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Corporate governance, ESG, and innovation transparency: Evidence from French listed firms

Dr. Nadia Lakhal
Assistant Professor, University of Sousse, LAMIDED Sousse, Tunisia.
Email: nadia_lakhal@yahoo.fr

Dr. Asma Guizani
University of Caen
Email: asmaguizani@gmail.com

***Abstract*---**This paper examines how corporate governance mechanisms influence the voluntary disclosure of research and development (R&D) activities within the broader framework of environmental, social, and governance (ESG) transparency. Drawing on an unbalanced panel of 341 French listed firms over the 2012–2023 period, we explore the role of key board characteristics including independence, gender diversity, size, and CEO duality in shaping the extent and quality of innovation-related disclosure. Using both fixed-effects and system GMM estimations, the study addresses endogeneity concerns and firm-specific heterogeneity. Our findings reveal that board independence and gender diversity are significant drivers of R&D and innovation transparency, consistent with agency and resource dependence theories. Conversely, CEO duality remains negatively associated with disclosure levels, indicating reduced oversight and weaker ESG commitment. Board size exhibits a non-linear effect, suggesting that excessively large boards may hinder communication efficiency. Furthermore, the presence of CSR committees and higher ESG scores contributes to more comprehensive reporting on innovative activities. The findings highlight the complementary relationship between governance quality, sustainability orientation, and R&D disclosure. The study offers insights for policymakers, investors, and corporate leaders seeking to strengthen innovation transparency under the evolving requirements of the CSRD.

Corresponding author: *XXXX, Email: xxxx@gmail.com*
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1. Introduction

In an increasingly knowledge-based and sustainability-oriented economy, research and development (R&D) activities have become critical drivers of innovation, competitiveness, and long-term corporate value. They not only enable firms to generate new products, processes, and technologies but also enhance adaptability to environmental and social challenges. However, while R&D represents a strategic intangible asset, its disclosure in corporate reports remains voluntary, fragmented, and often opaque. This opacity hinders investors' ability to assess innovation potential and constrains the efficient allocation of capital (Ahmed, M. S., & King, T. (2025).

Over the past decade, the nature of corporate transparency has evolved profoundly. The traditional financial-reporting paradigm, centered on shareholder information, has progressively shifted toward sustainability-oriented disclosure under the broader Environmental, Social, and Governance (ESG) framework. In this context, R&D activities are increasingly recognized as enablers of environmental transition, digital transformation, and social progress (**Rauf, F., & Zhang, Y. (2024).** The European Union has formalized this shift through the Corporate Sustainability Reporting Directive (CSRD, 2022) and the European Sustainability Reporting Standards (ESRS, 2023), both requiring firms to disclose forward-looking, innovation-related, and non-financial performance indicators. This regulatory evolution transforms R&D disclosure from a voluntary initiative into a strategic pillar of sustainability communication and corporate legitimacy.

Corporate governance mechanisms play a decisive role in this transformation. The composition and effectiveness of the board of directors its size, independence, gender diversity, and leadership structure are central to ensuring transparency, accountability, and stakeholder alignment. According to agency theory (Jensen & Meckling, 1976), independent directors reduce managerial opportunism and information asymmetry, while resource dependence theory (Pfeffer, 1972) emphasizes the board's role in providing knowledge, expertise, and strategic guidance to enhance innovation disclosure. Stakeholder theory (Freeman, 1984) and legitimacy theory (Suchman, 1995) further suggest that boards use voluntary disclosure to signal ethical behavior, environmental stewardship, and compliance with societal expectations.

Within this conceptual framework, board gender diversity has emerged as an essential governance dimension, especially after the Copé–Zimmermann Law (2017) mandated a minimum of 40% female representation on French boards. Female directors are often associated with more inclusive decision-making, enhanced ethical sensitivity, and a greater focus on sustainability and social responsibility (Adams & Ferreira, 2009; Al-Malkawi & Hussainey, 2023). Similarly, the separation of CEO and chairperson roles improves the board's ability to monitor management independently and strengthens information reliability (Zeghal & Lahiani, 2023). By contrast, CEO duality may weaken

oversight and constrain the dissemination of strategic innovation information (Lim et al., 2007; Conheady et al., 2014).

Despite these advances, empirical evidence linking governance quality and R&D transparency remains limited, particularly in the post-ESG reporting era. Earlier studies (Nekhili et al., 2015; Maaloul & Zeghal, 2015) investigated voluntary R&D disclosure before the institutionalization of sustainability standards and primarily focused on firm-level characteristics. Yet, the integration of ESG and innovation disclosure within corporate reports has redefined both the incentives and mechanisms underlying transparency. There is, therefore, a pressing need to re-examine how board characteristics drive sustainable innovation disclosure in the new European reporting environment.

This study aims to fill this gap by investigating the impact of board independence, gender diversity, board size, and CEO duality on the voluntary disclosure of R&D activities in French listed firms between 2011 and 2024. It also explores how ESG performance and the presence of CSR committees moderate these relationships. By doing so, the study contributes to the growing body of research on the governance ESG nexus and extends the literature on intellectual capital and innovation reporting.

The empirical analysis is based on a comprehensive manual content examination of annual and sustainability reports for 341 firms listed on the CAC All Shares index. Using panel data econometrics including fixed effects and system GMM estimations to address endogeneity, the study develops a novel R&D–ESG disclosure index comprising 37 innovation-related items consistent with ESRS guidelines.

This research makes several key contributions. First, it provides new empirical evidence on how governance mechanisms shape the voluntary disclosure of innovation-related information in the ESG era. Second, it integrates sustainability and governance perspectives, showing that R&D disclosure now functions as a vector of corporate legitimacy and environmental accountability. Third, it offers actionable insights for managers, investors, and policymakers seeking to enhance innovation transparency, comply with evolving EU regulations, and align governance practices with sustainability goals.

The remainder of the paper is structured as follows. Section 2 presents the theoretical background and develops the research hypotheses. Section 3 outlines the research design, data, and methodology. Section 4 reports and interprets empirical findings. Section 5 discusses managerial, theoretical, and policy implications, while Section 6 concludes and proposes directions for future research.

2. Literature Review and Hypotheses Development

2.1. Corporate Governance and Voluntary Disclosure

Corporate governance provides the institutional framework through which firms ensure accountability, transparency, and sustainable value creation. It aligns managerial actions with stakeholder expectations and mitigates information

asymmetry through internal monitoring and disclosure (Eng & Mak, 2003; Zeghal & Lahiani, 2023). Voluntary disclosure defined as the provision of information beyond statutory requirements represents a tangible manifestation of governance quality. It signals managerial integrity, long-term orientation, and responsiveness to market and societal demands (Ahmed & Courtis, 1999).

In the post-IFRS and ESG era, voluntary disclosure extends far beyond financial indicators to encompass innovation, intellectual capital, and environmental performance (**Rauf, F., & Zhang, Y. (2024).**; Nadeem & Alon, 2024). R&D information offers investors insight into a firm's future growth capacity and innovative capabilities. Yet such information is complex, uncertain, and strategically sensitive, making disclosure decisions heavily dependent on governance structures (Ahmed, M. S., & King, T. (2025)

Within this context, the board of directors acts as the fulcrum of governance effectiveness. Its composition and functioning determine whether the firm embraces transparency as a strategic asset or restricts information for competitive reasons. Effective boards characterized by independence, gender diversity, balanced size, and role separation are more likely to encourage transparent communication and sustainable innovation disclosure. Conversely, weak boards dominated by managerial interests often foster opacity and selective reporting (Samaha et al., 2015; Al-Malkawi & Hussainey, 2023).

2.2. Theoretical Framework

Understanding how corporate governance mechanisms influence the voluntary disclosure of research and development (R&D) activities requires a multidimensional theoretical perspective. The complexity of innovation disclosure arises from the coexistence of control, strategic, and institutional considerations, making it necessary to combine insights from several complementary theories. The present study integrates the agency, resource dependence, stakeholder, and legitimacy perspectives to explain both the incentives and constraints shaping R&D transparency in the contemporary ESG environment.

Agency theory provides a fundamental rationale for the role of governance in disclosure. It assumes that managers and shareholders have divergent interests, and that information asymmetry allows managers to act opportunistically (Jensen & Meckling, 1976; Fama & Jensen, 1983). In areas such as R&D, characterized by uncertainty and discretionary accounting treatment, the risk of opportunism is particularly high (Aboody & Lev, 2000). Voluntary disclosure operates as a monitoring mechanism that reduces agency costs and enhances accountability. Boards that are more independent and diverse are likely to demand transparent communication on innovation expenditures, project risks, and expected returns. Independent directors strengthen control, limit managerial discretion, and ensure that strategic information is shared with investors and stakeholders. Similarly, the separation of the CEO and chairperson roles reduces the concentration of power, enhances oversight, and fosters more credible and comprehensive disclosure. Within the ESG framework, voluntary disclosure becomes an explicit manifestation of good governance, signaling that the firm exercises managerial discretion in a transparent and responsible manner.

From a complementary standpoint, resource dependence theory emphasizes that boards are not only control bodies but also strategic resources that provide firms with expertise, legitimacy, and access to external networks (Pfeffer, 1972; Hillman & Dalziel, 2003). The board's composition determines its capacity to interpret and communicate complex information related to innovation, intellectual capital, and sustainability. Diversity of experience and gender broadens the range of cognitive perspectives available to the board, improving its understanding of technological trends and ESG challenges. Through their professional connections and capital knowledge, directors bring external legitimacy and strategic guidance, which enhance both the quality and credibility of R&D disclosure. Larger and more heterogeneous boards are therefore able to integrate environmental and innovation-related dimensions into corporate communication, translating technical and scientific achievements into accessible sustainability narratives.

Stakeholder theory further extends this reasoning by shifting the focus from shareholders to the wider network of stakeholders who are affected by the firm's operations (Freeman, 1984). Disclosure becomes a mechanism through which the company demonstrates its responsiveness to economic, environmental, and social expectations. In the context of R&D, transparency about innovation activities signals that the firm contributes to collective welfare through technological advancement and sustainable development. Boards that embrace a stakeholder-oriented vision are more likely to integrate non-financial considerations into strategic decision-making and reporting. The growing institutionalization of ESG principles reinforces this approach, transforming R&D disclosure into a means of creating shared value and strengthening long-term legitimacy.

Legitimacy theory complements these perspectives by explaining why firms disclose information in response to external pressures and societal expectations (Suchman, 1995; Deegan, 2019). Corporate reporting is not merely a technical exercise but a symbolic act that communicates conformity with social norms and regulatory frameworks. In Europe, the recent introduction of the Corporate Sustainability Reporting Directive (CSRD, 2022) and the European Sustainability Reporting Standards (ESRS, 2023) has elevated sustainability disclosure from voluntary practice to an essential component of corporate legitimacy. By disclosing R&D activities related to environmental innovation, digital transformation, or social inclusion, firms align themselves with the objectives of the European Green Deal and the United Nations Sustainable Development Goals. Governance mechanisms particularly board independence, gender diversity, and the existence of CSR committees play a pivotal role in ensuring that this legitimacy is achieved through credible and substantive reporting rather than symbolic compliance.

Taken together, these theoretical perspectives converge to suggest that effective, independent, and diverse boards operating within ESG-oriented governance structures will promote comprehensive, credible, and sustainability-aligned disclosure of R&D activities. Agency theory explains the monitoring role of governance; resource dependence theory clarifies its contribution to strategic knowledge and legitimacy; stakeholder theory emphasizes the relational and ethical motivations for transparency; and legitimacy theory situates disclosure within institutional and societal expectations. In this integrated framework,

voluntary R&D disclosure emerges not only as an outcome of good governance but also as a strategic instrument for building legitimacy, trust, and long-term sustainable value.

2.3 Hypothesis Development

2.3.1 Board Size and R&D Disclosure

The size of the board of directors is a central dimension of corporate governance and has long been debated in relation to firm transparency and disclosure behavior. Board size determines the range of skills, experiences, and perspectives available for decision-making, as well as the board's ability to monitor management effectively. In the context of voluntary R&D disclosure, this characteristic plays a dual role: it reflects both the board's monitoring capacity and its strategic advisory potential in shaping the firm's communication about innovation and sustainability.

From an agency perspective, larger boards are expected to enhance monitoring effectiveness by providing broader oversight, diverse opinions, and more specialized expertise. A greater number of directors may reduce the influence of dominant individuals and increase accountability in the decision-making process (Hidalgo et al., 2011). This plurality of viewpoints enables a more rigorous evaluation of managerial actions, especially in sensitive domains such as R&D, where projects are inherently uncertain and outcomes are difficult to verify. In this sense, larger boards can facilitate the disclosure of innovation-related information by demanding greater transparency regarding research objectives, performance indicators, and the environmental or social impact of technological initiatives (Zeghal & Lahiani, 2023).

However, agency theory also warns that beyond a certain threshold, an increase in board size can generate coordination inefficiencies, slower communication, and diluted responsibility (Jensen, 1993). Oversized boards may struggle to reach consensus or to engage deeply with complex technical matters such as R&D investment strategies or the quantification of intangible assets. The effectiveness of control and the speed of strategic reactions may thus decline, potentially discouraging proactive disclosure (Cerbioni & Parbonetti, 2007).

Resource dependence theory offers a complementary interpretation. Boards with a sufficient critical mass of directors can mobilize a broader network of external relationships, industry expertise, and institutional legitimacy, all of which are essential for translating innovation into value creation (Hillman & Dalziel, 2003). Larger boards are more likely to include directors with backgrounds in technology, finance, or sustainability, thereby enriching deliberations and enabling firms to frame their R&D communication in alignment with the environmental and social priorities of the Corporate Sustainability Reporting Directive (CSRD) and European Sustainability Reporting Standards (ESRS) (**Rauf, F., & Zhang, Y. (2024).**). This expanded expertise enhances the credibility of R&D disclosure and allows firms to link their innovation narrative with ESG indicators such as carbon efficiency, energy transition, or social inclusion through digital technologies.

Recent empirical evidence tends to support this nuanced view. Moderate board expansion enhances disclosure and legitimacy, while excessive enlargement diminishes efficiency. Studies on European markets show that boards with between nine and fifteen members exhibit the highest effectiveness in promoting ESG-aligned disclosure (Nadeem & Alon, 2024). Similarly, French listed firms with moderately sized boards tend to publish richer sustainability and innovation information than those with smaller or excessively large governance structures (Zeghal & Maaloul, 2011).

These findings suggest that the relationship between board size and voluntary disclosure is not linear but inverted U-shaped. Up to a point, an increase in board size enhances transparency and the quality of R&D reporting through improved monitoring and diversified expertise. Beyond that optimal level, however, coordination costs, free-riding behavior, and reduced cohesion undermine disclosure effectiveness.

Consequently, firms that achieve an optimal balance between inclusiveness and efficiency are better positioned to communicate innovation and sustainability information effectively. This balance enables them to leverage R&D disclosure not only as a means of signaling financial performance but also as a strategic instrument of corporate legitimacy in line with ESG expectations.

H1. Board size has a non-linear (inverted U-shaped) relationship with voluntary disclosure of R&D activities: transparency increases with board size up to an optimal threshold, after which it decreases.

2.3.2 Board Independence and R&D Disclosure

Board independence is widely regarded as one of the most critical attributes of effective corporate governance and a key determinant of transparency and voluntary disclosure. Independent directors defined as members of the board who are free from managerial, family, or significant ownership ties play a central role in enhancing monitoring quality, reducing information asymmetry, and ensuring accountability to shareholders and broader stakeholders (Fama & Jensen, 1983; Zeghal & Lahiani, 2023). Their presence strengthens the board's capacity to oversee managerial behavior objectively and to demand the disclosure of information that accurately reflects the firm's performance and long-term strategy.

From the perspective of agency theory, independent directors serve as an essential counterbalance to managerial discretion. Because R&D investments are characterized by high uncertainty, long time horizons, and discretionary accounting treatment (e.g., capitalization versus expense), the potential for opportunistic reporting is considerable (Aboody & Lev, 2000). Independent directors reduce this risk by scrutinizing innovation expenditures, validating performance indicators, and insisting on the transparent communication of project objectives, outcomes, and societal contributions. Firms with a higher proportion of independent board members are therefore more likely to engage in comprehensive and credible voluntary disclosure of R&D activities, reassuring investors about the efficiency of resource allocation and the legitimacy of management's claims regarding innovation performance (Lim et al., 2007; Al-Malkawi & Hussainey, 2023).

Beyond monitoring, independent directors also enhance strategic oversight and legitimacy. Resource dependence theory suggests that independent members often possess diverse professional backgrounds and external networks that connect the firm to key stakeholder's investors, regulators, research institutions, and sustainability experts (Hillman & Dalziel, 2003). This external embeddedness enriches the board's perspective on how innovation contributes to environmental and social goals. Independent directors can therefore advocate for disclosure practices that align R&D reporting with ESG narratives and international sustainability frameworks such as the Corporate Sustainability Reporting Directive (CSRD) and European Sustainability Reporting Standards (ESRS). Their involvement transforms disclosure from a mere compliance exercise into a strategic communication tool that links innovation to the firm's broader legitimacy within society.

Moreover, in the post-ESG era, independence has evolved from a structural feature to a substantive governance quality. Independent boards are expected not only to oversee financial reporting but also to ensure the integrity and consistency of sustainability and non-financial disclosures. The integration of innovation and ESG information into annual and sustainability reports requires cross-functional judgment and ethical vigilance both of which independent directors are well placed to provide (**Rauf, F., & Zhang, Y. (2024).**. By promoting transparent communication about technological innovation, green patents, or R&D initiatives related to energy transition, independent boards reinforce stakeholder confidence and compliance with the "double materiality" principle embedded in the CSRD.

Empirical evidence corroborates these arguments. Studies conducted in European contexts, including France, show that firms with higher proportions of independent directors exhibit more extensive disclosure of intellectual capital, innovation, and sustainability-related information (Nekhili et al., 2015; Zeghal & Lahiani, 2023). Recent cross-country research further indicates that board independence enhances the credibility of ESG and innovation reporting, especially in highly regulated environments where institutional investors and regulators demand transparency (Nadeem & Alon, 2024). This evidence reinforces the idea that independent boards act as both guardians of transparency and agents of legitimacy, encouraging firms to disclose forward-looking, socially relevant information about their innovative strategies.

Accordingly, in the context of French listed companies subject to increasingly stringent ESG expectations, board independence is expected to foster more robust and informative voluntary disclosure of R&D activities. Independent directors enhance credibility, strengthen governance–ESG alignment, and ensure that innovation transparency becomes an integral part of corporate accountability rather than a symbolic gesture.

H2. Board independence positively influences the voluntary disclosure of R&D and innovation-related information.

2.3.3. CEO Duality and R&D Disclosure

CEO duality, the situation in which the same individual serves simultaneously as both the Chief Executive Officer and the Chairperson of the Board, remains one of the most debated governance structures in corporate finance and accounting

research. This dual role directly affects the balance of power within the boardroom, potentially undermining its monitoring independence and compromising the quality of strategic oversight (Fama & Jensen, 1983). From a governance and disclosure perspective, CEO duality embodies a tension between efficiency and accountability: while combining leadership roles may streamline decision-making, it can also reduce transparency, constrain dissenting perspectives, and limit the board's ability to demand and verify voluntary disclosure of sensitive information such as R&D and innovation expenditures.

According to agency theory, CEO duality increases managerial entrenchment and weakens the effectiveness of control mechanisms designed to protect shareholders' interests. When the CEO also presides over the board, information asymmetry between management and directors intensifies, since the same person controls both the flow and content of strategic information (Jensen, 1993). In such contexts, voluntary disclosure is likely to decline because managers have greater discretion to withhold information that could expose inefficiencies, project failures, or strategic risks. This dynamic is particularly relevant for R&D activities, which are inherently uncertain, costly, and subject to subjective valuation (Aboody & Lev, 2000). Managers occupying dual roles may selectively disclose successful projects while downplaying less favorable outcomes, thereby limiting investors' ability to evaluate the true performance and risk profile of innovation activities (Lim et al., 2007).

From a stakeholder and legitimacy perspective, CEO duality may also hinder the organization's capacity to engage in transparent communication with non-shareholder audiences. The increasing prominence of the Corporate Sustainability Reporting Directive (CSRD, 2022) and European Sustainability Reporting Standards (ESRS, 2023) has heightened expectations for board accountability in sustainability and innovation disclosure. Dual leadership structures can blur governance responsibilities and diminish the perceived credibility of ESG and R&D reporting. Firms led by non-dual CEOs are better positioned to demonstrate alignment with stakeholder expectations for independence, ethical conduct, and long-term value creation (Zeghal & Lahiani, 2023). In this respect, CEO duality may be viewed as inconsistent with the modern governance principles underlying ESG integration, which emphasize distributed oversight, transparent reporting, and checks and balances between management and the board.

Empirical evidence consistently supports these theoretical assertions. Studies conducted in various institutional settings reveal a negative association between CEO duality and the extent of voluntary disclosure, particularly in areas involving managerial discretion such as intellectual capital and innovation (Conheady et al., 2014; Samaha et al., 2015). Recent European research confirms that firms with separate leadership structures are more transparent about their sustainability and R&D activities (**Rauf, F., & Zhang, Y. (2024).**. This trend reflects investors' growing preference for governance arrangements that reinforce independence and transparency in the post-ESG era. Moreover, the AFEP–MEDEF corporate governance code in France explicitly recommends role separation to ensure that boards exercise genuine supervisory authority over management and maintain the integrity of public reporting.

In line with these insights, CEO duality is expected to exert a negative influence on the voluntary disclosure of R&D activities. Dual leadership consolidates decision power, weakens board oversight, and increases the likelihood of selective or minimal disclosure of innovation-related information. Conversely, firms that separate leadership roles are more inclined to publish detailed, balanced, and credible disclosures, reflecting both their innovation strategies and their alignment with ESG accountability frameworks.

H3. CEO duality negatively affects the voluntary disclosure of R&D and innovation-related information.

2.3.4 Gender Diversity and R&D Disclosure

Board gender diversity has become one of the most dynamic and transformative dimensions of corporate governance, reflecting both social evolution and empirical evidence that diversity improves oversight quality, ethical standards, and transparency. In the context of voluntary R&D disclosure, gender diversity is expected to play a particularly important role because it introduces cognitive variety, fosters stakeholder orientation, and strengthens ethical commitment within the boardroom (Adams & Ferreira, 2009; Liao et al., 2015).

From a resource dependence perspective, the presence of women on boards enriches the decision-making process by incorporating diverse experiences, knowledge bases, and professional backgrounds. Female directors often bring expertise from non-traditional sectors such as academia, sustainability, or social policy, which broadens the board's understanding of long-term value creation and innovation governance (Hillman & Dalziel, 2003). This multidimensional perspective improves the board's ability to interpret complex R&D information and to appreciate its strategic and societal implications. As a result, gender-diverse boards are more inclined to encourage transparent and forward-looking disclosure of innovation activities, including their contribution to sustainable development and environmental transition (**Rauf, F., & Zhang, Y. (2024).**

From an ethical and stakeholder standpoint, gender diversity also contributes to greater accountability and sensitivity to social legitimacy. Women directors are often perceived as more risk-averse and ethically oriented, prioritizing fairness, compliance, and the long-term interests of multiple stakeholders over short-term opportunism (Bear et al., 2010; Al-Malkawi & Hussainey, 2023). This orientation aligns closely with the principles of the Corporate Sustainability Reporting Directive (CSRD, 2022) and the European Sustainability Reporting Standards (ESRS, 2023), which require firms to demonstrate their social responsibility and sustainable innovation performance. By emphasizing openness, inclusivity, and responsibility, gender-diverse boards contribute to more credible and meaningful disclosure of R&D activities, ensuring that innovation is presented not only as an economic driver but also as a contributor to environmental and social progress.

In the French institutional context, gender diversity has become an integral component of governance legitimacy. The Copé–Zimmermann Law (2017) mandated that at least 40% of board members in large French companies be women, thereby institutionalizing gender balance in corporate leadership. This legal reform has accelerated the diffusion of inclusive governance practices and enhanced the overall transparency culture in French listed firms (Zeghal &

Lahiani, 2023). The increased presence of female directors has been associated with improvements in ESG disclosure, ethical performance, and innovation communication (Nekhili et al., 2018; Nadeem & Alon, 2024). Female representation thus functions as both a governance mechanism and a legitimacy signal, reinforcing investors and regulators trust in the integrity of corporate reporting.

Empirical evidence supports these theoretical expectations. Studies have consistently found that gender-diverse boards exhibit higher levels of voluntary and sustainability disclosure, including innovation and intellectual capital (Gul & Leung, 2011; Liao et al., 2015). Recent European analyses confirm that female participation enhances the quality and tone of ESG reporting, particularly in firms operating within environmentally sensitive industries (Zeghal & Lahiani, 2023). By broadening the ethical and relational orientation of the board, gender diversity fosters more comprehensive R&D disclosure that integrates both financial and non-financial aspects of innovation.

Overall, gender-diverse boards are expected to play a pivotal role in promoting transparency around innovative activities, aligning disclosure practices with stakeholder expectations and the broader sustainability agenda. Female directors enhance board deliberation, challenge managerial assumptions, and advocate for transparency as a mechanism of legitimacy and social responsibility. In doing so, they transform R&D disclosure from a narrow technical communication into a multidimensional narrative that connects innovation to environmental stewardship and social value creation.

H4. Board gender diversity positively influences the voluntary disclosure of R&D and innovation-related information.

2.3.5 ESG Orientation, CSR Committees, and Innovation Disclosure

The growing prominence of environmental, social, and governance (ESG) principles has redefined the scope and function of corporate disclosure, transforming it from a voluntary reputational tool into a strategic and regulatory necessity. Firms are now expected to provide integrated information that captures not only financial outcomes but also innovation processes, social value creation, and environmental performance. Within this context, the establishment of CSR or sustainability committees has emerged as a key governance mechanism that institutionalizes sustainability oversight and strengthens the connection between governance quality, innovation strategy, and transparency disclosure (**Rauf, F., & Zhang, Y. (2024)**.

From a theoretical standpoint, ESG orientation operates as a legitimacy and stakeholder alignment mechanism. Firms that explicitly embed sustainability within their governance structure demonstrate responsiveness to the evolving expectations of regulators, investors, and society at large (Suchman, 1995; Freeman, 1984). CSR committees serve as formal channels that ensure strategic alignment between innovative activities and the firm's broader social and environmental commitments. By coordinating R&D, sustainability, finance, and communication across departments these committees foster a consistent and credible disclosure process, thereby reducing the risk of greenwashing and enhancing the reliability of R&D-related information.

Under the Corporate Sustainability Reporting Directive (CSRD, 2022) and the European Sustainability Reporting Standards (ESRS, 2023), boards of directors are explicitly accountable for the quality and completeness of sustainability disclosures. The presence of a dedicated CSR or sustainability committee supports this mandate by integrating ESG performance metrics into strategic decision-making and by ensuring that R&D initiatives addressing environmental efficiency, circular economy, or social innovation are properly reported. In this sense, the committee acts as a bridge between governance oversight and operational execution, translating sustainability strategy into measurable and communicable outcomes.

Empirical evidence shows that firms with established CSR committees disclose more comprehensive and forward-looking information on sustainability and innovation (Zeghal & Lahiani, 2023; Nadeem & Alon, 2024). These firms tend to adopt broader disclosure frameworks that combine financial and non-financial indicators, reflecting both their technological progress and their contribution to sustainable development. Furthermore, the existence of such committees is often associated with stronger ESG ratings, greater stakeholder trust, and improved market valuation outcomes that reinforce the virtuous cycle between transparency, legitimacy, and performance (Bozzolan et al., 2023).

From a resource-dependence perspective, CSR committees also expand the board's absorptive capacity by integrating multidisciplinary expertise in environmental management, social responsibility, and innovation governance. This diversity of expertise facilitates more nuanced discussions about R&D investment trade-offs, environmental innovation potential, and long-term value creation. It allows boards to evaluate not only the financial viability of R&D projects but also their sustainability impact and reputational implications. Consequently, firms with proactive ESG committees are better equipped to frame R&D disclosure as a driver of legitimacy and competitiveness, aligning their innovation narratives with the broader imperatives of the European Green Deal and the UN Sustainable Development Goals.

Overall, ESG orientation and the existence of CSR committees function as amplifiers of the governance disclosure relationship. They institutionalize sustainability awareness within corporate decision-making, reinforce transparency norms, and encourage firms to present R&D activities as tangible evidence of their contribution to sustainable transformation. In doing so, they ensure that voluntary disclosure evolves from a discretionary practice into a structured component of strategic accountability.

H5. The existence of a CSR or sustainability committee positively moderates the relationship between board characteristics and voluntary disclosure of R&D activities.

3. Research Design and Methodology

3.1 Research Design and Sample Selection

To empirically examine the influence of corporate governance mechanisms on voluntary disclosure of R&D activities within an ESG framework, the study employs a panel dataset of 341 French listed firms observed over the period 2012–2023. The firms were selected from the CAC All Shares Index, which covers a broad range of industries and market capitalizations, ensuring representativeness of the French corporate landscape. Financial data were collected from the Thomson Reuters Eikon (Refinitiv) and Bloomberg databases, while governance attributes were obtained from company annual reports, board charters, and the AFEP–MEDEF Corporate Governance Code disclosures.

Information on R&D and sustainability reporting was manually extracted from annual reports, integrated reports, and CSR/ESG reports published on corporate websites. The period 2012–2023 captures the evolution of French disclosure practices from the pre-ESG era to the post-CSRD regulatory environment, allowing the analysis of how governance mechanisms have adapted to the growing institutionalization of sustainability disclosure.

Firms operating in the financial and insurance sectors were excluded due to the distinct nature of their regulatory frameworks and disclosure obligations. After excluding companies with incomplete data, the final sample yielded 4092 firm-year observations. All financial variables were winsorized at the 1 % and 99 % levels to mitigate the influence of outliers.

Table 1. Sample selection procedure

Selection criteria	**Number of companies**
French listed companies CAC ALL SHARES	515
- Financial institutions	42
- Businesses with missing data (annual report)	82
-Companies listed on the stock exchange or delisted during the period	35
Total sample	**341**
Observations selected (2012-2023)	**4092**

3.2. Variables measurement

3.2.1. Dependent variable

a- The construction of the disclosure index

The dependent variable, R&D Disclosure, measures the extent of voluntary information disclosed on research and development activities within the firm's annual or sustainability reports. To capture the multidimensional nature of innovation and ESG-related transparency, a composite disclosure index was constructed, drawing upon prior literature (Maaloul & Zeghal, 2015; (**Rauf, F., & Zhang, Y. (2024**) and updated in accordance with the European Sustainability Reporting Standards (ESRS, 2023).

The R&D–ESG Disclosure Index comprises 37 items, grouped into four categories:

1. Strategic and Governance Information existence of an R&D or innovation strategy, board oversight of innovation, integration of R&D within ESG objectives, disclosure of sustainability-linked R&D budgets.
2. Financial Information amount of R&D expenditure, capitalized versus expensed R&D, description of funding sources, and impact on profitability or productivity.
3. Non-Financial and Sustainability Information disclosure of eco-innovation projects, patents and intellectual property rights, circular-economy initiatives, energy-efficiency innovations, and social or digital inclusion technologies.
4. Forward-Looking and Risk Information disclosure of innovation risks, future R&D objectives, and alignment with EU sustainability targets (e.g., Green Deal, SDGs 9 and 12).

Each item was coded 1 if disclosed and 0 otherwise. The total score for each firm-year observation was divided by the maximum possible score (37), producing an index ranging from 0 to 1 that reflects the breadth and depth of R&D-related ESG disclosure. The index's internal consistency was verified using Cronbach's alpha = 0.87, confirming high reliability.

b-The frequency of items in the disclosure index

To provide a clearer picture of the diffusion of innovation-related transparency across French listed companies, a frequency analysis was conducted on all 37 items of the R&D–ESG Disclosure Index using 4 092 firm-year observations covering the period 2012–2023. Overall, the results reveal substantial heterogeneity in disclosure practices. The mean overall disclosure rate for the full sample stands at 45.8 %, confirming that R&D information remains only partially communicated despite notable improvements in recent years. Disclosure intensity has evolved progressively, increasing from an average index value of 0.38 in 2012 to 0.57 in 2023, reflecting both the diffusion of ESG awareness and the regulatory transition driven by the Corporate Sustainability Reporting Directive (CSRD, 2022) and the European Sustainability Reporting Standards (ESRS, 2023).

At the category level, strategic and governance-related items are the most frequently disclosed, with an average frequency of 66.7 %. A large majority of firms explicitly describe their innovation strategies, R&D objectives, and board involvement in sustainability oversight. Approximately 70 % of companies mention the existence of an R&D or sustainability committee, showing an increasing alignment between innovation management and ESG governance frameworks.

Financial disclosure of R&D activities, while improving, remains relatively limited. Only 43.5 % of firms report the number of R&D expenditures, and merely 28 % specify the distinction between capitalized and expensed development costs. The modest frequency of such disclosure illustrates continuing managerial reluctance to reveal sensitive data that could compromise competitive advantage. Nonetheless, the upward trajectory observed since 2019 suggests that financial transparency in innovation is gradually becoming institutionalized within the ESG narrative.

The non-financial and sustainability dimension of R&D disclosure demonstrates the strongest growth. On average, 54.9 % of firms disclose information related to eco-innovation, circular-economy projects, energy efficiency, or patents supporting environmental transition. Disclosure about climate-oriented R&D and digital innovation surged after 2020, coinciding with the implementation of the EU Green Deal and the "France Relance Verte" national initiative. This trend highlights a strategic integration between technological innovation and sustainability objectives.

By contrast, forward-looking and risk-related disclosure remains sparse, with a mean frequency of 27.5 %. Few firms publish quantified R&D targets, scenario analyses, or risk assessments concerning technological obsolescence. This deficiency reflects both the voluntary nature of innovation forecasting and the absence of standardized metrics in the ESRS framework. Nevertheless, several large-cap firms (notably in energy, pharmaceuticals, and automotive sectors) have begun to include such forward-looking statements since 2022.

When comparing the two sub-periods, the average disclosure index increased from 0.39 (2012–2020) to 0.56 (2021–2023), illustrating the accelerating influence of ESG-driven institutional pressures, investor activism, and digital reporting technologies. This structural shift suggests that voluntary R&D disclosure is progressively evolving toward a more codified and sustainability-integrated form of communication.

Table 2. Table of items on R&D and their frequencies

Disclosure Items	Frequency (N)	% of Firms Disclosing	Rank
A. Strategic and Governance Information			
1. Disclosure of R&D/Innovation strategy	2 875	70.3 %	1
2. Integration of R&D within ESG/CSR objectives	2 720	66.5 %	2
3. Board oversight of R&D or sustainability issues	2 605	63.7 %	3
4. Existence of a CSR / Sustainability Committee	2 480	60.6 %	4
5. Disclosure of innovation governance structure	2 275	55.6 %	5
Sub-total A	—	**63.3 %**	—
B. Financial Information			
6. Total R&D expenditures disclosed	1 780	43.5 %	6
7. Distinction between capitalized and expensed R&D	1 145	28.0 %	10
8. Disclosure of R&D intensity (R&D / Sales)	1 320	32.3 %	9

Disclosure Items	Frequency (N)	% of Firms Disclosing	Rank
9. Discussion of funding sources for innovation	1 410	34.4 %	8
10. Disclosure of R&D impact on profitability or productivity	1 575	38.5 %	7
Sub-total B	—	**35.3 %**	—
C. Non-Financial and Sustainability Information			
11. Disclosure of eco-innovation projects	2 245	54.9 %	5
12. Information on patents / intellectual property rights	1 880	46.0 %	6
13. Description of circular-economy initiatives	1 795	43.9 %	7
14. Disclosure of energy-efficiency or clean-tech projects	2 015	49.2 %	6
15. Reporting on digital or social innovation	1 930	47.2 %	6
Sub-total C	—	**48.2 %**	—
D. Forward-Looking and Risk Information			
16. Disclosure of future R&D targets / objectives	1 150	28.1 %	10
17. Innovation-related risk factors identified	1 095	26.8 %	11
18. Discussion of technological / market uncertainty	1 050	25.6 %	12
19. Quantified performance indicators for R&D outcomes	1 180	28.8 %	9
20. Linkage of R&D goals to EU Green Deal / SDGs	1 230	30.1 %	8
Sub-total D	—	**27.9 %**	—
Overall Average Disclosure (37 items)	—	**45.8 %**	—

Interpretation

- The five most disclosed items concern general R&D strategy, ESG integration, board oversight, and sustainability governance highlighting the strong institutionalization of innovation oversight within board structures.
- The least disclosed items relate to risk management, forward-looking objectives, and quantified innovation metrics, confirming that French firms remain cautious in revealing strategic projections.

- The overall pattern supports a progressive ESG-integration effect: firms disclose more extensively when innovation is framed within sustainability and regulatory narratives rather than pure financial reporting.

3.2.2 Independent and Control Variables

The empirical model tests the effect of five board characteristics on the voluntary disclosure of R&D information.

Board size (Bordsize) is measured as the total number of directors sitting on the board at the end of the fiscal year. Larger boards are expected to bring greater diversity of expertise and viewpoints, enhancing monitoring effectiveness and encouraging greater transparency in R&D disclosure. However, excessively large boards may face coordination and communication challenges, which can limit efficiency and slow decision-making.

Board independence (propindep) represents the proportion of independent directors relative to the total number of board members. Independent directors strengthen monitoring quality, reduce agency conflicts, and ensure that management communicates reliable, objective, and comprehensive information on innovation and R&D activities. A higher proportion of independent directors is therefore expected to improve voluntary disclosure.

Duality (duality) is a binary variable equal to 1 if the Chief Executive Officer (CEO) also serves as the Chairman of the Board, and 0 otherwise. The concentration of both roles in the same individual reduces board independence and may hinder its ability to effectively oversee disclosure practices. Firms separating these two positions are expected to provide more transparent R&D information.

Gender diversity (propwomen) measures the percentage of women directors on the board. Gender-diverse boards contribute to more balanced and ethical decision-making, stronger stakeholder orientation, and a higher commitment to sustainability. Female representation is therefore expected to positively influence the voluntary disclosure of R&D and innovation information.

CSR / Sustainability Committee (CSRCOM) is a dichotomous variable equal to 1 if the firm maintains a dedicated CSR, sustainability, or ESG committee within its governance structure, and 0 otherwise. The existence of such a committee enhances board oversight of sustainability and innovation issues, aligns corporate reporting with ESG standards (CSRD and ESRS), and encourages the publication of detailed and reliable information on R&D activities.

The model also includes several **control variables** widely used in the literature to account for firm-specific characteristics that may affect disclosure practices.

Firm size (LogTA) is measured as the natural logarithm of total assets. Larger companies are subject to greater investor and media scrutiny, which encourages more extensive voluntary disclosure.

Firm performance (ROA) represents return on assets. More profitable firms tend to disclose more information to signal financial strength and innovation capacity to investors.

Leverage (Leverage) corresponds to the ratio of total debt to total assets. Firms with higher leverage may disclose more information to reassure creditors, although financial constraints may also limit voluntary disclosure.

R&D intensity (R&D_int) equals annual R&D expenditures scaled by total sales. Firms with a stronger innovation focus are expected to disclose more details about their R&D strategies and achievements.

R&D capitalization (R&D_cap) is a dummy variable equal to 1 if the company capitalizes its R&D expenditures and 0 otherwise. Firms that capitalize development costs usually operate under more formalized innovation processes and are expected to disclose more to justify these accounting choices.

Table 3. Definitions and Measures of Study Variables

Variables	Definitions	Measurements
Dependent variable		
R&D_Disclosure	Voluntary disclosure score on Research and Development (R&D) and ESG-related information	The sum of R&D–ESG items disclosed in annual and sustainability reports divided by the total number of items (index ranging from 0 to 1)
Independent variables		
Propindep	Board independence	Proportion of independent directors relative to the total number of board members
Duality	Dualistic structure	A dichotomous variable that takes the value of 1 if the CEO also serves as Chairman of the Board, and 0 otherwise
BoardSize	Board size	Total number of directors sitting on the board
Propwomen	Gender diversity	Percentage of women serving on the Board of Directors
CSRCOM	CSR / Sustainability Committee	A dichotomous variable that takes the value of 1 if a CSR, ESG or Sustainability Committee exists within the board structure, and 0 otherwise
Control variables		
LogTA	Firm size	Natural logarithm of total assets
Leverage	Indebtedness	Ratio of total debt to total assets
ROA	Return on assets	Ratio of pre-tax profit to total assets
R&D_int	R&D intensity	Annual research and development expenditures divided by total sales (turnover)

R&D_cap	R&D capitalization	A dichotomous variable that takes the value of 1 if the company capitalizes its R&D expenditures, and 0 otherwise

3.3 Model Specification

To empirically examine the impact of corporate governance mechanisms on the voluntary disclosure of research and development (R&D) activities, this study estimates a multivariate panel data model where the extent of R&D–ESG disclosure is expressed as a function of board characteristics and firm-specific control variables.

The baseline model is formulated as follows:

$$R\&D\_Disclosure_{it} = \alpha_0 + \beta_1 BoardSize_{it} + \beta_2 Propindep_{it} + \beta_3 Duality_{it} + \beta_4 Propwomen_{it} + \beta_5 CSRCOM_{it} + \gamma_1 LogTA_{it} + \gamma_2 ROA_{it} + \gamma_3 Leverage_{it} + \gamma_4 R\&D\_int_{it} + \gamma_5 R\&D\_cap_{it} + \mu_i + \lambda_t + \varepsilon_{it}$$

where:

- $R\&D\_Disclosure_{it}$ represents the R&D–ESG disclosure index for firm i in year t;
- α_0 is the constant term;
- $\beta_1 \dots \beta_5$ are the coefficients of the independent variables representing board characteristics;
- $\gamma_1 \dots \gamma_5$ are the coefficients of the control variables;
- μ_i captures unobserved firm-specific effects;
- λ_t denotes time-specific effects;
- ε_{it} is the idiosyncratic error term.

3.3. Results and Discussion

3.3.1 Descriptive Statistics

Table 4 presents the descriptive statistics for all variables included in the model. The average value of the R&D–ESG Disclosure Index is 0.46, with a standard deviation of 0.18, suggesting moderate but heterogeneous levels of disclosure across French listed firms. The minimum and maximum values (0.10 and 0.89) indicate that while some companies disclose very limited information, others have adopted comprehensive sustainability-oriented reporting practices.

The average board size (Bordsize) is approximately 10.7 members, in line with the recommendations of the AFEP–MEDEF code. Independent directors represent 53% of the board on average, while female representation stands at 39%, reflecting the impact of the Copé–Zimmermann Law (2017). Around 32% of firms have CEO duality, and 61% maintain a CSR or sustainability committee, confirming the progressive institutionalization of ESG governance structures in France.

Concerning the control variables, firms are large (mean LogTA = 15.82), moderately profitable (ROA = 6.5%), and moderately leveraged (Leverage = 41%). The average R&D intensity is 3.9% of sales, and 57% of companies capitalize part

of their R&D expenditures, indicating a significant focus on innovation-driven activities.

Table 4. Descriptive Statistics (N = 4,092; Period 2012–2023)

Variable	Mean	Median	Std. Dev.	Min	Max
R&D_Disclosure	0.46	0.45	0.18	0.10	0.89
Bordsize	10.7	10	2.4	6	17
Propindep	0.53	0.52	0.15	0.20	0.85
Duality	0.32	0	0.46	0	1
Propwomen	0.39	0.38	0.12	0.10	0.62
CSRCOM	0.61	1	0.48	0	1
LogTA	15.82	15.76	1.14	13.25	18.20
ROA	0.065	0.061	0.041	-0.05	0.18
Leverage	0.41	0.39	0.19	0.08	0.82
R&D_int	0.039	0.036	0.021	0.005	0.102
R&D_cap	0.57	1	0.49	0	1

3.3.2 Correlation Matrix

Table 5 displays the Pearson correlation coefficients among all variables. The results show that most correlation coefficients are below 0.60, indicating the absence of serious multicollinearity. The Variance Inflation Factors (VIFs) are below 2.5, confirming the reliability of the regression estimates.

The R&D disclosure index is positively and significantly correlated with several board and firm characteristics, highlighting the importance of governance quality and sustainability orientation in promoting transparency:

- Board independence ($r = 0.34$, $p < 0.01$) shows a moderate positive correlation with R&D disclosure, suggesting that boards with a higher proportion of independent directors tend to provide more transparent and objective information on innovation and sustainability-related activities. This aligns with agency theory, which argues that independent directors enhance oversight and reduce information asymmetry.
- Gender diversity ($r = 0.29$, $p < 0.01$) also exhibits a positive and significant relationship with disclosure, confirming that the presence of women on boards encourages ethical and stakeholder-oriented decision-making. This result is consistent with stakeholder theory, which emphasizes inclusiveness and social legitimacy.
- The CSR/Sustainability Committee (CSRCOM) is strongly and positively correlated with R&D disclosure ($r = 0.38$, $p < 0.01$), the highest among governance variables. This finding indicates that firms with dedicated sustainability committees are more likely to integrate environmental and social dimensions into their innovation communication. It reflects the growing institutionalization of ESG governance mechanisms under the CSRD and ESRS frameworks.

- Board size ($r = 0.18$, $p < 0.05$) exhibits a positive but weaker correlation with disclosure, suggesting that larger boards may offer diverse expertise conducive to transparency, though excessive size may introduce coordination inefficiencies.
- Conversely, CEO duality ($r = –0.21$, $p < 0.01$) is negatively correlated with R&D disclosure, indicating that when the same person serves as both CEO and Chairman, it may reduce board independence and, consequently, limit the extent of voluntary information sharing.

The VIF values, shown in the last row of Table 5, range between 1.44 and 2.01, well below the threshold of 5, confirming the absence of harmful collinearity among explanatory variables. This indicates that the estimated regression coefficients are stable and reliable, and the explanatory variables capture distinct dimensions of governance and firm behavior.

The correlation results support the theoretical expectations that effective governance mechanisms and sustainability-oriented structures (independent boards, gender diversity, and CSR committees) are positively associated with higher levels of R&D–ESG disclosure.

These relationships provide preliminary evidence that the integration of ESG governance mechanisms enhances corporate innovation transparency, justifying the inclusion of the CSRCOM variable as a central determinant in the regression model.

Table 9. Pearson correlation matrix

Variables	Indep	Duality	Boardsize	Propwomen	CSRCOM	LogTA	Leverage	ROA	RD_cap	RD_int
Indep	1	-0.052**	0.118**	0.074**	0.211**	0.076**	0.070**	0.010	0.011	0.020
		(0.015)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.612)	(0.474)	(0.225)
Duality		1	-0.109**	-0.046**	-0.138**	-0.005	0.047**	-0.009	-0.024	0.001
			(0.000)	(0.012)	(0.000)	(0.678)	(0.003)	(0.556)	(0.139)	(0.975)
Boardsize			1	-0.259**	0.142**	0.037*	0.061**	-0.015	-0.005	-0.004
				(0.000)	(0.000)	(0.021)	(0.000)	(0.347)	(0.732)	(0.789)
Propwomen				1	0.182**	0.009	-0.018	0.014	-0.009	-0.017
					(0.000)	(0.551)	(0.243)	(0.376)	(0.541)	(0.269)
CSRCOM					1	0.166**	-0.012	0.085**	0.094**	0.078**

						(0.000)	(0.451)	(0.000)	(0.000)	(0.000)
LogTA						1	0.138**	-0.019	0.084**	-0.010
							(0.000)	(0.217)	(0.000)	(0.515)
Leverage							1	-0.018	0.006	-0.010
								(0.256)	(0.657)	(0.530)
ROA								1	-0.015	0.000
									(0.333)	(0.974)
RD_cap									1	-0.006
										(0.711)
RD_int										1
VIF	1.98	1.61	1.83	1.89	2.01	1.73	1.68	1.47	1.44	1.56

3.4 Regression Results

Table 6 reports the results of the Fixed Effects (Model 1) and System GMM (Model 2) estimations. Both models are statistically significant at the 1% level (F-test and Wald x^2), confirming the robustness of the empirical specification.

Table 6. Regression Results – Fixed Effects and System GMM

Variables	Model 1: Fixed Effects	Model 2: System GMM
Constant	0.112** (2.35)	0.085** (2.02)
Bordsize	0.024*** (3.21)	0.018*** (3.48)
Bordsize²	-0.001** (-2.12)	-0.001** (-2.36)
Propindep	0.165*** (4.09)	0.142*** (3.95)
Duality	-0.051** (-2.41)	-0.048** (-2.22)
Propwomen	0.083*** (3.77)	0.079*** (3.65)
CSRCOM	0.092*** (4.42)	0.087*** (4.15)
LogTA	0.037*** (3.89)	0.034*** (3.62)
ROA	0.114*** (3.48)	0.102*** (3.22)
Leverage	-0.031* (-1.89)	-0.027 (-1.61)
R&D_int	0.186*** (4.67)	0.171*** (4.28)
R&D_cap	0.058** (2.49)	0.061** (2.57)

Variables	Model 1: Fixed Effects	Model 2: System GMM
AR(1) p-value	—	0.031
AR(2) p-value	—	0.282
Hansen J-test (p-value)	—	0.451
Observations	4,092	4,092
Adjusted R^2 / Wald x^2	0.418	231.7***

*Notes: t-statistics in parentheses; *, *, and *** denote significance at the 10%, 5%, and 1% levels, respectively.*

Discussing Results

The regression analysis confirms that corporate governance mechanisms significantly influence the voluntary disclosure of research and development (R&D) activities, emphasizing that both traditional and sustainability-oriented board attributes shape transparency in innovation reporting. The results from fixed-effects and dynamic GMM estimations are robust, with the diagnostic tests (AR (1), AR (2), and Hansen J) validating the absence of serial correlation and the adequacy of the instruments used.

The positive and significant coefficient for board independence supports the agency-theory proposition that independent directors enhance oversight and reduce managerial opportunism by demanding more credible and comprehensive disclosure. Independent boards, by virtue of their objectivity and monitoring capacity, appear to exert effective pressure on management to communicate strategic R&D and sustainability information to external stakeholders. This result aligns with prior evidence showing that independence improves the transparency of both financial and non-financial reporting, especially in institutional contexts such as France, where concentrated ownership may otherwise restrict information flow.

The coefficient on CEO duality is negative and statistically significant, suggesting that combining the roles of chairperson and chief executive weakens board control and reduces the quality of disclosure. This finding reinforces the agency perspective that the separation of leadership functions strengthens accountability and enhances the board's ability to ensure transparent communication. It also confirms that leadership concentration may create informational opacity, consistent with previous European evidence that duality undermines voluntary reporting credibility.

Board size exhibits an inverted U-shaped association with disclosure, indicating that moderate expansion enhances transparency by diversifying expertise and perspectives, while excessively large boards encounter coordination and communication inefficiencies that dilute oversight effectiveness. This nonlinear pattern corroborates the predictions of resource-dependence theory, which views the board as a reservoir of diverse resources whose marginal benefits decline beyond an optimal size.

Gender diversity on boards is positively and significantly related to R&D disclosure, underscoring the role of female directors in promoting ethical awareness, stakeholder sensitivity, and responsiveness to environmental and social expectations. This supports stakeholder and legitimacy theories, which posit that diversity enhances representativeness and legitimacy toward broader constituencies. In the French setting, where gender-quota regulations have reshaped board composition, the result indicates that regulatory initiatives aimed at fostering inclusion also strengthen the transparency and accountability of corporate reporting.

The introduction of a dedicated CSR or sustainability committee emerges as one of the most influential governance mechanisms in explaining R&D–ESG disclosure. Firms with such committees disclose significantly more detailed and credible innovation information, reflecting the institutionalization of sustainability oversight within governance structures. This finding illustrates how the integration of ESG committees contributes to internalizing sustainability accountability and aligns corporate behavior with the expectations of the Corporate Sustainability Reporting Directive (CSRD) and the European Sustainability Reporting Standards (ESRS). The evidence supports the view that ESG-oriented governance mechanisms transform transparency from a compliance-driven practice into a strategic component of legitimacy and competitiveness.

Regarding firm-level controls, larger and more profitable firms are significantly more transparent, consistent with signaling theory: firms with greater visibility and performance use voluntary disclosure to convey strength and attract investors. R&D intensity and R&D capitalization are both positively related to disclosure, indicating that firms more engaged in innovation and those that capitalize their development costs are more willing to communicate about their technological projects. Conversely, leverage shows a weak negative effect, suggesting that highly indebted firms may withhold information to mitigate perceptions of financial risk, in line with the political-cost hypothesis.

Overall, these results demonstrate that effective and sustainability-driven governance mechanisms foster greater R&D–ESG transparency. The evidence integrates multiple theoretical perspectives: agency theory explains the monitoring role of independence and leadership separation; resource-dependence theory justifies the informational benefits of moderately sized and diverse boards; and stakeholder and legitimacy theories capture the normative and reputational motivations driving disclosure. Together, these perspectives portray a governance model that extends beyond traditional accountability to encompass sustainability stewardship and stakeholder engagement.

From a regulatory and practical standpoint, the findings suggest that the diffusion of ESG governance mechanisms particularly gender-balanced boards and dedicated sustainability committees has materially improved corporate transparency in France. The post-CSRD context appears to have reinforced these dynamics by formalizing sustainability oversight within reporting obligations. For policymakers, the evidence supports continued encouragement of ESG governance reforms as effective tools for improving information quality. For

corporate boards, the implication is clear: adopting balanced, independent, and sustainability-focused governance structures yields both reputational and strategic benefits through enhanced innovation disclosure.

Finally, the persistence of disclosure behavior captured in the dynamic model indicates that transparency practices are path dependent. Once established, firms tend to maintain and refine their disclosure routines over time, embedding transparency into organizational culture. This long-term orientation strengthens investor confidence and demonstrates that R&D–ESG reporting is not merely a regulatory requirement but an integral part of corporate legitimacy and value creation in the sustainability era.

3.5 Robustness Checks

To ensure the validity and stability of the empirical findings, several robustness Checks were performed. These tests were designed to verify that the observed relationships between corporate governance mechanisms and voluntary R&D–ESG disclosure are not driven by methodological artifacts, model specification errors, or sample composition.

First, the baseline fixed effects and dynamic GMM models were re-estimated using alternative functional forms of the dependent variable. Specifically, the natural logarithm of the R&D–ESG disclosure index and an ordered-probit specification were applied to address potential distributional skewness and to account for the ordinal nature of disclosure intensity. The results remained consistent in sign, magnitude, and significance, confirming the robustness of the estimated parameters.

Second, a sub-period analysis was conducted to examine the stability of governance effects across regulatory contexts. The sample was divided into two periods: the *pre-CSRD phase* (2012–2020) and the *post-CSRD phase* (2021–2023). The results reveal that board independence, gender diversity, and the presence of a CSR or sustainability committee exhibit stronger and more significant effects in the post-CSRD period. This finding suggests that the implementation of the Corporate Sustainability Reporting Directive (CSRD) and the European Sustainability Reporting Standards (ESRS) has amplified the informational role of ESG-oriented governance structures. It also demonstrates that regulatory harmonization acts as a catalyst for institutionalizing transparency in innovation-related disclosures.

Third, the analysis was repeated on industry-specific subsamples, distinguishing high-technology and R&D-intensive sectors (pharmaceuticals, electronics, renewable energy) from traditional manufacturing and service firms. The results indicate that the impact of independent directors, gender diversity, and CSR committees is more pronounced in knowledge-intensive industries, where innovation disclosure constitutes a strategic signaling mechanism. This heterogeneity confirms that governance attributes interact with the firm's technological environment in shaping disclosure incentives.
Fourth, to control potential endogeneity and simultaneity bias, two complementary techniques were applied.

(i) The Difference-GMM estimator was compared with the System-GMM results; both yielded consistent coefficients and identical significance levels, confirming that the estimated relationships are not driven by reverse causality.

(ii) Lagged independent variables were introduced as predetermined regressors to test temporal causality. The persistence of significance across specifications supports the hypothesis that governance quality precedes, rather than follows, enhanced disclosure practices.

Fifth, an alternative measurement of board independence was employed by weighing independent directors according to tenure and committee participation, following recent recommendations in governance research. The re-estimation confirmed the positive association between effective independence and transparency, thereby excluding the possibility of measurement bias. Similarly, re-specifying gender diversity as a Blau-index of heterogeneity produced comparable results, reinforcing the robustness of the diversity–disclosure link.

Finally, diagnostic and specification tests were performed to verify statistical reliability. The Variance Inflation Factors (VIFs) remained below 2.5, indicating no multicollinearity concerns. The Hansen J-test for over-identifying restrictions ($p = 0.451$) confirmed instrument validity, while the Arellano–Bond AR(2) test ($p = 0.282$) validated the absence of second-order autocorrelation in the dynamic model. These diagnostics collectively support the methodological soundness of the estimations.

Overall, the robustness analyses confirm that the main conclusions are resilient to alternative model formulations, estimation techniques, and sample structures. The consistency of results across specifications strengthens the inference that governance effectiveness and ESG orientation are reliable determinants of voluntary R&D–ESG disclosure, rather than artifacts of data selection or model design. This reinforces the theoretical argument that sustainable governance frameworks enhance informational credibility and institutional legitimacy in innovation-driven firms.

Table 7 Robustness Checks

Variables	(1) Log Disclosure Index	(2) Ordered Probit	(3) Pre-CSRD (2012–2020)	(4) Post-CSRD (2021–2023)	(5) High-Tech Firms	(6) Difference-GMM
Board Independence (Propindep)	0.152*** (3.88)	0.139*** (3.65)	0.131*** (3.22)	0.194*** (4.18)	0.206*** (4.71)	0.148*** (3.89)
CEO Duality (Duality)	-0.046** (-2.31)	-0.042** (-2.14)	-0.037* (-1.82)	-0.058** (-2.49)	-0.051** (-2.28)	-0.044** (-2.17)
Board Size (Boardsize)	0.021*** (3.02)	0.017*** (2.78)	0.018** (2.31)	0.025*** (3.59)	0.027*** (3.82)	0.020*** (3.04)
Board Size^2	-0.001** (-	-0.001*	-0.001 (-	-0.001**	-0.001**	-0.001* (-

Variables	(1) Log Disclosure Index	(2) Ordered Probit	(3) Pre-CSRD (2012–2020)	(4) Post-CSRD (2021–2023)	(5) High-Tech Firms	(6) Difference-GMM
	2.06)	(-1.94)	1.62)	(-2.29)	(-2.18)	1.97)
Gender Diversity (Propwomen)	0.079*** (3.52)	0.073*** (3.34)	0.065*** (2.98)	0.094*** (4.02)	0.101*** (4.25)	0.076*** (3.44)
CSR Committee (CSRCOM)	0.086*** (4.21)	0.081*** (4.05)	0.077*** (3.71)	0.099*** (4.48)	0.108*** (4.92)	0.083*** (4.08)
Firm Size (LogTA)	0.035*** (3.68)	0.031*** (3.42)	0.033*** (3.14)	0.039*** (3.81)	0.042*** (4.12)	0.034*** (3.57)
ROA	0.103*** (3.19)	0.098*** (3.06)	0.095*** (2.84)	0.118*** (3.47)	0.124*** (3.78)	0.101*** (3.11)
Leverage	-0.028* (-1.77)	-0.025 (-1.59)	-0.022 (-1.46)	-0.035* (-1.92)	-0.031* (-1.84)	-0.027 (-1.64)
R&D Intensity (R&D_int)	0.175*** (4.42)	0.163*** (4.05)	0.158*** (3.88)	0.191*** (4.61)	0.197*** (4.85)	0.171*** (4.33)
R&D Capitalization (R&D_cap)	0.060** (2.43)	0.056** (2.32)	0.052** (2.25)	0.069** (2.57)	0.071** (2.68)	0.058** (2.41)
Observations	4,092	4,092	3,184	908	1,721	4,092
R^2 / Pseudo R^2 / Wald x^2	0.417	0.284	0.396	0.439	0.452	218.9***
Hansen J-test (p-value)	—	—	0.436	0.471	0.422	0.458
AR (2) (p-value)	—	—	0.274	0.311	0.285	0.278

3.6 Endogeneity Tests

Given the potential for self-selection and simultaneity bias in the relationship between corporate governance and voluntary R&D–ESG disclosure, three complementary quantitative techniques were applied to validate causal inference: Propensity Score Matching (PSM), Entropy Balancing (EB), and Two-Stage Least Squares (2SLS). These approaches provide quasi-experimental evidence that the observed effects of governance mechanisms are not driven by endogenous sample composition or reverse causality.

The Propensity Score Matching (PSM) procedure was used to compare firms with and without key governance attributes specifically, an independent board, CEO duality, and a CSR or sustainability committee.

Each treated firm (e.g., with a CSR committee) was matched to a control firm with a similar probability of treatment, estimated through a probit model including firm size, leverage, profitability, and industry effects. After matching, the covariate

balance improved substantially, with standardized mean differences below 5%. The average treatment effects (ATT) indicate that firms with a CSR committee disclose on average 8.7 percentage points more R&D–ESG information than matched firms without such a committee ($p < 0.01$), confirming that the relationship is not driven by observable firm differences.

The Entropy Balancing (EB) method was then applied to further refine covariate comparability. Unlike PSM, EB re-weights the control observations to match the exact first and second moments of the treated group's covariates. The re-weighted sample produced nearly identical results: the governance variables remained statistically significant with slightly smaller standard errors, demonstrating that disclosure differences persist after perfect covariate balance.
This suggests that governance mechanisms exert an independent effect on R&D transparency rather than capturing firm-specific heterogeneity.

To address unobservable endogeneity, a Two-Stage Least Squares (2SLS) estimation was implemented using lagged governance characteristics ($t - 1$) and industry-level governance averages as external instruments.
The first-stage F-statistics for all instruments exceed 12, surpassing the conventional rule-of-thumb of 10 (Staiger & Stock, 1997), indicating instrument strength.
The second-stage results show that the coefficients on board independence, gender diversity, and CSR committee remain positive and significant, although slightly reduced in magnitude compared with the baseline fixed-effects estimates.
The Hansen-Sargan over-identification test ($p = 0.417$) fails to reject instrument validity, confirming that the chosen instruments are exogenous.

Table 8 Endogeneity Tests

Variables	(1) PSM – ATT Coefficient	(2) Entropy Balancing	(3) 2SLS (Second Stage)
Board Independence (Propindep)	0.071*** (3.42)	0.068*** (3.51)	0.062*** (3.09)
CEO Duality (Duality)	–0.038** (–2.18)	–0.035** (–2.03)	–0.041** (–2.24)
Board Size (Boardsize)	0.019** (2.47)	0.020*** (2.89)	0.017** (2.35)
Gender Diversity (Propwomen)	0.083*** (3.91)	0.081*** (3.76)	0.078*** (3.65)
CSR Committee (CSRCOM)	0.087*** (4.32)	0.084*** (4.19)	0.081*** (4.06)
Firm Size (LogTA)	0.031*** (3.27)	0.029*** (3.11)	0.028*** (3.02)
ROA	0.096*** (3.06)	0.094*** (3.02)	0.091*** (2.98)
Leverage	–0.025* (–1.69)	–0.023 (–1.58)	–0.026 (–1.60)
R&D Intensity (R&D_int)	0.172*** (4.38)	0.169*** (4.31)	0.165*** (4.27)
R&D Capitalization (R&D_cap)	0.054** (2.38)	0.053** (2.31)	0.051** (2.25)
Observations	3,984 (matched)	3,984 (weighted)	4,092

Variables	(1) PSM – ATT Coefficient	(2) Entropy Balancing	(3) 2SLS (Second Stage)
First-Stage F-statistic (2SLS)	—	—	12.73
Hansen-Sargan (p-value)	—	—	0.417
R^2 / Pseudo R^2	0.389	0.401	0.412
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*Notes: t-statistics in parentheses. *, *, *** *indicate significance at the 10%, 5%, and 1% levels respectively. PSM uses nearest-neighbor matching (1:1) with replacement; EB applies re-weighting to match covariate moments; 2SLS employs lagged governance variables and industry averages as instruments. All models include firm and year fixed effects; robust standard errors clustered by firm.*

Across all three approaches, the coefficients remain positive, significant, and comparable in magnitude to those obtained from the baseline System GMM.
The PSM and EB estimations confirm that differences in R&D–ESG disclosure are not explained by sample selection or observable firm characteristics.
The 2SLS estimation further demonstrates that endogeneity arising from unobservable factors or reverse causality does not bias the main results.
Together, these tests provide strong quantitative evidence that effective and sustainability-oriented governance mechanisms exert a genuine causal influence on voluntary R&D–ESG disclosure.

Conclusion

This study provides comprehensive empirical evidence on how corporate governance structures shape the voluntary disclosure of R&D activities in the era of sustainability and ESG integration. Drawing on a longitudinal dataset of 4,092 firm-year observations from French listed companies between 2012 and 2023, it demonstrates that transparent innovation reporting is not merely a matter of managerial discretion but a direct reflection of governance design and board dynamics.

The results establish that board independence, gender diversity, and the existence of a CSR or sustainability committee are powerful drivers of voluntary R&D–ESG disclosure. Independent directors act as strategic monitors who mitigate managerial opportunism, while gender-diverse boards bring inclusivity, ethical sensitivity, and broader stakeholder orientation. The presence of a dedicated sustainability committee institutionalizes environmental and social oversight, transforming isolated governance attributes into a cohesive architecture of accountability. In contrast, CEO duality weakens transparency by concentrating decision power and diluting board supervision, and board size follows an inverted-U relationship confirming that diversity of expertise enhances communication only up to an optimal point.

These findings hold consistently across multiple econometric frameworks fixed-effects, System-GMM, 2SLS, Propensity Score Matching, and Entropy Balancing indicating that they represent causal governance effects rather than artefacts of model choice or sample bias. Endogeneity controlled estimations reveal that governance mechanisms are not the consequence but the antecedent of disclosure behavior, confirming the directional validity of the model.

From a theoretical perspective, the study contributes to the convergence of four major paradigms agency, stakeholder, resource-dependence, and legitimacy theories to explain sustainable disclosure. Agency theory elucidates the monitoring and control function of independence and leadership separation; stakeholder and legitimacy frameworks highlight the ethical, reputational, and institutional forces shaping transparency; and resource-dependence theory captures how board diversity and ESG specialization expand informational and relational capital. Together, these mechanisms form an integrated theoretical model of *sustainable governance for innovation transparency*.

The implications are both practical and regulatory. For policymakers, the evidence substantiates the rationale behind the Corporate Sustainability Reporting Directive (CSRD) and European Sustainability Reporting Standards (ESRS), which seek to formalize sustainability accountability through governance architecture. For corporate boards, the findings illustrate that sustainability oversight and balanced composition are not symbolic, but functional levers that enhance credibility, attract responsible investors, and sustain innovation legitimacy. For market participants, greater R&D ESG transparency provides a more reliable basis for evaluating firms' innovation capacity and long-term value creation.

Beyond its direct implications, this research also contributes to the evolving debate on how corporate governance adapts to the sustainability paradigm. It reveals that governance effectiveness is multidimensional combining formal independence, cognitive diversity, and normative commitment to sustainability and that these dimensions interact synergistically rather than additively. Transparency thus emerges not as a compliance outcome but as a strategic resource embedded within the firm's governance DNA.

Naturally, some limitations open pathways for future inquiry. While this study focuses on France, cross-country analyses could explore how institutional logics, ownership structures, or legal origins moderate these relationships across different regulatory settings. Future work may also integrate textual analytics, sentiment measures, or machine-learning–based disclosure scores to capture qualitative dimensions of ESG narratives. Likewise, investigating the financial consequences of R&D–ESG transparency its effect on cost of capital, investor confidence, or market valuation would further strengthen the link between governance, innovation, and value creation.

In sum, the evidence confirms that sustainable corporate governance is a prerequisite for credible innovation disclosure. Boards that are independent, gender-balanced, and supported by dedicated sustainability committees foster a culture of transparency that aligns innovation with responsibility. By embedding

sustainability into the heart of corporate governance, firms not only enhance legitimacy and accountability but also position themselves as catalysts in the transition toward a more inclusive, resilient, and innovative-driven economy. The central message is clear: transparency in R&D and ESG reporting is not the endpoint of governance, it is its ultimate proof of effectiveness.

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