Postponement of Waves 2 & 3	Extends reporting deadlines to FY2027 and FY2028	February 2025

Sources: Adopted by authors from (European Commission, 2025b)

5 Corporate Strategy Adaptations to Evolving Regulations

The European Union's Corporate Sustainability Reporting Directive (CSRD) has catalyzed a paradigm shift in corporate strategy (Petrova, 2024). As companies face increasingly stringent sustainability reporting requirements, they are compelled to rethink their governance structures, operational processes, supply chain strategies, and innovation frameworks (Velte, 2024). This chapter explores these adaptations in detail, emphasizing how firms are balancing compliance with the CSRD while leveraging opportunities for competitive advantage. The analysis integrates theoretical frameworks such as legitimacy theory and resource dependence theory to contextualize these changes within broader academic debates.

5.1 Governance Changes: Embedding Sustainability at the Core

Corporate governance has undergone a profound transformation in response to the CSRD's emphasis on transparency and accountability (Stojanović-Blab & Blab, 2024). (Tonello, 2025) shows that 61% of companies have an ESG steering committee at the C-Suite level, while 63% have such a committee

one or two levels below. Board oversight is also important, with many companies appointing a board committee to oversee the auditing of sustainability information. In response to the requirements set forth by the Corporate Sustainability Reporting Directive (CSRD), Siemens' establishment of a Sustainability Committee in 2023 went beyond mere compliance. It represented a strategic shift, effectively integrating Environmental, Social, and Governance (ESG) considerations into the core decision-making processes of the company's boardroom (Dimes & Molinari, 2024). These committees oversee sustainability initiatives, ensuring alignment with the European Sustainability Reporting Standards (ESRS) and integrating ESG metrics into strategic decision-making processes (Velte, 2024).

Case Study: Siemens

Siemens demonstrates the evolving integration of sustainability governance within corporate strategy, particularly through the centralization of environmental, social, and governance (ESG) leadership roles (Siemens AG, 2024). The appointment of a Chief People and Sustainability Officer in 2020 marked a strategic shift toward embedding sustainability objectives across operational and decision-making frameworks (Siemens AG, 2024). This governance restructuring has facilitated the alignment of ESG targets with core business performance, prioritizing initiatives such as decarbonization, supply chain emissions reduction, and workforce engagement. The company's DEGREE1 framework, encompassing decarbonization, ethics, governance, resource efficiency, equity, and employability, exemplifies this systemic approach, with measurable progress in emissions reduction and diversity metrics (Siemens AG, 2024).

The company's 2024 Sustainability Report reflects these advancements and aligns with double materiality principles outlined by European regulations. While not explicitly labeled as CSRD-compliant, this report sets a benchmark for integrating ESG metrics into corporate governance (Siemens AG, 2024).

Siemens continues to institutionalize sustainability within its corporate hierarchy through leadership roles like Wiese's and strategic frameworks like DEGREE. These efforts demonstrate the company's commitment to aligning with evolving regulatory standards while setting industry benchmarks for sustainable (Siemens AG,2024). Legitimacy theory provides a compelling framework for understanding these changes. It posits that firms adopt transparent governance practices to secure societal approval and

1 The DEGREE framework is Siemens' comprehensive sustainability strategy, structured around six core pillars designed to integrate environmental, social, and governance (ESG) principles into its operations and value chain. Introduced in 2021, the framework emphasizes measurable, long-term targets to align with global sustainability imperatives.

mitigate reputational risks. Siemens' proactive approach demonstrates how aligning governance structures with ESRS requirements can strengthen its legitimacy among stakeholders (Mio et al., 2020; Velte, 2024).

5.2 Operational Overhauls: Aligning with ESRS Requirements

Operational systems have been restructured to meet the granular disclosure requirements of the European Sustainability Reporting Standards (ESRS). By FY2025, many large companies integrated ESG data into their enterprise risk management (ERM) systems, enabling them to link environmental metrics directly to business risks such as carbon pricing and regulatory penalties (Krasodomska et al., 2024). These systems represent a critical step in aligning operational processes with sustainability goals, ensuring compliance with EU Taxonomy regulations and mitigating financial risks associated with climate change (Martínez-Torres, 2024).

Sectoral Case Study: TotalEnergies

TotalEnergies illustrates how operational overhauls can drive strategic alignment with sustainability goals. Historically an oil and gas giant, the company has accelerated its transition toward renewable energy in response to CSRD requirements. By FY2025, TotalEnergies aims to achieve 35 GW of gross renewable capacity, supported by investments exceeding $4 billion annually in low-carbon energy (TotalEnergies, 2025). This includes significant expansions in solar and wind projects, aligning operations with the EU Taxonomy's criteria for sustainable activities.

The company's dual-pillar strategy, combining profitable growth in oil and gas with accelerated investments in electricity, has positioned TotalEnergies as a leader in energy transition. Notably, its lifecycle carbon intensity target for energy products sold has been updated to a 17% reduction by FY2025, compared to 2015 levels (TotalEnergies, 2025). These achievements underscore how regulatory pressures like ESRS requirements can catalyze operational innovation across industries (Janik et al., 2020).

Despite these advancements, operational overhauls present significant challenges. A recent industrial report revealed that a vast number of companies struggle to collect accurate data for CSRD compliance, particularly for Scope 3 emissions. These challenges highlight the importance of digital transformation tools such as cloud-based analytics platforms and blockchain technologies in ensuring data accuracy and consistency across business units (Martinčević & Dorić, 2024).

5.3 Supply Chain Management Strategies

The CSRD's emphasis on value chain transparency has compelled companies to overhaul their supply chain strategies. As shown in Table 5, with Scope 3 emissions accounting for 75-85% of total greenhouse gas emissions across most sectors, firms are implementing rigorous due diligence protocols to ensure compliance. These protocols extend beyond environmental metrics to include social and human rights considerations (Rísquez Ramos & Ruiz-Gálvez, 2024).

Case Study: Volkswagen

Volkswagen's Sustainability Program exemplifies this shift toward supply chain accountability. In FY2024, the company audited over 40,000 suppliers, focusing on labor practices and environmental compliance in alignment with the Corporate Sustainability Due Diligence Directive (CSDDD) (Dempere et al., 2024). This comprehensive approach not only ensures regulatory compliance but also enhances operational resilience by identifying vulnerabilities along the value chain.

Resource dependence theory explains these adaptations by highlighting how firms mitigate supply chain risks through proactive due diligence. By aligning supplier audits with CSDDD mandates, companies can secure critical inputs while enhancing their overall sustainability performance (Dempere et al., 2024; European Commission, 2025b).

Table 5: Emissions Breakdown by Scope

Scope	% of Emissions	Focus Area
Scope 1	10%	Direct operations
Scope 2	10%	Energy consumption
Scope 3	80%	Supplier practices

Source: (Rísquez Ramos & Ruiz-Gálvez, 2024)

5.4 Innovation as a Strategic Response

Innovation has emerged as a cornerstone of corporate adaptation to sustainability regulations. Companies are investing heavily in green technologies and circular economy initiatives to not only comply with the CSRD but also secure long-term competitive advantages (Becchetti et al., 2024).

Between 2023 and 2025, Siemens has advanced significant investments in innovation, particularly in digitalization, automation, and sustainability-focused infrastructure. In July 2023, Siemens announced a €2 billion global investment strategy, including approximately €1 billion in Germany, to expand development and manufacturing capacities, establish a new Technology Campus in Erlangen, and drive forward the industrial metaverse and net-zero operations (Siemens AG, 2024). These initiatives are underpinned by a comprehensive sustainability and energy concept, with the new campus designed to be a net-zero location that meets the highest sustainability criteria. Siemens' portfolio and sustainability reporting demonstrate strong alignment with the EU Taxonomy, with Siemens Mobility achieving 86% alignment for FY2024 and the company as a whole reporting high eligibility and alignment rates across revenue, CapEx, and OpEx. These investments reinforce Siemens' position as a leader in sustainable innovation and support the EU's climate and circular economy objectives (Siemens AG, 2024).

5.5 Risk Management Architecture Transformation

Risk management in sustainability reporting has become a critical area of focus for businesses, stakeholders, and regulatory bodies within the European Union (EU). The integration of risk management practices into sustainability reporting is essential for addressing social, environmental, and ethical risks, which can significantly impact corporate performance and stakeholder trust. This section explores the current state of sustainability reporting tools, risk assessment methodologies, and the implications of risk disclosure in the EU context (Fitriana & Wardhani, 2020).

State of the Art in Sustainability Reporting and Risk Assessment

Sustainability reporting has evolved to include comprehensive risk management practices, addressing non-financial risks such as climate change, data fraud, and social issues. The development of Environmental, Social, and Governance (ESG) standards and metrics has provided companies with frameworks to measure, manage, and mitigate these risks (Antoncic, 2019). Despite advancements, the

reliability and authenticity of sustainability reporting remain under scrutiny due to issues with non-financial information recording, management discretion, and limited assurance (Bischof, 2022).

Methodologies in Risk Disclosure

The research methodology for studying sustainability risk disclosure involves creating relational semantic maps and developing structural equation models using partial least squares (PLS-SEM). This approach helps in understanding the variables affecting risk disclosure within corporate sustainability reporting practices. The exploratory study on Italian public and private organizations applying the G4 sustainability reporting guidelines highlights the importance of risk identification and mitigation strategies (Truant et al., 2017).

Typologies of Risks in Sustainability Reporting

Sustainability reports often illustrate various types of risks, including ethical, social, and environmental risks. These reports also forecast social and environmental impacts, providing stakeholders with insights into potential future challenges. The integration of risk management tools into sustainability reporting is crucial for addressing these risks effectively (Truant et al., 2017).

Impact of Risk Disclosure on Stakeholders

Risk disclosure in sustainability reporting serves as an external decision tool for banks, investors, rating agencies, and other stakeholders interested in corporate performance and risk avoidance mechanisms. The disclosure of risk management practices enhances transparency and helps stakeholders make informed decisions regarding investments and corporate strategies (Siri & Zhu, 2019).

Case Studies and Empirical Evidence

Empirical studies have shown that enterprise risk management (ERM) and sustainability reporting quality positively affect firms' performance, particularly in terms of return on assets (ROA) (Antoncic, 2019). Companies that manage both internal and external risks, including social and environmental risks, tend to perform better financially. Additionally, stakeholder engagement in sustainability reporting is found to be a process of managing reputational risk, with companies using rhetorical strategies to address social issues and increase market share (Dragomir et al., 2024).

Challenges and Future Directions

Despite the progress in sustainability reporting and risk management, several challenges remain. The need for uniform and global sustainability reporting standards is evident, as stakeholders demand more transparent and reliable information (Gebhardt et al., 2024). Future research should focus on developing improved methodologies for risk assessment and sustainability practices, ensuring that risks are managed resourcefully to avoid unsustainability practices (Dragomir et al., 2024). Risk management in EU sustainability reporting is a dynamic and evolving field that requires continuous improvement and adaptation. The integration of risk management practices into sustainability reporting enhances transparency, stakeholder trust, and corporate performance (Andersson & Arvidsson, 2023). As the regulatory landscape evolves, companies must adopt comprehensive risk management frameworks to address social, environmental, and ethical risks effectively. Further research and development of standardized reporting practices will be crucial for advancing sustainability and risk management in the EU context (Siri & Zhu, 2019).

5.6 Workforce and Organizational Culture Adjustments

The transition to sustainability reporting under frameworks like the Corporate Sustainability Reporting Directive (CSRD) and European Sustainability Reporting Standards (ESRS) has necessitated profound changes in workforce strategies and organizational culture. Companies are increasingly recognizing that compliance requires not only technological upgrades but also a transformation in how employees engage with sustainability goals (Wijethilake et al., 2023). This section explores how organizations are adapting through training programs, cross-functional collaboration, and cultural shifts, supported by empirical evidence and academic insights.

Building Competencies Through Training Programs

Employee training is pivotal for equipping the workforce with the skills required to manage ESG data effectively, interpret regulatory requirements, and contribute to broader sustainability strategies. Siemens, for example, has invested heavily in cultivating an active learning culture across its workforce, emphasizing digitalization, leadership, and sustainability. The company's employees accrued an average of 23 hours of digital learning annually in 2023, with plans to increase this to 25 hours per year by FY2025

(Siemens AG, 2024). These efforts ensure that employees are well-prepared to handle the complexities of ESG reporting while fostering a culture of continuous learning.

Academic research highlights the importance of training initiatives tailored to sustainability reporting frameworks like CSRD. (Wijethilake et al., 2023) argue that sustainability reporting can overcome resistance to organizational change by fostering transparency and improving internal communication. Furthermore, (Wijethilake et al., 2023) found that companies investing in sustainability education reported higher levels of employee engagement and smoother transitions during regulatory implementation phases. These findings underscore the critical role of training programs in driving workforce readiness for sustainability reporting.

Cross-Functional Teams for ESG Integration

To address the complexity of sustainability reporting, companies are forming cross-functional teams dedicated to ESG initiatives. Such teams integrate individuals from diverse departments (HR, finance, operations, and procurement) each contributing unique expertise toward achieving sustainability goals. Siemens exemplifies this approach by embedding cross-functional collaboration into its organizational fabric. These teams work together to collect ESG data, create materiality matrices, and implement double materiality assessments required under CSRD guidelines (BASF SE, 2025).

Cross-functional collaboration is particularly critical for integrating ESG metrics into enterprise risk management (ERM) systems (Truant et al., 2017). By leveraging diverse expertise across departments, companies ensure that sustainability goals align with broader corporate strategies. Cross-functional teams not only enhance reporting accuracy but also foster innovation by encouraging knowledge-sharing across functional boundaries. This collaborative model is essential for breaking down silos within organizations and ensuring seamless compliance with regulatory requirements (Mezzanotte, 2023).

Cultural Shifts Toward Sustainability Awareness

Organizational culture plays an integral role in embedding sustainability into corporate DNA. Studies have shown that cultural change is among the most significant factors influencing the success of sustainability initiatives (Vodonick, 2018). Siemens has adopted a people-centered approach to this transformation by investing $482 million in employee education programs that emphasize inclusivity and future-ready skills (SIEMENS REPORT). The company's commitment to diversity is reflected in its

achievement of surpassing its 2025 target for women in top management roles (32.6% as of FY2024) underscoring the importance of equity in driving cultural change (Siemens AG, 2024).

Additionally, (Caputo et al., 2021) argue that transparency fostered through sustainability reporting can lead to more open organizational climates where employees feel empowered to contribute to ESG goals. Siemens Foundation's "Everyone Charging Forward" initiative further demonstrates how workforce development can align with broader decarbonization goals while advancing diversity in clean energy industries (Siemens AG, 2024). These efforts highlight how cultural shifts toward inclusivity and accountability can drive both compliance and innovation (Vodonick, 2018).

6 Sectoral Impacts: Varied Responses Across Industries

The Corporate Sustainability Reporting Directive (CSRD) and European Sustainability Reporting Standards (ESRS) have introduced transformative changes across industries, compelling companies to adapt their strategies to meet stringent sustainability reporting requirements (Wijethilake et al., 2023). However, the impact of these regulations varies significantly across sectors, depending on their environmental footprint, operational complexity, and stakeholder expectations (De Micco et al., 2021). This chapter examines sector-specific responses to the CSRD, focusing on high-impact industries such as energy, manufacturing, and automotive; the financial sector; small and medium-sized enterprises (SMEs); the technology sector; and the agriculture and food industry. By analyzing academic insights and case studies, this chapter highlights how different industries navigate these challenges while leveraging opportunities for sustainability-driven innovation.

6.1 High-Impact Sectors: Energy, Manufacturing, and Automotive

High-impact sectors such as energy, manufacturing, and automotive are under intense regulatory scrutiny due to their significant contributions to greenhouse gas emissions. These industries are compelled to adopt aggressive decarbonization strategies to align with ESRS requirements and broader EU climate goals (Rísquez Ramos & Ruiz-Gálvez, 2024).

The energy sector exemplifies this transformation. Companies like TotalEnergies are realigning their portfolios by targeting a 30% renewable energy mix by FY2025. This shift is driven by ESRS E1 requirements for climate-related disclosures, which mandate detailed reporting on Scope 1–3 emissions

and renewable energy investments (Becchetti et al., 2024). TotalEnergies' strategic shift reflects not only the influence of regulatory pressures but also a response to the evolving market dynamics, characterized by an increasing consumer demand for sustainable energy solutions (TotalEnergies, 2025).

Manufacturing firms are leveraging circular economy practices to reduce emissions and optimize resource use (Paz & Ruiz Gálvez, 2020). Siemens has implemented innovative waste reduction strategies that have contributed to a 15% reduction in emissions over the past five years. These practices align with ESRS E5 requirements for resource use and circular economy disclosures, demonstrating how manufacturing companies can integrate sustainability into their operational frameworks (Siemens AG, 2024).

The automotive industry is undergoing a profound transformation driven by EU Taxonomy regulations and ESRS mandates. Companies like Volkswagen are transitioning toward electric vehicles (EVs) and other low-emission technologies, achieving emission reductions of up to 25% compared to traditional internal combustion engines. This transition underscores the role of regulatory frameworks in accelerating innovation within high-impact sectors (Gebhardt et al., 2024).

6.2 Financial Sector Adaptations

The financial sector has emerged as a leader in integrating ESG factors into its core investment strategies. Regulatory measures such as the Sustainable Finance Disclosure Regulation (SFDR) and CSRD have compelled financial institutions to align their portfolios with sustainability goals. ING Bank exemplifies this adaptation by increasing its allocation of Taxonomy-aligned assets from 30% in FY2023 to 40% in FY2025 (Posadas et al., 2023).

The financial sector’s focus on ESG integration is driven by both regulatory imperatives and strategic risk management considerations. Limited assurance processes under CSRD enhance the credibility of ESG disclosures, boosting investor confidence while ensuring transparency in an increasingly competitive market. Institutional theory explains this convergence in practices as essential for achieving legitimacy among stakeholders (Gebhardt et al., 2024).

Case studies highlight how financial institutions leverage sustainability reporting for strategic differentiation. ING Bank’s alignment with SFDR and CSRD requirements has positioned it as a front-

runner in sustainable finance. By prioritizing green bonds and renewable investments, the bank has reduced portfolio risks while enhancing market credibility (Posadas et al., 2023).

6.3 SMEs: Indirect Impacts Through Value Chains

Small and medium-sized enterprises (SMEs) are largely exempt from direct CSRD reporting due to provisions under the Omnibus Package. However, they face considerable indirect pressures from larger corporate partners demanding detailed Scope 3 emissions data. The introduction of ESRS Lite has facilitated voluntary sustainability reporting among SMEs, with adoption rates increasing from 10% in FY2023 to 40% in FY2025 (Krasodomska et al., 2024).

Voluntary reporting is critical for SMEs seeking market access and competitiveness as major companies increasingly require detailed sustainability information from their supply chains (Paz & Ruiz Gálvez, 2020). EcoWeave, a mid-sized textile firm in the Netherlands, exemplifies this trend by implementing ESRS Lite protocols to secure contracts with major retailers. By voluntarily reporting its Scope 3 emissions, EcoWeave has enhanced its market credibility while minimizing supply chain risks (Fontaine et al., 2024).

SMEs form the backbone of the European economy, representing a vast majority of businesses (European Financial Reporting Advisory Group, 2024). The expansion of sustainability reporting requirements under the CSRD inevitably raises questions about their inclusion and the principle of proportionality (Bischof, 2022). While SMEs collectively contribute significantly to environmental and social impacts, they often possess limited resources and expertise to navigate complex reporting framework (European Financial Reporting Advisory Group, 2024).

The response of SMEs (Cariola et al., 2020) to sustainability reporting is therefore likely to be contingent on the nature of these tailored standards and the extent to which they align with their specific governance, organizational structures, and resource availability. Some SMEs, particularly those within high-impact sectors or those integrated into the value chains of larger companies, may face indirect pressures to enhance their sustainability reporting. For instance, a small manufacturing firm supplying a large multinational corporation might be required to provide sustainability data to enable the larger entity to fulfill its own reporting obligations (Cariola et al., 2020). Leveraging digital technologies could also play a crucial role in facilitating sustainability reporting for SMEs, potentially making the process more efficient and less burdensome (Cariola et al., 2020).

6.4 The Tech Sector: Digital Footprints and ESG Transparency

The technology sector plays an increasingly pivotal role in driving ESG transparency through digital transformation tools such as big data analytics, cloud computing, and blockchain technologies. These innovations streamline data collection processes while enabling real-time monitoring of sustainability performance across industries (Jilková & Kotesovcová, 2023).

Tech companies are also developing digital platforms that facilitate cross-industry transparency by integrating ESG metrics into dashboards accessible to regulators and investors alike. This approach not only enhances accountability but also sets new standards for transparency that benefit stakeholders across sectors (Gebhardt et al., 2024).

6.5 Agriculture and Food Industry: Sustainable Supply Chains and Biodiversity Reporting

The agriculture and food industry faces unique challenges due to its direct impact on natural resources and biodiversity. Companies in this sector are increasingly required to report on practices such as regenerative agriculture, optimized water management, and biodiversity conservation under ESRS guidelines (Dragomir et al., 2024).

Integrating biodiversity metrics into ESG disclosures not only helps companies meet regulatory requirements but also appeals to environmentally conscious consumers and investors. Case studies highlight how firms like Nestlé have adopted sustainable sourcing practices that align with ESRS E4 requirements for biodiversity reporting while enhancing brand reputation among stakeholders (Posadas et al., 2023).

6.6 construction industry

The construction industry, for example, is increasingly scrutinized for its environmental footprint, from material sourcing and energy consumption in buildings to waste management (Wijethilake et al., 2023). Sustainability reporting in this sector necessitates a focus on green building practices, the use of sustainable materials, and the management of construction waste. Similarly, the textile and garment industry face intense scrutiny regarding labor conditions in its global supply chains and the environmental impacts of fast fashion (Dinh et al., 2023). Sustainability reporting in this sector often involves detailed

disclosures on supply chain due diligence, fair labor practices, and efforts to reduce textile waste and pollution (Wijethilake et al., 2023).

Even within a specific sector, responses can vary based on company size, ownership structure, and stakeholder engagement. Larger, publicly listed companies generally face greater pressure from investors and regulatory bodies to produce comprehensive sustainability reports compared to smaller, privately held entities (before the CSRD's expanded scope) (Camilleri, 2015). Companies with strong stakeholder engagement are also more likely to prioritize and enhance their sustainability reporting to address the concerns and expectations of their diverse stakeholders, including employees, customers, communities, and NGOs (Du Toit, 2024).

7 Challenges and Opportunities in Compliance

The evolving landscape of corporate sustainability reporting in the European Union is driven by a growing recognition that corporate performance should be evaluated not only through financial results but also by considering the social and environmental impacts of business operations (Baumuller & Sopp, 2022; Cavallaro et al., 2024; De Micco et al., 2021). This understanding is central to the European Green Deal and the EU Taxonomy for Sustainable Activities, which aim to direct capital flows towards sustainable investments to address critical global challenges such as climate change, social inequality, and biodiversity loss (Horn, 2024). The transition towards more comprehensive and standardized sustainability reporting under EU regulations, particularly through directives like the Non-Financial Reporting Directive (NFRD) and its successor, the Corporate Sustainability Reporting Directive (CSRD), presents both significant challenges and promising opportunities for businesses (Baumuller & Sopp, 2022; Cavallaro et al., 2024).

The core purpose of these regulatory developments is to ensure transparency and accountability regarding environmental, social, and governance (ESG) factors, ultimately fostering a more sustainable and responsible economy (Cavallaro et al., 2024). This shift necessitates substantial adjustments in how companies collect data, manage reporting processes, and strategically integrate sustainability considerations into their core operations (Baumuller & Sopp, 2022; Cavallaro et al., 2024). The increasing demand from policymakers and regulatory bodies for companies to engage in sustainability initiatives and transparent reporting underscores the mainstreaming of sustainability reporting as a crucial practice (De Micco et al., 2021; Vander Bauwhede & Van Cauwenberge, 2022). While sustainability reporting is becoming a generally accepted practice, it is also acknowledged as a complex process to manage, carrying

considerable challenges, especially in handling and communicating non-financial information effectively (De Micco et al., 2021). Addressing these challenges effectively, however, can transform them into significant business opportunities (De Micco et al., 2021). Understanding how companies navigate these hurdles and the mechanisms they employ, to achieve the goal, is vital for improving the overall quality and impact of sustainability reporting (De Micco et al., 2021).

7.1 Challenges in Achieving Compliance with Evolving Regulations

Complying with the expanding scope and increasing complexity of EU sustainability reporting regulations presents numerous challenges for businesses. These challenges span data quality, the availability of expertise, cost implications, and the complexities of new concepts like double materiality (De Micco et al., 2021; Petrova, 2024).

Data Quality

A fundamental challenge lies in ensuring the quality and reliability of the sustainability data being disclosed (Petrova, 2024). The credibility of sustainability reporting is often questioned due to concerns about its relevance and effectiveness in truly supporting sustainable development (Petrova, 2024). A persistent issue is the heterogeneous nature of the information reported, often assessed against varying standards, which undermines comparability and overall utility (Calabrese et al., 2020). High-quality sustainability reporting demands accuracy, reliability, comparability, and completeness of information across environmental, social, and governance dimensions (Breijer & Orij, 2022; Fiandrino et al., 2022). The European Commission intends to adopt the revised delegated act for the ESRS as quickly as possible to provide clarity and legal certainty to undertakings (European Commission, 2025a). The revision will focus on removing less critical data points, emphasizing quantitative data, clarifying materiality application, improving consistency with other EU legislation, simplifying the standards' structure, and enhancing interoperability with global standards (European Commission, 2025a).

Tracking Scope 3 Emissions

One significant aspect of data quality challenges revolves around the complexities of tracking Scope 3 emissions (Emborg et al., 2023). Historically, companies primarily concentrated on reporting and reducing direct emissions from their own operations (Scope 1) and emissions from purchased electricity

(Scope 2) (Emborg et al., 2023). However, the urgency of mitigating greenhouse gas (GHG) emissions has intensified the focus on Scope 3 emissions, which occur within a corporation's supply chain (Emborg et al., 2023). While taking responsibility for these indirect emissions has been encouraged for over a decade, it has not yet translated into substantial reductions in supply chain emissions (Emborg et al., 2023).

A major impediment to reporting Scope 3 emissions is the difficulty in obtaining accurate and reliable data (Fritsch et al., 2024; Vieira et al., 2024). Companies often lack comprehensive visibility into their entire value chain, making it difficult to gather the necessary data from a diverse range of suppliers, customers, and other stakeholders (Fritsch et al., 2024; Vieira et al., 2024). This is particularly true for companies with intricate global supply chains, where data collection can be hampered by limited communication with suppliers and a lack of standardized reporting practices (Fritsch et al., 2024; Vieira et al., 2024).

The Greenhouse Gas Protocol (GHGP3) standard directly aims to address this by requiring firms to measure their Scope 3 emissions, essentially conducting a value chain emissions audit (Patchell, 2018). This necessitates obtaining information from external entities beyond the reporting company's direct control, a task that is both complex and resource-intensive, and the sheer number and variety of external entities involved pose a significant hurdle in acquiring reliable data (Gopalakrishnan, 2022; Patchell, 2018).

Beyond data collection, companies face other substantial challenges in managing their Scope 3 emissions. Reporting and assigning responsibility for these emissions have limited impact if the emissions are not accurately measured or even estimated in the first place (Gopalakrishnan, 2022). Furthermore, there is a lack of clear understanding regarding the "scope" of Scope 3 emissions, specifically how far into their supply chains companies should delve to measure and manage emissions (Gopalakrishnan, 2022). Regulations that set too narrow a scope, such as mandating reporting only from immediate suppliers, could inadvertently lead to increased subcontracting, where emission-intensive processes are simply moved deeper into the supply chain (Gopalakrishnan, 2022; Pacces, 2021). This highlights the urgent need for regulators and standards organizations to establish clear and consistent frameworks for measuring and defining the scope of supply chain emissions (Gopalakrishnan, 2022). While regulations like the Sustainable Financial Disclosure Regulation (SFDR) touch upon the disclosure of GHG emissions, the comprehensive accounting of Scope 3 emissions remains a considerable obstacle (Bataleblu et al., 2024; Pacces, 2021).

The complexity is amplified by the need to collect data from a multitude of sources across the value chain, many of which may have varying levels of maturity in their own sustainability reporting practices (De Micco et al., 2021). The diversity of data points related to each pillar of sustainability also

limits the probability of achieving consistency in reporting (Bataleblu et al., 2024). The CSRD's mandatory reporting of Scope 3 emissions imposes new compliance challenges for companies. Non-compliance with these reporting obligations can lead to legal and financial consequences, along with potential harm to a company's reputation. To avoid these risks, businesses must allocate resources to develop systems and processes that ensure adherence to the CSRD and related regulations (Martínez-Torres, 2024; Pantazi, 2024).

Limited data availability from Small and Medium-sized Enterprises (SMEs)

Another significant challenge is the limited data availability from Small and Medium-sized Enterprises (SMEs) (Nowak et al., 2024). Until recently, sustainability reporting mandates, such as the NFRD, primarily applied to large enterprises of public interest, typically those with over 500 employees (Fiandrino et al., 2022; Kristofík et al., 2016; Nowak et al., 2024). This meant that SMEs, despite their significant role in the European economy, were largely excluded from these mandatory reporting requirements (Fiandrino et al., 2022). Consequently, data on their sustainability impacts and practices has been less readily available and standardized (Cuomo et al., 2024; Matuszak & Rózanska, 2021).

While the CSRD aims to extend disclosure requirements to listed SMEs, the challenge of obtaining data from these entities remains significant (Cuomo et al., 2024; Petrova, 2024). Many SMEs lack the dedicated staff, expertise, and financial resources necessary to implement the sophisticated data collection and reporting systems demanded by the new directive (Nowak et al., 2024). Even established sustainability reporting procedures like the Global Reporting Initiative (GRI), which require substantial resources and capabilities, are primarily adopted by large corporations and may not adequately consider the specific characteristics and needs of SMEs, including their stakeholders, impacts, and motivations for sustainability reporting (Klimczak et al., 2023; Nowak et al., 2024). This underscores the need for a holistic and tailor-made approach to sustainability reporting for SMEs (Nowak et al., 2024).

Recognizing the challenges faced by SMEs, the proposal aims to reduce the number of undertakings subject to mandatory reporting by taking out of scope large undertakings with up to 1000 employees and listed SMEs. For companies not subject to mandatory reporting, the Commission proposes a proportionate standard for voluntary use, based on the VSME standard developed by EFRAG, and intends to issue a recommendation on voluntary reporting based on this standard (European Commission, 2025a).

Additionally, the value-chain cap would be extended and strengthened to protect all undertakings with up to 1000 employees by limiting the information requests from larger companies to the level of the

voluntary standard. To further support SMEs, the Commission intends to launch capacity-building initiatives, such as a multi-country project under the 2025 Technical Support Instrument, aimed at enhancing Member States' ability to assist companies, particularly SMEs, in implementing CSRD and EU Taxonomy reporting requirements (European Commission, 2025a).

EFRAG has also launched an SME forum to discuss the implementation of sustainability reporting requirements and how digital solutions can facilitate reporting for SMEs. These measures collectively demonstrate a focus on easing the reporting burden, particularly for smaller businesses, while still encouraging progress towards sustainability goals (European Commission, 2025a).

Complexity and Lack of expertise

Beyond data-related challenges, a lack of expertise and understanding of the new regulations poses a significant hurdle (Calabrese et al., 2020; Pantazi, 2024; Petrova, 2024). The CSRD and ESRS require extensive disclosures on sustainability impacts, risks, and strategies, creating a multifaceted reporting environment (Bataleblu et al., 2024). The interconnectedness of various regulations, including the Taxonomy Regulation and Sustainable Finance Disclosure Regulation, adds layers of complexity, making it difficult for companies to keep track of compliance requirements (Hummel & Jobst, 2024). The new sustainability reporting standards, such as the European Sustainability Reporting Standards (ESRS), are acknowledged to be extremely complex, requiring a high degree of technical expertise not only from the reporting companies but also from those who will be using the reported information (Bergmann & Posch, 2018; Pantazi, 2024).

Terms like "double materiality," introduced by the NFRD and reinforced by the CSRD and ESRS, represent a novel approach to determining what information should be included in sustainability reports, distinct from the traditional financial materiality principle (Mezzanotte, 2023). Double materiality encompasses both financial materiality, which concerns the impact of sustainability matters on the company's financial performance, and impact materiality, which focuses on the company's impacts on society and the environment. While financial materiality is a relatively well-understood concept, the notion of impact materiality is new and untested within a framework of mandatory rules (Dragomir et al., 2024; Mezzanotte, 2023).

Implementing the impact materiality assessment is not a straightforward process and introduces new sources of legal risk for reporting companies (Mezzanotte, 2023). This process requires engaging affected stakeholders to identify relevant impacts, which itself can raise legal questions. Furthermore, issues with the availability and quality of impact-related information can compromise the accuracy of

disclosures, increasing the likelihood of misleading statements or omissions (Dragomir et al., 2024; Mezzanotte, 2023). The criteria for determining materiality can also differ depending on the type of materiality and the stage of assessment, creating uncertainty about the legal interpretation of impact materiality. The expectation that companies will not only identify and report on negative impacts but also develop plans to mitigate or remedy them adds another layer of complexity and potential legal exposure (Mezzanotte, 2023).

Cost Implications

Finally, cost implications represent a significant challenge, particularly for startups and SMEs operating in sensitive industries (Dempere et al., 2024). The new compliance obligations imposed by directives like the CSRD can directly and indirectly affect these smaller businesses through increased compliance costs, administrative burdens, and potential barriers to market entry (Dempere et al., 2024). Companies may face higher operational costs and a higher cost of capital as they redesign business processes to become more sustainable, driven by pressure from creditors and investors as well as the objectives of the Green Deal (Burca et al., 2024).

The initial implementation of CSR disclosure mandates, like the NFRD, has already incurred significant resource allocation and additional costs for firms reporting for the first time, including investments in capabilities and systems for GHG emissions accounting and meeting diverse stakeholder expectations (Nampoothiri et al., 2024). The relatively higher cost of compliance for smaller firms compared to their larger peers can pose a significant threat to their dynamism and competitiveness within the EU (Bergmann & Posch, 2018; Cavallaro et al., 2024). Large corporations often benefit from economies of scale and may have existing resources and capabilities for reporting, while SMEs frequently need to make substantial new investments in systems, processes, and expertise to meet the regulatory requirements (Bergmann & Posch, 2018).

Greenwashing

greenwashing emerges as a significant challenge within the realm of sustainability reporting, particularly in the context of the EU's regulatory landscape (Buttigieg & Pulis, 2024; Zhao, 2023). Greenwashing can be broadly defined as the overstatement or misrepresentation of sustainability credentials of investment products or corporate activities to appear more environmentally or socially

responsible than they actually are (Buttigieg & Pulis, 2024; Kishan & Azhar, 2024; Xu et al., 2023; Zhao, 2023).

Some companies exploit the market's preference for sustainability reporting to overstate and misrepresent their sustainability strengths in management or business by engaging in 'greenwashing' practices, aiming to attract investors and persuade them and other stakeholders of their social and environmental value, capabilities, or contributions (Buttigieg & Pulis, 2024; Xu et al., 2023). This misrepresentation poses a threat to investor protection and market integrity because consumers may be sold products that do not align with their sustainability objectives, leading to a loss of trust in financial providers and markets in general (Buttigieg & Pulis, 2024). Complexity of the regulations creates opportunities for companies to selectively present data, omit key details, use vague language, and make unsubstantiated claims (Buttigieg & Pulis, 2024).

7.2 Strategic Opportunities Arising from Compliance

Despite the considerable challenges, compliance with the evolving EU sustainability reporting regulations also unlocks significant strategic opportunities for businesses. These opportunities include improved risk management, enhanced reputation and stakeholder trust, better access to sustainable finance, and the stimulation of innovation in sustainable practices and technologies (Baumuller & Sopp, 2022; Cavallaro et al., 2024; Dempere et al., 2024).

Enhancing Stakeholder Trust

Furthermore, effective sustainability reporting can substantially enhance a company's reputation and build trust with its stakeholders (Dempere et al., 2024; Moya, 2024; Pantazi, 2024). The growing interest of investors, consumers, and other stakeholders in ESG issues has intensified the focus on corporate sustainability performance and transparency (Vander Bauwhede & Van Cauwenberge, 2022). Regulatory bodies are increasingly mandating sustainability reporting, which in turn increases the need for companies engaged in sustainable practices to credibly signal their commitment and differentiate themselves (Partiti, 2024; Vander Bauwhede & Van Cauwenberge, 2022).

Transparent reporting on ESG impacts fosters confidence among investors, consumers, and other stakeholders, contributing to a more positive perception of the company (Villiers, 2022). Sustainability reporting is viewed as a mechanism to ensure clarity and honest conduct by corporations, providing useful information for investors, creditors, and other users to make informed decisions and hold management

accountable (Nampoothiri et al., 2024). The global trend towards mandatory disclosure of non-financial performance alongside financial information reflects a recognition that transparency is crucial for well-functioning financial markets and for building stakeholder trust in the information provided (Nampoothiri et al., 2024).

Companies that effectively report on their Scope 3 emissions and demonstrate progress in reducing their environmental impact are particularly likely to enhance their reputation and build stakeholder trust. Conversely, failure to meet reporting requirements or perceived inadequacy in emission reduction strategies can lead to reputational risks and stakeholder backlash (Moya, 2024; Pantazi, 2024).

A reduction in transparency can undermine stakeholders' ability to make accurate assessments and damage the perception of a company's integrity and responsibility (Martínez-Torres, 2024). Subjectivity in reporting can also erode trust, as stakeholders expect clear and complete reports that faithfully reflect the environmental and social challenges and risks companies face (Martínez-Torres, 2024). Adhering to robust sustainability reporting regulations presents an opportunity to enhance stakeholder trust by providing the clarity and completeness they expect (Partiti, 2024). By improving reporting practices, businesses not only meet stakeholder expectations but also contribute to Sustainable Development Goals (SDGs), strengthening their reputation and stakeholder trust, positioning themselves for long-term value creation (Lombardi et al., 2022; Petrova, 2024).

Access To Sustainable Finance

Another key strategic opportunity is improved access to sustainable finance. Sustainability disclosures for financial products are vital for ensuring transparency and directing capital towards desirable sustainable economic activities (Dempere et al., 2024; Partiti, 2024). EU regulations aim to encourage companies to better integrate sustainability considerations into their investment processes and to enable investors and stakeholders to assess companies' long-term value creation and their potential exposure to sustainability risks (Moneva et al., 2023; Partiti, 2024). By providing information on long-term value creation and sustainability risks, reporting allows stakeholders to make informed assessments, potentially improving a company's attractiveness to investors focused on sustainability (Partiti, 2024). Implementing a sustainable finance strategy is increasingly key for companies and financial institutions to meet climate objectives demanded in various regions (Moneva et al., 2023).

A common EU-wide label and standards for socially and environmentally responsible investments make it easier for companies meeting these criteria to attract sustainable finance (Moneva et al., 2023).

Corporate sustainability reporting is central to the EU Sustainable Finance policy, which aims to promote both the management of sustainability risks and the allocation of capital to sustainable investments (Habermann, 2021).

Investors are increasingly urging companies to incorporate ESG factors into their investment decisions (Chrzan & Pott, 2024). EU regulations like the CSRD and the EU Taxonomy are designed to provide investors with the necessary information for "green" investing and to establish a common understanding of what constitutes a green investment (Chrzan & Pott, 2024; Hummel & Bauernhofer, 2024). The EU Taxonomy Regulation has spurred internal discussions within companies about aligning their strategies with sustainability, fostering a competitive environment that encourages advancements in sustainability practices (Chrzan & Pott, 2024).

By providing investors with transparent and standardized information on green investments, companies can tap into the growing pool of capital directed towards sustainable activities (Hummel & Bauernhofer, 2024). The EU Taxonomy links sustainability reporting with key financial metrics like capital expenditure (CapEx) and operating expenditure (OpEx), ensuring a focus on investment in sustainable technologies and ESG-related improvements (Hummel & Bauernhofer, 2024). This presents a strategic opportunity to connect sustainability performance with core financial metrics, enhancing long-term financial viability and investor appeal (Hummel & Bauernhofer, 2024).

Companies that excel in sustainability reporting can gain a competitive advantage as investors and lenders increasingly consider ESG factors in their decisions (Horn, 2024; Hummel & Bauernhofer, 2024). The very purpose of the European Green Deal and the EU Taxonomy is to channel capital flows towards sustainable investments, implying that companies aligned with the Taxonomy will have enhanced access to this capital (Horn, 2024; Tettamanzi et al., 2024).

EU regulations guide investors towards integrating sustainability into their investment policies and assessing the environmental impact of their potential investments, enabling companies to define policies aimed at reducing negative externalities and to report on their progress in a comprehensive and comparable manner (Tettamanzi et al., 2024). Mandatory corporate taxonomy disclosure aims to stimulate investment in environmentally sustainable activities, offer transparency and protection against greenwashing, and provide the financial sector with the data needed to redirect capital to genuinely sustainable activities (Ostojic et al., 2024).

Metrics like revenue alignment with the EU Taxonomy indicate a company's current sustainability performance, while CapEx alignment reflects its future direction (Ostojic et al., 2024). Companies actively seek advice to develop and incorporate balanced ESG strategies into their policies (Danila et al., 2022).

The green asset ratio (GAR) is considered a useful indicator for investors to compare institutions and better direct capital towards those with stronger green financing performance, suggesting that companies with a good GAR will have better access to sustainable finance (Danila et al., 2022).

By mandating the inclusion of sustainability reports within consolidated annual accounts, the CSRD creates a direct link between financial and non-financial reporting, emphasizing their relevance to the market and the economy, thereby supporting the green transition and highlighting the critical role of investors and sustainable finance (Martínez-Torres, 2024).

To provide financial incentives and greater flexibility, the Omnibus proposal introduces an "opt-in" regime for large undertakings that do not exceed a certain size threshold and do not claim full alignment with the EU Taxonomy (European Commission, 2025a). These companies would have the option to disclose limited Taxonomy-related KPIs without the full burden of compliance. This "opt-in" approach aims to entirely eliminate the cost of compliance with Taxonomy reporting rules for such undertakings that do not claim their activities are environmentally sustainable under the Taxonomy Regulation (European Commission, 2025a). Furthermore, these undertakings would be allowed to report on activities that partially meet the Taxonomy's technical screening criteria, encouraging a gradual environmental transition (European Commission, 2025a).

Improving Risk Management

Sustainability reporting, particularly as mandated by the NFRD and the upcoming CSRD, requires companies to disclose information on environmental, social, and governance (ESG) risks (Breijer & Orij, 2022; Raith, 2023). This process encourages businesses to identify, assess, and manage a broader range of risks, including climate-related , social and employee-related, human rights risks, and risks related to corruption and bribery (Breijer & Orij, 2022; Dembowska, 2021; Mio et al., 2020). Compliance with the directive can significantly improve a company's risk management capabilities (Dempere et al., 2024).

By systematically collecting and analyzing sustainability data, companies gain a deeper understanding of their environmental and social risks, allowing them to develop more effective mitigation strategies. This proactive approach to risk management can protect companies from potential operational disruptions, regulatory penalties, and reputational damage (Martínez-Torres, 2024; Pantazi, 2024).

Catalyst for Innovation

Finally, the directive's emphasis on sustainability can act as a powerful catalyst for innovation in sustainable practices and technologies (Dempere et al., 2024). The narrative of European sustainability regulations begins with a challenge, pushing companies beyond conventional practices and towards uncharted territories of innovation (Becchetti et al., 2024). These regulations, such as Directive 2014/95/EU, initially aimed to provide stakeholders with more complex and comparable information (Matuszak & Rózanska, 2021). However, they are faced with the need to comply and transparently disclose their impact, businesses are compelled to rethink their production and decision-making processes. This push not only rewards more sustainable and innovative businesses but also incentivizes others to adopt more responsible approaches (Siri & Zhu, 2019).

The emphasis on sustainability embedded in directives can serve as a catalyst for innovation in sustainable practices and technologies (Dempere et al., 2024). To transform the added costs of activities like recycling into a competitive advantage, manufacturers are driven to innovate in efficiency, flexibility, and scalability (Bataleblu et al., 2024). As companies strive to meet the more stringent reporting requirements and demonstrate improved sustainability performance, they are incentivized to develop and adopt innovative solutions that reduce their environmental footprint and enhance their social impact. This can lead to the creation of new products, services, and business models that not only contribute to a more sustainable economy but also provide companies with a competitive edge in the market (Dempere et al., 2024).

8 Future Outlook

8.1 EU Sustainability Reporting Post-2025

Looking ahead, the trend in EU sustainability reporting is towards increasingly stringent rules aimed at enhancing companies' awareness of their negative externalities and promoting honest business processes in the long term (Cavallaro et al., 2024). The primary goal is not only to harmonize reporting processes and ensure the provision of clear, transparent, reliable, and verifiable information but also to recognize the intrinsic financial value of sustainability reporting, acknowledging the relevance of environmental, social, and governance issues to overall business success (Cavallaro et al., 2024).

The CSRD represents a significant expansion of the previous NFRD, requiring more detailed reporting and affecting a much larger number of companies (Becchetti et al., 2024). It broadens the scope

of sustainability reporting obligations to all large companies (those with over 250 employees) and all companies listed on regulated markets, including listed SMEs but excluding listed micro-enterprises (Becchetti et al., 2024). Furthermore, the CSRD mandates the verification of reported sustainability information, introduces more detailed reporting obligations aligned with the EU sustainability reporting standards (ESRS), and requires companies to disclose information digitally to enhance transparency (Becchetti et al., 2024). This expansion is evident in the projected increase in the number of companies required to integrate non-financial disclosures into their sustainability reports, from approximately 11,700 under the NFRD to around 49,000 under the CSRD (Moya, 2024; Ostojic et al., 2024).

The CSRD came into effect on January 1, 2024, with a phased implementation timeline (Martínez-Torres, 2024; Moya, 2024; Stojanović-Blab & Blab, 2024). Large public companies already subject to the NFRD were required to report in 2025 for the financial year 2024. Large companies not previously subject to the NFRD will need to report in 2026 for the financial year 2025. Listed SMEs will begin reporting in 2027 for the financial year 2026, with an option for voluntary exclusion until 2028 (Martínez-Torres, 2024; Moya, 2024). However, there have been noted inconsistencies and potential exemptions within the ESRS that might seem to contradict the broader aims of the CSRD, such as allowing companies with fewer than 750 employees to omit certain environmental data in the initial years of reporting, including detailed Scope 3 emissions information which the CSRD emphasizes as essential (Martínez-Torres, 2024; Stojanović-Blab & Blab, 2024).

The "Omnibus Package" represents a recent development aimed at balancing the ambition of sustainability goals with concerns about the competitiveness of businesses. This package includes proposals for phased implementation timelines, simplified reporting standards, financial incentives, and measures to support SMEs (European Commission, 2025a).

Future regulatory reforms are also expected to place a greater emphasis on biodiversity reporting (Stojanović-Blab & Blab, 2024). The European Commission has already identified the protection and restoration of biodiversity and ecosystems as one of the six key environmental objectives within its regulations (Camilleri, 2015). This indicates that biodiversity is already recognized as a crucial aspect of EU sustainability regulations, and future reforms are likely to strengthen the requirements and frameworks related to reporting on this area, potentially focusing on biodiversity loss as a material risk for businesses (Stojanović-Blab & Blab, 2024).

The ESRS includes a specific standard, ESRS E4, covering all disclosure requirements related to biodiversity and ecosystems (Stojanović-Blab & Blab, 2024; Velte, 2024). While this standard exists, there has been debate about potential exemptions for smaller companies in the initial reporting periods

(Martínez-Torres, 2024). Despite these nuances, the overall direction is towards greater integration of biodiversity considerations into sustainability reporting, with transition plans under the CSRD already required to refer to the EU Biodiversity Strategy for 2030 and the new Post-2020 Global Biodiversity Framework (Velte, 2024).

8.2 The Role of Technology in Enhancing Sustainability Reporting

The integration of technology in sustainability reporting is crucial for improving accuracy, transparency, and efficiency. Artificial intelligence (AI) systems, for instance, significantly enhance the quality of financial reports by automating the recording and processing of accounting operations, thereby providing more appropriate information for rational investment decisions . AI's ability to automatically report and correct errors in data entry further sustains the quality of financial reports, increasing their reliability and credibility (Gshayish & Faik, 2023).

Technology, particularly Artificial Intelligence (AI) and blockchain, is playing an increasingly significant role in transforming sustainability reporting, offering solutions to enhance efficiency, accuracy, and transparency (Correia & Água, 2024; Seretakis & Mezzanotte, 2023). Digitalization is a significant driver of Sustainable Development Goals (SDG) reporting, particularly in emerging economies. Countries with higher adoption of digital technologies tend to demonstrate improved sustainability reporting, along with strong performance in environmental health, ecosystem vitality, and economic progress (Ștefănescu, 2024).

AI-Powered ESG

AI-powered data analysis presents a powerful tool for improving ESG reporting by automating data collection and analysis through machine learning, natural language processing, and predictive analytics (Correia & Água, 2024). These technologies can integrate data from diverse sources, providing a more holistic and accurate view of ESG performance (Correia & Água, 2024). AI also enables real-time data processing, shifting ESG reporting from a backward-looking exercise to a proactive strategy that can predict future trends and outcomes (Correia & Água, 2024; Rane et al., 2024).

Businesses are already leveraging AI technologies to monitor and report ESG metrics with greater precision, allowing them to track environmental impacts, optimize resource use, and reduce carbon emissions (Rane et al., 2024). The application of Natural Language Processing (NLP) and machine learning algorithms in ESG data analytics has enhanced the robustness and insightfulness of sustainability

reporting, facilitating better alignment of business strategies with global sustainability goals (Rane et al., 2024). ESG ratings have been shown to correlate positively with corporate financial performance. Companies with high ESG scores tend to exhibit better long-term financial returns, particularly during periods of market volatility, such as the COVID-19 pandemic. This positive correlation is attributed to enhanced risk management capabilities and financial resilience in firms with robust ESG practices (Juthi et al., 2024). By analyzing vast amounts of data from various sources, AI can provide valuable insights into the environmental impact of different business practices and suggest more sustainable alternatives (Rane et al., 2024).

AI-based systems can also automate the detection of fraudulent activities, monitor regulatory changes, and ensure compliance with legal standards (Rane et al., 2024). AI and machine learning technologies play a crucial role in ESG data collection and analysis. These technologies enable more accurate and real-time risk assessment and decision-making, which are essential for sustainable corporate performance and investment strategies (Juthi et al., 2024).

Tech-based ESG reporting platforms are emerging to offer comprehensive suites of features that enable organizations to effectively manage and report their ESG performance (Markova-Karpuzova et al., 2024). These platforms utilize AI, machine learning, and big data analytics to automate data collection, analysis, and reporting processes, thereby improving efficiency, accuracy, and transparency (Markova-Karpuzova et al., 2024). Key features of these AI-driven platforms include automated data collection and aggregation, sophisticated data analysis and visualization, customizable reporting templates, and tools for stakeholder engagement (Markova-Karpuzova et al., 2024). AI-powered systems can also analyze extensive financial data to detect patterns and provide predictive insights with unprecedented accuracy and speed, enabling organizations to automate complex accounting tasks, reduce human error, and generate more reliable financial reports (Budiarto et al., 2024).

Blockchain Technology

Blockchain technology also offers significant potential for enhancing supply chain transparency in sustainability reporting (Correia & Água, 2024; Seretakis & Mezzanotte, 2023). As a decentralized and immutable ledger, blockchain can enhance trust and transparency while reducing fraud (Seretakis & Mezzanotte, 2023). Its ability to automatically update the ledger and make changes observable to users makes tampering extremely difficult, improving the permanence and immutability of transaction records. Blockchain is also resilient against cyberattacks and failures of individual nodes (Seretakis & Mezzanotte, 2023).

Emerging technologies like blockchain can enhance ESG data management by creating more secure and transparent systems, with blockchain's immutable ledger ensuring data integrity and providing an additional layer of security and trustworthiness (Correia & Água, 2024). In governance, AI-driven risk management tools combined with blockchain technologies can strengthen corporate governance by ensuring compliance and transparency in supply chains and financial reporting (Seretakis & Mezzanotte, 2023). Moreover, blockchain can significantly improve sustainability reporting, aiding firms in implementing the requirements introduced by the CSRD (Seretakis & Mezzanotte, 2023).

Current corporate systems for tracking transactions and aggregating data often struggle with global and multi-layered supply chains, and existing verification and auditing systems rely on human intervention, making them susceptible to fraud and waste (Seretakis & Mezzanotte, 2023). Blockchain technology provides transparency and traceability throughout supply chains, enhancing social responsibility by ensuring fair labor practices and ethical sourcing of materials. This technology contributes to environmental sustainability by reducing carbon emissions and dependence on fossil fuels, thus mitigating climate change. Additionally, blockchain technology streamlines operations and increases efficiency, reducing costs and improving profitability while minimizing the environmental footprint (Kiyani, 2023).

Blockchain's features, such as creating a distributed and continually updated record, can make sustainability data automatically and widely available (Seretakis & Mezzanotte, 2023). The tamper-resistant nature of blockchain databases makes fraud and data manipulation extremely difficult, contributing to the creation of more sustainable supply chains by verifying the sustainability attributes of products (Seretakis & Mezzanotte, 2023)

Challenges and Recommendations

Despite the numerous benefits, there are also challenges, limitations, and risks associated with the use of AI in ESG reporting (Markova-Karpuzova et al., 2024; Rane et al., 2024). Ensuring the quality and reliability of the data used for reporting is a primary concern, as companies often rely on various internal and external sources with varying levels of accuracy and completeness (Markova-Karpuzova et al., 2024).

Robust data validation processes, data cleansing techniques, and ongoing monitoring are essential to address these issues (Markova-Karpuzova et al., 2024). Integrating tech-based ESG reporting platforms with existing systems and processes can be complex and time-consuming, potentially involving compatibility issues and resistance to change from employees (Markova-Karpuzova et al., 2024). Seamless

integration requires careful planning, stakeholder engagement, and investment in training and organizational change management (Markova-Karpuzova et al., 2024). Keeping pace with evolving regulatory requirements and standards is another significant challenge, necessitating ongoing monitoring, updates to reporting templates, and alignment with industry best practices (Markova-Karpuzova et al., 2024). The collection, storage, and processing of sensitive data by these platforms raise concerns about data privacy and security, requiring robust data protection measures to mitigate the risk of breaches and unauthorized access (Markova-Karpuzova et al., 2024).

The use of AI algorithms and machine learning techniques introduces the risk of algorithm bias and interpretation errors, which can lead to inaccurate or misleading results, undermining the credibility of ESG reports (Markova-Karpuzova et al., 2024). Careful assessment of algorithm validity, sensitivity analyses, and transparent disclosures about limitations are crucial (Markova-Karpuzova et al., 2024). There is also a risk of overreliance on technology and automation, potentially leading to a reduction in human oversight and judgment, which is necessary to consider nuanced or context-specific factors. A balance between automation and human expertise is essential (Markova-Karpuzova et al., 2024). Other major barriers to the widespread adoption of AI in ESG reporting include data quality and integration issues, the substantial computational resources and expertise required, ethical and privacy concerns such as data misuse and the "black box" problem (lack of transparency in how AI arrives at its conclusions), the high cost of AI technology, and the need for scalable and reliable systems, as well as the complexity added by the evolving regulatory landscape (Correia & Água, 2024).

To overcome these challenges, companies should invest in robust data governance frameworks, adopt transparent AI practices, scale AI systems cautiously, and stay informed about regulatory changes to maximize the benefits of AI in enhancing corporate transparency and accountability while driving sustainable business practices (Correia & Água, 2024). Stakeholder collaboration is essential for achieving comprehensive sustainability goals, as engaging suppliers, customers, and regulatory bodies is crucial (Blessing Ameh, 2024). The strategic implementation of digital tools and AI is advocated as pivotal enablers of sustainable supply chain management, providing organizations with the capability to adapt to changing environmental regulations and consumer expectations (Blessing Ameh, 2024).

9 Conclusion

This thesis has systematically explored the evolving relationship between sustainability reporting regulations—specifically the Corporate Sustainability Reporting Directive (CSRD)—and Enterprise Risk Management (ERM) practices within the European Union.

Through a comprehensive literature review of post-2015 scholarly articles and official reports, the study uncovered how CSRD acts not merely as a compliance framework but as a strategic driver, influencing corporate behavior, risk culture, and governance mechanisms.

The integration of stakeholder theory and the principle of double materiality emerged as foundational conceptual lenses, enabling a deeper understanding of how sustainability risks are reclassified and internalized within ERM systems. Moreover, the analysis demonstrated how CSRD contributes to the formalization of sustainability-related risks, the refinement of internal control structures, and the alignment of ERM processes with long-term corporate sustainability strategies.

Case studies from TotalEnergies, Siemens, and Volkswagen provided real-world illustrations of how large corporations interpret and operationalize CSRD guidelines, highlighting both the opportunities and challenges inherent in implementation. These examples revealed sectoral differences in readiness and capacity to embed sustainability in risk governance, suggesting that uniform regulatory pressure yields differentiated organizational responses.

From a managerial perspective, this research emphasizes the growing importance of integrating ESG considerations not only into reporting processes but into core strategic and risk management decisions.

From a policy perspective, the study indicates that the CSRD may serve as a model for future non-financial regulation, pushing firms toward holistic risk-awareness and more transparent accountability mechanisms.

Nevertheless, the research also revealed a number of unresolved questions, particularly concerning how SMEs and less-resourced firms will adapt to CSRD requirements, and how internal ERM transformations will be monitored and assessed over time. Future studies could benefit from comparative, empirical research across industries and regions, as well as long-term case studies that trace how sustainability and risk converge under dynamic regulatory environments. In conclusion, this thesis demonstrates that the CSRD is not only redefining how companies report, but also how they think, plan, and act in relation to sustainability and risk—laying the groundwork for a more resilient and accountable corporate landscape in Europe.

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