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Impact de la qualité de la communication GES sur la valorisation des investisseurs dans un contexte réglementaire : le cas des entreprises du SBF 120

Impact of GHG reporting quality on investors' valuations in a regulatory context: The case of SBF 120 companies

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Résumé

Cet article étudie l'impact de la qualité de la communication réglementée des entreprises en matière d'émissions de Gaz à Effet de Serre (GES) sur la valorisation des investisseurs et ceci dans un contexte de renforcement des contraintes législatives et de croissance des exigences informationnelles des parties prenantes. En utilisant un score de communication GES estimé à partir des publications réalisées entre 2016 et 2019 par les entreprises françaises du SBF 120, nous montrons que la qualité des communications GES règlementées s'est améliorée sur la période d'étude malgré l'absence de mesures coercitives et apparaît particulièrement plus élevée chez les entreprises des secteurs polluants. Nos résultats suggèrent également que si les marchés financiers sont sensibles à la qualité des informations GES exigée par le législateur français, ils tendent à valoriser différemment cette information extra-financière en fonction du secteur d'activité de l'entreprise.

Mots clés : *Reporting* environnemental, qualité de l'information GES, réglementation, valorisation des investisseurs, secteur d'activité.

Abstract

This article studies the impact of the quality of mandatory corporate reporting of greenhouse gas (GHG) emissions on investors' valuations in a context of increasing legislative constraints and stakeholders' growing information requirements. Using a GHG reporting score estimated from disclosures provided by French companies listed on the SBF 120 from 2016 to 2019, we show that

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the quality of mandatory GHG reporting improved over the study period despite lack of enforcement measures and appears to be higher among firms in polluting sectors. Our results also suggest that while financial markets are sensitive to the quality of GHG information required under French legislation, they tend to calibrate their valuations of this extra-financial information to the type of sector in which firm operates.

Keywords: Environmental reporting, quality of GHG information, regulation, investors' valuations, sector.

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Introduction

Just as governments have committed to meeting quantified targets for reductions to greenhouse gas (GHG) emissions,[1] businesses also must fulfill various stakeholders' expectations in the fight against global warming. They must provide transparent reporting of these efforts and should expect these commitments to be scrutinized regularly. In 2019, businesses spent €124 billion to reduce their CO_2 emissions, but they may have to double that number to reach the targets set by Brussels for 2050 (an 80% to 95% reduction from 1990 levels). All European companies, and consequently French companies, will be required to report on their activities.

The framework of regulated GHG reporting prescribed under the French legislative regime requires companies to report on the carbon policies they have implemented by disclosing the volume of gas emissions produced that contribute to increasing the greenhouse effect and their current or planned emissions reduction programs. To ensure quality information, this reporting must comply with the principles of transparency, credibility, clarity and comparability, particularly as set out in ISO 14064-1, a standard on establishing carbon emissions (Ministère de l'Écologie, 2016). These principles are similar to the quality principles of the Global Reporting Initiative (GRI).

Although several French laws have sought to promote the quality of GHG reporting ever since the enactment of the *Loi sur les Nouvelles Régulations Economiques* (NRE, 2010), the influence of this criterion on financial valuations of firms is still unclear, both for the lawmakers who set the rules and for the managers who must comply with them. From the lawmakers' point of view, it is important to determine whether investors will consider it relevant to have expanded content on GHG emissions and more demanding requirements on reliable reporting, as prescribed by recent legislative amendments, and whether this would be useful for improved investment and valuation decisions. For the firms, it may be important to adopt solid GHG reporting strategies even though lawmakers have not imposed a specific format and do not penalize non-compliance. The challenge is therefore to assess the impacts of higher-quality reporting on the financial valuations of firms, and therefore, indirectly, on the financing of their economic activities and growth.

Numerous studies suggest that financial markets are sensitive to corporate GHG disclosures. Given investors' expectations about litigation risks and the added expense of compliance in the event of stricter regulatory requirements, the quantity of a firm's CO_2 emissions has a negative impact on its stock value, albeit in different ways, depending on the sector (Chapple et al. 2013; Griffin and Sun 2013). Although there is evidence that investors penalize lack of reporting (Matsumura et al. 2014; Griffin et al. 2017) and positively value its presence (Liesen 2015; Jaggi et al. 2018), no study has

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looked at the sensitivity of financial markets to GHG disclosure quality or what happens when legislation establishes a framework for this information.

The purpose of this study is to examine whether the quality of GHG disclosures is a parameter that can influence how investors value the information disclosed. More specifically, we address two main questions in the context of the amendments the French government has introduced over the last decade to strengthen its legislation: (1) Does the quality of the regulated GHG disclosures by French firms differ between sectors? and (2) Is the financial valuation of a firm sensitive to the quality of its reporting?

To answer these questions, we assigned a "qualitative" score ─ based on the criteria of presence, type (hard/soft; Plumlee et al. 2015), understandability and comparability of GHG information ─ to the contents of management and environmental reports published from 2016 to 2019 by SBF 120 companies (a total of 480 data sets). We then estimated its influence on financial performance (measured by each firm's Market-to-Book ratio) by differentiating firms according to the degree of air pollution in their sector.

Two main results emerged from our study. First, we found that firms in polluting sectors make significantly greater efforts to report GHG information, despite evidence that reporting by firms in less polluting sectors has improved considerably. Furthermore, our work indicates that, although financial markets are sensitive to the quality of reported GHG information when valuing financial results, their response to this factor varies by sector.

In terms of theory, this study contributes to the literature on GHG reporting by being the first to demonstrate that the quality of such reporting influences investors' confidence in corporate disclosures. As for regulatory frameworks, while the results of our study underscore how lawmakers may be tempted to implement regulations that impose very detailed disclosures, our findings stand as a warning that more detailed disclosures may have an undesirable impact on the valuations of low-polluting firms.

The paper is organized as follows: we provide a description of the regulatory context under study (section 1), and then present our theoretical framework and proposed research hypotheses (section 2). This is followed by a discussion of our field of study and the methodology used (section 3). Lastly, we present the results (section 4) and discuss them (section 5).

1. Background

Since the entry into force of Section 225 of the *Loi sur les NRE* (France's law on new economic regulations, Grenelle 2 - 2010), publicly listed French companies have been required to publish a

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CSR (corporate social responsibility) report that must include indicators that various stakeholders can use to gauge the impact of their operations on climate change. The main measures to strengthen the law concern an obligation to publish a GHG emissions report (Decree 2012-557) and to have it certified by an independent third-party organization (Decree 2012-557). The objectives and the means implemented to reduce emissions must be stated, preferably along with data comparisons and presentation of the methodology.

We investigate exclusively the GHG emissions reporting policies of French firms, which are regulated by application decree No. 2012-557 dated April 24, 2012 (part of the Grenelle laws). Under these rules, businesses are required to provide a GHG emissions report in their CSR report, including Scopes 1 and 2 (Scope 3 is optional). Scope 1 concerns the direct emissions from fixed and mobile sources required for the company's operations; Scope 2 deals with indirect emissions, such as the consumption of electricity, heat and steam; and Scope 3 refers to transportation, travel, purchasing and subcontracting activities.

Recently, Order No. 2017-1180 and Decree 2017-1265, which translate the European Directive 2014/95/EU into French law, reaffirmed the obligations related to GHG emissions reporting and requested that the legislative proposals provide for "a sufficient level of comparability to meet the needs of investors and other stakeholders"[translation]. In addition, France's Department of the Environment[2] has developed a methodological guide on how to assess GHG emissions, based on the quality criteria contained in ISO standard 14064-1, applicable to the carbon emission reports required under the Grenelle 2 law. In this standard, the quality of GHG information is based on principles and expectations respecting the transparency, credibility, clarity and comparability of the information, the criteria we use in this study (see the Appendix).

However, despite this regulatory framework, French firms are still relatively free to determine the content of their reporting and how they present their GHG emissions reports, the informational depth and quality of which are partly linked to the firm's form of governance (Depoers 2010). In the absence of penalties for non-compliance with regulatory expectations, firms may decide to publish only low-quality information, or even not to disclose any information on this environmental parameter. In fact, some studies suggest that a regulatory framework does not always improve the quality and quantity of the environmental information published by businesses, which sometimes respond simply out of fear of incurring penalties (Freedman and Stagliano 2002). However, other studies show that firms cannot resist complying with the legislation indefinitely (Criado-Jiménez et al. 2008) and eventually embrace it if the standards appear coherent to them (Bebbington et al. 2012). In this regard, Chelli et al. (2014) have pointed out that the legislation is generally effective at fostering better environmental reporting, even in the absence of penalties for non-compliance (which is the case in France).

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Therefore, following a comparison of the reporting practices of French and Canadian firms, Chelli et al. (2018) suggest that the French legislative framework is more effective than market mechanisms at achieving normativity[3] in environmental reporting.

2. Theoretical framework and research hypotheses

2.1. Theoretical framework

When making investment decisions, financial actors can expect GHG reporting to help them achieve their financial and non-financial utilities by reducing their information asymmetry with managers. According to agency theory (Jensen and Meckling 1976), as further extended to all stakeholders by Hill and Jones (1992), the manager (agent), as someone to whom management of a firm has been entrusted, holds information on GHG emissions that investors (the principals) can take note of and assign a value to if the manager chooses to disclose it voluntarily or if a regulatory framework requires such disclosure. If, on the other hand, the firm decides not to share information on this parameter, the investors will be deprived of information that would be useful in evaluating the decisions made by the manager and in valuing the company (Flammer 2013; Middleton 2015).

Such information makes it possible for investors to understand the opportunities and risks associated with carbon policies so it can be used alongside accounting information to refine evaluations of a firm's overall economic situation and growth prospects. Management's commitment to the environment can have a positive impact on the firm's reputation among its various stakeholders and, consequently, on their expectations concerning its future profitability. In view of climate challenges and expectations regarding corporate responsibility, a carbon policy considered to be effective and ambitious can lead to an increase in sales (Brown and Dacin 1997) and improved contractual relations with employees and suppliers. But this positioning can also generate additional capital expenditures, which can reduce or even fully offset the profitability that investors may expect, at least in the short term. On the other hand, a firm that is not very responsible in terms of its GHG emissions may acquire a bad reputation, leading investors to revise their assessments of its financial results due to the costs that this altered image could entail (Cormier and Magnan 2007; Qiu et al. 2016). By helping reduce moral hazard, GHG information reporting can therefore be understood as a means to better determine the present value of a firm's assets and liabilities, and this may affect its financial performance and cost of financing (Déjean and Martinez 2009; Clarkson et al. 2013; Plumlee et al. 2015). Lastly, this disclosure may also be useful to some financial actors who derive moral benefits from socially responsible investment (Riedl and Smeets 2017; Chatzitheodorou et al. 2019).

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However, financial actors must consider information to be informative and reliable before it can be used in their investment decision-making process and truly reduce information asymmetry. Experimental investigations have revealed the existence of a positive response to an objective external evaluation of environmental reporting. By increasing the trust that financial actors place in this information, environmental reporting positively influences assessments of share value (Lackmann et al. 2012; Cohen and Simnett 2015). This is particularly true when firms manage to achieve a high level of certification (Rivière-Giordano et al. 2018).

Furthermore, according to Boyer (2017), proper market functioning depends on firms publishing complete, quality information. The purpose of financial reporting regulations is to satisfy these criteria and, by extension, to meet investors' expectations. Reliable and good-quality GHG information may help investors incorporate this information into their asset allocation and valuation decisions. Based on work carried out by the IASB (International Accounting Standards Board) in 1989, Botosan (2004) defines quality of information in terms of four attributes that are useful for economic decision-making: relevance, reliability, comparability and understandability. The new conceptual framework for financial reporting (IASB, 2010) specifies the fundamental and enhancing qualitative characteristics of financial information. To the extent that non-financial reporting must provide usable information just as financial reporting does, its regulation should seek to promote completeness and quality.

2.2. Research hypotheses

Extant research has shown that investors differ in their interest in and response to environmental reporting (Déjean and Martinez 2009). In their efforts to meet expectations regarding mandatory disclosure while also addressing stakeholders' needs through voluntary disclosure, firms have developed environmental reporting strategies such as opportunistic and quality strategies, which vary from sector to sector (Depoers and Jérôme 2017; Jaggi et al. 2018). As GHG reporting is a specific aspect that affects investors' financial valuations of firms (Matsumura et al. 2014; Griffin et al. 2017), we have formulated hypotheses that examine relationships between three main factors: GHG reporting, sector effects and investors' financial valuations.

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2.2.1. GHG reporting and sector effects

Numerous studies conducted over many years have suggested that the nature of a firm's environmental disclosures is tied to its sector (Cowen et al. 1987; Hackston and Milne 1996). In response to greater stakeholder pressure (Patten 1992), firms in environmentally sensitive sectors choose to disclose better-quality environmental information than firms in other sectors do (Wiseman 1982), even when they exceed their allocated GHG emission quotas (Depoers 2010). According to Brammer and Pavelin (2006), polluting sectors are under considerable pressure to make their commitments to environmental issues visible, due to the firms' potentially high environmental impact. In a study on the mandatory environmental disclosures of French, German and English firms, Barbu et al. (2014) also concluded that firms in sensitive sectors publish more environmental information than firms in other sectors do. However, Déjean and Martinez (2009) suggest that sectors do not diverge significantly in terms of the volume and type of their voluntarily disclosed information. According to Depoers and Jérôme (2017), firms in sensitive sectors report this information in a symbolic way to give the impression of complying with disclosure requirements, but without revealing too much about their environmental policies, for fear of losing legitimacy. According to the authors, "the facade response represents a third path taken by firms looking to resist institutional rules" [translation] (p. 56). These findings suggest the need to examine the quality of GHG reporting more closely. In fact, it would appear that, given the poor quality of the information published, it may not be very useful to stakeholders. For example, Radu et al. (2020) show significant differences among the reports of the largest industrial GHG emitters in Quebec. The authors conclude that, despite the pressures from stakeholders on climate issues, firms are not doing enough to improve the quality of their reporting, since they are not sufficiently reporting what they have accomplished in terms of carbon strategies and performance.

As a result, a legislative framework that strengthens transparency requirements for GHG reporting may influence the quality of reporting by all firms (Chelli et al. 2018), thereby altering the quality gap between sectors. This leads us to formulate the following hypothesis:

H1: Polluting and low-polluting sectors differ in the quality of their regulated GHG reporting.

2.1.2. GHG reporting and investors' valuations

Despite the large body of work on investor response to GHG disclosures, studies have not reached a consensus on the issue. Matsumura et al. (2014) and Griffin et al. (2017) suggest that investors

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penalize non-disclosing firms, resulting in lower market capitalizations compared to disclosing firms. Matsumura et al. (2014) conclude that investors respond positively to disclosure and apply a penalty for non-disclosure. These results confirm those obtained by Griffin and Sun (2013) and Liesen (2015), who point out that investors respond positively to GHG disclosures, which they consider to be relevant and important information when pricing stocks. According to Jaggi et al. (2018), carbon disclosures positively influence stock prices by enabling investors to make comparative assessments of risk across firms when making investment decisions.

However, some studies point out that no positive relationship has been found between GHG reporting and firm value. Bansal and Kistruck (2006) and Prado-Lorenzo et al. (2009) find a negative relationship between the amount of data disclosed and economic performance, and Kim and Lyon (2011) find no relationship between carbon disclosure and firm value. More generally, Saghroun and Eglem (2008) suggest that analysts and financial markets are not very sensitive to non-financial information.

The nuanced results of these studies (Jaggi et al. 2018) demonstrate the need to assess not only the quantity of the information disclosed but also its quality, including its comparability and understandability. While Talbot and Boiral (2015) point out that studies have raised questions about the quality of the information disclosed, they also highlight how few studies have focused on the environmental data itself. It should be noted, however, that some studies highlight certain problems in terms of the calculation methodology used, the manipulations of data or the exclusion of certain GHG emissions data from sustainability reports (Depoers et al. 2016). When sustainability reports do not provide high-quality, valid and verified data, disclosures lose their value in the eyes of stakeholders, including investors (O'Dwyer and Owen 2005). Lee et al. (2015), for example, show that carbon disclosure types are sometimes considered to be of poor quality due to their complexity and poor comparability.

Given the importance of the quality criterion for CSR reporting, we assume that a legislative framework could contribute to investors' use of GHG information by improving the relevance, reliability and comparability of the information disclosed. By requiring all listed companies to publish information on their carbon emissions, certify it and present their emission reduction programs in a documented manner, lawmakers could prove more useful to investors by making a comparative and temporal assessment of the risks possible between all firms in the same sector, rather than only between those that voluntarily choose to publish the information.

In this respect, we formulate the following hypothesis:

H2: The quality of regulated GHG reporting has a significant impact on investors' financial valuations.

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2.1.3. GHG reporting, sector effects and investors' financial valuations

Chapple et al. (2013) suggest that voluntary GHG reporting would not have the same impact on financial valuations, depending on the sector. They show that the discount applied by the market for each ton of GHG emitted is higher for the largest emitters. Similarly, Griffin et al. (2017) demonstrate that GHG emission levels between 2006 and 2012 had a stronger effect on the market valuations of the largest S&P500 issuers. The market's response to firms' GHG disclosure quality choices in response to their regulatory obligations may therefore depend on the sensitivity of the sector in which the firm operates.

We hypothesize that the largest emitters' efforts at transparency may be positively valued by investors because they enable more effective evaluations of their carbon policies. Investors are then better able assess potential costs in terms of reputation, litigation and compliance expenses associated with the stricter regulatory requirements that their high GHG emissions could trigger. With better information, the market could then eliminate, or at least reduce, the opacity premium applied to the market capitalizations of the largest GHG emitters when their disclosures are considered informative. As a result, this could decrease the amount of the discount per ton of CO_2 identified by Chapple et al. (2013) and Griffin et al. (2017). Conversely, low GHG emitters may not reap the same benefits from good GHG reporting. Chapple et al. (2013) and Griffin et al. (2017) found that the discount applied to their market capitalization per ton of CO_2 is less than that applied to major emitters; this suggests that the market anticipates that lower indirect costs (reputation, litigation, etc.) will be associated with their carbon policies. It is therefore likely that the gains in stock market valuation that these firms can derive from good GHG reporting are very different from the gains available to polluting firms, which incur greater distrust from stakeholders regarding their environmental reporting (Aerts and Cormier 2009; Du and Vieira 2012; Kanso and Gonzales 2015). This leads us to formulate the following hypothesis:

H3. Investors' valuations further to their assessment of regulated GHG reporting quality differ according to whether the disclosing organization operates in a polluting or a low-polluting sector.

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3. Data collection and research methodology

3.1. Sample

Our sample consists of the financial and non-financial data published for the period from 2016 to 2019 by the 120 largest French companies in the Euronext SBF 120 index at the end of the estimation period (480 data sets). We chose this sample to assess whether investors see utility in having a stronger legislative framework for the content and quality of listed companies' GHG disclosures. By studying the period during which France's Grenelle 2 law was applied, we sought more specifically to assess the influence on investor confidence of the requirements for GHG data documentation, justifications and comparability.

Table 1. Distribution of observations by sector according to the GICS classification

GICS Sector	**Observations**
Industrials	21%
Consumer Staples (Food & Drug Retail, Personal Products, etc.)	20%
Financials (Banks, Financial Services and Insurance)	17%
Information Technology	10%
Energy	8%
Health Care (Equipment, Pharmaceuticals, Biotechnology)	8%
Materials	6%
Other Consumer Goods (Automobiles, Apparel, Consumer Services, etc.)	4%
Utilities	3%
Telecommunications	3%
	100%

Table 1 presents the distribution by sector of the firms in our sample according to the Global Industry Classification Standard (GICS), which is widely used by the financial community. To assess the influence of the sector on our results, two subsamples were formed based on the results of a 2019 report by the *Centre Interprofessionnel Technique d'Études de la Pollution Atmosphérique* (CITEPA), which is the authority charged with assessing GHG emissions in France. The first sample (N=180) consists of the sectors with France's largest GHG emitters: Transportation, Waste Treatment, Energy, Chemicals, Materials and Heavy Industry. The second sample (N=300) comprises the less sensitive, so-called low-polluting sectors. In contrast with many other studies conducted in the context of Carbon Disclosure Project surveys (Chapple et al. 2013; Matsumura et al. 2014; Griffin et al. 2017), this study focuses on all large firms subject to the CSR disclosure obligations of Grenelle 2. In this way, the sample can be considered representative of the population of the largest French companies, thus eliminating the influence of bias (self-reporting and selection) on our results.

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3.2. Methodology

3.2.1. Content analysis

To measure the influence of GHG information quality on investors, an environmental score (EnvIndex) was assigned to each company following a coding process based on a content analysis of annual financial and environmental reports. Report type and quality were used as a proxy for the reporting strategy selected by each company in response to its regulatory obligations. The quality of the GHG information was defined based on the principles set out in the ISO 14064-1 Standard on the transparency, credibility, clarity and comparability of the disclosures.[4]

The first phase of analysis involved identifying the main GHG information required under Grenelle 2 and detailed in ISO 14064-1: organizational boundaries, emission items for individual operational categories, methodological items for assessment, action plans undertaken, and expected volume of GHG emission reductions. Following the methodology used by Depoers (2010) for GRI principles, two qualitative criteria, characterized by four items (accessibility, documentation/justification, quantification and comparability), were then designated to adhere to the quality principles set out in the ISO standard.

The first criterion concerns the presence, form and understandability of the GHG disclosures on direct and indirect emissions[5] (Scopes 1 and 2). The purpose of the second criterion is to assess the comparability of a firm's quantitative data, when available. Based on an analysis of the characteristics of the information published by the firms in our sample, a measurement scale was developed, comprising the four qualitative items selected and pre-tested on about 15 reports (each report was coded by each of the authors in a triple-blind process) to remove lexical ambiguities and refine the coding grid.[6] As noted by Cormier and Magnan (2007), this qualitative evaluation of the information makes it possible to determine the "value" of the reports, weighting them according to their utility. Table 2 presents the items and the coding used to determine the quality of published GHG information.

As a result, if the information on GHG emissions was easily accessible, well structured, detailed and clearly justified and quantified, the firm obtained a maximum score of 3 for the first criterion. If the disclosures provided a temporal comparison of total emissions in terms of tons of CO_2 equivalent to show the effectiveness of the reduction measures implemented and permit inter-sectoral comparisons, the firm obtained a score of 2 for the second criterion.

This coding is consistent with research findings that have suggested that numerical information increases a firm's environmental legitimacy with shareholders, especially the socially committed ones

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(Aerts and Cormier 2009). This is in contrast with narrative information, which is often ignored as it is considered too superficial (Campbell and Slack 2011).

A score for GHG reporting quality was then calculated for each firm by dividing the sum of the scores obtained for each criterion by the maximum score of 5. This EnvIndex score can therefore fall within a range of 0, for firms that do not meet ISO 14064-1 requirements, to 1, for those considered to provide high-quality GHG reporting.

Table 2. Coding to assess the quality of GHG reporting

	Items	Coding
Presence, type, understandability	Information that is easily accessible	Coded 1 if the information for the reporting year (Scopes 1 and 2) and the planned reduction actions were quickly accessible and identifiable, 0 otherwise.
	Information that is structured, clearly documented and justified	Coded 1 if the information was detailed, well structured, explicit and justified by the description of the methodological choices and their possible changes in terms of the organizational boundaries, GHG emissions calculation method and classification (detailed information on the nature of the sources of emissions per scope), and 0 otherwise.
	Numerical information	Coded 1 if the firm provided numerical information and expected volumes of emission reductions by emission category in future years, and 0 otherwise.
Comparability	GHG data that is comparable over time and across sectors	Coded 2 if a history was provided of total tCO2e over at least two consecutive years, or if a comparison was provided of tCO2e with the selected reference year.
		Coded 1 if the numerical information was not comparable over time or was presented in a form that does not allow for intra or inter-intersectoral comparisons (e.g., expressed as volume of activity/employee or as a percentage change).
		Coded 0 if no figures were provided.

3.2.2. Research model

The impact of GHG disclosures on investors' valuations of financial results was studied using a five-factor model[7] applied alternatively to the two samples of firms (Low Polluting and Polluting). In this way, the sector factor is isolated from other potential causal factors. The model's equation is as follows:

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$$Market_to_Book_{i,t} = \beta_0 + \beta_1 \frac{1}{SE_{it}} + \beta_2 ROE_{it} + \beta_3 EnvIndex_{it}. + \beta_4 ROE_{it} \times EnvIndex_{it} + \beta_5 Size_{it} + e_{it}$$

where the dependent variable, $Market_to_Book$, is a proxy for financial performance. This measure reflects how investors perceive managers' decisions by analyzing the available financial and environmental information (Cormier and Magnan 2007). A value greater than 1 indicates that the correct anticipation of the firm's future earning capacity leads to a higher valuation of the firm's equity (Market Value) than of its book value (Book Value). This performance measure is theoretically equivalent to Tobin's Q (Varaiya et al. 1987), which has been used in many studies on CSR reporting (Lee et al. 2015, Radhouane et al. 2019). However, the Market-to-Book variable has the empirical advantage of overcoming the methodological problems associated with implementation of Tobin's Q. Construction of the Market-to-Book variable requires neither estimating the market value of debt nor estimating the replacement value of assets, whose approximations may lead to underestimating the importance of firm-specific parameters, such as risk. Lastly, the fact that 17% of our sample consists of financial institutions requires that we adopt an *equity* approach that does not require taking into account the cost of borrowed capital, as is the case in the *entity* approach, and which would lead to erroneous results for this sector.

Consequently, a significantly positive (negative) β4 would lead one to believe that quality GHG disclosures can improve (diminish) the value ascribed to a firm's financial results, thereby increasing (decreasing) its market capitalization relative to its equity. Conversely, a non-significant coefficient would indicate that investors do not consider this parameter important when assessing financial information. Table 3 presents the model's variables and some examples of studies that have used them.

Table 3. Variable definitions and related references

Variable	Description	References
Market_to_Book	Ratio of the market value of equity (product of the number of shares outstanding and their price) to its book value at the end of year *t*	Cormier and Magnan (2007), Prado-Lorenzo et al. (2009), Clarkson et al. (2013)
$\frac{1}{SE}$	Inverse of Shareholders' equity (billion euros) in year *t*.	Cormier and Magnan (2007), Clarkson et al. (2013), Plumlee et al. (2015)

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ROE	Financial profitability: Ratio of net income to Shareholders' equity in year *t*	Cormier and Magnan (2007)
EnvIndex	Quality score for GHG reporting, from 0 to 1 (see 3.2.1) in year *t*	Adapted from Cormier and Magnan (2007)
ROE x EnvIndex	Variable on the interaction between financial profitability (ROE) and the GHG quality score, used to assess the impact of GHG disclosures on the valuation of financial results (ROE) and its potential marginal effects (increase or mitigation of the impact of the ROE variable)	Adapted from Cormier and Magnan (2007)
Size	Napierian logarithm of total assets for year *t*	Déjean and Martinez (2009), Depoers (2010), Ory and Petitjean (2011), Griffin et al. (2017)

4. Results

4.1. Quality level of GHG disclosures

The data in Table 4 show that the scale used to assess the quality of GHG disclosures has good reliability (standardized Cronbach's alpha of 0.89). The items have correlations of 0.68 to 0.82, so they are all consistent with the scale and useful for discriminating between the firms studied (reliability is not improved by omitting an item).

Table 4. Descriptive statistics for the quality items and study of the scale's reliability

	Low Polluting					**Polluting**					Correlation /total scale	Cronbach's α (item omitted)
	Mean	SD	Δ mean (period)	Med.	Inter-quartile range	Mean	SD	Δ mean (period)	Med.	Inter-quartile range		
Accessibility	0.91	0.29	+8%	1.00	0.00	0.94	0.24	+7%	1.00	0.00	0.68	0.78
Documentation/ Justification	0.87	0.34	+13%	1.00	0.00	0.89	0.31	+8%	1.00	0.00	0.82	0.72
Quantification	0.80	0.40	+18%	1.00	1.00	0.86	0.35	+5%	1.00	0.00	0.79	0.71
Comparability	1.45	0.83	+6%	2.00	2.00	1.70	0.61	+8%	2.00	1.00	0.70	0.87
EnvIndex score	0.80	0.33	+12%	1.00	0.40	0.86	0.30	+7%	1.00	0.20		
Standardized Cronbach's Alpha (N=480) for the scale											0.89	

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The descriptive statistics for the EnvIndex quality score and for each item used to assess it lead us to make several observations. First, it is notable that the average score for polluting firms (0.86) is higher than that for low-polluting firms (0.80), which have a higher dispersion of the quality score below the median (interquartile range of 0.4, compared to 0.2 for the polluting firms). Since the distributions of this variable are statistically different (Table 5), the quality of GHG reporting is therefore significantly higher in the sensitive sectors, confirming our H1 hypothesis.

Furthermore, while the quality score (EnvIndex) improved over the study period among polluting firms (+7%) and low-polluting firms (+12%), the improvement appears to be significantly greater among low-polluting firms due to a significant increase in the number of reports presenting detailed and clearly justified GHG information (+13%) as well as numerical information that is easier for investors to use (+18%). While rapid access to GHG information is confirmed for most of the firms in our sample, comparisons over time and across sectors based on annual reporting are significantly weaker for low-polluting firms, despite the fact that this item improved over the period (+6%) and there being a greater disparity within this group of firms (average and interquartile range of 0.83 and 2, respectively, compared with 0.61 and 1, respectively, for polluting firms).

4.2. Effect of GHG reporting quality on financial performance

Table 5 presents descriptive statistics of the variables used as well as the parametric and non-parametric tests comparing the distributions.

Table 5. Descriptive statistics of the variables for the two samples

	Low Polluting N = 300					Polluting N = 180					Test of differences	
	Mean	SD	Min.	Med.	Max.	Mean	SD	Min.	Med.	Max.	t Pr >|t|	Mann-Whitney (U)
Capitalization	13.11	13.91	0.15	6.20	130.41	18.91	24.31	0.08	9.05	124.00	-1.78 *	24,083 *
Market-to-Book	2.05	2.26	0.28	1.71	9.76	2.84	3.21	0.09	1.79	25.82	3.16 ***	24,034 **
1/SE	0.19	8.82	0.01	0.25	6.71	1.11	4.08	0.01	0.27	47.76	1.31	26,757
ROE	0.13	0.58	-0.30	0.10	0.51	0.07	0.40	-3.80	0.11	1.16	-1.27	25,756
EnvIndex	0.80	0.33	0.00	1.00	1.00	0.86	0.30	0.00	1.00	1.00	1.98 **	24,029 ***
EnvIndex*ROE	0.11	0.58	-0.30	0.08	0.51	0.06	0.37	-3.80	0.10	0.99	-1.04	24,043 **
Size	16.36	1.72	11.07	16.12	21.45	16.25	1.71	11.15	16.40	19.46	-0.63	26,406

***, **, * mean that the coefficient is significant for thresholds of 1%, 5% and 10%, respectively.

First, we can see that the significant difference between the distributions of the Market-to-Book variable at the 1% and 5% thresholds validates our decision to work on two subsamples, since

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investors' valuations differ by sector: the average Market-to-Book ratio of polluting firms (2.84) appears to be higher than that of low-polluting firms (2.05), and the variable also shows greater dispersion.

Furthermore, on average, the values of the shareholder's equity (SE) and financial profitability (ROE) variables for low-polluting firms are significantly higher than they are for polluting firms over the period. Lastly, the distributions of the capitalization variable for the two subsamples are significantly different at the 10% threshold, with a higher average valuation for polluting firms, which also have higher quality GHG reporting.

The model's parameters were estimated using partial least squares (PLS) regression. The PLS method is recommended in exploratory settings (Fernandez 2012; Hair et al., 2022) for which no theoretical model is predefined, as is the case in this study. The PLS method also has the advantage of solving the problem of the collinearities that can arise between some exogenous variables through its use of orthogonal factors. In this sense, the 1/SE variable was found to be highly correlated with the ROE factor and the interaction variable, which were also found to be correlated with each other (coefficients greater than 0.9). Lastly, the properties of the PLS method are a good fit with the lack of normality in our data distributions and the size of one of our samples (N=180), which rules out using covariance-based methods such as LISREL (Fernandez 2012).

Table 6 presents the results of the PLS regressions performed on the two subsamples.

Table 6. Results of the PLS regressions on the two subsamples

	Low Polluting (N=300)		**Polluting (N=180)**		
	1 component (Q^2 cum = 0.242)		2 components (Q^2 cum = 0.501)		
	R^2 Y cum = 32.69% / R^2 X cum = 57.29%		R^2 Y cum = 64.96% / R^2 X cum = 71.18%		
Source	Standardized coefficients	VIP (comp1)	Standardized coefficients	VIP (comp1)	VIP (comp2)
1/SE	0.21	**1.35**	0.66	**1.71**	**1.47**
ROE	0.18	**1.18**	0.21	0.48	**0.98**
EnvIndex	-0.04	0.25	0.01	0.02	0.03
ROE*EnvIndex	-0.19	**1.22**	0.11	0.65	**0.93**
Size	-0.07	0.48	-0.43	**1.19**	**1.01**
% DModX>Dcrit (X) at 95%	3.67%		3.89%		
% DModY>Dcrit (Y) at 95%	4.33%		2.78%		

(*VIP scores greater than or close to 1 are shown in bold.*)

Following the recommendations of Tenenhaus (1998), a threshold value for Q^2 was set at 0.0975 to allow for the addition of a new component. As can be seen in the last two rows, the percentage of observations that are poorly reconstructed for the exogenous variables (X) and for the endogenous variable is less than 5% for both regressions, attesting to their good quality. To assess the importance

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of each variable in the projection (i.e., its contribution to explaining the endogenous variable), a variable importance in projection (VIP) score was calculated. Among the low polluting firms, three factors stand out for having a VIP greater than 1. The variables 1/SE, ROE and ROE*EnvIndex therefore weigh heavily in explaining the Market-to-Book variable, in contrast with the EnvIndex and Size variables. For the polluting firms, the variables 1/SE and Size appear to be the most significant, whichever axis is studied, to which the interaction variable and ROE are added for Component 2. This result tends to confirm our H2 hypothesis, suggesting that, independent of the environmental sensitivity of the firm, the quality of its GHG reporting will influence the way investors value its ROE. An examination of the standardized coefficients obtained for each of the models reveals that, over the period of the study, the level of the 1/E factor and the ROE positively influence the value of the Market-to-Book variable. However, there is a significant difference between the two subsamples when the coefficients of the ROE*EnvIndex interaction factor are compared. This factor, whose importance was underscored by the VIP score, has a negative sign for low-polluting firms and a positive sign for polluting firms. This suggests that, depending on the environmental sensitivity of the firm's sector, investors adopt the opposite behavior with regard to GHG reporting. Regarding polluting firms, investors tend to positively value the high quality of GHG reporting when assessing financial results (ROE). In contrast, this effect is negative for low polluting firms. These results therefore tend to validate our H3 hypothesis.

Table 7 presents the results of our study of the effect of ROE on the Market-to-Book variable for different quality levels ($\frac{\partial Y}{\partial ROE}$).

Table 7. Effect of ROE on Market-to-Book at different quality levels $\frac{\partial Y}{\partial ROE}$

EnvIndex	**Low Polluting**	**Polluting**
0	0.18	0.21
0.2	0.14	0.23
0.4	0.11	0.25
0.6	0.07	0.27
0.8	0.03	0.29
1	-0.01	0.32
t-test	0.09 *	0.26 ***

****, **, * mean that the coefficient is significant for thresholds of 1%, 5% and 10%, respectively.*

The marginal effect of this reporting variable on valuations of financial profitability appears to be significantly different from 0 under both models. For low polluting firms, the positive effect of ROE on the Book-to-Market ratio decreases as the level of reporting increases. When low polluting firms

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have a large amount of GHG reporting (index of 1), the effect of ROE even appears slightly negative, indicating that they suffer a penalty when they report more extensively on GHG emissions. Conversely, as polluting firms increase the quality of their GHG reporting, their ROE effect increases. It is even one-and-a-half times greater for polluting firms with a high level of quality (0.32) than for their counterparts with a zero reporting index (0.21).

5. Discussion and conclusion

This empirical study provides a better understanding of the GHG reporting practices adopted by large French firms since the Grenelle 2 law came into force and of the impact of these practices on investors' valuations. Our study therefore makes several key contributions.

First, even though the quality of GHG reporting improved over the period of the study despite the lack of enforcement measures, it appears to be higher in the polluting sectors (H1). This contribution tends to corroborate the results of several studies conducted on various regulatory frameworks and over earlier periods (Cowen et al. 1987; Patten 1992; Hackston and Milne 1996; Depoers 2010; Barbu et al. 2014). Nevertheless, it diverges from the results of studies such as Déjean and Martinez (2009) and Depoers and Jérôme (2017), conducted in France before the 2012 overhaul of the NRE law, which found that a firm's economic sector has no influence. We suggest that this difference may be due to the tightening of the 2012 regulatory framework, combined with current governmental and stakeholder demands for GHG emission reductions. In this new environment, the largest emitters choose to adopt a GHG disclosure strategy that can respond to stakeholders' growing information demands regarding the carbon policies implemented by firms to meet the current climate challenges. This result supports Chelli et al. (2014), who conclude that French firms in environmentally sensitive sectors tend to demonstrate greater compliance with the law's requirements for environmental reporting in an effort to guarantee the legitimacy of their organization with respect to the cultural demands expressed by the law, without the need for a coercive legislative regime.

According to Freedman and Stagliano (2002), this tendency is also aimed at maintaining stakeholder support. This suggests that current stakeholder demands complement the role of legislation, by "disciplining" the reporting policies of the most polluting firms. Our results thus enrich knowledge about the type of stakeholders that impacts corporate reporting policy, completing the work of Bebbington et al. (2012), who show that the standards of other firms in the sector (those acting as entrepreneurs for the standard) are more widely adopted due to their greater legitimacy. This non-regulatory pressure reduces information asymmetry, to the benefit of investors in the process of assessing the indirect costs generated by firms' carbon policies.

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The second contribution is the finding that investors are sensitive to regulated GHG reporting and reporting quality when valuing companies (H2). We can therefore conclude that financial markets consider this type of reporting to be relevant to valuations. Consequently, a legislative framework that promotes the informational content and reliability of GHG disclosures (e.g., by requiring certification) can be considered useful to investors. In this way, regulation may help build confidence in mandatory disclosures by making them more credible and relevant. Access to the GHG data of all listed French companies, rather than only to voluntary disclosures, may have contributed to their consideration and valuation by facilitating comparisons among firms in the same sector. Better informed and more confident investors would then have reduced the amount of the discount per ton of CO_2 (Chapple et al. 2013; Matsumura et al. 2014; Griffin et al. 2017) applied in their financial valuations of the polluting firms considered to have good quality GHG reporting. This result can be compared to the findings of Liesen (2015) and Jaggi et al. (2018), who also identify a positive relationship between stock prices and GHG reporting. This positive impact of GHG reporting quality on the valuations of polluting firms can be seen as the result of a reduced opacity premium in an environment where there is pressure to reduce carbon emissions.

Lastly, while financial markets appear to be sensitive to the quality level of regulated GHG information, our results show that they respond differently, depending on the firm's sector (H3). We found that a high volume of quality GHG information has a negative impact on valuations of the financial results of low-polluting firms.

This potential effect of environmental reporting was previously identified by Prado-Lorenzo et al. (2009). They state that firms must report clearly and concisely, so that stakeholders can easily evaluate their environmental policies. However, by being transparent, and in particular by publishing historical data and targets, firms run the risk of damaging their image if their performance falls short, an outcome they will need to justify (Bansal and Kistruck 2006).

These results could also be understood in terms of the characteristics of the investors in these types of firms and, in particular, ethical investors (Chatzitheodorou et al. 2019). Since ethical investors are more demanding in terms of environmental commitments, they could significantly penalize organizations considered to be "non-polluting" when they eventually do report pollution. Among these investors could be socially responsible mutual funds (Sparkes 2001), idealistic investors (Chatzitheodorou et al. 2019), and religious and charitable organizations (Renneboog et al. 2008) that can exclude investments from their portfolios if the firms are profitable but do not meet their non-financial utility goal regarding pollution.

A firm's sector is therefore a significant factor in measuring the influence of the quality of mandatory non-financial information on the financial valuations of firms.

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From a theoretical perspective, this study contributes to the literature as the first to suggest that the quality of regulated GHG disclosures influences investors, but not necessarily in a positive way. From a regulatory perspective, this work shows that a stronger but non-coercive legislative framework for environmental disclosure can help provide information useful for investors' valuation decisions. However, investors' negative response to the quality of the GHG reporting of low-polluting firms suggests that vigilance is required with respect to regulations that seek to impose overly detailed reports, including temporal data. This leads us to a proposal on implementing mandatory regulations and on firms adopting GHG reporting strategies that are differentiated by sector (polluting/low-polluting).

In terms of methodology, our original contribution concerns how to measure the quality of GHG information. Here the innovation is the reading evaluation grid used to analyze the content of the firms' reports, and particularly, the use of Scopes 1 and 2. This approach provides a relevant consideration of the firm's direct and indirect GHG emissions.

The significance of our results is subject to certain limitations inherent in our sample selection, which focused on the largest companies in France, thereby excluding companies with lower market capitalizations and firms operating under different regulatory frameworks. As a result, this study opens up two important avenues of research on the impact of GHG reporting quality on investors' valuations. The first would be to further analyze the negative response to GHG reporting by firms in low-emission sectors in light of the growing interest among some investors in socially responsible funds. The second avenue involves studying the impact of GHG emissions reporting on a given sector. This would make it possible not only to analyze the response to GHG reporting by type of investor, but also to find more detailed explanations for the differences between sectors.

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[1] A methodological guide for carrying out GHG emission assessments, published in 2016 by France's Department of the Environment, Energy and the Sea, defines GHG information as an assessment of the total volume of GHG emitted into the atmosphere in one year by the activities of a legal person on the territory of France, expressed in equivalent tons of carbon dioxide.

[2] The first method for calculating carbon emissions was published in 2011 in accordance with section 75 of Law No. 2010-788 of July 12, 2010 on the national commitment to the environment (ENE). A fifth version, currently in development, will integrate the latest update of ISO 14064-1:2018.

[3] State of compliance with rules that are set either by legislation or by informal reporting regimes (Bebbington et al. 2012).

[4] These criteria are consistent with the principles defined in the Global Reporting Initiative (accuracy, reliability, clarity and comparability) and the IASB and FASB standard-setting organizations (fair presentation, verifiability, understandability and comparability).

[5] The gases contributing to an increased greenhouse effect and retained within the framework of the Kyoto Protocol are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF_6) and nitrogen trifluoride (NF_3).

[6] The main point of discussion was the comparability of the numerical data, due to the wide range of presentations: (1) historical with or without accumulation of scopes, (2) emissions related to the volume of activity (e.g.: number of rooms) or to the number of employees, and (3) emissions presented in relation to the reference year or as a percentage of change.

[7] The proposed model is the final result of a PLS regression containing only the significant variables, i.e., those whose VIP score is close to or greater than 1 on at least one of the selected components and that make it possible to minimize the prediction error to guarantee that the model is of good quality at the 5% risk threshold.

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Appendix. Definitions of Quality Principles Based on ISO 14604-1

Principle	Definition
Transparency	Disclose GHG information in a detailed and accurate manner so as not to compromise its relevance, by enabling a correct assessment of all the organization's emission sources (completeness).
Credibility	Explain and justify the approach, the methodological choices for quantifying GHG emissions and the sources of the data to judge the reliability and accuracy of the figures disclosed.
Clarity	Disseminate clear GHG information, structured by type of emission source and with an appropriate aggregation of individual sources so that it can be easily understood and used.
Comparability	Report any significant changes (accounting methods, data consolidation, restatements of previous year's emissions accounts/benchmarks) to allow comparisons of GHG information and to ensure consistency in reporting from one period to the next.

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