Disclosure of carbon in embedded reserves in the oil and gas industry: Determinants and stock market valuation

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Abstract

Climate change put increasing pressure for environmental protection worldwide. Our study builds upon the rise in societal expectations regarding the environmental performance of corporations, which has certainly been spectacular in recent years. Such pressures by various stakeholders and society entail a greater scrutiny of corporate environmental practices. The aim of this paper is to assess the relevance for the stock markets of carbon emission data and the role of the quality of the governance, environmental performance and the media pressures on CO$_2$ issues. Results based on a sample of US and Canadian firms in the Oil & gas industry are the following. The disclosure of embedded CO$_2$ is positively related to analyst following and share price volatility, i.e., a reduction of information asymmetry. Concerning consequences on the stock market valuation of proven embedded reserves, results suggest that embedded CO$_2$ reduces market value substantially. However, stock markets price proven reserves around 5 times the negative impact of CO$_2$ included in these reserves. For firms with a good environmental performance, this negative relation between embedded CO$_2$ and stock market value is increased, suggesting that disclosure on environmental issues allow market participants to better assess the negative impact of embedded CO$_2$. We observe a substitution effect between environmental performance and embedded CO$_2$ on their effect on the stock market valuation. A good environmental performance is value relevant after considering its negative valuation of embedded CO$_2$.

Key words. Carbon emissions, corporate governance, environmental performance, oil & gas reserves, value relevance.
Résumé

Les changements climatiques exercent une pression croissante pour la protection de l'environnement dans le monde entier. Notre étude s’appuie sur l’augmentation des attentes de la société en matière de performance environnementale des entreprises qui a été spectaculaire ces dernières années. De telles pressions exercées par divers acteurs et par la société en général exigent un examen plus approfondi des pratiques environnementales des entreprises. L’objectif de cette étude est d’évaluer la pertinence pour les marchés boursiers des données sur les émissions de carbone et le rôle de la qualité de la gouvernance, de la performance environnementale et des pressions des médias sur les émissions de CO₂. Les résultats basés sur un échantillon d’entreprises américaines et canadiennes du secteur du pétrole et du gaz sont les suivants. La divulgation du CO₂ incorporé dans les réserves enchâssées est positivement corrélée au suivi des analystes et à la volatilité du prix des actions, c’est-à-dire une réduction de l’asymétrie de l’information. En ce qui concerne les conséquences sur la valorisation boursière des réserves enchâssées prouvées, les résultats suggèrent que le CO₂ enchâssé réduit considérablement la valeur de l’action. Cependant, les marchés boursiers évaluent les réserves prouvées à environ 5 fois l’impact négatif du CO₂ inclus dans ces réserves. Pour les entreprises affichant une bonne performance environnementale, cette relation négative entre le CO₂ enchâssé et la valeur boursière est accrue, ce qui suggère que la divulgation d’informations sur les questions environnementales permet aux acteurs du marché de mieux évaluer l’impact négatif du CO₂ enchâssé. Nous observons un effet de substitution entre la performance environnementale et le CO₂ enchâssé sur leur effet sur la valorisation boursière. Une bonne performance environnementale est créatrice de valeur après avoir pris en compte sa valorisation négative du CO₂ enchâssé.

Mots clés. Émissions de carbone, gouvernance, performance environnementale, réserves de pétrole et gaz, valorisation boursière.
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Disclosure is not costless for companies. By voluntarily disclosing information, firms are particularly exposed to proprietary or opportunity costs (Qiu et al., 2016). Disclosure of bad news is all the more costly since it is likely to cause a reduction of the stock market value. So why do firms disclose? According to Verrecchia (1983), a firm will disclosure information if the resulting benefits outweigh the costs it entails. The advantages of this practice mentioned in the literature are, among other things, a reduction in the information asymmetry often linked to a decrease of the cost of capital (e.g. Dhaliwal et al., 2011; Blacconiere et al., 1994); a positive impact on the market valuation (e.g. Plumlee et al., 2015; Cahan et al., 2016) and an improvement in analysts' forecasts (e.g. Dhaliwal et al., 2012; Cormier et al., 2014). It can also improve business reputation; an advantage in the current context where society's interest in societal and environmental issues is growing (Cahan et al., 2016).

The numerous benefits and costs associated with voluntary disclosure have certainly contributed to the extended literature in this area. Knowing that voluntary disclosure requires resources that could be allocated for other purposes, some academics have sought to identify the motivations for voluntary disclosure. Others have tried to determine its economic or societal benefits. Hence, various stakeholders are asking firms to account for the social responsibility of their actions (e.g., Cormier, Gordon and Magnan, 2004; Fernandez-Feijoo, Romero and Ruiz, 2014) while investors are seeking to obtain assurance that such potentially costly actions are not hide behind unrealistic
financial reporting (e.g., Simons and De Wilde, 2017). Over the years, these pressures have become increasingly institutionalized with the emergence of Corporate Social Responsibility (CSR), environmental or sustainability rankings (e.g., Corporate Knights), stock market indices (e.g., Dow Jones Sustainability Index), measurement and reporting metrics (such as the Global Reporting Initiative, i.e., GRI), CSR assurance experts (e.g., environmental auditors) or management processes (e.g., ISO 14000, ISO 26000).

The current paper, focusing on these two components, contributes to the existing literature. Specifically, we attempt to determine whether there are determinants to voluntary environmental disclosure, specifically embedded CO₂. Subsequently, we test the existence of a relationship between this type of disclosure and the stock market value. Referring to the studies of Qiu et al. (2016), de Villiers, and van Staden (2011), we find that it is difficult to determine from previous research the direction of the relationship between environmental disclosure and financial performance. It is possible that firms with superior environmental performance and the resources to do so decide to report it to the market to differentiate themselves. It is also possible to assume that firms voluntarily publish information to be more transparent, which increases the number of investors and other stakeholders, and ultimately their market valuation.

Results of the study of US and Canadian firms from the oil and gas industry, which published information on CO₂ emissions between 2014 and 2017, show that the disclosure of embedded CO₂ is positively related to analyst following and share price volatility. Concerning consequences on the stock market value of proven embedded reserves, results suggest that embedded CO₂ reduces market value substantially. Stock pricing of proven reserves is around 5 times the negative impact of CO₂ included in these
reserves. However, for firms with a good environmental performance, this negative relationship between embedded CO$_2$ and stock market value is enhanced, suggesting that reduced disclosure about environmental issues allow market participants to better assess the negative impact of embedded CO$_2$ on market capitalization. The stock market would attribute a lower value to polluting than non-polluting assets. We observe a substitution effect between environmental performance and embedded CO$_2$ on their effect on stock market value. A good environmental performance is value relevant after considering its negative valuation of embedded CO$_2$.

The first section of this article discusses CO2 regulations. Section 2 reviews the existing literature and presents hypotheses. The third section presents the sample and the methodology. The fourth section discusses the main results, and the last section presents the conclusion.

**Regulation about CO2 emission disclosure**

According to Matsumara et al. (2014), firms are facing increasing pressure to measure and disclose their CO$_2$ emissions. Indeed, greenhouse gas emissions can have a negative impact on firm’s future cash flow, a valuable information used by investors to assess a firm’s value. Therefore investors have expressed concerns over GHG effects on financial risks, namely: Institutional activism. A strategy focusing on using the power of institutional investors has emerged (Harmes, 2011). This might explain why in 2002, institutional investors started to address these concerns collectively via the CDP (Kim and Lyon, 2011).
As a United Nations initiative, the carbon disclosure project (CDP) was initiated in 2000 with the aim of collecting and disseminating firm level climate change information in an effort to create a unified response against global warming (Wegener et al., 2013). Since 2002, the CDP, an independent not-for-profit organization acting on behalf of over 300 institutional investors around the world, sends annually a questionnaire to the world’s 500 largest firms to get information about their CO₂ emissions, risks, strategies and plans for managing and reducing these emissions (Wegener et al., 2013; Matsumura et al., 2014. In Canada, 60% of the top 200 largest firms listed on the Toronto Stock Exchange (S&P/TSX) responded to the CDP questionnaire in 2014 (CDP, 2014). However, the Canadian government has decided in 2011 not to comply with CDP, while many other countries simply chose to ignore it (RCGT, 2016).

The Greenhouse Gas Reporting Program (GHGRP) collects information on greenhouse gas (GHG) emissions annually from facilities across Canada. It is a mandatory program for those who meet the requirements. Facilities that emit 50 kilotons or more of GHGs, in carbon dioxide (CO₂) equivalent (eq.) units, per year must report their emissions to Environment and Climate Change Canada.

Emissions data are available by gas (in tons and tons of CO₂ (eq.) for each facility and each year of data collected (2004-Present). The GHGs included are carbon dioxide (CO₂), methane (CH4), nitrous oxide (N2O), hydrofluorocarbons (HFC), perfluorocarbons (PFC) and Sulphur hexafluoride (SF6).
For our sample, data on embedded CO\textsubscript{2} comes from Company annually reported sources only (Corporate Social Responsibility reports, annual reports, SEC Filings, websites, or any additional documents, such as Code of Conduct or CDP report, that are available on the Company site). Bloomberg does not take any documents from third-party sources or any sites that require credentials to gain access. GHG specific data generally comes from CSR reports, CDP reports, or annual report. As for total embedded carbon, data fields are sourced from the company's 10-K annual Filing.

Literature review and hypotheses development

CSR disclosure

Due to growing public concern about the environment and the fair use of resources in the society, many studies have been done on corporate social and environmental responsibility (CSR). Studies in this field come from different academic fields, such as corporate governance, accounting and sociology. As a result, few studies focus on the same issues and the methodologies used are often very different. Research on this topic is therefore still relevant. (It should be noted that the field of this literature that interests us for this research is that related to the voluntary disclosure of environmental information.)

The relevance of studying voluntary environmental disclosure comes from the fact that it allows various stakeholders to judge the corporate responsibility and the way in which firms fulfil this objective. Hence, it allows investors to judge the quality of
environmental performance, which is often difficult to assess. The publication of information is often not mandatory, it follows that it generates additional costs for firms, which can be offset by the benefits it provides. Several researchers have therefore sought to know what could encourage firms to publish information voluntarily and the impacts of this proactive behaviour. Concerning the motivations for disclosure, by referring to the literature, one can first note that the motives can be socio-political or economic. Socio-political motives are based on the theory of legitimacy (e.g., O’Donovan, 2002; Deegan, 2002; Aerts, Cormier, Magnan, 2006; Campbell, 2007; Aerts and Cormier, 2009; Cho, Roberts, Patten, 2010), while those of economic order are based on the theory of voluntary disclosure proposed by Verrecchia (1983).

According to the theory of voluntary disclosure, firms that have good news are encouraged to communicate them to avoid a problem of adverse selection (Verrecchia, 1983). Based on this reasoning as well as on resource theory, Qiu et al. (2016) as well as Clarkson et al. (2011) state that firms with good economic and environmental performance have the resources to signal their superiority and have an interest in doing so by using objective and verifiable means of disclosure. Releasing information difficult to imitate by firms with poor performance should improve competitive advantage. Moreover, by maintaining a superior environmental performance, firms can raise rival cost, which constitutes an economic benefit (Clarkson and Richardson, 2004). Therefore, firms with good environmental performance become more attractive for market participants. From an economic perspective, voluntary disclosure does not only prevent adverse selection, it can reduce informational asymmetry as well as the cost of capital. According to de Villiers et al. (2011), the fact that public companies are generally not
managed by their owners (especially diffuse ownership firms) creates informational asymmetry between managers (the agent) and shareholders (the principal), which can be reduced by the voluntary publication of credible information. Cahan et al. (2016), for example, mention that the reduction of information asymmetry may arouse the interest of institutional investors and financial analysts, which ultimately will yield new capital.

Indeed, in regards of institutional investors, Hahn et al. (2015) in a review of the literature on carbon disclosure mentioned that this practice helps help them in their estimation of a company’s regulatory and natural risks related to climate change. By being able to better evaluate the future cash flows of the firm, institutional investors should be more incline to invest. According to Kumar et al. (2012), managers who are monitored by shareholders with long term stakes in the firm will have incentives to disclose good news as well as bad news. Their results suggest that the long term investment efficiency gains resulting from disclosure outweigh the short term negative effect of bad news. Finally, Kim and Lyon (2011) show that institutional activism can increase firm value when the external business environment becomes more climate conscious.

Voluntary disclosure therefore seems beneficial from both an economic and social point of view, and that is probably why it is widely used. Regardless of the reasons for voluntary disclosure, it is important to question its effects. The ones we are particularly interested in are those related to environmental information.

By reviewing the literature, Plumlee et al. (2015) find that research can be grouped into three categories: those related to the relationship between environmental disclosure and environmental performance, those relating to the relevance of
environmental disclosure and those dealing with the managerial strategy with respect to environmental disclosure. Our research lies more in the first two fields, so we will give them special attention.

Referring to the de Villiers et al. (2011), results of research on the relationship between voluntary disclosure and environmental performance are mixed. They stipulate that some studies including those of Cho et al. (2007) and Patten (2002) show a negative relationship, while those of Clarkson et al. (2008) and Al-Tuwajri et al. (2014) show that it is positive. Some studies, including those by Wiseman (1982), fail to demonstrate the existence of a relationship between these two parameters. Healy and Palepu (2001), Cormier and Magnan (2011) and Clarkson et al. (2011) have also studied these two parameters and note that it is the less successful firms that publish the most. Healy and Palepu (2001) believe that companies use environmental disclosure to publicize the reasons for their poor performance and the actions they plan to take to address it in order to avoid adverse selection. Clarkson et al. (2011) also looked at the types of disclosure: "hard" and "soft" and find that the largest polluters are more reliant on disclosures of the first type. This means makes it possible to obtain more objective and verifiable information. As a result, hard disclosure is considered more relevant for stock market participants. As we can see, the topics and results regarding disclosure and environmental performance are mixed, which is why it is worth pursuing research in this area. In addition, several researchers such as Clarkson et al. (2013) consider it important to control for environmental performance when studying the relationship between environmental disclosure and stock pricing. This relationship is an integral part of the second field of literature.
To judge the relevance of the disclosure of voluntary information, several researchers have tried to verify its effects on the stock market valuation or on analyst forecasts. The studies of Dhaliwal et al. (2011), Clarkson et al. (2013), Matsumara et al. (2014), Plumlee et al. (2015), Cahan et al. (2016) suggest that there is a relationship between environmental disclosure and the financial performance of firms. Specifically, the results of Dhaliwal et al. (2011) suggest that firms with a high capital cost can reduce it by publishing a report on their social responsibility. Plumlee et al. (2014) also note that the publication of environmental information can influence the cost of capital of firms. They find that it decreases when the quality of the information provided increases. They therefore conclude that overall, quality disclosure has a positive effect on the market valuation. Clarkson et al. (2014), for their part fail to show the effect of the disclosure on the cost of capital, but consider that the environmental information, especially that provided in the Toxics-Release Inventory (TRI) are relevant in the assessment of financial performance.

Although different from the previously mentioned studies, the results of Cahan et al. (2016) also seem to show the existence of a relationship between disclosure and stock market value. These researchers, however, specify that this relationship is influenced by the countries studied and the type of information provided. They show that "unexpected information" (a proxy for the incremental information contained in CSR disclosures) positively affects financial performance as measured by Tobin’s Q and that it is more pronounced in countries where voluntary disclosure is not widespread.

Voluntary disclosure can directly affect the market valuation, but it can also do so indirectly, notably by improving the accuracy of financial analyst forecasts. Investors
often evaluate companies by considering their risks. The lower forecast accuracy, the higher the risks and the higher the price of the shares. By reducing informational asymmetry, the disclosure should therefore improve analyst forecasts and that is why, some studies including those of Aerts, Cormier and Magnan (2007), Dhaliwal (2012), Cormier and Magnan (2014) and Liensen et al. (2017) addressed this issue.

For the current study, we think that a control sample of disclosure firms versus nondisclosure firms will make it possible to judge the relevance for the stock markets of carbon emission data and the role of the quality of the governance, environmental performance and the media pressure on the environmental issues.

*Carbon disclosure*

Matsumara et al. (2014), for their part, analyzed the impact of the disclosure of "hard" environmental information and noted that it had some impact on the stock market. Specifically, in studying carbon emissions, they find that firms were systematically penalized by the market and that the penalties were higher for firms that do not disclose their carbon emissions. More specifically, Matsumara et al. (2014), using hand collected carbon emission data examined the effects on market value of carbon emissions and voluntary disclosure to that effect. They find that, on average, for every thousand tons of additional carbon emissions, firm market value declines by $212,000. The authors also examine the effects on the stock market value of the decision to disclose information on carbon emissions. They find that the median market value of firms disclosing their carbon emissions is about $2.3 billion higher on average than comparable firms that do not disclose. The results suggest that markets penalize all firms for their carbon emissions,
but an additional penalty is imposed by the market on firms that do not disclose information on emissions.

Luo and Tang (2014) attempt to examine whether voluntary carbon disclosure reflects firms’ true carbon performance. The level of carbon disclosure was measured based on content analysis of Carbon Disclosure Project (CDP) reports, and their carbon performance index focused on both carbon intensity of emissions and carbon mitigation. Based on a sample of 474 U.S., U.K., and Australian firms, their findings show a significant positive association between carbon disclosure and performance, suggesting that firms’ voluntary carbon disclosure in the CDP is indicative of their actual underlying carbon performance. This result is consistent with signalling theory.

Griffin et al (2017) examined the relationship between voluntary carbon disclosures (CDP) and the equity value of S&P 500 companies. They concluded that whether the firms disclosed the carbon emissions or whether they were estimated, the impact of a ton of emissions reduction represents a reduction of about one-half of 1 percent of market capitalization.

Liesen et al. (2017) empirically assess the value relevance of information on corporate climate change disclosure and performance to asset prices, and discusses whether this information is priced appropriately. Their findings indicate that corporate disclosures of quantitative GHG emissions and, to a lesser extent, carbon performance are value relevant. However, their results suggest that the market is inefficient and that portfolios constructed from companies disclosing and those not disclosing quantitative GHG emissions show differences in risk-adjusted returns. The existence of disclosure of quantitative GHG emissions is relevant to asset prices. In brief, the information
transparency for carbon emissions disclosure has become crucial for investors and other stakeholders, as it fulfills their expectations for CSR. This concept that firms should be transparent regarding the carbon emissions disclosure has theoretical support from legitimacy theory, institutional theory, signalling theory, and voluntary disclosure theory.

As we could see by reviewing the literature on carbon and more specifically by referring to the articles of Matsumara et al (2014) and Luo and Tang (2014), stock markets penalize all firms for their emissions. Therefore, we expect that the more embedded CO\(_2\), the more the stock market will impound liabilities to a firm (unbooked liabilities). We also argue that proven reserves of oil and gas should be valued by stock market participants to a larger extent than firm’s other assets accounted for in financial statements. Moreover, stock markets would attribute a lower value to high-polluting than low-polluting assets.

Based on Qiu et al. (2016), de Villiers and van Staden (2011), and Hahn et al. (2015), we posit that a good environmental performance should influence the association between embedded CO\(_2\) and firm value. However, the reasons and the sign of the relation are not clear. Tuwajiri et al. (2004) explain the positive relation between environmental and economic performance as a result of good management strategies. Kim and Lyon (2011) state that “CDP participation created positive shareholder value for firms faced with a greater regulatory threat”. Clarkson et al. (2004) suggest that a consequence of good environmental performance is an increase in an industry’s standards. In the case of a new regulation, firms having a good environmental performance should encounter lower compliance costs than the other firms, resulting in an economic advantage.
Aerts, Cormier and Magnan (2007), Dhaliwal (2012), Cormier and Magnan (2014) and Liensen et al. (2017) show that environmental disclosure and/or a good environmental performance increase firm value by reducing information asymmetry. However, by reducing information asymmetry, participants on the stock market should also be able to better predict future costs. Disclosure about environmental issues should then allow market participants to better assess the negative impact of embedded CO$_2$ on market capitalization. Therefore, good environmental performance is expected to influence the negative relationship between CO$_2$ emissions and firm value.

No matter how environmental performance influences the relation between CO$_2$ emissions and firm value, Bernardi and Stark (2017) and Liensen et al. (2017) believe that the information is value relevant for the stock market. While Bernardi and Stark (2017) argue that disclosures concerning environmental performance is value relevant and demanded by informed market participants, Liensen et al (2017) provide evidence that the existence and quality of corporate carbon disclosure in particular is regarded as important for asset pricing. Their results also suggest “that incompletely reporting companies were penalized by financial market” during the time of their study.

This gives rise to the following hypotheses:

H1: There is a negative association between embedded CO2 and stock market valuation.

H2: The association between embedded CO2 (unbooked liability) and stock market value is influenced by a good environmental performance.
H3: A good environmental performance is value relevant.

**Method**

**Sample**

We will focus our analysis on the Oil and Gas industry and on US and Canadian firms for the 2015-2017 period. For the first stage model focusing on the determinants of the decision to disclose information on embedded CO$_2$, the sample concerns 746 firm-year observations for which environmental performance score and Governance scores are available in Bloomberg's database (758 for CDP data availability). For the second stage model focusing on the value relevance of embedded CO$_2$ data, the sample is 362 firm-year observations for CDP model 347 firm-year observations for Environmental disclosure score model.

**Empirical model**

We aim to investigate the impact on the stock market valuation of CO$_2$ emission data as well as embedded CO$_2$. Since the fact to focus on firms that disclose this information in their annual report, we may face the problem of selection bias. Thus, we will rely on Heckman's selection model with a two-step selection.

The model is the following:
First stage

Embedded CO\textsubscript{2} disclosure (1/0) =

ROE + Analyst following + Price volatility + Tobin + News publications + Firm size

Second stage

Stock market value =

Assets + Assets*Reserves Oil & gas + Reserves Oil & gas + Liabilities + Embedded CO\textsubscript{2} + Embedded CO\textsubscript{2}*Environmental performance + Environmental performance + Governance + Net income + Year-specific dummies

Based on Matsumara et al. (2014) who suggest that that unscaled market value of equity estimates generally perform better than scaled market value models, we do note scale market value and CO\textsubscript{2} measure.

**Measurement of variables**

*Environmental performance*. Bloomberg rates firms based on their disclosure of quantitative and policy-related ESG data, relying on different sources: Annual reports, sustainability reports, press releases, direct communication with companies, including meetings, phone interviews, email exchanges and survey responses. Bloomberg is on track to cover more than 13 000 firms with Environmental, Social and Governance data in 83 countries by the end of 2018. The aim is to assess a firm's environmental performance. Examples of issues treated are: Environmental (environmental Policy,
environmental management systems, voluntary codes, product stewardship and life cycle assessment, sustainability investing – commitment to ecologically sustainable development, climate change risk, carbon emissions, toxic waste treatment, raw materials scarcity, water scarcity, air pollution, natural resources used, environmental opportunities. The score is called Environmental disclosure score.

As another proxy for environmental performance, recent papers have used CDP integrated performance score (Carbon Disclosure Project) (e.g. Luo and Tang, 2014. CDP score reflects the level of company’s commitment to climate change mitigation, adaptation, and transparency. CDP scores companies that respond on-time to the questionnaire sent on behalf of an investor’s request. Bloomberg converts Carbon Disclosure Project (CDP) letter scores to numerical values as follows:

8 - Score A (>87.5%)
7 - Score A- (>75%)
6 - Score B (>62.5%)
5 - Score B- (>50%)
4 - Score C (>37.5%)
3 - Score C- (>25%)
2 - Score D (>12.5%)
1 - Score D- (>0%)
0 - F = Failure to provide sufficient information to CDP to be evaluated for this purpose (0%). Not all companies requested to respond to CDP do so. Firms who are requested to disclose their data and fail to do so, or fail to provide sufficient information to CDP to be
evaluated will receive an F. An F does not indicate a failure in environmental stewardship.

The CDP processes the information provided by companies to produce a score of progress made by the company in the fight against climate change. Based on a sample of 474 companies in the United States and Australia, Luo and Tang (2014) showed that disclosure of carbon emissions under the CDP is a good indicator of companies' actual performance on this issue.

*Embedded CO$_2$.* Carbon dioxide (CO$_2$) emissions embedded in total oil and gas reserves. The formula uses carbon dioxide emission factors of 0.448546 metric tons per barrel of crude oil and 0.061 metric tons per cubic foot of gas. The factors are taken from Intergovernmental Panel on Climate Change (IPCC) 2006 Guidelines for National Greenhouse Gas Inventories. Calculated as: Worldwide Proven Reserves of Crude Oil x 0.448546 + Worldwide Proven Reserves of Gas x 0.061. Figures are reported in millions. Published in Bloomberg.

*Reserves oil & gas.* We estimate proven reserves of oil and gas based on embedded CO2 data published in Bloomberg database. Bloomberg also publishes a percentage of embedded CO2 concerning Oil reserves as well as gas reserves. This information allows us to estimate embedded equivalent barrels of oil reserves and gas reserves. We proceed as follows to estimate equivalent oil & gas in millions of barrels:

\[
\text{Embedded CO}_2 \text{ TM} \times \% \text{ Oil} + (1-\% \text{ Oil}) \text{ Embedded CO}_2 \text{ TM} \\
0.448546 + 0.061/0.173 = 0.3526 \times 0.3526 \times 0.173 \text{ barrel by TM of CO}_2 \text{ (based on Intergovernmental Panel on Climate Change (IPCC) 2006 Guidelines for National Greenhouse Gas Inventories).}
\]
**Governance.** Ethical business conduct, ownership of organization, organizational structure and management, risk management, audit and compliance, executive compensation, shareholder rights and reporting.

**News publications.** Total number of news stories published for the parent company on a particular day published in Bloomberg. The number of news stories that refer to a particular firm’s activities in a given year.

**Economic Variables.** We posit that ROA (e.g. financial strength), Analyst following, share price volatility and firm size are positively related to embedded CO2 disclosure while no prediction is made for Tobin (first stage model 1). Firms with high market-based performance as proxied by Tobin may disclose more non-financial information, such as carbon information, to fulfill stakeholders’ needs. For example, Lo and Sheu (2007) find a significantly positive relationship between sustainability disclosure and Tobin’s q. Moreover, the more a firm has to make long-term investments in intangible assets, as reflected by its Tobin’s Q, the more it requires financing by external financial resources providers, thus leading it to engage in less voluntary disclosure. However, the greater a firm’s Tobin’s Q (i.e., market to book premium), the more it is likely to be scrutinized by market participants, thus inducing disclosure. Hence, we do not make a directional prediction between Tobin’s Q and the disclosure of embedded carbon. Finally, considering the investors activism literature, we posit that the presence of an institutional investor will impact positively the decision to disclose (e.g. Harmes, 2011; Kim and Lyon, 2011; Cotter and Najah, 2011; Kumar et al., 2012).
We select economic variables based on prior research on environmental disclosure and governance (e.g. Clarkson, Richardson and Vasvari, 2008; Aerts and Cormier, 2009; Hahn et al, 2015; Bernardi and Stark, 2017; Cormier and Magnan, 2017).

Results

Descriptive statistics

Table 1 reports descriptive statistics. First, we observe that environmental performance (disclosure score) (mean = 11.26) and governance (mean = 52.08) show quite low scores. This is not surprising for a polluting sector such Oil & Gas. Results also show a low CDP integrated score at a mean of 0.604. Among firms for which we see an environmental disclosure score and a Governance score in Bloomberg, 52% disclose embedded CO\textsubscript{2}. These firms are quite large (Mean asset of 13.6 billion $), exposed to media (mean of 14 articles) and highly followed by analysts (mean of 12 analysts). The institutional ownership is quite high (30.87%) with 28.15% in Canada and 32.28% in the US. Therefore, according to the institutional activism, these firms should be inclined to disclose information about their environmental practices. They should do so since GHG and embedded reserves normally have long terms effects on a firm’s performance. We notice some differences when comparing Canadian and US firms. Environmental performance (CDP and environmental disclosure scores) are much higher in Canada than in the US. On the opposite, proven oil & gas reserves and embedded CO\textsubscript{2} are higher in the US as well as the news publications in the press, analyst following and share price volatility.

[Insert Table 1]
**Multivariate analyses**

**Stock market valuation**

Since we focus on firms that elect to disclosure information on CO₂, there is likely to have a problem of sample selection bias. To control for that bias, we estimate a Heckman selection model with two-step sample selection. In the first stage, we estimate the determinants of embedded CO₂ disclosure (1 or 0).

In Table 2, we report results on consequences on stock market value of embedded reserves of Oil & Gas and embedded reserves of carbon. We will focus on OLS regression since they provide very similar results compared with Heckman procedure. Results show that embedded reserves of Oil & Gas increases stock market value as shown by the coefficient on Asset*Reserves Oil & gas (0.203; p < 0.000) and Reserves Oil & gas (5.183; p < 0.004). As expected, this suggests that oil & gas proven reserves are more valued than other assets. As expected, the coefficient on embedded CO₂ (-10.095; p < 0.000) is negative and significant. This is consistent with hypothesis 1 and the results of Marsumara et al. (2014) and Griffin et al. (2017). The coefficient on embedded CO₂*CDP is also negative and significant (-0.191; p < 0.087), which is consistent with hypothesis 2. Information on environmental performance would allow stock market participants to better assess the negative impact of embedded CO₂ on stock markets. However, the main effect of environmental performance is positive and significant (209.88; p < 0.001), suggesting a substitution effect between embedded CO₂ and environmental performance on their impact on stock markets. This is consistent with hypothesis 3. Hence, for firms with a good environmental performance, this negative relation is reduced. This result is in line with Marsumara et al. (2014) who find a negative
relation between CO$_2$ emissions and stock market value. Finally, as expected, corporate governance is positively related to stock market value (30.429; p < 0.022).

Moreover, environmental disclosure score is used as a second proxy for environmental performance. Results presented in Table 3 do not differ from those presented in Table 2. This suggests that both measures reflect to some extent the environmental performance of the firm.

[Insert Table 2 and Table 3]

To assess the economic impact of embedded CO$_2$ on stock market value, we take the mean scores of independent variables for the group disclosing on CO$_2$ emissions and embedded CO$_2$. The economic impact on stock market value appears as follows:

The economic impact on stock market value appears as follows:

*Model with CDP*

<table>
<thead>
<tr>
<th>Term</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asset: 0.826 X 13 615$ =</td>
<td>11 246$</td>
</tr>
<tr>
<td>Asset*Reserves Oil &amp; gas: 0.0000202 X 13 615$ X 935 =</td>
<td>283$</td>
</tr>
<tr>
<td>Asset valuation</td>
<td>11 529$</td>
</tr>
<tr>
<td>Reserves Oil &amp; gas: 5.183 X 935 =</td>
<td>4 846$</td>
</tr>
<tr>
<td>Total valuation Oil &amp; gas =</td>
<td>16 375$</td>
</tr>
<tr>
<td>Per barrel = 17.50$ (16 375$ / 935 = 17.50$)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Term</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Embedded CO$_2$: -10.09 X 363 =</td>
<td>-3 663$</td>
</tr>
<tr>
<td>Embedded CO$_2$ X CDP = -0.191 X 363 X 0.604 =</td>
<td>-42$</td>
</tr>
</tbody>
</table>
CDP: 210 X 0.604 = 127$

Total liability embedded CO\textsubscript{2}: 3\textsubscript{5}78$

Per barrel 3.83$ per barrel (3\textsubscript{5}78$/ 935 = 3.83$)

Per metric ton 9.86$ (3\textsubscript{5}78$/ 363 = 9.86$)

Total negative impact of embedded CO\textsubscript{2} on stock pricing is: 3\textsubscript{5}78$/ 11\textsubscript{0}5$ = 32.2% of market capitalization.

For firms with a good environmental performance, this negative relation between embedded CO\textsubscript{2} and stock market value is increased, suggesting that disclosure on environmental issues allow market participants to better assess the negative impact of embedded CO\textsubscript{2}.

With the highest CDP (excellent environmental performance 8/8)

Embedded CO\textsubscript{2}: -10.09 X 363 = -3 663$

Embedded CO\textsubscript{2} X CDP = -0.191 X 363 X 8 = -555$

CDP: 210 X 8 = 1 680$

For firms with a good environmental performance (taking the highest CDP score), this negative relation between embedded CO\textsubscript{2} and stock market value is increased (555$), suggesting that disclosure on environmental issues allow market participants to better assess the negative impact of embedded CO\textsubscript{2}. However, environmental performance as proxied by CDP surpasses by 3.2 (1 680$/555$) the negative impact on the valuation of embedded CO\textsubscript{2}. 

25
Model with Environmental disclosure score

Asset: 0.706 X 13 615$ = 9 612$

Asset*Reserves Oil & gas: 0.0000222 X 13 615$ X 935 = 283$

Asset valuation 9 895$

Reserves Oil & gas: 4.617 X 935 = 4 317$

Total valuation of Oil & gas = 14 212$

Per barrel = 15.12$ (14 212$ / 935 = 15.12$)

Embedded CO₂: -7.021 X 363 = -2 549$

Embedded CO₂ X EnvPerfScore: -0.043 X 363 X 11 = -172$

EnvPerfScore: 32.35 X 11 = 356$

Total liability embedded CO₂: 2 365$

Per barrel 2.53$ per barrel = (2 365$ / 935 = 2.53$)

Per metric ton 6.52$ (2 360$ / 363 = 6.52$)

Total negative impact of embedded CO₂ on stock pricing is: 2 365$ / 11 105$ = 21.3% of market capitalization.

With the highest environmental disclosure score (the highest score is 71)

Embedded CO₂: -7.021 X 363 = -2 549$

Embedded CO₂ X EnvPerfScore: -0.043 X 363 X 71 = -1 108$
Estimated market value of oil & gas proven reserves as well as embedded CO2 appear low. Focusing on voluntary carbon disclosures studies subsequent to 2013, Depoers et al (2016) examined the relationship between carbon disclosures from different sources to assess their consistency. Based on a sample of French companies, they compared GHG emission disclosures in corporate reports those made by the Carbon Disclosure Project (CDP). They found that the corporate report disclosed lower emissions.

Decision to disclosure embedded CO2

Concerning the first-step regression on the determinants to the decision to disclose information on embedded CO₂, results from the Heckman procedure show in Table 2 that analyst following (0.039; p < 0.000), share price volatility (0.002; p < 0.005), firm size (LnAssets) (0.093; p < 0.020) and the percentage on institutional ownership (0.021; p < 0.000) are positively related to the decision to disclose the information on embedded CO2 publicly. This is consistent with the results of Cotter et al. (2017) and Kim and Lyon (2011).
Sensitivity analyses

First, since environmental regulations may vary between Canada and the United States as well as the level of market efficiency, we estimate our models adding interaction terms embedded CO2*USA, Embedded CO2*CDP*USA and CDP*USA. These interaction terms are all not statistically significant, suggesting that our results hold for Canadian and US data.

Second, prior empirical research (e.g., Bernard, 1995; Amir and Lev, 1996; Lo and Lys, 2000) used market-to-book as a dependent variable in valuation models. As a sensitivity analysis, we choose it instead of stock price as it is a more robust variable, with less econometric problems. For instance, prior research argues that there is a problem with an omitted correlated variable, the scale factor, in price-based models. Brown, Lo and Lys (1999) argue that if a firm has a two-to-one stock split, stock prices and accounting variables such as book values and earnings per share would be halved. Results not tabulated show quite similar results than those presented in Table 2 and Table 3 based on unscaled market value of equity estimates.

Lastly, instead of using net income as a growth variable in the valuation model, we estimate residual income based on Capital Asset Pricing Model.

\[
\text{Residual income} = \text{Net income} - [R_t + \beta (R_m - R_f)]
\]
We did not rely on CAPM at the beginning because we observe a negative Rm in 2015 in Canada \( r_m = -0.09 \). Results (not reported) do not significantly differ from those presented in Tables 2 and 3.

**Conclusion**

Our study builds upon the rise in societal expectations regarding the environmental performance of corporations, which has certainly been spectacular in recent years. Climate change put increasing pressure for environmental protection worldwide. Such pressures by various stakeholders entail a greater scrutiny of corporate environmental practices. In this context, firms must improve their environmental performance to fulfil the demand from various stakeholders. This includes transparency in the disclosure of their performance in this matter. One question is whether stock market assessment of corporate environmental performance and disclosure, more specifically carbon emissions, can reflect other stakeholder concerns concerning the ecology and the protection of the environment.

The aim of this paper is to assess the relevance for the stock markets of embedded carbon emission data integrating the role of the quality of the governance, environmental performance and the media pressures on CO\(_2\) issues. To better assess the relevance of carbon disclosure, we use a control sample of non-disclosing firms. Our analyses focus on the oil & gas industry in Canada and the US.

Our findings show that the decision to disclose information on embedded CO\(_2\) is positively related to analyst following, share price volatility, firm’s size and Institutional
investors. Concerning consequences on stock market value of proven embedded reserves, results suggest that embedded CO\(_2\) reduces market value substantially. The stock market valuation of proven reserves is around 5 times CO\(_2\) included in these reserves. However, for firms with a good environmental performance, this negative relationship between embedded CO\(_2\) and stock market value is enhanced. This suggests that the disclosure on environmental issues allow market participants to better assess the negative impact of embedded CO\(_2\) on market capitalization. The stock market would attribute a lower value to polluting than non-polluting assets. We observe a substitution effect between environmental performance and embedded CO\(_2\) on their effect on stock market value. A good environmental performance is value relevant after considering its negative valuation of embedded CO\(_2\). This result suggests that the stock market assessment of corporate environmental performance and disclosure can reflect other stakeholder concerns concerning the ecology and the protection of the environment. Our results also show the importance to integrate the environmental performance when assessing the impact of CO\(_2\) emissions on the market valuation.

The paper potentially sheds some additional light on the debate regarding the relation between environmental performance and financial performance (stock market performance). We show the role of the quality of the governance and environmental performance on CO\(_2\) issues.
<table>
<thead>
<tr>
<th>First stage model (N : 758) 881</th>
<th>( \text{ROA} )</th>
<th>-80.44</th>
<th>27.95</th>
<th>-0.04</th>
<th>8.14</th>
<th>-0.05</th>
<th>-0.03</th>
</tr>
</thead>
<tbody>
<tr>
<td>News publications</td>
<td>0</td>
<td>450</td>
<td>14.15</td>
<td>34.26</td>
<td>5.24</td>
<td>21.67</td>
<td></td>
</tr>
<tr>
<td>Analyst following</td>
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<td>45</td>
<td>12.13</td>
<td>10.53</td>
<td>8.50</td>
<td>15.19</td>
<td></td>
</tr>
<tr>
<td>Price volatility (%)</td>
<td>0.01</td>
<td>10 277.20</td>
<td>152.35</td>
<td>361.27</td>
<td>114.19</td>
<td>184.61</td>
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<tr>
<td>Institutional investors (%)</td>
<td>0</td>
<td>100</td>
<td>30.87</td>
<td>34.78</td>
<td>28.15</td>
<td>32.28</td>
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</tr>
<tr>
<td>Tobin</td>
<td>0.34</td>
<td>218.36</td>
<td>1.12</td>
<td>8.62</td>
<td>0.96</td>
<td>1.25</td>
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</tr>
<tr>
<td>Embedded CO\textsubscript{2} 1/0</td>
<td>0</td>
<td>1</td>
<td>0.52</td>
<td>0.49</td>
<td>0.50</td>
<td>0.53</td>
<td></td>
</tr>
</tbody>
</table>
*Carbon dioxide (CO$_2$) emissions embedded in total oil and gas reserves. The formula uses carbon dioxide emission factors of 0.448546 metric tons per barrel of crude oil and 0.061 metric tons per cubic foot of gas. The factors are taken from Intergovernmental Panel on Climate Change (IPCC) 2006 Guidelines for National Greenhouse Gas Inventories. Calculated as: Worldwide Proven Reserves of Crude Oil x 0.448546 + Worldwide Proven Reserves of Gas x 0.061.
Table 2: Consequences on stock market value of embedded Carbon - CDP

<table>
<thead>
<tr>
<th>Market value</th>
<th>OLS regression</th>
<th></th>
<th>Heckman selection model with two-step sample selection</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sign</td>
<td>Coefficient</td>
<td>T</td>
<td>P value*</td>
</tr>
<tr>
<td>Assets</td>
<td>+</td>
<td>0.826</td>
<td>15.88</td>
<td>0.000</td>
</tr>
<tr>
<td>Asset*Reserves Oil &amp; Gas</td>
<td>+</td>
<td>0.203*</td>
<td>31.81</td>
<td>0.000</td>
</tr>
<tr>
<td>Liabilities</td>
<td>-</td>
<td>-0.632</td>
<td>-8.08</td>
<td>0.000</td>
</tr>
<tr>
<td>Reserves Oil &amp; Gas</td>
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<td>5.183</td>
<td>6.21</td>
<td>0.000</td>
</tr>
<tr>
<td>Embedded CO₂</td>
<td>-</td>
<td>-10.095</td>
<td>-4.66</td>
<td>0.000</td>
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<tr>
<td>Embedded CO₂*CDP</td>
<td>+/-</td>
<td>-0.191</td>
<td>-1.72</td>
<td>0.087</td>
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<td>CDP</td>
<td>+</td>
<td>209.880</td>
<td>2.35</td>
<td>0.001</td>
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<td>Governance</td>
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<td>30.429</td>
<td>2.02</td>
<td>0.022</td>
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<tr>
<td>Net income</td>
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<td>0.052</td>
<td>3.13</td>
<td>0.001</td>
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<tr>
<td>Year-specific dummies</td>
<td>Yes</td>
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<td></td>
<td>Yes</td>
</tr>
<tr>
<td>R-square</td>
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<td>97.4%</td>
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<tr>
<td>F test</td>
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<td>1244.3 (0.00)</td>
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</tr>
<tr>
<td>N</td>
<td></td>
<td>362</td>
<td></td>
<td></td>
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<tr>
<td>Embedded CO₂ disclosure (1/0)</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ROA</td>
<td>+</td>
<td>-0.005</td>
<td>-1.54</td>
<td>0.123</td>
</tr>
<tr>
<td>Analysts</td>
<td>+</td>
<td>0.039</td>
<td>4.84</td>
<td>0.000</td>
</tr>
<tr>
<td>Price volatility</td>
<td>+</td>
<td>0.002</td>
<td>2.60</td>
<td>0.005</td>
</tr>
<tr>
<td>Tobin</td>
<td>+/-</td>
<td>-0.061</td>
<td>-1.19</td>
<td>0.213</td>
</tr>
<tr>
<td>News publications</td>
<td>+</td>
<td>-0.001</td>
<td>0.69</td>
<td>0.480</td>
</tr>
<tr>
<td>Firm size</td>
<td>+</td>
<td>0.093</td>
<td>2.05</td>
<td>0.020</td>
</tr>
<tr>
<td>Institutional investors (%)</td>
<td>+</td>
<td>0.021</td>
<td>11.97</td>
<td>0.000</td>
</tr>
<tr>
<td>Inverse Mills ratio</td>
<td></td>
<td>-1.15(0.25)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wald Chi2</td>
<td></td>
<td>4368(0.00)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td></td>
<td>758</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*One tailed if a predicted sign.
Table 3: Consequences on stock market value of embedded Carbon – Environmental disclosure score

<table>
<thead>
<tr>
<th>Market value</th>
<th>OLS regression</th>
<th>Heckman selection model with two-step sample selection</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sign</td>
<td>Coefficient</td>
</tr>
<tr>
<td>Assets</td>
<td>+</td>
<td>0.706</td>
</tr>
<tr>
<td>Asset*Reserves Oil &amp; Gas</td>
<td>+</td>
<td>0.0000222</td>
</tr>
<tr>
<td>Liabilities</td>
<td>-</td>
<td>-0.514</td>
</tr>
<tr>
<td>Reserves Oil &amp; Gas</td>
<td>+</td>
<td>4.617</td>
</tr>
<tr>
<td>Embedded CO2</td>
<td>-</td>
<td>-7.021</td>
</tr>
<tr>
<td>Embedded CO2*Environmental disclosure score</td>
<td>+/-</td>
<td>-0.043</td>
</tr>
<tr>
<td>Environmental disclosure score</td>
<td>+</td>
<td>32.352</td>
</tr>
<tr>
<td>Governance</td>
<td>+</td>
<td>40.416</td>
</tr>
<tr>
<td>Net income</td>
<td>+</td>
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<tr>
<td>Year-specific dummies</td>
<td>Yes</td>
<td></td>
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<tr>
<td>R-square</td>
<td>97.4%</td>
<td></td>
</tr>
<tr>
<td>F test</td>
<td>347</td>
<td></td>
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<tr>
<td>N</td>
<td>347</td>
<td></td>
</tr>
</tbody>
</table>

**Embedded CO2 disclosure (1/0)**

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>T</th>
<th>P value*</th>
<th>Coefficient</th>
<th>T</th>
<th>P value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROA</td>
<td>-0.003</td>
<td>-1.38</td>
<td>0.168</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Analysts</td>
<td>0.038</td>
<td>4.23</td>
<td>0.000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Price volatility</td>
<td>0.002</td>
<td>2.64</td>
<td>0.008</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tobin</td>
<td>-0.026</td>
<td>-1.23</td>
<td>0.217</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>News publications</td>
<td>-0.001</td>
<td>-0.72</td>
<td>0.474</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Firm size</td>
<td>0.087</td>
<td>1.91</td>
<td>0.028</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Institutional investors (%)</td>
<td>0.021</td>
<td>11.78</td>
<td>0.000</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Inverse Mills ratio -1.52(0.13)

Wald Chi2 4368(0.00) N 746

*One tailed if a predicted sign.
Reference


Raymond Chabot Grant Thornton – RCGT. 2016. GHG emission reduction strategies, running the gamut from opportunism, to enthusiasm to clear-headedness. December 5, 2016.
