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THE IMPACT OF CARBON EMISSIONS DISCLOSURE ON THE MARKET VALUE OF PUBLIC CANADIAN FIRMS

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L'IMPACT DE LA DIVULGATION DE CARBONE SUR LA VALEUR BOURSIÈRE DES ENTREPRISES CANADIENNES

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"If I have seen further it is only by standing on the shoulders of giants."

Isaac Newton

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LIST OF ABREVIATIONS AND ACRONYMS

AAR	Average Abnormal Return
AMEX	American Stock Exchange
AE	Abnormal Earnings
AR	Abnormal Return
BC	British Columbia
BVE	Book Value of Equity
CAAA	Clean Air Act Amendment
CAAR	Cumulative Average Abnormal Return
CAD	Canadian Dollars
CAPM	Capital Asset Pricing Model
CAR	Cumulative Abnormal Return
CDP	Carbon Disclosure Project
CEPA	Canadian Environmental Protection Act
CH_4	Methane
CICA	Canadian Institute of Chartered Accountants
CMRM	Constant Mean Return Model
CO_2	Carbon Dioxide
CRLIST	Cross-Listing
CRR	Corporate Responsibility Reporting
CSR	Corporate Social Responsibility
ECE	Environmental Capital Expenditures
EMH	Efficient Market Hypothesis
EMIS	Emissions
EMS	Environmental Management System
EPA	Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-know Act
ESG	Environmental, Social and Governance (Information)
EU ETS	European Union Emission Trading Scheme
FASB	Financial Accounting Standards Board

FT Global 500	Financial Times Global 500 (Index)
FTSE 500	Financial Times Stock Exchange 500 (Index)
GES	Global Ethical Standard
GHG	Greenhouse Gas
GHGRP	Greenhouse Gas Reporting Program
GICS	Global Industry Classification Standard
GRI	Global Reporting Initiatives
HFCs	Hydrofluorocarbons
IND	Industry type
IPCC	Intergovernmental Panel on Climate Change
KRX	Korea Stock Exchange
LEV	Leverage
LSE	London Stock Exchange
MM	Market Model
MVE	Market Value of Equity
N_2O	Nitrous Oxide
NI	Net Income
NYSE	New York Stock Exchange
O_3	Ozone
OLS	Ordinary Least Square (Regression)
PFCs	Perfluorocarbons
ROA	Return on Asset
ROE	Return on Equity
S&P 500	Standard and Poor's 500 (Index)
SD	Standard Deviation
SF_6	Sulphur Hexafluoride
SFF	Swedish society of financial analysts
SO_2	Sulphur Dioxide
TRI	Toxic Release Inventory
TSX	Toronto Stock Exchange
USD	US Dollars
VIF	Variance Inflation Factor

ABSTRACT

The ever-increasing greenhouse gases (GHGs) in the atmosphere has led to the phenomenon of climate change. In this scenario, industrial companies have one of the main contributions. As a result, there have been growing demand from stakeholders and general public for the disclosure of firms' GHG emissions and their carbon-related risks, opportunities and plans. In this regard, some previous studies have examined whether the disclosure of GHG emissions (or carbon emissions) is important for stock market participants. These studies use different sources of information and different methods to examine the relationship between carbon emissions disclosure and share prices. However, in spite of the increasing importance of firms' carbon-related information, there are not sufficient studies on this topic. In particular, Canadian context has received scant attention by researchers. The objective of our study is, therefore, to examine the stock market effects of Canadian firms' carbon emissions information.

We collected the emissions information of firms from the GHG Reporting Program (GHGRP). The GHGRP is a mandatory program in Canada and all facilities emitting 50000 tonnes or more of GHGs must report their total emissions to the program. Then, the emissions information of all reporting facilities is publicized on the website of *Environment and Climate Change Canada*. At the first step, we performed an event study to analyze whether the first-ever release of GHG emissions information in 2006 acted as relevant news for market participants. The results of the event study indicate that the first publication of GHG emissions information did not affect stock prices, and therefore did not provide unexpected and new information for investors.

At the second step, we aimed to assess the valuation-relevance of GHG emissions. To this end, a market valuation analysis, based on Ohlson's model (1995), was employed for the GHG emissions of public Canadian firms for the years of 2014, 2015 and 2016. The results of the valuation model reveal that the level of GHG emissions are value-relevant for investors and there is a negative relationship between GHG emissions and firm value. The negative association implies that investors use the total level of GHG emissions to assess future environmental liabilities. Our results indicate that for every additional tonne of GHG emissions, the firm value decreases by 71 dollars. Moreover, we find that the negative association between GHG emissions and firm value is more prominent for firms operating in low-GHG-emitting industries.

Our results provide some practical implications for the management of firms and accounting-standard setters. According to the economic consequence of GHG emissions (a decrease of 71 dollars per additional tonne of GHG emissions) reported in our study, managers should consider taking actions to control and to reduce the level of GHG emissions. Considering the valuation-relevance of GHG emissions, the standard setters could make policies and provide guidelines for firms to report carbon-related information in the financial statements.

Key words: carbon, greenhouse gases (GHG), emissions, carbon disclosure, market value, share prices.

RÉSUMÉ

L'augmentation des gaz à effet de serre (GES) dans l'atmosphère a entraîné le phénomène du 'Changement Climatique' et les entreprises industrielles jouent un rôle important dans ce phénomène. Par conséquence, les parties prenantes incluant les investisseurs et le public ont demandé plus d'information sur les émissions de GES des entreprises. À cet égard, plusieurs études ont examiné si la divulgation des émissions de GES était importante pour les participants du marché boursier. Ces études utilisent différentes sources d'information et différentes méthodes pour examiner l'association entre la divulgation des émissions de GES (carbone) et les cours boursiers. Cependant, malgré l'importance croissante des informations carbone, les études sur ce sujet sont insuffisantes. En particulier, le contexte Canadien a retenu peu d'attention des chercheurs. Notre étude a, donc, pour objectif d'examiner les effets des divulgations de carbone sur les cours boursiers des entreprises Canadiennes.

Nous avons recueilli les informations sur les émissions de carbone qui sont rapportées dans le cadre du «Greenhouse Gas Reporting Program (GHGRP)». Le GHGRP est un programme obligatoire au Canada et toutes les installations émettant 50000 tonnes ou plus de GES doivent déclarer leurs émissions totales au programme. Ensuite, les émissions de toutes les installations déclarantes sont publiées sur le site Web *d'Environnement et Changement climatique Canada*. À la première étape, nous avons fait une étude événementielle pour déterminer si la toute première publication d'informations sur les émissions de GES en 2006 constituait une nouvelle pertinente pour les participants du marché boursier. Les résultats de l'étude événementiel indiquent que la première publication d'informations sur les émissions de GES n'a pas

eu d'impact sur les cours boursiers et n'a donc pas fourni d'informations inattendues et nouvelles aux investisseurs.

À la deuxième étape, nous avons analysé le lien entre les émissions de GES et la valeur boursière des entreprises publiques. À cette fin, un modèle de valorisation, fondée sur le modèle d'Ohlson (1995), a été utilisée pour les années 2014, 2015 et 2016. Les résultats du modèle de valorisation révèlent que le niveau des émissions de GES est pertinent pour les investisseurs et qu'il existe une relation négative entre les émissions de GES et la valeur marchande de l'entreprise. Cette association négative implique que les investisseurs utilisent le niveau total d'émissions de GES pour estimer les passifs environnementaux futurs. Les résultats nous montrent que pour chaque tonne supplémentaire d'émissions de GES, la valeur de l'entreprise diminue de 71 dollars. De plus, nous constatons que l'association négative entre les émissions de GES et la valeur des entreprises est plus prononcée pour les entreprises opérant dans des secteurs à faibles émissions de GES.

Nos résultats ont des implications pratiques pour la gestion des entreprises et les normalisateurs comptables. Selon la conséquence économique des émissions de GES (une diminution de 71 dollars par tonne d'émissions de GES) rapportée dans notre étude, les gestionnaires devraient envisager de prendre des mesures pour contrôler et pour réduire le niveau des émissions de GES. Enfin, compte tenu de la pertinence des émissions de GES pour les investisseurs, les normalisateurs pourraient élaborer des politiques et fournir des lignes directrices aux entreprises pour la communication d'informations carbone dans leurs états financiers.

Mots clés : carbone, gaz à effet de serre (GES), émissions, divulgation de carbone, valeur marchande, cours boursiers.

INTRODUCTION

Climate change is a concerning issue in the present world and refers to the long-term shift in weather patterns, identified by changes in the average of temperature, winds, precipitations and some other indicators[1]. According to a report by the Intergovernmental Panel on Climate Change (IPCC), the global temperatures are now the highest since 1885 and they are expected to increase further by 6.4°C by the year 2100[2]. Moreover, due to climate change, sea levels are predicted to rise by 26-81 centimeters by 2100[2]. In Canada, over the period of 1948 to 2013, the average annual temperature has increased by 1.6°C, which is a higher rate of warming in comparison to other regions in the world[1]. The increase in the concentration of greenhouse gases (GHGs), mainly due to the human activities and burning of fossil fuels, is the major cause of climate change. GHGs exist naturally in the lower layers of Earth's atmosphere, being mainly composed of carbon dioxide (CO_2), water vapor, methane (CH_4), nitrous oxide (N_2O) and ozone (O_3)[3], to hold a portion of the infrared radiation of the sun. This natural process is called "GHG effect", which maintains the possibility of life on the Earth. However, since the industrial revolution in the 18th century, the amount of GHGs has increased significantly and, subsequently, the GHG effect has been amplified[3], holding extra portions of sun radiations resulting in the global temperature rise.

The important role of industrial companies in GHG emissions (also referred as carbon emissions) on one hand, and the attitude of global economy towards the idea of

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[1] https://www.canada.ca/en/environment-climate-change/services/climate-change/causes.html
[2] https://www.ipcc.ch
[3] http://www.mddelcc.gouv.qc.ca

sustainable development on the other hand, has created the new thinking of how companies address the issues related to climate change and global warming (Bimha and Nhamo, 2017). As a result, there is an increasing demand for firms to report their climate change strategies and carbon-related information (Luo and Tang, 2014). For instance, since 2002, institutional investors, by initiating the Carbon Disclosure Project (CDP), request the world's 500 largest firms annually to report voluntarily their GHG emissions, carbon-related risks and opportunities, and management strategies.

By introducing the role of industrial companies in climate change and the growing demand for carbon-related information, it is evident that firms' performance is not measured only by their financial bottom line, but also by their impact on the environment and more specifically, on climate change (Bimha and Nhamo, 2017). Some observers argue that because of the link between GHG emissions and climate change, there will be a redistribution of value from the firms which do not control their GHG emissions to the firms which reduce and control their emissions (GS Sustain 2009). The main research question of our study is therefore, whether there is a relationship between GHG emissions and the stock market value of firms.

A number of studies have attempted to examine the relationship between firm value and the level of GHG emissions. These studies, in general, conclude that there is a negative association between GHG emissions and market value of firms (Choi and Luo, 2017; Matsumura *et al.*, 2014; Baboukardos, 2017; Chapple *et al.*, 2013 and Clarkson *et al.*, 2015). Despite the growing interest in companies' carbon performance and carbon-related information, there is not sufficient studies on this topic. Moreover, the existing literature has been mostly conducted in the context of the US (Matsumura *et al.*, 2014; Johnstone *et al.*, 2008), Australia (Chapple *et al.*, 2013), Korea (Lee *et al.*, 2015), and European countries (Clarkson *et al.*, 2015; Brouwers *et al.*, 2016 and Baboukardos, 2017), and yet there is not an empirical evidence in the context of Canada. Finally, the majority of prior studies have considered the GHG emissions of

firms reported under two programs, (1) the Carbon Disclosure Project (CDP) which is a voluntary program (Griffin *et al.*, 2010; Matsumura *et al.*, 2014 and Choi and Luo, 2017), and (2) the cap-and-trade system, which is a mandatory jurisdiction (Johnstone *et al.*, 2008; Clarkson *et al.*, 2015 and Brouwers *et al.*, 2016). Therefore, other reporting programs have received less attention by researchers. Motivated by these gaps in the literature, the purpose of our study is to examine the impact of mandatory reporting of GHG emissions on the stock market value of public Canadian firms.

Since 2004, under the authority of Section 46 of the Canadian Environmental Protection Act, 1999 (CEPA 1999), all facilities emitting 50000 tonnes or more of GHGs must report their emissions annually to the government of Canada through the GHG Reporting Program (GHGRP)[4]. Then, the total levels of GHG emissions of facilities are publicized on the website of *Environment and Climate Change Canada*. We used these published GHG emissions of Canadian firms in our study. At the first step, we undertook an event study to examine whether the first public release of emissions information of 47 public Canadian firms in 2006 has triggered a significant stock market reaction. The results of the event study show that the public provision of carbon emissions of 2004 (published in 2006) did not result in a significant market reaction. At the second step, a modified version of Ohlson's equity-valuation model was employed to assess the valuation relevance of firms' GHG emissions of 2014, 2015 and 2016. The finding of our valuation model suggests that stock market participants take into consideration the level of GHG emissions in their valuation analysis and there is a negative association between carbon emissions and firm value (consistent with previous studies). We found that, on average, for every additional tonne of GHG emissions, the firm value decreases by 71 dollars (CAD). Moreover, we found that the negative association between GHG emissions and firm value is more pronounced for

[4] https://www.canada.ca/en/environment-climate-change/services/climate-change/greenhouse-gas-emissions/facility-reporting/about.html

firms operating in low-GHG-emitting industries. As a result, investors penalize GHG emissions of low-GHG-emitters more than high-emitting firms.

This study, in general, extends the literature on the relationship between environmental performance of firms and their market value. More specifically, our findings add and contribute to the growing literature on the stock market impacts of carbon disclosure in a number of ways. First, we provide empirically evidence on the valuation-relevance of GHG emissions, indicating that stock market participants care about carbon emissions of firms and use them as the proxy for future environmental liabilities (or implicit environmental liabilities). In addition, our results support the theoretical basis of Ohlson's equity-valuation model (1995) regarding the valuation-relevance of non-accounting information. Ohlson's model presumes that the stock prices reflect both accounting and non-accounting value-relevant information. Second, to our knowledge, this study is the first to examine the stock market effects of GHG emissions exclusively in the context of Canadian firms. Third, we attempted to examine the stock market effects of GHG emissions' public provision by the Canadian government, and the stock market impacts of the level of GHG emissions, at the same time. Fourth, we report the market valuation-relevance of GHG emissions which are reported under a mandatory reporting program. Therefore, the problem of self-selection bias existent in the voluntary reporting studies is not a problem in our study. And finally, our results indicate a considerable higher firm-value penalty for GHG emissions of firms operating in the low-GHG-emitting industries than high-emitting companies.

The remainder of our study is structured as follows. The next chapter (Chapter one) presents our review of the literature on the stock market impacts of both environmental disclosure and carbon emissions disclosure. Then, we provide the theoretical argument and development of our three hypotheses in Chapter two. We then explain our sample selection process, data sources and research design in Chapter three. Data analysis,

results and discussion are presented in Chapter four and finally, we conclude our study in the Conclusion section.

CHAPTER I

LITERATURE REVIEW

1.1 Introduction

The stock market impact of firms' environmental performance reporting has been an area of interest in academic literature during previous decades (Lorraine *et al,* 2004). Nevertheless, prior studies have focused on different perspectives of environmental reporting and have employed various data sources and different research methodologies. Therefore, trying to draw a general and conclusive result from the extant literature would be misleading.

In this chapter, based on the main purpose of our research, we review previous related studies under two major categories. The first category includes the literature on the stock market effects of environmental disclosure and the second category includes the literature specifically on the stock market valuation of carbon emissions disclosure. Then, articles in each category are explained and synthesized consistent with the same classification basis of environmental disclosure employed by Berthelot *et al.* (2003). Berthelot and her colleagues suggested that the environmental performance of companies is communicated to the stakeholders through three reporting channels: corporates voluntary reporting, external sources of disclosure, and corporates mandatory reporting.

1.2 Environmental disclosure and stock market value of firms

Financial statements are not the only sources of information for investors in their decision-making process (Berthelot *et al.*, 2003), and investors and other market participants need non-financial social and environmental information in their valuation analysis. The earliest empirical evidence mostly has shown the existence of a relationship between environmental disclosure and market value of firms; however, the results have been contradictory. Some studies have indicated that the environmental performance disclosure had a negative effect on firms' stock prices (Shane and Spicer, 1983 and Blacconiere and Patten, 1994), and in some articles the results have shown a positive effect of environmental disclosure on the market value of firms (Belkaoui, 1976). Some other studies, however, have not provided any evidence for the existence of relationship between the environmental disclosure and market value of firms (Freedman and Jaggi, 1986). In the following three sections, we will present the extant literature on the market value effects of voluntary, externally and mandatory environmental disclosure.

1.2.1 Voluntary environmental disclosure

Voluntary environmental disclosure of firms is not mandated by regulatory bodies and depends on the willingness of corporates' managers. This kind of disclosure can take several forms of reporting including disclosure in annual reports, separate sustainability reports, or any other reports produced by firms. Considering the heterogeneous nature of corporates voluntary disclosure, previous research on the valuation relevance of voluntary environmental reporting has produced mixed results. However, the evidence on the valuation relevance of firms' voluntary disclosure is predominant.

In the context of the US, Campbell *et al.* (2003), Freedman and Patten (2004) and more recently, Clarkson *et al.* (2013) investigated the incremental relevance of voluntary environmental disclosure over the information published by the Environmental Protection Agency (EPA). These studies find that voluntary reporting can increase firm value by mitigating the negative impact of their pollution performance revealed by the EPA. In more detail, Campbell and her colleagues (2003) examine the uncertainty-reduction role of environmental liabilities information available in footnotes and also in financial statements (as accruals) on the valuation of contingent Superfund liabilities[5] publicized by the EPA. According to the authors, the amount and timing of future contingent liabilities are uncertain and subject to future events. Therefore, the uncertainty-reducing role of accounting information in the context of contingent Superfund liabilities is examined in this study (Campbell *et al.,* 2003). The authors identify two sources (reasons) of uncertainty in estimating Superfund liabilities of each individual company. Uncertainty in the eventual cost of cleaning of a Superfund site (site uncertainty), and uncertainty of the portion of Superfund site cleaning allocated to an individual company (allocation uncertainty) (Campbell *et al.*, 2003). The authors posit that private information reduces uncertainties in Superfund liabilities estimation and hence, affects the stock market value of firms. In order to test their hypothesis, they utilize the extended version of the valuation model employed in the study of Barth and McNichols (1994).

Empirical analysis reveals that providing both accruals and footnote disclosures by firms, although costly, are value-relevant and have uncertainty-reducing role of contingent liabilities and mitigate the negative association (as shown by Barth and McNichols, 1994) between Superfund liabilities and firm value (Campbell *et al.,* 2003).

Freedman and Patten (2004), considering the Toxic Release Inventory (TRI) information published by the EPA, attempt to examine the impact of voluntary

[5] See the website of (https://www.epa.gov/superfund) for the details on Superfund sites.

environmental disclosure on the market valuation of TRI firms. Particularly, they investigate whether additional voluntary disclosure in 10-K annual reports of firms may reduce negative market reaction to the pollution performance of firms publicized through the TRI program. The authors use a daily market model which was also employed in the studies of Blacconiere & Patten (1994) and Brown & Warner (1985). The results of valuation analysis indicate that market reacts negatively to high-polluting firms and the results of content analysis of 10-K reports and its impact on the market reaction show that firms with lower extent of voluntary environmental disclosure face with a more negative market reaction compared to firms with more extensive voluntary disclosure. This study documents that companies use positive voluntary disclosure to manipulate the stakeholders' perception and reduce the market impact of actual pollution performance (Freedman and Patten, 2004).

In a more recent work, Clarkson *et al.* (2013), consistent with the same viewpoint of Campbell *et al.* (2003) and Freedman and Patten (2004), address the question of whether voluntary environmental disclosure of firms is incrementally informative over the TRI information. The authors argue that firms' voluntary environmental disclosure may be incrementally informative over TRI information for three reasons. First, TRI only provides information about the release of 600 pollutants, and do not provide information about other aspects of environmental performance of firms like energy efficiency, use of water and greenhouse gas (GHG) emissions. Second, TRI reveals firms' historical information and doesn't capture firms' current and future strategies. This is while firms can provide information about their environmental management system, future environmental protection commitment and also their environmental strategy of management. Third, corporates voluntary environmental disclosure may act as a competitive advantage driver, since it provides information about firms' innovative actions to improve operational efficiency, to reduce future pollution and to develop environmentally friendly new products (Clarkson *et al.,* 2013). The authors employ the valuation model of Ohlson (1995) for a sample of 195 firm-year observations. The

results of the valuation model indicate that firms' TRI ranking is negatively and significantly related to value of firms (consistent with Freedman and Patten, 2004) and voluntary environmental disclosure has incremental relevance to investors. This study suggests that proactive environmental strategy and signaling this strategy by transparent disclosure increases firm value (Clarkson *et al.* 2013).

The results of three studies (Campbell *et al.*, 2003, Freedman and Patten, 2004 and Clarkson *et al.*, 2013), although employing different valuation models and different kinds of voluntary disclosure, are consistently supporting the legitimacy theory (as suggested by Freedman and Patten, 2004). According to the results obtained, companies in order to mitigate the stock market impact of their negative environmental performance, tend to disclose more voluntary positive information to sustain their social and environmental performance without having to change their operations.

A series of studies in the context of European countries, show mixed results (Murray *et al.*, 2006; Cormier and Magnan, 2007; Moneva and Cuellar, 2009 and Schadewitz and Niskala, 2010). Schadewitz and Niskala (2010) address the research question of how communication via responsibility reporting affects shareholder value of Finnish firms. In order to answer their research question, the authors employ a conventional valuation model based on Ohlson's equity valuation model (1995). They use responsibility reporting of firms which have applied Global Reporting Initiatives (GRI) for 2002-2005. In Finland, since 2000, all listed firms which report their sustainability activities, have been applying GRI guidelines[6] (Schadewitz and Niskala, 2010). The results of this study show that the GRI sustainability reporting is value-relevant and act as an additional communication tool to decrease the informational asymmetry between

[6] Global Reporting Initiatives (GRI) which was introduced in 1997 was a big step in developing a global reporting framework for sustainability reporting of firms all around the world (Schadewitz and Niskala, 2010).

managers and investors. In conclusion, the GRI responsibility reporting provides more precise market valuation of firm (Schadewitz and Niskala, 2010).

Moneva and Cuellar (2009), using financial and non-financial environmental information in published annual reports of listed Spanish firms, investigate whether such information, being either voluntary or mandatory, are value-relevant. This study, hence, investigates the value relevance of voluntary and compulsory information at the same time. In order to measure the environmental performance of companies, the authors employ non-financial and financial indicators. For the non-financial indicators, environmental policy and environmental management system (EMS) information in annual reports are analyzed. For the financial information, three indicators are used: environmental assets (investments), environmental expenditures and environmental liabilities and contingencies (Moneva and Cuellar, 2009). The authors integrate the voluntary or compulsory nature of environmental information using two different periods: six years before introducing an obligatory environmental reporting regulation and three years after its introduction. In this study, the authors employ a valuation model based on equity-valuation model of Ohlson (1995). The results of this study, first, show that non-financial environmental information has no relationship with the market value of firms. In contrast the three financial indicators (environmental assets, costs and liabilities) have a negative impact on value of firms. The results also show that the compulsory environmental reporting increases the value relevance for only financial environmental information (Moneva and Cuellar, 2009).

With a different perspective, Cormier and Magnan (2007) investigate the impact of voluntary environmental disclosure on investors' evaluation of firms' earnings. The authors consider three different countries with widely different environmental reporting systems, socio-political systems and different institutional environments, to assess the impact of country-specific context on their analysis. To do so, they consider publicly traded firms in a common law country (Canada) and firms in two civic law

countries (Germany and France). Cormier and Magnan point to the results of earlier studies (Amir and Lev, 1996; Botosan and Plumlee, 2002), which showed that "investors rely on the non-financial information disclosure to assess the market value of firms' earnings". The authors, therefore, posit that voluntary environmental reporting enhances the market valuation of firms' earnings (Cormier and Magnan, 2007). The results of this study show that environmental reporting affects investors' valuation of firms' earnings and subsequently reduces the cost of equity in German firms, whilst its impact is statistically insignificant in Canada and France. The findings provide evidence that institutional environment may affect the value relevance of environmental reporting.

While the studies of Schandewitz and Niskala, 2010; Moneva and Cuellar, 2009 and Cormier and Magnan, 2007, show evidence of the valuation-relevance of voluntary environmental disclosure, Murray *et al.* (2006) finds no relationship between market value of firms and social and environmental disclosure in the UK's listed firms. The main argument in this study is to find evidence of whether managers are exhibiting wastefulness in voluntary disclosure of information or they are signaling their environmental competences (such as their awareness of potential environmental costs and their ability to manage them or their awareness of environmental liabilities) to stock markets (Murray *et al.* 2006). The authors consider the number of pages in annual reports allocated to social and environmental disclosure and also the results of a content analysis as variables for the voluntary disclosure of firms. Therefore, using longitudinal data for ten years of stock returns and four different cross-sectional analysis, they attempt to attribute any share prices behavior to the environmental and social disclosure of firms. The results of empirical analysis indicate no association between share prices and voluntary disclosure of social and environmental performance. According to the authors, one possible explanation for this result is that the disclosure in the annual reports is not detailed and precise to be value-relevant and to affect the decision-making of investors (Murray *et al.*, 2006).

In terms of the relevance of voluntary disclosure in developing countries, De Klerk and De Villiers (2012) attempt to examine the association between voluntary non-financial information disclosure and market value of firms in the context of South Africa. The main idea of this study is that the combination of non-financial and financial information may explain better the market attributes than only financial information (De Klerk and De Villiers, 2012). In this study, the authors use a different theoretical argument to support their hypothesis. Based on the information asymmetry aspect of the agency theory, they argue that investors and other market participants need environmental information of companies and the information on how managers address environmental risks, in their risk assessment and valuation process of firms. Therefore, environmental information can reduce information asymmetry and subsequently increase share prices, otherwise, the lack of environmental information will be considered as a negative implication of environmental performance of non-reporting firms (De Klerk and De Villiers, 2012). The authors therefore expect a positive relationship between environmental reporting level and share prices of companies. Moreover, the authors investigate the relationship between non-financial reporting and share prices in environmentally sensitive industries and other industries. They use modified Ohlson's model employed in Hassel *et al.* (2005) to examine the impact of corporate responsibility reporting (CRR) in share prices. The results of empirical analysis show a positive and significant relationship between CRR and market value of firms, implying that corporate responsibility reporting provides additional value-relevant information for market participants. The results, however, do not empirically support the idea of the difference between environmentally sensitive industries and other industries in value relevance of CRR (De Klerk and De Villiers, 2012).

A summary of findings of prior research on the market value effects of voluntary environmental disclosure is presented in Table A.1 of Annex A.

1.2.2 Externally environmental disclosure

Investors also rely on external environmental disclosure published in newspapers, financial journals, other media and governmental reports and not disclosed by the company itself (Berthelot *et al.*, 2003). This method of obtaining information, however, requests more time-investment from investors (Berthelot *et al.*, 2003). Earlier studies indicated that environmental information publicized in financial journals like the *Wall Street Journal* or the *New York Times* are value-relevant to investors (Shane and Spicer, 1983 and Bosch *et al.*, 1998). Empirical evidence on the valuation relevance of firms' environmental disclosure by governmental bodies reveals that investors consider the governmental reporting, when assessing the value of firms (Hamilton, 1995; Konar and Cohen, 1997; Cormier and Magnan, 1997; Khanna *et al.*, 1998; Lanoie *et al.*, 1998 and Connors *et al.*, 2013).

One area of interest in the research on the environmental reporting is the Toxic Release Inventory (TRI) information introduced by the Environmental Protection Agency (EPA) in the US. TRI provides resources on chemical releases and pollution prevention activities of the industrial facilities[7]. As noted by Hamilton (1995), the EPA uses innovatively the TRI information as a regulatory tool to control pollution performance of firms. According to the website of EPA, the TRI program is 'mandatory' and the industrial facilities must report annually their pollution performance to the program[8]. However, since in this program, the pollution performance of firms is ultimately publicized by the government, and consistent with the environmental disclosure classification of Berthelot *et al.* (2003), we put the literature related to the TRI information in the category of externally environmental disclosure. Empirical evidence, generally, show the valuation relevance of TRI information. In the previous

[7] https://www.epa.gov/toxics-release-inventory-tri-program
[8] https://www.epa.gov/toxics-release-inventory-tri-program/learn-about-toxics-release-inventory

section "voluntary environmental disclosure", we presented the two studies of Freedman and Patten (2004) and Clarkson *et al.* (2013), which primarily indicated the mitigating role of voluntary disclosure of firms on the negative stock market impact of TRI information. A number of studies, however, examine exclusively the valuation relevance of TRI information (Cohen, Fenn and Konar, 1995; Hamilton, 1995; Konar and Cohen, 1997; Khanna *et al.*, 1998 and Connors *et al.*, 2013)

For the first time, Hamilton (1995), attempts to investigate whether the first release of TRI information in 1989 is "news" for investors. According to the author, TRI information can act as relevant news only if the actual emission levels diverge from the expected emissions (Hamilton, 1995).

Hamilton employs the event study to analyze the market reaction to pollution performance of companies publicized through the TRI program in June 1989. The results of the event study show statistically significant negative abnormal returns and a loss of $4.1 million in stock value on the day of data release. Negative abnormal returns indicate the perception of investors about future environmental liabilities, regulatory and compliance costs and reputational risks for polluting firms (Hamilton, 1995).

Furthermore, a cross-sectional analysis shows that the market reaction is not related to the level of emissions, but to the number of chemical types released by companies. For every additional chemical of a firm reported through TRI, the firm's stock value dropped by $236,000 (Hamilton, 1995). According to Hamilton, the information on whether a specific chemical is released has more credibility than the level of emissions. Moreover, since the method of measuring the emissions was up to firms' choice, some firms reported a higher level of emissions than actual level in the first year of TRI and reported a lower level of emissions in the next years to show that they were engaged in pollution control activities (Hamilton, 1995).

Konar and Cohen (1997), based on the results of Hamilton (1995) which shows the stock market decline following the first release of TRI information, investigate whether the stock market drop is associated with subsequent emissions reduction by firms. Konar and Cohen show that only 11 of 40 highest-polluting firms (based on the TRI) experience significant negative abnormal returns. This finding provides evidence on the argument that a firm experiencing a significant change in market value does not need to be necessarily a polluting firm. In contrast, when the actual emissions are different from the expected levels, there is a negative market reaction (Hamilton, 1995; Konar and Cohen, 1997). Furthermore, the results of this study (Konar and Cohen, 1997) suggest that firms with a drop in their stock prices reduce significantly their emissions level and improve their environmental performance. This finding implicates that publicized environmental information can act as quasi-regulatory mechanism or as a substitute for environmental regulations (consistent with Hamilton, 1995).

The overall conclusion of Hamilton (1995) and Konar and Cohen (1997) is that investors react negatively to the pollution performance of firms in the first year of TRI information release in 1989. Furthermore, firms which are not known as "polluters" experience more negative abnormal returns than firms already being in polluting-firms group.

Following Hamilton (1995) and Konar and Cohen (1997), Khanna *et al.* (1998) further investigate the TRI information impact on the stock market value of a sample of chemical firms. In specific, the authors examine investors' reaction to the repeated provision of TRI information. The results of the event study show, first, that abnormal returns in the first release of TRI information in 1989 are negative but not statistically significant. This finding is justified in two perspectives. First, based on the evidence provided by Hamilton (1995) and Konar and Cohen (1997), since chemical firms are already known as polluters, therefore, their pollution levels are not new and surprising for investors. Second, according to Khanna *et al.* (1998), in the first year the pollution

data of firms are not as reliable as the subsequent years. The results, moreover, indicate that the repeated provision of TRI data during 1990-1994 increased the negative abnormal returns. The increase in negative returns is particularly for firms whose pollution performance worsened relative to the previous years and relative to other firms. In fact, the repeated TRI information acts as an environmental benchmark for investors (Khanna *et al.*, 1998).

Cohen, Fenn and Konar (1995) analyze the association between environmental performance and financial performance of S&P 500 firms. The environmental performance is measured using nine different variables including the TRI information, number of litigations, number of oil spills and other indicators (eight variables are selected from government's reports and one is selected from 10-K reports[9]). Based on the environmental variables, the authors rank firms of each industry category in 2 groups of "low-polluting" and "high-polluting" firms. Financial performance of firms is measured using return on assets (ROA) and return on equity (ROE) and also stock market returns. However, according to the authors, the stock market return is a better assessment of firms' financial performance, since stock market returns can't be manipulated and therefore, they are more comparable between firms (Cohen, Fenn and Konar, 1995). The results of empirical tests generally indicate that environmental performance of firms is positively associated with financial performance. This study reveals that the stock market returns are statistically significant and lower for high-polluting firms based on their TRI information for the year 1989, the year TRI information for the first time was publicized (Cohen, Fenn and Konar, 1995). This result is consistent with the findings of Hamilton (1995) and Konar and Cohen (1997).

The valuation relevance of TRI information was also evaluated recently by Connors *et al.* (2013). Their analysis is related to the market response to the emissions of firms in

[9] See the website of U.S. securities and exchange commissions for the details on 10-K filings: (https://www.sec.gov/fast-answers/answers-form10khtm.html).

three different industries: electric utility industry, chemicals and pulp and paper. The authors refer to the earlier studies which have considered only one industry (Khanna *et al.*, 1998), or different industries without categorizing the results in the context of industries (Hamilton, 1995 and Konar and Cohen, 1997). Connors and her colleagues argue that industries are different in environmental costs, environmental risks, social and political attention, technologies. Therefore, the stock market reaction to their pollution performance is likely to be different (Connors *et al.*, 2013).

Using the event study for a sample period of 2000-2005 (6 years), the authors examine market reaction around the days of TRI information releases. The authors find that market responses to the TRI information are different for different industries (as expected). In the electric utility industry, investors do not penalize increases in emissions but they award decreases of emissions. In contrast, in the chemical industry, investors penalize increases but do not reward decreases in emissions. The results do not show any market reaction to changes in emission levels in the pulp and paper industry. The findings of this study imply that investors find TRI information as a measure of environmental performance of firms depending on the industry type (Connors *et al.*, 2013).

In the Canadian context, some studies which are coincident with the TRI studies (1990s), examine the relationship between pollution performance of firms (published by the Canadian governmental agencies) and their market value (Cormier *et al.*, 1993; Cormier and Magnan, 1997 and Lanoie *et al.*, 1998).

Cormier *et al.* (1993), based on the ethical investor hypothesis[10], predict that firms with better (bad) environmental performance sell their shares at a premium (discount). The authors additionally argue that firms with bad environmental performance face with a

[10] This hypothesis implies that firms with good (bad) environmental performance should sell their securities at a premium (discount) because of high (lower) demand for their stock (Jaggi and Freedman, 1982).

decrease in future cash flows because they are more likely to buy pollution-control equipment. In addition, firms with bad pollution performance are likely to be subject of sanctions and penalties. Therefore, polluting firms face potential future environmental liabilities which may affect negatively their market valuation (Cormier *et al.*, 1993). The authors use the measure of firms' water pollution, published annually by the environment ministries of Quebec and Ontario, for the years of 1986, 1987 and 1988, and employ an accounting-identity based valuation model. The results show that relative pollution performance of firms is significantly and negatively associated with the stock market value of firms. This result implies the existence of potential environmental liabilities for polluting firms. The results, however, show that ethical investors do not bid down (up) the share prices of high (low) polluting firms, not supporting the ethical investor hypothesis (Cormier *et al.*, 1993).

Cormier and Magnan (1997) utilize the same environmental performance measure of Cormier *et al.* (1993), which is based on the water pollution of Canadian firms. Cormier and Magnan (1997) extend the study of Cormier *et al.* (1993) by taking a longer sample period (six years instead of three years), and also conducting industry-specific analysis to see if industry variation affects the relationship between pollution performance and market valuation of firms (Cormier and Magnan, 1997). The results of this study are consistent with the evidence provided by Cormier *et al.* (1993) and reveal that the stock market value of a firm decreases according to its poor environmental performance, indicating the existence of implicit environmental liabilities. In addition, this study shows that the relationship between environmental performance and value of firms is conditional on the industry type. In pulp and paper, chemical and oil refineries, poor environmental performers experience higher punishment from stock market participants (Cormier ad Magnan, 1997).

It should be taken into consideration, however, that in the two articles of Cormier *et al.* (1993) and Cormier and Magnan (1997), only one aspect of pollution performance

(water pollution) is analyzed, this is while the environmental performance is broader than only water pollution (Cormier and Magnan, 1997).

Some contradictory results are obtained by Lanoie *et al.* (1998) which also examine how investors react to the environmental information published by an environmental agency in Canada. The authors propose that public environmental disclosure of firms can act as an incentive for pollution control (as concluded by Hamilton, 1995 and Konar and Cohen, 1997). To support their proposition, the authors argue that firms usually trade-off the benefits and costs of pollution control and if expected penalties are lower than pollution abatement costs, firms decide not to allocate their resources to pollution reduction. In this case, we can think that penalties and fines are not the best solutions to improve firms' environmental performance. There should be therefore, other mechanisms (or incentives) to encourage firms to reduce their emissions. Hence, by providing public environmental information of firms, markets are expected to act as incentives for firms to improve their pollution performance. Nevertheless, the stock market reaction to public information happens only if the information is new and if they can change expectations of present value of firm's future profitability (Lanoie *et al.*, 1998).

Since 1990, the environment ministry of British Columbia publishes a list of pollutants every six month. The list includes two types of companies, out-of-compliance companies and of-concern companies (Lanoie *et al.*, 1998). In order to investigate how and to what extent investors react to firm's environmental performance and to see if they create a subsequent incentive for firms to reduce emissions, the authors conduct the event study for the first five reports of polluting firms published by the environment ministry of British Columbia. The results of event study do not indicate any negative abnormal returns, implying that firms' environmental performance was not new for the investors. The authors, moreover, examine the stock market impact of the two categories of pollutant firms (out-of-compliance and of-concern) separately. According

to the authors, the group out-of-compliance can be considered by investors as more threatening for the environment. In addition, the group of-concern can be considered as newer information than out-of-compliance, implying the possibility of negative returns for one of the groups. The empirical analysis, however, does not show any negative abnormal returns for neither of the groups (Lanoie *et al.*, 1998). As presented, the Canadian empirical work indicates mixed results. Previous studies focusing on the European firms also suggest inconsistent results (Hassel *et al.*, 2005, Semenova *et al.*, 2009, Lorraine *et al.*, 2004).

Hassel *et al.* (2005) investigate whether the environmental information enhances the valuation relevance of traditional financial statements information of the companies listed on the Stockholm Stock Exchange. The authors' argument is based on the statement of Swedish society of financial analysts (SFF) (2000), regarding the increasing importance of environmental information for investors and financial analysts: "*Environmental factors will increasingly influence the future cash flows of firms in both a positive and negative way. Equity valuation, credit analysis, and other economic decisions that involve financial analyses are based on forecasts of future earnings or cash flows. These forecasts are influenced by or complemented with sensitivity analysis and risk estimation. The opinion of the Society is that such estimation will be increasingly determined by environmental factors*" (SFF, 2000, p. 58; author's translation) (as quoted by Hassel *et al.*, 2005).

Consequently, Hassel and his colleagues assume that the environmental performance of firms provides additional value-relevant information for the investors and financial analysts. The authors, however, do not presume whether environmental performance affects positively or negatively the firm value. Nevertheless, they bring up the two different arguments on the relationship between environmental performance and shareholder value: the cost-concerned argument and the value-creation argument. According to the cost-concerned argument, environmental investment increases costs

and therefore, has a negative effect on earnings and a subsequent negative impact on share prices. On the contrary, the value-creation argument posits that environmental investment is incorporated with competitive advantages for firms and results in the increased value of firms (Hassel *et al.*, 2005). The authors use the modified version of Ohlson's model (1995) to examine the value relevance of environmental information. An environmental index developed by a Swedish company (*Caring Company Research AB*) is used to measure the environmental performance of sample firms. The information of this database is collected from annual reports or interim reports, or directly from contacting with firms. The index ranges from 0 to 3, higher score indicating better environmental performance. The results of regression analysis indicate that financial and environmental information are significantly associated with market value of equity. The results interestingly show a negative association between the environmental performance ranking and market value of firms, supporting the cost-concerned argument (Hassel *et al.*, 2005).

Semenova *et al.* (2009), investigate the relevance of environmental and social information in market valuation in the same context of Hassel *et al.* (2005) (Sweden). The authors argue that the variation in market value cannot be explained only by financial and accounting information. They presume that non-financial information including environmental, social and governance information (ESG) can also affect the market value of firms (Semenova *et al.*, 2009). The authors utilize a residual income valuation model and examine the association between market value of equity and environmental performance of Swedish firms. Environmental performance of firms is collected from *Global Ethical Standard* (GES) *Investment Services Risk Rating* database. The results indicate that environmental indicators are significantly and positively associated with firm value (inconsistent with Hassel *et al.*, 2005). One reason for the conflicting results of Hassel *et al.* (2005) and Semenova *et al.* (2009) may be attributed to using two different environmental performance indicators. Results obtained by Semenova *et al.* (2009) are coherent with the evidence provided by the

largest proportion of related studies. Moreover, Hassel *et al.* (2005) argue that the small sample of Swedish firms and the short time period may be the reasons for the different results on the association between environmental performance and share prices (Hassel *et al.*, 2005).

Lorraine *et al.* (2004), in a UK based research, consider a totally different proxy for the environmental performance, compared with the two other European studies (Hassel *et al.*, 2005 and Semenova *et al.*, 2009). The authors address the question of whether published news about fines imposed on pollutant firms and also commendations for environmental performance improvements affect stock market value of firms. The results of the event study indicate that there is only a significant negative stock market response to companies' bad news, especially one week after the event day. According to the authors, the reason of significant share prices movement on day t+7 (t = the day of the release of news) could be that after publishing the news about fines, investors also discuss with financial analysts and personnel of companies and therefore, it takes about one week to consider the implication of news about companies' environmental performance (Lorraine *et al.*, 2004).

Table A.2 of Annex A presents the summary of the literature on externally environmental disclosure discussed in this section.

1.2.3 Mandatory environmental disclosure

A part of environmental reporting is mandated by accounting regulators, governmental agencies, environmental bodies or other stakeholders, in the form of standards and regulations. Mandatory disclosure framework provides more coherent disclosure by all reporting firms and minimizes the informational asymmetry between investors and managers. Moreover, mandatory disclosure decreases the costs incurred by investors

in searching the information they need (Berthelot *et al.*, 2003). Previous studies, which are elaborated in the next paragraphs, suggest that the investors care about mandatory environmental reporting of firms and use it in assessing implicit environmental liabilities (Li and McConomy, 1999; Hughes, 2000; Clarkson *et al.*, 2004 and Bewley, 2005).

In 1990, the *Canadian Institute of Chartered Accountants* (CICA) in its handbook, added a new section with the title of "capital assets" to require mining and oil and gas companies to disclose their accrued liabilities for future site restoration and removal costs. Canadian accounting setters clearly stated that disclosing information about future removal and site remediation costs would provide useful and important information for the investors (Li and McConomy, 1999). However, the adopting time of the new regulation by firms was flexible, either before the determined adoption date, or after (Li and McConomy, 1999). Li and McConomy (1999) argue that different attributes of firms may impact the adoption timing of the new regulation. The authors attempt to define the determinants of adoption time by firms, further they investigate the valuation-relevance of mandated reporting of environmental liabilities. The empirical results of this study show that the new regulation has a big impact on disclosing future removal and site remediation costs by firms. Moreover, firms with greater environmental commitment (as disclosed in their annual reports), firms with superior financial performance, and firms with less uncertainty in their estimation of site restoration costs tend to adopt the new regulation earlier than its determined adoption date (Li and McConomy, 1999). Finally, the results of the valuation analysis, which is based on the models of Ohlson (1995), Barth and McNichols (1994) and Campbell *et al.* (1996), show that information on future removal and site remediation costs is value-relevant for investors. This result suggests that capital markets use future removal and site remediation costs as the proxy for future environmental liabilities (Li and McConomy, 1999).

In the US context, Hughes (2000) investigates whether the informational value of Sulphur dioxide (SO_2) emissions of electric utility firms changes with the introducing of a new environmental regulation; the 1990's Clean Air Act Amendment (CAAA). According to the 1990's CAAA, which was created to decrease the acid rains, the targeted high-polluting firms were required to reduce their SO_2 emissions by 1995. In order to reach the goal of CAAA, companies were allowed to trade allowances for SO_2 emissions (Hughes, 2000). The author examines the association between firm value and non-financial information of SO_2 emissions. According to Hughes, non-financial information can help investors to assess future environmental liabilities in their valuation analysis (Hughes, 2000).

The results of the valuation analysis indicate that the air pollution information (SO_2 emissions disclosure) of high-polluting firms targeted to the CAAA is value-relevant for investors, implying these firms' exposure to future environmental liabilities. Evidence provided by this study reveals a decline in the mean share price of targeted firms by 16 percent. The share prices of untargeted firms were unaffected by their emissions reporting (Hughes, 2000).

Consistent with the same perspectives of Li and McConomy (1999) and Hughes (2000), Bewley (2005) provides more evidence of the impact of financial reporting regulations on the valuation-relevance of environmental liabilities, in both US and Canadian firms. The author assumes that regulations issued from regulators with higher enforcement power have greater impact on the environmental liabilities' valuation. According to Bewley, the enforcement power of regulators depends on their power in imposing sanctions and penalties (Bewley, 2005). The author considers four financial reporting regulations for her analysis. In the US context, the two regulations of SAB.92 and SOP96-1 are chosen which have different enforceability powers (SAB.92 higher than SOP96-1). In the Canadian context, the two regulations used are S.3060 (with higher enforceability) and AuG19 (with lower enforceability) (Bewley, 2005).

Using a residual income valuation model adopted from Ohlson (1995), the author analyses differences in the market valuation of environmental liabilities pre-and-post of enacting the regulations. The results show that in both Canadian and US firms, there is an increase in the association between the value of firms and environmental liabilities, after introducing the new regulations. The enforceability argument, however, is more supported by results of the US firms (Bewley, 2005).

Following some accounting standards issued from the Financial Accounting Standards Board (FASB, 1989-1990), requiring firms to capitalize for their environmental capital expenditures (ECE), Clarkson *et al.* (2004) examine the market valuation of ECE reported by pulp and paper firms.

The authors firstly rank the sample firms and determine low-polluting and high-polluting firms based on their TRI information. Then, they employ a valuation model based on Ohlson's model (1995) to examine whether market participants assess the ECE in their valuation process. The valuation analysis reveals that the ECE is positively assessed by capital markets in low-polluting firms, and not in high-polluting firms. Moreover, the results show that investors use the environmental performance information of firms to evaluate implicit environmental liabilities of high-polluting firms (consistent with evidence provided by Li and McConomy, 1999, Hughes, 2000 and Bewley, 2005).

A summary of the literature on mandatory environmental disclosure is presented in Table A.3 of Annex A.

1.3 Carbon emissions disclosure and stock market value of firms

A number of studies have investigated the valuation-relevance of greenhouse gas (GHG) emissions (usually known as carbon emissions) for stock market participants.

These studies generally indicate a negative relationship between carbon emissions and market value of firms, however, with different perspectives, different sources of information and different research methods. In the next three sections, we will describe the literature on the capital market effects of mandatory, externally and voluntary reporting of carbon emissions.

1.3.1 Mandatory carbon disclosure

The European Union, in order to limit carbon emissions and to mitigate the impacts of climate change, initiated a cap and trade system, under the name of European Union Emission Trading Scheme (EU ETS) in 2005 (Hoffmann, 2007). Since then, some non-European countries also have implemented the emission trading schemes, including: Japan, Australia, US (California) and Canada (Quebec and Alberta) (Clarkson *et al.*, 2015). Nevertheless, the EU ETS is the largest multi-country ETS in the world (Clarkson *et al.*, 2015; Brouwers *et al.*, 2016). The EU ETS and other emission trading schemes work on the basis of cap-and-trade system. The European Commission defines the cap-and-trade system as follows.

"A cap is set on the total amount of certain GHGs that can be emitted by installations covered by the system. The cap is reduced over time so that total emissions fall. Within the cap, companies receive or buy emission allowances which they can trade with one another as needed. They can also buy limited amounts of international credits from emission-saving projects around the world. The limit on the total number of allowances available ensures that they have a value. After each year a company must surrender enough allowances to cover all its emissions, otherwise heavy fines are imposed. If a

company reduces its emissions, it can keep the spare allowances to cover its future needs or else sell them to another company that is short of allowances.[11]"

Under cap-and-trade systems, subjected firms are obligated to report annually their actual carbon emissions (verified emissions) and their emission allowances. Some authors investigate the association between carbon emissions, emission allowances and share prices of firms under the jurisdiction of EU ETS (Clarkson *et al.*, 2015; Brouwers *et al.*, 2016, Johnstone *et al.*, 2008). Clarkson *et al.* (2015) and Brouwers *et al.* (2016) find a negative relationship between allowance shortages and market value of firms, implying the existence of implicit environmental liabilities for firms with allowance deficiencies.

In more detail, Clarkson *et al.* (2015) posit that under cap-and-trade systems, firms' free allowances are not valued by stock markets. However, when carbon emissions of firms exceed their allocations, the capital markets react negatively to the allowance shortages (Clarkson *et al.*, 2015). The authors consider carbon emissions level as the proxy for firms' exposure to latent environmental liabilities. An equity-valuation model based on Ohlson (1995) is employed in order to examine the valuation-relevance of carbon emissions for a sample of 843 firm-year observations for 2006-2009. The authors include the three variables of total carbon emissions, emission allowances and allocation shortfalls in their valuation analysis. The results, first, show that there is a negative and significant association between total carbon emissions and firm value (consistent with the findings of Griffin *et al.*, 2010; Matsumura *et al.*, 2014 and Choi and Luo, 2017), inferring that the capital markets penalize firms based on their carbon emission levels. Furthermore, the results indicate that under the EU ETS the allocation shortfalls are value-relevant for the investors and there is a negative relationship

[11] https://ec.europa.eu/clima/policies/ets_en

between allocation shortfalls and firm value, however, the free allowances are not value-relevant (Clarkson *et al.*, 2015).

The authors also examine the valuation-relevance of voluntary reporting of carbon emissions through the Carbon Disclosure Project (CDP). They find that the carbon emissions reported under the EU ETS have a greater impact on the firm value compared to the carbon emissions disclosure through the CDP. This result implies that the carbon emissions disclosure under a mandatory reporting framework has more valuation-relevance than under a voluntary disclosure basis (Clarkson *et al.*, 2015).

Brouwers *et al.* (2016) argue that since carbon is priced in the EU ETS, it is a management issue and should be considered by investors in their valuation analysis. For example, firms with surplus allowances can sell the excess allowances or can inventory them for future uses and therefore this can positively affect their share prices. In contrast, firms with allowance shortages have to buy emission allowances from the companies having excess allowances. Therefore, investors may take into account the allowance shortages in their assessment of carbon liabilities and this process may affect negatively the value of firms (Brouwers *et al.*, 2016).

The authors consider eight verification announcement events of the first two phases of the EU ETS (three verification events for phase one and five events for phase two). During the verification events, verified emissions (actual emissions level) and the allocated emissions of firms are announced. The authors conduct an event study to assess the impact of the eight verification events of the EU ETS on the market value of 368 firms from 25 European countries. The results indicate that only the first announcements of each phase trigger significant market responses. According to the authors, the dropped price of carbon in subsequent years may explain the insignificant market response to the subsequent events (Brouwers *et al.*, 2016). The cross-sectional analysis indicates a negative association between allowance shortages and the stock prices. This result implies that allowance shortages are considered as carbon liabilities

for firms and thus decrease the stock market value of firms. The results moreover show that the negative relationship between stock prices and allowance shortages is more pronounced in carbon-intensive firms (Brouwers *et al.*, 2016).

Johnstone *et al.* (2008) attempt to examine the valuation-relevance of GHG emission allowances, however, at the time of their study data about the GHG emission allowances under the EU ETS has not been completely available. Therefore, the authors investigate the valuation-relevance of Sulphur dioxide (SO_2) allowances in SO_2 emission trading scheme in the US, which was initiated from 1995. According to Johnston and his colleagues, although SO_2 is not a GHG, there are similarities between SO_2 and GHGs. For example, emission trading schemes are implemented to reduce both SO_2 and CO_2 (carbon dioxide) emissions (or GHG emissions), and there are many similarities between SO_2 ETS in the US and the EU ETS (Johnstone *et al.*, 2008). Based on the main purpose of the article, this study is, therefore, included in the GHG studies of our literature review. The authors argue that the firms' excess emission allowances are considered as an asset by market participants for two reasons. First, firms can inventory emission allowances to use in future or sell them to other entities (consistent with the argument provided by Brouwers *et al.*, 2016). Second, since firms need to release the SO_2 emissions during their operations, with surplus emission allowances, firms can continue generating products to sell to the consumers. Therefore, stock market participants tend to value positively the emission allowances held by firms (Johnstone *et al.*, 2008). The results of the valuation model are consistent with the expectations and indicate a positive relationship between emission allowances and market value of the electric utility firms.

In a non-European context, Chapple *et al.* (2013) examine the Australian capital market's assessment of the proposed national ETS. The government of Australia, in March 2008, announced its intention on implementing a national ETS in Australia, at the time was supposed to be initiated in 2011. In this study, the authors based on the

results of previous industry-based research and academic research, discuss that a proposed national ETS may increase the environmental liabilities due to the increased future compliance costs, in particular for carbon-intensive firms (Chapple *et al.*, 2013).

The authors employ the event study to examine the stock market reaction to the five information events related to the proposed Australian ETS. Four of the events increased the likelihood of initiation of the national ETS and one of them decreased its likelihood. The authors hypothesize that firms with intensive carbon profile experience negative abnormal returns following the events of increasing the likelihood of ETS and experience positive abnormal returns with the events of decreasing the likelihood of ETS implementation (Chapple *et al.*, 2013). The results are consistent with the hypothesis and indicate negative abnormal returns following the events of increasing the likelihood of ETS and positive abnormal returns with the events of decreasing the likelihood of ETS. The results confirm that the stock market reaction is stronger for the carbon-intensive firms (Chapple *et al.*, 2013).

The UK's government in 2013, required all companies listed on the London Stock Exchange (LSE) to report their annual GHG emissions in annual reports for financial years ending on or after September 30, 2013. Baboukardos (2107) investigates whether the negative relationship between GHG emissions level and the firm value (as demonstrated by the literature) decreases with the introduction of a mandatory reporting regulation.

Using a linear price-level model and a large sample of 742 firm-year observations, the author examines the association between market value and GHG emissions level of firms listed on the London Stock Exchange (LSE) for 2011-2014 (the sample period including before and after the 2013 regulation, to see the impact of the new regulation on the association between carbon emissions and firm value). The results of the valuation model affirm that there is a significant negative relationship between carbon emissions level and the market value of firm. This result is consistent with previous

studies (Chapple *et al.*, 2013; Matsumura *et al.*, 2014; Clarkson *et al.*, 2015). Moreover, the results show that although the negative association remains significant and negative after the introduction of the 2013 regulation, it declines significantly, particularly for firms operating in carbon-intensive industries. The findings of this study suggest that a mandatory reporting regulation by governments may be considered by the investors as a signal for a decrease in future emissions (Baboukardos, 2017).

Table B.1 of Annex B summarizes the results of prior literature on mandatory carbon disclosure.

1.3.2 Voluntary carbon disclosure

Corporates' voluntary carbon communication is mostly through the Carbon Disclosure Project (CDP), which was initiated by the institutional investors in 2002. Carbon Disclosure Project (hereafter as CDP) is a consortium of over 650 investors with $87 trillion in assets in 2018[12] which created the largest global data collection system of self-reported environmental information. Every year, the CDP asks companies, cities, states and regions all around the world to report their environmental performance by answering several questionnaires. Firms can decide to respond or not to respond to the CDP request, however, the number of firms responding to the CDP questionnaires has been increasing every year. In 2018, over 7000 companies, 620 cities and 120 regions and states from 90 countries have participated in the CDP[12]. The CDP by analyzing firms' responses, creates detailed data on critical environmental risks, opportunities and impacts. So that investors, businesses and policy makers can use the data publicized on the website of CDP in their decision-making process[12].

[12] https://www.cdp.net/en/info/about-us

Considering the voluntary nature of disclosure through the CDP, a series of studies address the question of whether the act of firms' voluntary disclosure through the CDP is associated with changes in the stock market value of reporting firms (Kim and Lyon, 2011; Matsumura *et al.*, 2014 and Lee *et al.*, 2015).

Kim and Lyon (2011) examine the circumstances under which the CDP may be associated with increase in shareholder value for firms participating in the project. The argument of this work is based on the voluntary disclosure theory (Milgrom, 1981 and Verrecchia, 1983), which claims that firms decide to disclose their environmental performance only if they have good news to report. So, in the context of this study, the authors posit that firms participating in the CDP have superior environmental performance and therefore, disclosing such good news results in the increased shareholder value (Kim and Lyon, 2011). Moreover, the authors refer to the Russia's ratification of the Kyoto Protocol on October 22, 2004 and argue that such event can increase the regulatory threat. According to the authors, under the regulatory threats, firms which are better prepared (for example by participating in the CDP) for the regulation costs, experience increase in their shareholder value (Kim and Lyon, 2011).

The results of the event study for the first four CDP disclosures of the FT Global 500 firms show that participation in the CDP is not associated with increase in shareholder value. This result might imply that the investors are not interested in firms' environmental disclosure through the CDP. A more compelling explanation for this result is that participation in the CDP is not purely voluntary and firms face pressure from institutional investors and regulatory authorities to participate in the CDP. The results, however, show that with the Kyoto protocol's ratification in Russia, participation in the CDP has increased the shareholder value. Therefore, it is concluded that the CDP participation can increase the shareholder value only if the probability of environmental regulation increases. In this case, the investors consider the CDP participants as better prepared for the regulatory threats (Kim and Lyon, 2011).

Unlike most of the studies on carbon disclosure, which are in the context of western developed countries such as the US (Matsumura *et al.*, 2014, Griffin *et al.*, 2010) and Australia (Chapple *et al.*, 2013), Lee *et al.* (2015) examine the market value effects of carbon disclosure in a developing Asian country (South Korea). Korean firms started first to participate in the CDP in 2006 as the CDP Asia-ex Japan. However, in 2008, the CDP of Korea became independent and selected public firms listed on the Korea Exchange (KRX) index and requested them to report their carbon emissions, risks, and opportunities. In 2008, 16 of 50 requested firms responded to the CDP and in 2009, all 100 firms listed were requested by the CDP and 50 of them responded to the request (Lee *et al.*, 2015).

Lee and his colleagues use the CDP information of Korean firms for the years of 2008 and 2009, to see how firms' voluntary disclosure of carbon emissions affect their share prices. The authors posit that there is a negative relationship between carbon information disclosure and firm value, because the CDP is assumed to be a quasi-regulatory mechanism and the CDP sends its requests to the large firms with big environmental impacts. Hence, investors may recognize these firms as highly polluting firms which have to control and reduce their GHG emissions (Lee *et al.*, 2015).

The results of the event study indicate that the Korean capital market reacts negatively and significantly to firms' voluntary carbon disclosure through the CDP (consistent with the authors' proposition). This suggests that investors consider carbon disclosure of firms as bad news. The authors moreover investigate how firms can mitigate the negative impact of voluntary disclosure. To answer this question, Lee and his colleagues conduct a content analysis of Korean newspapers to find the frequency of carbon communication of sample firms through the media. The empirical results show that the regular carbon communication of firms through the media mitigates the negative market reaction to their carbon disclosure (Lee *et al.*, 2015).

Matsumura *et al.* (2014) examine the firm value effects of carbon emission levels and also the act of voluntary disclosure of carbon emissions through the CDP. The data of firms' carbon emissions are hand-collected form the CDP 2006-2008 (3 years) for the S&P 500 firms. Using a balance-sheet-based valuation model which was also employed previously by Campbell *et al.* (2003), the authors first examine firm value effects of carbon emissions. The results of the valuation analysis indicate that there is a negative and significant association between carbon emission levels and the stock market value of firms. For every additional one thousand metric tons of carbon emissions, value of the firms decreases by 212,000 dollars (USD) (Matsumura *et al.*, 2014).

Considering the result of the first analysis indicating the negative impact of carbon emissions on firm valuation, an important question is propounded by Matsumura and her colleagues. The question is that if market participants punish firms for their emissions, then why managers decide to voluntarily disclose their carbon emissions? The authors argue that managers evaluate costs and benefits of disclosure and choose to disclose only if the benefits outweigh the costs. According to the authors, the reasons for voluntary carbon disclosure are to reduce informational asymmetry between managers and stakeholders and to avoid investors to consider non-reporting firms as high-pollutants. Based on this argument, the authors additionally investigate the impact of the act of voluntary carbon disclosure on the stock market value of firms.

The empirical evidence indicates that the value of disclosing firms is higher (2.3 billion dollars higher) than the value of comparable non-disclosing firms. This finding implies that the stock markets penalize firms both for their carbon emissions and also for not disclosing their emissions (Matsumura *et al.*, 2014).

Griffin *et al.* (2010) and Choi and Luo (2017), based on multi-country data, both document a significant and negative relationship between stock market value of firms and carbon emissions, consistent with Matsumura *et al.* (2014).

Griffin *et al.* (2010) use the carbon emissions data from the CDP, for S&P 500 firms for a four-year period (2006-2009) and also for the large TSX (Toronto Stock Exchanges) 200 firms for a five-year period (2005-2009). At the first stage, the authors use a GHG prediction model to estimate the carbon emissions of non-CDP participants, based on their operating features and their industry types. This increased the sample size from 1083 of only the CDP participants to 2917 of the CDP participants and non-participants.

At the second stage, a residual income valuation model based on Ohlson (1995) is used to assess the valuation-relevance of GHG emissions information. The results of valuation analysis show that there is a negative relationship between carbon emission levels (predicted and actual) and the stock prices and this negative association is stronger for carbon-intensive industries. The results imply that investors take into account the carbon emissions information, whether disclosed or not, in their firm value assessment (Griffin *et al.*, 2010).

In a newly published work, Choi and Luo (2017) discuss that the earlier studies have used different proxies for the implicit environmental liabilities such as the Superfund sites' clean-up costs (Barth and McNichols, 1994), water pollution scores (Cormier and Magnan, 1997) and SO_2 emissions (Hughes, 2000). According to Choi and Luo, carbon emission levels can also act as the proxy for implicit environmental liabilities in evaluating the value of firms. The authors utilize carbon emissions data collected from the CDP for 2008-2015 of Global FTSE 500 firms and a developed valuation model of Ohlson (1995). The results show a negative association between market value of reporting firms and carbon emissions levels, inferring that polluting firms are penalized by the stock markets. The results also indicate that the negative market impact of carbon emissions is more dominant in countries with a national ETS and also in countries with more stringent environmental regulations. However, a good corporate governance can mitigate the negative impact of carbon emissions. Firms with good

corporate governance may have higher capabilities to control carbon related risks in comparison with firms with poor corporate governance (Choi and Luo, 2017).

A summary of voluntary carbon disclosure literature is presented in Table B.2 of Annex B.

1.3.3 Externally disclosure of carbon emissions

Previous studies on the market valuation of externally non-firm carbon disclosure have shown conflicting results. While Hsu and Wang (2012) show negative stock market reactions to the firms' climate-change related actions, Beatty and Shimshack (2010) indicate stock market punishment for firms with lower climate-change related actions.

Hsu and Wang (2012) examine if corporates' responses to climate change is valued by the investors. This study is based on the argument of whether corporate social responsibility (CSR) and also corporates' actions against climate change increase their shareholder value. On one hand, some believe that combating against climate change puts firms in a competitive and economic disadvantage and firms may experience a decrease in shareholder wealth. On the other hand, based on empirical evidence, climate-change-related actions can increase shareholder value because firms can eventually reduce future compliance costs and can improve their social image (Hsu and Wang, 2012).

The authors conduct their empirical analysis based on the US firms' coverage in the *Wall Street Journal* for the sample period of 1989-2008, to have information on firms' responses to climate change. Using the cross-sectional event study and a valuation model based on Ohlson (1995), this study indicates that capital markets react positively to negative words about firms' climate change responses, however, this positive reaction is mitigated for high-polluting firms. The results imply that investors consider

the costs of combating against climate change higher than its benefits. Hence, investors perceive the firms' decisions regarding not to reduce carbon emissions as good news. Additionally, the results implicate that firms in environmentally-sensitive industries face a greater pressure from regulators, and hence, are exposed to higher compliance costs. Therefore, the market's reaction to negative media coverage of polluting firms is less positive than firms in non-environmentally sensitive industries (Hsu and Wang, 2012).

Beatty and Shimshack (2010) consider companies' climate-change-related ratings publicized on June 19, 2007 by a non-profit environmental organization named *Climate Counts*. Firm-level ratings are based on companies' plans for measuring, reporting and reducing the GHG emissions, including qualitative and quantitative scores based on 22 criteria (Beatty and Shimshack, 2010). The authors investigate the association between stock market value and environmental ratings of a sample of 47 firms. Beatty and Shimshack mention that the firms rated by the *Climate Counts* do not influence their ratings and hence, the ratings are exogenous from firms' perspectives. Therefore, the problem of self-selection and self-reporting biases, which is common in environmental disclosure related research, is minimized in this study.

The findings show that the ratings by the *Climate Counts* have a valuation-relevance for the investors and firms with lower ratings experience a penalty from capital markets. The results show a market valuation drop by 0.6-1.6%, indicating a value decrease of 2.7 to 7.2 billion dollars for firms with lower ratings. However, the empirical results do not suggest the stock market benefits for the firms with higher ratings. In general, findings of this study implicate that the capital markets penalize firms for poor environmental performance but do not award the better environmental performers (Beatty and Shimshack, 2010).

Table B.3 of Annex B presents the summary of the literature on external carbon disclosure.

CHAPTER II

HYPOTHESIS DEVELOPMENT

The main research question of our study is whether the disclosure of public Canadian firms' carbon emissions affects their stock prices. In order to answer our research question, we develop several hypotheses according to the theoretical frameworks and empirical backgrounds. Our first hypothesis assumes that the first release of Canadian firms' GHG emissions information, in 2006, results in the stock market reaction. The second and third hypotheses relate to the association between the level of carbon emissions and firm value and the impact of industry differences on their relationship. The development of each hypothesis is explained in detail in the next sections.

2.1 The role of public information as a quasi-regulatory mechanism

Governments are considered as one of the most influential stakeholders because of their regulatory and enforceability power. Governments, by passing laws and regulations, can force companies to evolve their strategies into the strategies focusing on both the environmental and societal issues (Lee *et al.*, 2015). However, according to Lanoie *et al.* (1998), when a non-compliance is found, the fines and penalties are too low for some companies to control their pollution performance. In more detail, profit-maximizing companies usually trade-off the costs and benefits of pollution reduction investments. Companies choose not to invest in pollution abatements if the costs of

penalties and fines are lower than the investment costs. Environmental penalties, hence, cannot act as the best solutions of governments to control the pollution performance of firms. This is while the total annual amounts of environmental fines imposed by regulators in Canada are much lower than the penalties in the US (Lanoie *et al.*, 1998). There should be, therefore, other mechanisms to create incentives of firms' pollution control.

During the past decades, governments use the publicized information on firms' environmental performance as a regulatory or quasi-regulatory mechanism. Konar and Cohen (1997) particularly refer to the President Clinton's decision on issuing the "Reinventing Environmental Regulation" report. In this report, the president Clinton has underlined the power of information in creating significant changes in the quality of the environment (Konar and Cohen, 1997). However, public provision of information can act as an alternative for regulations if it affects the financial performance of firms and in particular, their stock market performance. Indeed, if providing information can cause investors to change their portfolios, it provides market-based incentives for firms to improve their environmental performance (Lanoie *et al.*, 1998 and Konar and Cohen, 1997).

One example of reporting the environmental performance of firms to the public and using it as a regulatory mechanism is the Toxic Release Inventory (TRI) program initiated by the Environmental Protection Agency (EPA), in the US. In 1986, the Congress passed the section 313 of the Emergency Planning and Community Right-to-Know Act (EPCRA)[13]. Under the provision of the EPCRA, the EPA required industrial facilities which manufacture, process or use a threshold amount of 300 chemicals, to report their emissions through the program of TRI. Currently, there are more than 650 chemicals covered by the TRI program[13]. The list of reportable chemicals can vary from year to year, because the EPA makes changes in the list through the annual

[13] https://www.epa.gov/toxics-release-inventory-tri-program/learn-about-toxics-release-inventory

reviews[13]. A series of studies examine the stock market responses to the TRI information. Hamilton (1995) argues that governments use the public information as pollution-control programs to encourage firms to improve their environmental performance. Following the public provision of information, firms decide to decrease their emissions because of reputational risks, potential environmental liabilities, and future pollution abatement costs. Hamilton assumes that the market reaction to the first release of TRI information in 1989 depends on the extent to which this information is new and unexpected to the investors. This study shows that the firms reporting to the TRI program experience significant negative abnormal returns on the day of the first release of the information. The findings indicate the changes in investors' expectations of future environmental costs upon the release of TRI information.

Konar and Cohen (1997), Khanna *et al.* (1998) and Connors *et al.* (2013) refer to the efficient market hypothesis (EMH) (Fama, 1970), which is mostly used in the finance literature. The efficient market hypothesis (EMH) assumes three types of efficient markets; weak, semi strong and strong form. In the weak form of efficient markets, the information available to the capital market participants is just the historical prices. In the semi-strong form of markets, the stock prices reflect the obviously public information such as stock splits and annual earnings announcements. Finally, in the strong well-functioning markets, stock prices fully reflect all the information available about the present value of expected future profits (Fama, 1970). We consider that the information on firms' pollution performance may act as relevant information for the investors in efficient markets. However, according to Konar and Cohen (1997) and Khanna *et al.* (1998), providing new information about the pollution performance of firms may cause changes in stock prices only if the new information is different from the investors' expectations and if the investors perceive that the new information can ultimately affect the profitability of firms.

Konar and Cohen (1997), consistent with Hamilton (1995), report a significant negative market reaction to the first release of TRI information in April 1989. Khanna *et al.* (1998), however, do not report any significant market reactions to the first release of TRI information. The analysis of Khanna *et al.* (1989) is in the context of chemical firms, and the authors argue that the reason for insignificant market response could be that sample firms were already known as polluting firms and therefore their TRI information was not new and surprising for stock market participants. The results of Khanna *et al.* (1998) indicate that the repeated publication of the TRI information in the years 1990-1994 created significant negative abnormal returns, implying that the TRI data acted as a benchmark for the investors. Recently, Connors *et al.* (2013) showed that the market reaction to the TRI information are different for the different industry types.

In general, studies investigating the valuation-relevance of TRI information suggest that the TRI information are new for the investors, in particular, upon the first release in 1989. These studies confirm that the investors use the new information of firms' environmental performance in their valuation analysis and this consequently affects the stock prices and market returns.

In the Canadian context, Lanoie *et al.* (1998) also refer to the regulatory role of public information. The authors examine the stock market effects of the pollution performance information published by the environment ministry of British Columbia (BC). The environment ministry of BC publishes a list of polluting firms every 6 months. The results of this study, however, do not show any significant abnormal returns following the publication of the list of polluting firms. The authors discuss that the information published by the environmental ministry of BC was not new and unexpected for the investors. The study of Lanoie *et al.* (1998) differs from the articles related to the TRI program in two aspects. First, the TRI program includes almost all the manufacturing facilities all around the US. This is while the companies covered by the environment

ministry of BC perform only in the British Columbia province of Canada. Second, the reports of the environment ministry of BC provide a smaller range of pollution performance of firms than the TRI program.

The Canadian government, since March 2004, required all facilities to report annually their greenhouse gas (GHG) emissions (or carbon emissions) through the GHG Reporting Program (GHGRP). This reporting program is initiated under the authority of Section 46 of the Canadian Environmental Protection Act, 1999 (CEPA 1999), and aims at assessing and monitoring Canada's environmental performance. All facilities that emit 50000 tonnes or more of GHGs (a threshold of 10000 tonnes from 2017) are obligated to report their emissions the government by the annual June 1st reporting deadline[14]. Each year, the Canadian government publishes the information about companies' carbon emissions on the website of *Environment and Climate Change Canada*.

The GHGRP of Canadian government is similar to the TRI program. The two programs are initiated by the governments to substitute for environmental regulations and to control the environmental performance. Moreover, both the TRI and the GHGRP are mandatory programs[15]. Connors *et al.* (2013) and Moneva and Cuellar (2009) argue that in mandatory reporting programs like the TRI and the GHGRP, firms are required to report their pollution performance (or environmental performance) to the governmental agencies, and then the government publishes all the reported information at the same time. This process limits companies' influence on the timing and type of disclosure (unlike the voluntary disclosure). Therefore, mandatory reporting programs provide unbiased, uniform and consistent information to the public (Connors *et al.*, 2013; Moneva and Cuellar, 2009). However, even under the mandatory reporting

[14] https://www.canada.ca/en/environment-climate-change/services/climate-change/greenhouse-gas-emissions/facility-reporting/about.html
[15] https://www.epa.gov/toxics-release-inventory-tri-program/learn-about-toxics-release-inventory

programs, the responsibility of measuring the emissions are the duty of firms and therefore, governments cannot monitor the measurement process.

According to the results and arguments provided by previous studies (Hamilton, 1995; Konar and Cohen, 1997; Khanna *et al.*, 1998; Lanoie *et al.*, 1998 and Connors *et al.*, 2013), and the efficient market hypothesis (EMH) (Fama, 1970), we assume that the mandatory reporting of GHG emissions (carbon emissions) and publishing them by the Canadian government affect the stock prices of reporting firms for two reasons. First, since there has not been any other carbon emissions reporting program in Canada before the GHGRP, the information of the GHG emissions of firms are quite new for the investors. Investors, therefore, use such unexpected information in their assessment of firm value. Second, the mandatory reporting program provides a homogeneous set of public information and therefore, facilitates the analysis and the comparison of the environmental performance of firms. Based on the provided argument, the first hypothesis is established as follows:

H_1: There is a stock market reaction to the first release of carbon emissions information of Canadian firms through the GHGPR in 2006.

2.2 The impact of environmental liabilities on the stock market value of firms

While the act of environmental disclosure is important and has been the subject of some previous research, the environmental performance of firms included in mandatory, voluntary and public reports is also of interest by researchers. Cormier *et al.* (1993), Cormier and Magnan (1997), Cohen, Fenn and Konar (1995) and Semenova *et al.* (2009), using different aspects of pollution performance, report a negative association between the pollution level of firms and their stock market values. These studies document that the worst pollution performance of firms, the lower their market

valuation. With regards to the carbon performance of firms, the empirical evidence reports also a negative association between carbon emissions and the market value of firms (Griffin *et al.*, 2010; Matsumura *et al.*, 2014; Clarkson *et al.*, 2015; Baboukardos, 2017 and Choi and Luo, 2017).

Most of the studies on the valuation-relevance of firms' environmental performance bring up the concept of implicit environmental liabilities. Implicit environmental liabilities are the environmental costs and losses a company is expected to incur in the future but are not accounted for in the current financial statements. These costs include direct expenses (such as legal fees and fines) and indirect expenses (such as pollution control costs and prevention costs) (Cormier and Magnan, 1997). In addition, according to Karpoff and Lott (1993), except for the direct and indirect costs, firms' poor environmental performance may create the phenomenon of "reputational penalty". This phenomenon implies that the polluting firms are likely to face with higher input prices, lower output prices and may have difficulty in relocating their plants because of their pollution records.

In the Canadian context, Cormier *at al.* (1993) and Cormier and Magnan (1997) use the water pollution performance of Canadian firms published by the environment ministries of Quebec and Ontario, as the proxy for implicit environmental liabilities. These two studies indicate that there is a negative association between pollution performance and stock market valuation of firms. The results imply that stock market participants use the pollution performance of firms to evaluate the potential environmental liabilities.

Hughes (2000) uses the non-financial measures of SO_2 emissions as the proxy for implicit environmental liabilities. According to Hughes, non-financial information can help investors in assessing implicit environmental liabilities. The results of this study indicate that the SO_2 emissions of high-polluting firms are value-relevant for the investors, implicating firms' exposure to future environmental liabilities. Clarkson *et*

al. (2004) document that the investors use the information on the environmental capital expenditure (ECE) of high-polluting firms to evaluate the implicit environmental liabilities. According to Clarkson *et al.* (2004), these environmental liabilities represent future abatement costs incurred by high-polluting firms.

More recently, some authors have considered carbon emissions as the proxy for future environmental liabilities. Chapple *et al.* (2013) argue that a proposed national Emission Trading Scheme (ETS) in Australia, may increase environmental liabilities due to the increased future compliance costs. This study indicates that there are negative abnormal returns following the published news of initiating the national ETS, implying the increased probability of environmental liabilities for the Australian firms subjected to the proposed ETS.

Brouwers *et al.* (2016) argue that investors may take into account the emission allowance shortages of firms subjected to the European ETS (EU ETS) in their assessment of carbon liabilities and this process may affect negatively the value of firms. The authors find that when there is an allowance shortage (verified emissions surpassing the allocated emissions), the stock prices decline. This result is consistent with the view that allowance shortages are considered as carbon liabilities by the investors.

Clarkson *et al.* (2015) investigate the impact of carbon emissions on the stock market value of European firms subjected to the EU ETS. The authors consider the carbon emission levels as the proxy for firms' exposure to latent environmental liabilities. The results show that there is a negative and significant association between total carbon emissions and the firm value, which infers that capital markets penalize firms based on their total carbon emission levels.

Choi and Luo (2017) refer to the earlier studies on the valuation-relevance of environmental liabilities and mention that the earlier studies have used different proxies

for the implicit environmental liabilities; Superfund sites' clean-up costs (Barth and McNichols, 1994), water pollution scores (Cormier and Magnan, 1997) and SO_2 emissions (Hughes, 2000). Choi and Luo argue that carbon emissions can also act as the proxy for implicit environmental liabilities and higher levels of carbon emissions may indicate higher future environmental liabilities. The results of the study of Choi and Luo (2017) show that the firm value is negatively associated with the carbon emissions level of firms, implying that carbon emissions are related to the environmental liabilities.

All of these studies suggest that investors use the pollution performance and the carbon performance of firms to assess the magnitude of future environmental liabilities. The results, in general, indicate that investors discount share prices based on the implicit environmental liabilities.

Consistent with the results of previous studies, we posit that carbon emission levels of Canadian firms also act as the proxy for future environmental liabilities. These environmental liabilities affect ultimately the stock market value of firms for 3 reasons. First, companies with higher carbon emissions are likely to incur costs related to changing their production process into an eco-friendlier process. Second, high-emitting firms are likely to be subjected to extra taxes, penalties, and sanctions from the governmental bodies. And third, pressures from environmental agencies, environmental activists, government, consumers, and other stakeholders on measuring, reporting and monitoring carbon emissions would impose extra costs on the firms. These costs are not accounted for in the current financial statements, but will affect future cash flows and future profitability of firms. Investors, hence, discount share prices based on the level of carbon emissions. In line with these arguments, we propose the second hypothesis as follows:

H_2: There is a negative relationship between carbon emissions and the stock market value of public Canadian firms.

The industry difference effects on the valuation-relevance of environmental performance are investigated in prior studies. Cormier and Magnan (1997), using the water pollution measures of Canadian firms, show that the stock market value of a firm decreases according to its poor environmental performance. This study also indicates that the negative relationship between firm's environmental performance and its stock market value is conditional on the firm's industry type. In the pulp and paper, chemical and oil refineries, which are known as polluting industries, the poor environmental performers are more punished by stock market participants.

In order to examine the stock market effects of environmental performance, a number of studies consider only one type or some specific types of industries in their analysis. For example, Khanna *et al.* (1998) consider the firms in the chemical industry to study the investors' reaction to the repeated public provision of the TRI information. According to Khanna *et al.* (1998), chemical industry firms in the US accounted for 53% of toxic releases reported by the TRI in 1989. Clarkson *et al.* (2004) investigate the market valuation of environmental capital expenditure (ECE) in the pulp and paper industry. Campbell *et al.* (2003) examine the uncertainty-reduction role of private information in estimating the environmental liabilities in the chemical industry. Hughes (2000) investigates the valuation-relevance of SO_2 emissions in the electric utility firms. And finally, Connors *et al.* (2013) examine the differences in the market responses to the TRI information in three different industries: the electric utility industry, chemicals, and pulp and paper. These studies, in general, show that the investors' assessment of environmental performance depends on the sector of activity of firms.

According to the *Environment and Climate Change Canada*, firms operating in three sectors of oil and gas, transportation and electricity are Canada's largest-GHG-

emitters[16]. These three industries, together, account for 50% of GHG emissions in Canada. Considering that companies in these sectors of activity (known as high-GHG-emitting industries) are likely to be different from companies operating in other industries (low-GHG-emitters), in terms of environmental costs, environmental risks, social and political attention and technologies, we assume that the valuation-relevance of carbon emissions is different in these two groups of industries. Consequently, the third hypothesis is suggested as follows:

H_3: Companies' sector of activity changes the relationship between GHG emissions and the stock market value of public Canadian firms.

[16] https://www.canada.ca/en/environment-climate-change/services/environmental-indicators/greenhouse-gas-emissions.html

CHAPTER III

RESEARCH METHODOLOGY

As discussed in the previous chapters, the research question of our study is to examine whether carbon emissions (GHG emissions) of publicly-traded Canadian firms affect their stock prices. Hence, we developed three hypotheses to be able to answer the research question. In this chapter, we discuss the methods that we use to test our hypotheses and the justification of employing these methods. At first, the sample selection procedure and the data sources are presented in detail. Then, the event study methodology and the market model are explained. Finally, we present the equity-valuation approach in the last section of the chapter.

3.1 Sample selection

The targeted sample of our research consists of public Canadian firms which have participated in the Greenhouse Gas Reporting Program (GHGRP) for the years 2004, 2014, 2015 and 2016. Since 2004, the Canadian government publishes annually the list of all facilities emitting 50 kilotons or more of GHGs. As a result, the public firms which have reported their GHG emissions of 2004 to the GHGRP, consist our sample firms to test the first hypothesis. The hypothesis H_1 of our study assumes that there is a market reaction to the first public provision of firms' GHG emissions information. In order to test our second hypothesis suggesting that there is a negative association

between GHG emissions and firm value, we choose three years of 2014, 2015 and 2016 to get the results of the most recent data available on GHG emissions of Canadian firms. The GHG emissions are reported at the facility-level and not at the firm-level. However, each facility name is associated with the company and the parent company's information. At first, we identify the name of all emitting companies and investigate whether the companies can be included in our sample. The companies in order to be included in the sample must fulfil following criteria:

1- should be headquartered in Canada,
2- should be listed on the Toronto Stock Exchange (TSX),
3- should not operate in the sector of financial services.

Considering these conditions, foreign-owned and privately-held companies and also companies operating in financial services are eliminated from the sample. As a result, we identify 47 public firms which have reported their GHG emissions of the year 2004 to the government and did not have any confounding event with our event of interest. This is the final number of firms after examining the availability of their market-based data. Our sample firms for the second and third hypotheses consist of 68 public Canadian firms which have complete set of accounting-based data and have reported their GHG emissions of at least one of the years 2014, 2015 and 2016. Ultimately, we identify 182 firm-year observations to test our second and third hypotheses.

Table 3.1 presents the names and the sectors of activity of sample firms for the test of first hypothesis and Table 3.2 indicates our final sample firms for the test of second and third hypotheses. Firms' sectors of activity are determined using the Global Industry Classification Standard numbers (GICS numbers), which are extracted from *Compustat* database. The GICS is an industry classification developed by the MSCI

Inc. and *S&P Dow Jones*, and consists of 11 sectors, 24 industry groups, 69 industries and 158 sub-industries[17].

3.2 Data sources

Data related to the GHG (carbon) emissions of sample firms are collected from the reports published by the *Environment and Climate Change Canada* on their website. However, as it is mentioned in the previous section, the GHG emissions for each year are reported at the facility-level. Therefore, we identify all the facilities of each company and compile the emissions of facilities at the firm-level. The total GHG emissions are the sum of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6) emissions[18].

For the event study, the historical daily stock prices of the sample firms are obtained from *Compustat- North American daily updates* database. *Compustat* is a comprehensive database which includes the fundamental financial, market-based and statistical information of active and inactive companies around the world. With regards to the equity valuation model, data for the measurement of dependent and independent variables are gathered from *Compustat Annual Updates- Fundamentals Annual.* Complementary information regarding the data and samples are explained in the subsequent sections.

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[17] https://www.msci.com/gics

[18] https://www.canada.ca/en/environment-climate-change/services/climate-change/greenhouse-gas-emissions/facility-reporting/overview-2016.html

Table 3.1 Sample firms for the test of first hypothesis (GICS numbers are presented for each company)

Company	GIC Numbers	Company	GIC Numbers	Company	GIC Numbers
1. Abitibi-Consolidated	151050	17. Fording	151040	33. PrimeWest Energy	101020
2. Agrium	151010	18. Hudbay Minerals	151040	34. Shell Canada	101020
3. Alcan	151040	19. Husky energy	101020	35. Sherritt International	151040
4. ATCO Group	551030	20. Imperial Oil	101020	36. St Lawrence Cement	151020
5. Boralex	551050	21. INCO	151040	37. Suncor Energy	101020
6. Bonavista Petroleum	101020	22. Inter Pipeline	101020	38. Talisman Energy	101020
7. Canadian Natural Resources	101020	23. IPSCO	151040	39. Teck Comminco Metals	151040
8. Canadian Oil Sands	101020	24. Keyera	101020	40. Tembec	151050
9. Canadian Utilities (CU)	551030	25. Maxim Power	551050	41. Timminco	151040
10. CANFOR	151050	26. Methanex	151010	42. TransAlta	551050
11. Cascades	151030	27. Nexen	101020	43. TransCanada	101020
12. Domtar	151050	28. Northland Power	551050	44. Union Gas	101020
13. Emera	551010	29. NOVA Chemicals	151010	45. West Fraser Timber	151050
14. Enbridge	101020	30. Pengrowth	101020	46. Westcoast Energy	551010
15. EnCana	101020	31. Penn West Petroleum	101020	47. Western Forest Products	151050
16. Falconbridge	151040	32. Petro Canada	101020		

- Sectors of activity according to GICS numbers: 101020: oil, gas and consumable fuels; 151010: chemicals; 151020: construction materials; 151030: containers and packaging; 151040: metals and mining; 151050: paper and forest products; 551010: Electric Utilities; 551030: multi-utilities and 551050: power and renewable electricity.

Table 3.2 Sample firms for the test of second and third hypotheses (GICS numbers are presented for each company)

Company	GIC Number	Company	GIC Number	company	GIC Number
1. Advantage Oil and Gas	101020	24. EnCana	101020	47. Seven Generation Energy	101020
2. Agnico-Eagle Mines	151040	25. Fortis	551010	48. Sherritt International	151040
3. Agrium	151010	26. Fortress paper	551050	49. Suncor Energy	101020
4. AltaGas	551020	27. Hudbay Minerals	151040	50. Taseko Mines	151040
5. ARC Resources	101020	28. Husky Energy	101020	51. Teck Resources	151040
6. ATCO Group	551030	29. Imperial Metals	151040	52. Tembec	151050
7. Athabasca Oil	101020	30. Imperial Oil	101020	53. Tidewater Midstream	101020
8. Bellatrix Exploration	101020	31. Inter Pipeline	101020	54. Tourmaline Oil	101020
9. Birchcliff Energy	101020	32. Keyera	101020	55. TransAlta	551050
10. Brampton Brick	151020	33. Labrador Iron Ore	151040	56. TransCanada	101020
11. Canadian Malartic GP	151040	34. Maxim Power	551050	57. Veresen	101020
12. Canadian Natural Resources	101020	35. MEG Energy	101020	58. West Fraser Timber	151050
13. Canadian Utilities (CU)	551030	36. Metanor Resources	151040	59. Western Forest Products	151050
14. CANFOR	151050	37. Methanex	151010	60. Connacher Oil and Gas	101020
15. Capital Power Generation	551050	38. Northland Power	551050	61. Norbord Industries	151050
16. Cascades	151030	39. Pembina Pipeline	101020	62. Crescent Point Energy	101020
17. Cenovus Energy	101020	40. Pengrowth Energy	101020	63. Catalyst Paper	151050
18. Champion Iron	151040	41. Penn West Petroleum	101020	64. Capstone Infrastructure	551050
19. Detour Gold	151040	42. Peyto E&D	101020	65. Brookfield Renewable	551050
20. Dominion Diamond	151040	43. PotashCorp	151040	66. Newalta	101010
21. Domtar	151050	44. Pretium Resources	151040	67. Paramount Resources	101020
22. Emera	551010	45. Resolute forest Products	151050	68. Talisman Energy	101020
23. Enbridge	101020	46. Rogers Sugar	302020		

- Sectors of activity according to GICS numbers: 101010: energy equipment and services; 101020: oil, gas and consumable fuels; 151010: chemicals; 151020: construction materials; 151030: containers and packaging; 151040: metals and mining; 151050: paper and forest products; 302020: food products; 551010: electric utilities; 551020: gas utilities; 551030: multi-utilities and 551050: power and renewable electricity.

3.3 Research design

Our research is conducted using a two-stage methodology. At the first stage, we employ an event study method to test the first hypothesis and to examine whether the publication of carbon emissions acts as a quasi-regulatory mechanism. Using this method, we test whether the public release of carbon emissions information creates significant abnormal returns for the reporting firms. At the second stage, we conduct an equity valuation analysis based on Ohlson's model (1995) to test the second and the third hypotheses. Using the modified version of Ohlson's model, we examine the association between the level of carbon emissions and the stock market value of firms.

3.3.1 Event study method (test of the first hypothesis)

In order to test the first hypothesis and to see whether the first public provision of carbon emissions of the year 2004 provides relevant news for the investors, we employ the event study method. Event study is a well-established method to measure the impacts of a specific event on the stock market value of firms (MacKinlay, 1997 and Lee *et al.*, 2015). The theoretical foundation of this method is that in the efficient capital markets, at any moment, the price of securities reflects investors' expectations about future cash flows and future profitability of companies. Therefore, if the publication of any new information changes the investors' expectations about future cash flows, it will create abnormal returns at the time of the release of information and will ultimately result in the decline or rise in the security prices (Cormier, 2007). Since the hypothesis H_1 is proposed based on the efficient market hypothesis (EMH) (Fama, 1970) and the event study's theoretical foundation also relies on the EMH, the event study is the most appropriate method to test our first hypothesis.

MacKinlay (1997) refers to the history of event study and mention that probably the first event study was utilized by Dolley (1933). However, according to MacKinlay (1997) and Cormier (2007), the event study method, as the same one used today, was introduced by Ball and Brown (1968) and Fama *et al.* (1969). A number of studies have employed the event study to examine the stock market effects of firms' environmental disclosure. Hamilton (1995), Konar and Cohen (1997), Khanna *et al.* (1998) and Connors *et al.* (2013) have examined the market effects of the Toxic Release Inventory (TRI) information using the event study. In the Canadian context, Lanoie *et al.* (1998) have used the event study method to see if the publication of list of polluting firms by the environment ministry of British Columbia affects the stock prices of enlisted firms.

Regarding the market effects of carbon emissions, some authors have utilized the event study. Brouwers *et al.* (2016), using the event study, have investigated whether the verification events of the European Union Emission Trading Scheme (EU ETS) affect share prices of the European firms. Kim and Lyon (2011) and Lee *et al.* (2015) have conducted an event study to examine the impact of voluntary carbon disclosure on stock prices. Lorraine *et al.* (2004) and Hsu and Wang (2012) have utilized the event study to examine the impact of news about the environmental performance of firms on their stock prices.

In our research, the event of interest is the public provision of Canadian firms' GHG emissions information by the *Environment and Climate Change Canada*. Although the GHG emissions of Canadian firms from 2004 to 2016 are available to the public, the release dates are not provided on the website. Therefore, we contacted an agent of the GHG reporting program (GHGRP) to obtain the exact dates of the release of GHG emissions information. The *Environment and Climate Change Canada* publishes the emissions information with a lag of 12-18 months. Table 3.3 presents the release dates of carbon emissions information for the year of 2004, and also 2005 and 2006. The two

years of 2005 and 2006 constitute the sample years for our sensitivity tests, which are explained in detail in the next chapter (Chapter four).

Table 3.3 The release dates of GHG emissions information

Fiscal year related to the GHG emissions	**Release date**
2004	June 21, 2006
2005	December 21, 2006
2006	October 31, 2007

3.3.1.1 Market model

The basic idea of the event study is that in the efficient conditions, new and unexpected information can create abnormal returns for the securities (Brouwers *et al.*, 2016). Therefore, the null hypothesis in the event studies is that the abnormal return (AR) on the event day or the cumulative abnormal return (CAR) for the event window is equal to zero. The alternative hypothesis, hence, would be that the AR or the CAR is significantly different from zero. Given these explanations, calculating the abnormal return is a crucial step in the event studies. Abnormal return is calculated as the difference between the actual return and the expected return on a security. There are several approaches to calculate the abnormal return, such as the Constant Mean Return Model (CMRM), the Capital Asset Pricing Model (CAPM) and the Market Model (MM). Consistent with the previous studies (Kim and Lyon, 2011; Brouwers *et al.*, 2016 and Lee *et al.*, 2015) and considering that the market model is based on the efficient market hypothesis (EMH), we use the market model to determine the abnormal returns (ARs) of our sample firms.

The market model is based on the assumption that when there is not any unexpected and new information in the capital markets, the association between the return on a security and the return on the market portfolio is constant. Therefore, on the event day, when there is a new information, we use the return on market portfolio to anticipate the expected return (or normal return) of the security. Then, by calculating the difference between the normal return and the actual return on the event day, we can compute the abnormal return on the security (MacKinlay, 1997; Khanna *et al.*, 1998 and Hamilton, 1995). The calculation of abnormal return and cumulative abnormal return using the market model is explained step by step as follows.

Equation (1) indicates the standard market model (MM):

$$R_{it} = \alpha_i + \beta_i R_{mt} + \varepsilon_i \qquad (1)$$

where

R_{it}= Return on security i on day t (calculated as the price of security i on day t minus its price on day t-1, divided by the price on day t-1),

R_{mt} = Return on market portfolio m on day t (calculated as the price of the market portfolio on day t minus the price on day t-1, divided by the price on day t-1),

α_i and β_i = Parameters of the market model,

ε_i = Error term.

In order to calculate the market parameters (α_i and β_i), we need to determine the estimation window (the period prior to the event day) and to calculate the daily returns on the securities and on the market index for the estimation window. The estimation window, in our research, includes 100 trading days before the event day (starting from the day -103 to the day -3), which are not usually affected by the event of interest. The

starting dates and the ending dates of the estimation window are shown in Table 3.4. Note that the first row indicates the estimation window of our main event study to test the first hypothesis. The two others are the estimation windows for the sensitivity tests.

Table 3.4 The starting and ending dates of estimation windows

The event date	**Starting date of the estimation period**	**Ending date of the estimation period**
June 21, 2006	January 26, 2006	June 16, 2006
December 21, 2006	July 27, 2006	December 18, 2006
October 31, 2007	June 5, 2007	October 26, 2007

We collect the historical daily prices of the sample firms and the *S&P/TSX Composite Index* from the *Compustat* database. Then, we calculate the daily returns on the securities and also the daily returns on the market portfolio for the estimation window. Then, using the market model we determine the market parameters.

Next, we calculate the daily returns on the firms' stock and on the market portfolio for the event windows. The market parameters calculated from the estimation window and the daily returns for the event windows are then used to calculate the daily abnormal returns for the event windows using Equation (2):

$$AR_{it} = R_{it} - (\alpha_i + \beta_i R_{mt}) \qquad (2)$$

where

AR_{it} = Abnormal returns on security i on day t.

We consider a main event window of eight days (-2, 5) and five sub-windows (-2,2), (-1,1), (0,1), (0,2) and (0,3). The event windows include the days before the event day and after the event to capture the possibility of information leakage and to reflect the possible delays in the integration of the new information into the share prices. At the next step, for each firm in the sample, we calculate the cumulative abnormal return (CAR) for each event window, by aggregating the abnormal returns:

$$CAR_i(t_1, \dots, t_T) = \sum_{t=1}^{T} AR_{it} \qquad (3)$$

where

$CAR_i(t_1, \dots, t_T)$ = Cumulative abnormal return on security i for day t_1 to day t_T.

We also calculate the average abnormal return (AAR) of our sample firms for each day of the event windows, using Equation (4), to eliminate the idiosyncrasies in measurement because of particular stocks.

$$AAR_t = \frac{1}{N}\sum_{t=1}^{N} AR_{i,t} \qquad (4)$$

where

AAR_t = Average abnormal return on day t,

N = Total number of companies.

Finally, in order to calculate the cumulative average abnormal return (CAAR) for each event window, we sum up the average abnormal returns (AAR) as follows:

$$CAAR_T = \sum_{t=1}^{T} AAR_t \qquad (5)$$

where

$CAAR_T$ = Cumulative average abnormal return for period T (day t_1 to day t_T).

We use the *Microsoft Excel* and the software of *Event Study Metrics* to conduct the event study method. The *Event Study Metrics* applies several parametric and non-parametric test statistics to examine whether the cumulative average abnormal return (CAAR) is significantly different from zero. As explained earlier in this section, the null hypothesis tested in our event study is that the CAAR is equal to zero. The test statistics are explained in detail in the next chapter (Chapter four).

3.3.2 Equity-valuation approach

3.3.2.1 Test of the second hypothesis

The second hypothesis in our research relates to the valuation-relevance of GHG emission (carbon emissions) and assumes that there is a negative association between GHG emissions and the market value of Canadian firms. In other words, we aim to examine whether the carbon emissions of Canadian firms act as the proxy for implicit environmental liabilities. Hence, the second stage in our research design is the market valuation approach.

Previous studies examining the valuation-relevance of firms' environmental performance have used different models and also various environmental performance indicators. However, among the different valuation models, the residual-income valuation model of Ohlson (1995) has become a standard approach in the value-

relevance studies. Ohlson's model is based on the assumption that the investors' expectations about future cash flows and profitability of firms are reflected in the accounting-based information and other non-accounting value-relevant information (Semenova *et al.*, 2009). Consistent with prior studies (Amir and Lev, 1996; Hassel *et al.*, 2005; Cormier and Magnan, 2007; Semenova *et al.*, 2009; Johnstone *et al.*, 2008 and De Klerk and De Villiers, 2012), we employ Ohlson's model to test the second and third hypotheses. In this model, the market value of equity is considered as a function of the book value of equity, accounting earnings and other non-accounting information. The non-accounting information is usually the variable of most interest in the literature. Different studies have used different proxies for the non-accounting information, ranging from voluntary environmental reporting in corporate social responsibilities (Cormier and Magnan, 2007 and Moneva and Cuellar, 2009) to the different pollution performance of firms (Hughes, 2000; Clarkson *et al.*, 2013; Chapple *et al.*, 2013; Johnstone *et al.*, 2008). Ohlson's basic valuation model is derived as follows:

$$MVE_{i,t} = \alpha_0 + \beta_1 BVE_{i,t} + \beta_2 AE_{i,t} + \beta_3 v_{i,t} + \varepsilon_{i,t} \qquad (6)$$

considering that i denotes for firm and t denotes for time (year),

$MVE_{i,t}$= Market value of equity,

$BVE_{i,t}$= Book value of equity,

$AE_{i,t}$ = Abnormal earnings,

$v_{i,t}$ = Other non-accounting value-relevant information,

$\varepsilon_{i,t}$ = Error term.

Abnormal earnings are calculated as the difference between net income of firm *i* for period *t* and the book value of common equity, multiplied by the required rate of return. However, since the data required to calculate the abnormal earnings are constrained (because of unavailability of required rate of returns), we employ the modified version of Ohlson's model employed by Hassel *et al.* (2005) and Cormier and Magnan (2007). In these studies, the authors substitute abnormal earnings with the net income (earnings) and restate Equation (6) as follows:

$$MVE_{i,t} = \alpha_0 + \beta_1 BVE_{i,t} + \beta_2 NI_{i,t} + \beta_3 v_{i,t} + \varepsilon_{i,t} \qquad (7)$$

where

$NI_{i,t}$ = Net income (earnings) for firm *i* at time *t*.

Equation (7) constitutes the basic regression model in our study. The next step is to develop our regression model (Equation 7) by adding the non-accounting value-relevant information. We use the total GHG emissions of Canadian firms as the proxy for other non-accounting information ($v_{i,t}$):

$$MVE_{i,t} = \alpha_0 + \beta_1 BVE_{i,t} + \beta_2 NI_{i,t} + \beta_3 EMIS_{i,t} + \varepsilon_{i,t} \qquad (8)$$

where

$EMIS_{i,t}$ = Total GHG emissions of firm *i* at time *t*.

Finally, in order to test our second hypothesis, we integrate five control variables including industry dummy ($IND_{i,t}$), year dummies ($YR16_{i,t}$, $YR15_{i,t}$), dummy variable of cross-listing ($CRLIST_{i,t}$) and the variable of leverage ($LEV_{i,t}$) to Equation (8), and constitute Equation (9) as follows:

$$MVE_{i,t} = \alpha_0 + \beta_1 BVE_{i,t} + \beta_2 NI_{i,t} + \beta_3 EMIS_{i,t} + \beta_4 CTRL_{i,t} + \varepsilon_{i,t} \quad (9)$$

where

$CTRL_{i,t}$ = Control variables.

Equation (9) is used to test our second hypothesis. In the next two sections, we explain the measurement of the dependent variable, independent variables and control variables and the expected signs for their coefficients.

3.3.2.2 Measurement of dependent and independent variables

$MVE_{i,t}$ (market value of equity): The market value of equity is the sum of all trading and non-trading issues and is calculated as common shares outstanding multiplied by the month-end price that corresponds to the period end date. Market value of companies, in million dollars, are collected from *Compustat, North American annual updates*.

$BVE_{i,t}$ (book value of equity): The book value of equity, which is also referred as shareholders' equity, comprises the common equity, preferred equity, non-redeemable non-controlling interest of a company, capital surplus and retained earnings. This item can also be calculated as the difference between total assets and total liabilities. Book value of equities, in million dollars, are collected from *Compustat, North American annual updates.*

$NI_{i,t}$ (net income): The net income which is also referred as earnings represents the fiscal year's income or loss reported by a company after subtracting expenses and losses from all revenues and gains. Net incomes of sample firms are collected from *Compustat, North American annual updates* and are presented in million dollars.

Consistent with previous studies (Cormier and Magnan, 2007; Hassel *et al.*, 2005; Johnstone *et al.*, 2008 and Semenova *et al.*, 2009) we expect positive signs for β_1 and β_2, which are the coefficients of $BVE_{i,t}$ and $NI_{i,t}$, respectively.

$EMIS_{i,t}$ (GHG emissions): The total GHG emissions of Canadian firms is the independent variable of interest in our equity-valuation model (Equation 9). The total amount of GHG emissions is calculated by aggregating the GHG emissions of facilities to the company-level. Although the emissions of firms for each year are disclosed by the Canadian government with a gap of 12-18 months, we use the subsequently published GHG emissions of each year as the best estimate of market expectations (Matsumura *et al.*, 2014). Following prior studies (Barth and McNichols, 1994; Cormier *et al.*, 1993; Cormier and Magnan, 1997; Hughes, 2000; Clarkson *et al.*, 2004 and Chapple *et al.*, 2013), we assume that the level of GHG emissions act as the proxy for environmental liabilities and hence, is negatively associated with the firm value. Therefore, we predict a statistically significant and negative sign for the coefficient of GHG emissions (β_3).

3.3.2.3 Measurement of control variables

Based on prior literature, we incorporate five control variables, which are likely to have a potential impact on the dependent variable, into the valuation model (Equation 9).

$IND_{i,t}$ (industry): We explained in the previous chapter (Chapter two) that firms operating in the sectors of oil and gas, transportation and electricity were responsible for about 50% of GHG emissions in Canada and therefore, were the largest GHG-emitting firms[19]. In order to control for the effects of firms' membership to the two different types of industry groups, high-GHG-emitting and lower-emitting industries,

[19] https://www.canada.ca/en/environment-climate-change/services/environmental-indicators/greenhouse-gas-emissions.html

we define a dummy variable of industry. Our sample firms are classified into two sub-samples of high-GHG-emitting firms (firms operating in oil and gas, transportation and electricity) and low-GHG-emitters (firms operating in other industries), based on their Global Industry Classification Standard numbers (GICS numbers). We identify the industry type of firms based on the 6 digits of GICS for each company. The following GICS numbers are considered as the high-GHG-emitting industries:

1) 101020: oil, gas and consumable fuels
2) 551030: multi utilities
3) 551050: independent power and renewable electricity producers
4) 551010: electric utilities,

none of the sample firms is operating in the sector of transportation. 38 companies of our sample firms (68 firms) operate in the high-GHG-emitting industries (oil and gas and electricity) and the rest (30) of them are in the category of low-GHG-emitters. Our dummy variable of industry is equal to 1 for high-GHG-emitting firms and 0 otherwise. The coefficient of this dummy variable will show the possible systematic differences which are unknown between the two types of industry groups (Hassel *et al.*, 2005).

LEV_{it} (leverage): This control variable is measured as total liabilities divided by the book value of equity. Total liabilities are the sum of current liabilities, long-term debt and other non-current liabilities, including deferred taxes and investment tax credit. The total liabilities and the book value of equity, which are necessary to calculate the leverage of the sample firms, are collected from *Compustat, North American annual updates*. We assume that a higher leverage not only indicates that the firm is risky, but also shows that such firm is less likely to invest its resources in pollution control equipment and activities. Previous studies have shown that the leverage was negatively associated with firm value (Hsu and Wang, 2012 and Baboukardos, 2017). Consistent with the results of these studies, we anticipate a negative sign for the coefficient of this control variable.

$CRLIST_{it}$ (cross-listing): Some of the companies in our sample are cross-listed in other stock exchanges such as the New York Stock Exchange (NYSE) or the American Stock Exchange (AMEX). Since the objective of our research is to examine the impacts of carbon emissions on the Canadian stock market prices, we decide to incorporate a control dummy variable of cross-listing in the valuation model. We consider 1 for cross-listed firms and 0 for firms which are only listed on the Toronto Stock Exchange (TSX). There is a growing literature examining whether cross-listing creates value for the firms. Miller (1999) finds that non-US firms which are listed on a US stock market experience a significant positive market reaction from their domestic stock markets. Doidge *et al.* (2004) also indicate that firms which are cross-listed on a US stock exchange have higher stock market valuation than non-cross-listed firms. Consistent with the results of Miller (1999) and Doidge *et al.* (2004), we assume that Canadian firms which are cross-listed on a US-based stock exchange have a higher market valuation than other firms and hence, we predict a positive sign for the coefficient of this variable.

$YR16_{it}$ and $YR15_{it}$: In order to conduct our market-valuation analysis, we gathered the data for three years of 2014, 2015 and 2016. Therefore, we need to control for the effects of time differences. As a result, two dummy variables of year are created and then integrated into our market-valuation model (Equation 9).

Table 3.5 summarizes the definitions of dependent variable and independent and control variables used in the valuation model.

Table 3.5 Summary of variables used in the valuation model

List of variables	Measurement of the variables
Dependent and independent variables	
$MVE_{i,t}$ (market value of equity)	Number of shares outstanding multiplied by the month-end price that corresponds to the period end date
$BVE_{i,t}$ (book value of equity)	The difference between total assets and total liabilities
$NI_{i,t}$ (net income)	All revenues and gains minus expenses and losses
$EMIS_{i,t}$ (GHG emissions)	Total number of GHG emissions (in tonnes) of Canadian public firms
Control variables	
LEV_{it} (leverage)	Total liabilities divided by book value of equity
$CRLIST_{it}$ (cross-listing)	A dummy variable which is equal to 1 for cross-listed firms and 0 otherwise
$IND_{i,t}$ (industry)	A dummy variable which is denoted 1 for high-GHG-emitters and 0 otherwise
$YR16_{it}$	A dummy variable which is equal to 1 for the year 2016 and 0 otherwise
$YR15_{it}$	A dummy variable which is denoted 1 for the year 2015 and 0 otherwise

3.3.2.4 Test of the third hypothesis

Our third hypothesis assumes that companies' sector of activity changes the association between GHG emissions and firm value. We propose that there is a difference in the valuation-relevance of GHG emissions between firms operating in high-GHG-emitting industries (oil and gas and electricity) and firms of other industries. In order to test this hypothesis, we create a moderator variable of industry, which is the interaction between

our industry dummy variable (presented in previous section) and the variable of interest (GHG emissions). Some previous studies, by introducing moderator variables, have also examined the impact of other factors such as time differences, new regulations and corporate governance on the association between pollution performance and firm value (Baboukardos, 2017 and Choi and Luo, 2017).

By incorporating the moderator variable of $(EMIS_{i,t} * IND_{i,t})$ into Equation (9), Equation (10) is proposed to test our third hypothesis:

$$MVE_{i,t} = \alpha_0 + \beta_1 BVE_{i,t} + \beta_2 NI_{i,t} + \beta_3 EMIS_{i,t} + \beta_4 IND_{i,t} + \beta_5 (EMIS_{i,t} * IND_{i,t}) + \beta_6 CTRL_{i,t} + \varepsilon_{i,t} \quad (10)$$

By interpreting the coefficient of the interaction variable (β_5), we can conclude whether the industry type of companies has a moderating role on the relationship between GHG emissions and market value of firms. If the coefficient of GHG emissions (β_3) is negative and statistically significant, and at the same time the coefficient of interaction (β_5) is significant and negative, then we conclude that the negative association between GHG emissions and firm value is more pronounced in high-GHG-emitting firms. In contrast, if the coefficient of GHG emissions (β_3) is significant and negative, and the coefficient of the interaction variable (β_5) is significant and positive, it is concluded that the negative association between GHG emissions and firm value is prominent in low-GHG-emitters and therefore, stock market participants penalize higher levels of carbon emissions for low-GHG-emitters more than high-GHG-emitting firms.

CHAPTER IV

DATA ANALYSIS, RESULTS AND DISCUSSION

The main research question of our study is whether carbon disclosure and carbon performance of public Canadian firms affect their stock prices. We developed three research hypotheses to be able to answer our research question. In the previous chapter, the research methodology and the procedure for testing of each hypothesis are explained in detail. In this chapter, we present the results of the tests for the event study and the regression analysis and discuss whether our research hypotheses are rejected or confirmed. This chapter is organized as follows: Section 4.1 presents the results obtained from the event study, Section 4.2 explains and discusses the findings of the market valuation analysis, and Section 4.3 presents the summary of research findings.

4.1 Empirical results of the event study

We employed the event study to test hypothesis H_1, which assumed that the public provision of GHG emissions (carbon emissions) in 2006 acted as relevant news for investors and hence, created abnormal returns for the reporting firms. This hypothesis is focused on the first release of GHG emissions information by the *Environment and Climate Change Canada*. However, we also conducted the event study, as sensitivity test, for the two subsequent public provisions of emissions information. Our intention was to examine whether there has been stock market reaction to the two subsequent

publications of carbon emissions. As explained in the chapter of research methodology (Chapter three), we used the "*Event Study Metrics*" program which was specified for the event studies. This software applies different parametric and non-parametric statistic tests to confirm or reject the null hypothesis. The null hypothesis presumes that the cumulative (average) abnormal return (CAAR) is equal to zero ($CAAR = 0$). If the test statistics indicate that the CAAR for the event window is statistically different from zero, then we can conclude that the event of interest affects the stock prices and creates abnormal returns for the target companies. While the parametric tests assume that the abnormal returns are distributed normally, the non-parametric tests do not take this assumption. Table 4.1 presents the statistical tests performed by the *Event Study Metrics*[20].

Table 4.1 Test statistics for the event study and their characteristics[20]

Statistical test	Characteristics
T-test (time-series and cross-sectional)	T-test assumes that the abnormal returns are distributed normally. Brown and Warner (1980) proposed the cross-sectional t-test to control the cross-correlation issue in the time-series t-test.
Standardized residual test	This test is developed by Patell (1976) and is robust to heteroscedasticity of abnormal returns in event windows.
Standardized cross-sectional test	This test is developed by Boehmer *et al.* (1991), by combining the standardized residual test with the standardized cross-sectional test, to resolve the event-induced variance.
Corrado rank test	This non-parametric test is developed by Corrado (1989). Using this test, abnormal returns are transformed into the ranks to test the significance of null hypothesis.
Generalized sign test	This non-parametric test is proposed by Crown (1992) and is based on the portion of positive cumulative abnormal return over the event window.

[20] https://eventstudymetrics.com/index.php/event-study-methodology.

4.1.1 Results from the test of first hypothesis

Our event study relates to the first public release of Canadian firms' GHG emissions (carbon emissions) information on June 21, 2006. The results of the event study are presented in Table 4.2. This table contains the average abnormal return (AAR) for the event day (day 0) and also the cumulative average abnormal return (CAAR) for the main event window and for sub-windows. The test statistics and their probability values (p-values) are also shown in the table. The results of different test statistics included in Table 4.2 indicate whether the publication of GHG emissions of Canadian firms results in a significant stock market reaction on a statistical basis. As it can be seen from the table, on the event day (the day on which the information is released), the average abnormal return (AAR) of 47 sample firms is equal to -0.0031. The results of all parametric and non-parametric tests and probability values (p-values) show that the average abnormal return (AAR) on the event day is not statistically different from zero. As it can be seen from the table, for the main event window (-2,5), the cumulative average abnormal return (CAAR) is -2% and for sub-windows of (-2,2), (-1,1), (0,1), (0,2) and (0,3) are -1%, -1%, -1%, -1% and -2% respectively. However, the test statistics indicate that the CAARs are not significant at the conventional levels ($p < 0.01$, $p < 0.05$ and $p < 0.10$). In short, the data of Table 4.2 suggest that the stock market reaction to the first public provision of GHG emissions is not statistically significant. The pattern of cumulative average abnormal return (CAAR) for the main event window (-2,5) is shown in Figure 4.1. Figure 4.1 indicates that there is a weak market reaction to the release of GHG emissions information, however, this reaction is not significant at the statistical basis.

Table 4.2 Average abnormal returns and test statistics of the event study

Date	AAR/CAAR	Pos: Neg	T-test time-series	T-test cross-sectional	Patell z	Boehmer *et al.*	Corrado rank	Sign test
Day 0	-0.0031	22: 25	-0.1615 (0.8717)	-0.5337 (0.5936)	0.2031 (0.839)	0.102 (0.9187)	0.0601 (0.952)	-0.3036 (0.7615)
Main event window (-2,5)	-0.0198	24: 23	-0.3664 (0.714)	-0.9728 (0.3306)	0.3783 (0.7067)	0.1728 (0.8628)	0.384 (0.701)	0.28 (0.7795)
Sub-windows								
(-2,2)	-0.0115	22: 25	-0.2704 (0.7868)	-0.9259 (0.3545)	0.0754 (0.9399)	0.0348 (0.9723)	0.432 (0.6658)	-0.3036 (0.7615)
(-1,1)	-0.0104	22: 25	-0.314 (0.7535)	-0.977 (0.3286)	-0.7697 (0.4415)	-0.3477 (0.728)	-0.4275 (0.669)	-0.3036 (0.7615)
(0,1)	-0.0062	23: 24	-0.229 (0.8189)	-0.7394 (0.4597)	-0.0276 (0.978)	-0.0119 (0.9905)	-0.0372 (0.9703)	-0.0118 (0.9906)
(0,2)	-0.009	24: 23	-0.2719 (0.7857)	-0.7046 (0.4811)	0.734 (0.4629)	0.3361 (0.7368)	0.8289 (0.4072)	0.28 (0.7795)
(0,3)	-0.0158	25: 22	-0.4151 (0.6781)	-0.8771 (0.3804)	0.8556 (0.3922)	0.3803 (0.7038)	0.4905 (0.6238)	0.5718 (0.5675)

Notes: Number of observations: 47, p-values are presented in parentheses.

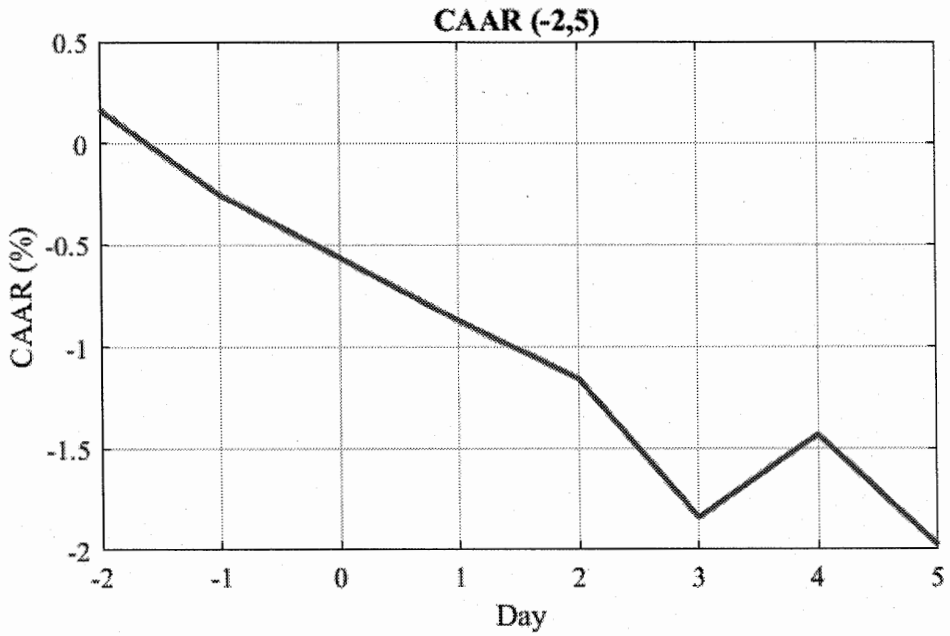

Figure 4.1 Cumulative average abnormal return (CAAR) for the main event window

According to the results of event study for the first year (2006), the public provision of GHG emissions did not create statistically significant abnormal returns for the reporting firms. The average abnormal return (AAR) on the event day and the average of cumulative abnormal return (CAAR) for the event windows are close to zero and hence, the first hypothesis of our study is not supported.

Our first hypothesis was developed on the basis of the efficient market hypothesis (EMH) (Fama, 1970) and aimed to examine whether the first public release of GHG emissions information acted as relevant news for investors and therefore, acted as a quasi-regulatory mechanism to control the pollution performance of firms. Some earlier studies also examine the same hypothesis (Hamilton, 1995; Khanna *et al.*, 1998 and Lanoie *et al.*, 1998). Hamilton (1995) assumes that the publication of Toxic Release Inventory (TRI) information is relevant news for investors. He conducts an event study to see whether the public release of firms' pollution performance creates

abnormal returns for reporting firms. The results of Hamilton indicate the significant negative abnormal returns upon the first release of TRI information in 1989. Khanna *et al.* (1989) examine the stock market impact of the TRI information for the firms operating in chemical industry, however, they do not report significant abnormal returns for the sample firms at the first release of TRI information. In the Canadian context, Lanoie *et al.* (1989) do not indicate any significant abnormal returns upon the publication of the list of polluting firms by the environment ministry of British Columbia.

Our result regarding the first hypothesis is, therefore, consistent with Khanna *et al.* (1998) and Lanoie *et al.* (1998). The lack of significance in abnormal returns for our sample firms upon the first release of the GHG emissions information may be justified by some reasons. First, our sample firms, according to their GICS numbers[21], all operate in the sectors of energy, materials and utilities. Firms operating in these sectors are generally known as polluting firms and investors may have already estimated the level of GHG emissions for these firms. As a result, the level of GHG emissions of sample firms is not unexpected and new for stock market participants. We consider that the firms' GHG emissions have already been integrated in their stock prices (market valuation) and therefore, the publication of GHG emissions information in 2006 by the government did not trigger any significant market responses. Khanna *et al.* (1998) also discuss that the reason for the insignificant abnormal returns at the first release of TRI information is because the sample firms operate in the chemical industry and the pollution level of firms is already anticipated by stock market participants. Lanoie *et al.* (1998) argue that the companies included in the list of polluting firms publicized by the environment ministry of British Columbia are operating in the primary sector (resources) and therefore, their pollution report do not provide new and important information for the Canadian investors. Additionally, Konar and Cohen (1997) indicate

[21] The GICS is an industry classification developed by the *MSCI Inc.* and *S&P Dow Jones*, and consists of 11 sectors, 24 industry groups, 69 industries and 158 sub-industries.

that from 40 firms which experience the highest negative abnormal returns upon the first release of TRI information (as reported by Hamilton, 1995), only 11 firms are among the highest TRI emitters. Konar and Cohen (1997) explain that many of highest TRI emitters are already known as high-polluting firms by investors and therefore, the level of their emissions does not diverge from investors' expectations. In contrast, the reason for the significant results obtained by Hamilton (1995) is that he examines a relatively larger sample with firms operating in a broader range of activities. Moreover, the Environmental Protection Agency (EPA) in the US provides detailed information of all aspects of firms' pollution performance such as air pollution, underground injections, land releases, water pollution and the amount of waste shipped offsite to the disposal facilities (Hamilton, 1995). Therefore, it is not surprising that such detailed information would be quite new and unknown for investors.

Second, Canadian firms' yearly GHG emissions information is publicized with a long delay (12-18 months) by the Canadian government. Therefore, it is possible that the investors have already obtained firms' GHG emissions information from other sources such as Bloomberg database or firms' annual reports.

Third, the minimum threshold of GHGs, which should be reported to the program, is 50000 tonnes or more (however, since 2017, the minimum threshold has been reduced to 10000 tonnes)[22]. Therefore, facilities emitting more than 50000 tonnes of GHGs must report their emissions to the government. As a result, a firm emitting more than its expected normal level but less than 50000 tonnes has the choice of not reporting its emissions to the program. In other words, a firm which does not report its emissions to the government is not necessarily a good environmental performer. Therefore, the government's annually reports on the GHG emissions of Canadian firms lack the list of firms which could have caused significant market responses (Lanoie *et al.*, 1998).

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[22] https://www.canada.ca/en/environment-climate-change/services/climate-change/greenhouse-gas-emissions/facility-reporting/about.html

Fourth, another possible reason for the difference between the US-based studies (Hamilton, 1995 and Konar and Cohen, 1997) and Canadian studies (Lanoie *et al.*, 1998 and our research), examining the quasi-regulatory role of public information, is that the release of GHG emissions information in Canada has not been covered well by press and media to inform the public. Whereas, Hamilton (1995) indicates the media coverage of TRI information during the first year of release (1989) and he reports that 40% of the firms' media coverage is on the release day and the day after. The TRI program has been initiated specifically with the objective of affecting firms' pollution performance through the public pressure, which was indeed successful as indicated by the empirical evidence (Hamilton, 1995 and Konar and Cohen, 1997). Finally, it seems that the government of Canada has not been as successful as the US authorities in specifying regulatory penalties for the poor environmental performance of companies. Consequently, Canadian investors may not see considerable threats for the GHG emissions of the public companies (Lanoie *et al.*, 1998).

4.1.2 Sensitivity tests

We conducted the event study for the two subsequent releases of GHG emissions information, as sensitivity tests, to see whether they create significant abnormal returns for the reporting firms. The results show that the average abnormal return (AAR) of 49 public firms[23] for the second event day (December 21, 2006) is positive and equal to 0.002, however, different test statistics indicate that the AAR is not statistically different from zero. For the main event window (-2,5) the cumulative average abnormal return (CAAR) is 0.0042 which is insignificant according to all the test statistics. Therefore, the null hypothesis assuming that the cumulative average abnormal return

[23] The list of sample firms for the second and third event studies are presented in Annex C and Annex D, respectively.

is equal to zero ($CAAR = 0$) is not rejected. The CAAR for sub-windows of (-2,2), (-1,1), (0,1), (0,2) and (0,3) are also not statistically different from zero. Our empirical result of the stock market reaction to the third release of GHG emissions information on October 31, 2007 is consistent with the results of the first and second event studies. The average abnormal return (AAR) of 44 public firms[23] on the event day (day 0) is equal to -0.0029 which is not significant according to the parametric and non-parametric test statistics. The cumulative average abnormal return (CAAR) is -1.5% for the main event window (-2,5), however, test statistics show that it is not statistically different from zero, and therefore, the null hypothesis ($CAAR = 0$) is not rejected. We do not find a statistically significant amount of CAAR for the sub-windows as well. In conclusion, our results do not indicate any significant stock market responses to the first three publications of the GHG emissions information. It seems that, on average, the disclosure of firms' GHG emissions information did not provide new and surprising information for the Canadian investors. The results of our event studies are similar to those obtained by Lanoie *et al.* (1998). Lanoie *et al.* (1998) indicate that the Canadian firms appearing on the first five lists of polluting firms, publicized by the environment ministry of British Columbia, do not experience significant abnormal losses on the event days.

4.2 Empirical results of the market-valuation analysis

In this section, we report the results of Ohlson's based market valuation analysis. Using the market valuation regression, we tested our second and third hypothesis for a sample of 68 public Canadian firms for the period of 2014-2016 (pooled sample of 182 firm-year observations). The results of each test are elaborated in the following sections.

4.2.1 Descriptive statistics

Table 4.3 provides descriptive statistics on the pooled sample of 182 firm-year observations for the measures of market value of equity, book value of equity (stockholders' equity), net income (earnings), GHG emissions, and leverage. As can be seen from the whole table, our sample is widely distributed in all dimensions. The mean (median) of market value of equity (MVE) is 8035.32 (2920.60) million dollars, ranging from 3.82 to 73221.42 million dollars. The median for this variable is less than mean, indicating that this variable is skewed to the right (positively skewed) and indicating that we have some extremely large companies in our sample (consistent with the descriptive statistics of firms' market value reported by Matsumura *et al.*, 2014). For the book value of equity (BVE), its mean (median) is 5557.98 (2509.67) million dollars, with the minimum of -116.70 and maximum of 44630.00 million dollars. Further, the mean (median) net income (NI) of our pooled sample is 66.95 (24.37) million dollars with the minimum value of -7147.80 and maximum value of 3935.03 million dollars. The average amount of the net income indicates that our sample firms are profitable in general, however, we have some extremely profitable firms. In sum, the average amounts for three variables of market value of equity, book value of equity and net income reveal that our sample firms are relatively large and profitable Canadian companies. With regard to the variable of interest, GHG emissions ($EMIS$), on average, our sample firms emit 2311459.89 tonnes of carbon and carbon equivalents annually. The median amount of this variable is 361444.89 tonnes and the scores range from 1777.72 to 26798472.50. The substantial difference between the mean and median values for the GHG emissions indicates that we have some very high-GHG-emitters in our sample firms and the largest amount of GHG emissions reported is 26798472.50 which is related to the company of *TransAlta*. Some previous studies provide higher average amounts of GHG emissions. For example, Matsumura *et al.* (2014) report an average of 11455410 tonnes of GHG emissions for a sample of US-based companies.

Clarkson *et al.* (2015) report an average GHG emissions of 5247000 tonnes for a sample of European firms. The considerable difference of GHG emissions reported in these studies and our study can be attributed to the different contexts (US and European countries), larger firm-year observations and also using earlier time periods in both studies, 2006-2008 for Matsumura *et al.* (2014) and 2006-2009 for Clarkson *et al.* (2015).

Finally, the variable of leverage (debt-to-equity ratio) has a mean (median) of 1.94 (1.09) and ranges from -8.88 to 114.15, indicating that some of our sample firms are highly leveraged.

Table 4.3 Descriptive statistics on the pooled sample of 182 firm-year observations

Variable	Mean	Median	SD	Minimum	Maximum
Number of observations: 182					
MVE (in million dollars)	8035.32	2920.60	12858.29	3.82	73221.42
BVE (in million dollars)	5557.98	2509.67	7921.22	-116.70	44630.00
NI (in million dollars)	66.95	24.37	1018.73	-7147.80	3935.03
EMIS (in metric tonnes)	2311459.89	361444.89	5194061.31	1777.72	26798472.50
LEV	1.94	1.09	8.63	-8.88	114.15

- Definitions of variables: *MVE* is market value of equity, calculated as shares outstanding multiplied by the month-end price that corresponds to the period end date; *BVE* is book value of equity which is calculated as the difference between total assets and total liabilities; *NI* is net income (earnings); *EMIS* is total GHG (carbon) emissions in tonnes and *LEV* is leverage which is calculated as total liabilities divided by book value of equity.

- *MVE*, *BVE*, and *NI* are expressed in Canadian dollars (CAD) (if reported in USD, converted to CAD).

- Standard deviation is denoted as SD.

4.2.2 Pearson's correlation coefficients

Table 4.4 presents the correlation coefficients between the variables of market value of equity, book value of equity, net income, GHG emissions and leverage. The indicators (dummy variables) of our regression models are not included in the table. As it can be seen from the table, market value of equity (MVE) and book value of equity (BVE) are strongly associated (0.925) with a significance of ($p < 0.01$). Market value of equity (MVE) is significantly and positively correlated with net income (NI) (0.355) at the level of 1%.

As revealed in the table, market value of equity (MVE) and total GHG emissions ($EMIS$) are positively related (0.470) and the correlation coefficient is statistically significant ($p < 0.01$). The positive correlation between market value of equity and GHG emissions may be due to the firm size (Matsumura *et al.*, 2014). Presumably, larger firms in terms of market value have also higher levels of GHG emissions.

Regarding the correlation coefficients of explanatory variables (independent variables), the table does not indicate any multicollinearity problems. This is also confirmed by calculation of variance inflation factor (VIF). The VIF for all independent variables are less than two, which highly support that there is not any multicollinearity problem in our study. According to the correlation matrix, there is a positive and significant association between book value of equity (BVE) and net income (NI) (0.246). This is consistent with the significant and positive correlation coefficients between book value of equity and net income reported by Hassel *et al.* (2005) and Semenova *et al.* (2009). Total GHG emissions ($EMIS$) is also positively related to the two explanatory variables of book value of equity (BVE) (0.542) and net income (NI) (0.224), and both correlation coefficients are statistically significant at the level of 1%.

Table 4.4 Pearson's correlation coefficients for the pooled sample of 182 firm-year observations, p-values are in parentheses

Variable	*MVE*	*BVE*	*NI*	*EMIS*	*LEV*
Number of observations: 182					
MVE	1.00				
BVE	0.925* (0.000)	1.00			
NI	0.355* (0.000)	0.246* (0.000)	1.00		
EMIS	0.470* (0.000)	0.542* (0.000)	0.224* (0.001)	1.00	
LEV	-0.039 (0.303)	-0.051 (0.246)	-0.018 (0.402)	-0.026 (0.364)	1.00

*Indicates a significant correlation at the level of 1% (1-tailed).

- This table doesn't include the indicator variables including industry (*IND*), the interaction of industry dummy with GHG emissions (*IND* ∗ *EMIS*), cross-listing (*CRLIST*) and the year dummies.

- Definitions of variables: *MVE* is market value of equity, calculated as shares outstanding multiplied by the month-end price that corresponds to the period end date; *BVE* is book value of equity which is calculated as the difference between total assets and total liabilities; *NI* is net income (earnings); *EMIS* is total GHG (carbon) emissions in tonnes and *LEV* is leverage which is calculated as total liabilities divided by book value of equity.

4.2.3 Results from the test of second hypothesis

Table 4.5 provides the results of ordinary least square (OLS) regression analysis which was used to test the second and third hypotheses. Our second hypothesis proposes that the level of GHG emissions (carbon emissions) of Canadian firms can act as the proxy for future environmental liabilities and therefore, there is a negative association between GHG emissions and market value of firms. In order to test this hypothesis, we employed a modified version of Ohlson's (1995) equity-valuation model. Basically, Ohlson's model suggests that market value of firms should reflect accounting-based information and other non-accounting value-relevant information (social and environmental disclosure). The two basic accounting variables used in our valuation model are book value of equity (BVE) and net income (NI) and the total GHG emissions ($EMIS$) is used as the proxy for other non-accounting variable. According to previous studies (Cormier and Magnan, 2007; Hassel *et al.*, 2005; Johnstone *et al.*, 2008; Semenova *et al.*, 2009 and Clarkson *et al.*, 2015) and consistent with theory, we predicted positive coefficients for the book value of equity and net income. The estimated coefficients of basic valuation model, in which the market value of equity is regressed on the book value of equity (BVE) and net income (NI) are shown in the column of Model 1 in Table 4.5. As can be seen from this column, the coefficients of book value of equity (0.891) and net income (0.136) are positive and highly significant ($p < 0.01$), as expected. In the next column (column of Model 2), we present the estimated coefficients of the basic model which also includes the variable of GHG emissions ($EMIS$). The coefficients of book value of equity and net income are 0.923 and 0.142 respectively, and still statistically significant ($p < 0.01$). Moreover, the variable of interest ($EMIS$) has a negative coefficient (-0.062) which is significant at the level of 5%, consistent with our expectation and previous studies (Chapple *et al.*, 2013; Matsumura *et al.*, 2014; Clarkson *et al.*, 2015; Baboukardos, 2017 and Choi and Luo, 2017).

Table 4.5 Regression results for the pooled sample of 182 firm-year observations

Model 1: $MVE_{i,t} = \alpha_0 + \beta_1 BVE_{i,t} + \beta_2 NI_{i,t} + \beta_3 v_{i,t} + \varepsilon_{i,t}$

Model 2: $MVE_{i,t} = \alpha_0 + \beta_1 BVE_{i,t} + \beta_2 NI_{i,t} + \beta_3 EMIS_{i,t} + \varepsilon_{i,t}$

Model 3: $MVE_{i,t} = \alpha_0 + \beta_1 BVE_{i,t} + \beta_2 NI_{i,t} + \beta_3 EMIS_{i,t} + \beta_4 CTRL_{i,t} + \varepsilon_{i,t}$

Model 4: $MVE_{i,t} = \alpha_0 + \beta_1 BVE_{i,t} + \beta_2 NI_{i,t} + \beta_3 EMIS_{i,t} + \beta_4 IND_{i,t} + \beta_5 (EMIS_{i,t} * IND_{i,t}) + \beta_6 CTRL_{i,t} + \varepsilon_{i,t}$

Variable	Predicted sign	Coefficients (t-tests in parentheses)			
		Model 1	Model 2	Model 3	Model 4
Constant		-119.98 (-0.285)	-60.17 (-0.14)	-1046.60 (-1.36)	-309.06 (-0.382)
BVE	+	0.891 (32.34)***	0.923 (28.94)***	0.90 (24.57)***	0.917 (25.01)***
NI	+	0.136 (4.94)***	0.142 (5.16)***	0.143 (4.92)***	0.144 (5.07)***
EMIS	-		-0.062 (-1.96)**	-0.071 (-2.18)**	-1.01 (-2.76)***
LEV	+/-			0.008 (0.30)	0.009 (0.348)
IND	+/-			0.045 (1.49)	0.006 (0.169)
*IND * EMIS*	+/-				0.949 (2.58)***
CRLIST	-			0.027 (0.866)	0.033 (1.09)
YR16	+/-			0.039 (1.27)	0.040 (1.33)
YR15	+/-			-0.004 (-0.124)	-0.002 (-0.078)
Adj R2		0.871	0.873	0.873	0.877
F-value		611.53	415.41	156.38	144.28
Number of observations: 182					

**Statistically significant at the level of 5% ($p < 0.05$)

***Statistically significant at the level of 1% ($p < 0.01$)

- Definitions of variables: *MVE* is market value of equity, calculated as shares outstanding multiplied by the month-end price that corresponds to the period end date; *BVE* is book value of equity which is calculated as the difference between total assets and total liabilities; *NI* is net income (earnings); *EMIS* is total GHG (carbon) emissions in tonnes and *LEV* is leverage which is calculated as total liabilities divided by book value of equity.

In the column of Model 3 of the table, the results of regression model, which was used specifically to test our second hypothesis, are provided. Model 3 includes accounting variables of (BVE) and (NI), the variable of interest ($EMIS$) and control variables. As expected and consistent with Model 1 and Model 2, the two variables of book value of equity (BVE) and net income (NI) are positively and significantly ($p < 0.01$) associated with market value of equity, with coefficients of 0.90 and 0.143 respectively.

The coefficient of GHG emissions ($EMIS$) in Model 3, is negative (-0.071) and statistically significant ($p < 0.05$), consistent with model 2. These findings confirm the second hypothesis of our research regarding the negative association between firm value and GHG emissions and suggests that GHG emissions information is value-relevant for the Canadian investors. This result is consistent with the previous studies which discuss that market participants interpret carbon emissions (or other aspects of pollution performance) as the indicator of implicit environmental liabilities (Barth and McNichols, 1994; Cormier *et al.*, 1993; Cormier and Magnan, 1997; Hughes, 2000; Clarkson *et al.*, 2004; Chapple *et al.*, 2013 and Choi and Luo, 2017). According to the estimated coefficient of $EMIS$ (-0.071), on average, for every additional tonne of carbon emissions, the market value of companies decreases by 71 dollars (CAD). This amount of valuation reduction has significant economic consequences for the public companies.

Our results also confirm the theoretical argument of Ohlson's model (1995), suggesting that the market value of companies reflect both financial performance and environmental performance (such as carbon emissions) of firms. This is also confirmed by comparing the $adjusted\ R^2$, which is increased from Model 1 (including only the accounting-based variables) to Model 2 and 3 (consisting of accounting variables and non-accounting variables).

As shown in the column of Model 3, this regression model controls for the effects of industry differences (IND), leverage (LEV), cross-listing ($CRLIST$) and year

differences. However, the coefficients of control variables are not significant at the conventional levels.

4.2.4 Results from the test of third hypothesis

The third hypothesis of our study assumes that firms' sector of activity changes the relationship between GHG emissions and the market valuation of firms. We predict that there is a difference in valuation-relevance of GHG emissions between high-GHG-emitters (firms operating in the sectors of oil and gas and electricity) and low-GHG-emitters (firms operating in other industries). In order to test this hypothesis, we created a moderator variable of industry which is simply the interaction of the industry dummy variable and the GHG emissions, ($IND * EMIS$). By integrating the interaction term into Model 3, we estimated Model 4 (indicated in the last column of Table 4.5) to be able to capture any difference in the coefficient of GHG emissions ($EMIS$) across high-emitters and low-emitting firms.

As shown in the last column of the table, the coefficient of GHG emissions is negative (-1.01) and highly significant ($p < 0.01$), similar to Model 2 and Model 3. Interestingly, the coefficient of interaction variable is positive (0.949) and statistically significant ($p < 0.01$). This result indicates that the coefficient of GHG emissions is lower for high-GHG-emitting firms (-0.061) in comparison to the low-GHG-emitters (-1.01), suggesting that the negative association between market value of firms and carbon emissions is more pronounced for low-GHG-emitting firms. This finding confirms our third hypothesis regarding the important moderating role of industry type on the relationship between firm value and GHG emissions. It seems that market participants penalize firms operating in low-GHG-emitting industries for their GHG emissions, more than firms operating in high-GHG-emitting industries (oil and gas and electricity). On average, for every additional tonne of GHG emissions, market value of

low-GHG-emitters decrease by 1010 dollars (CAD). Whereas, for high-GHG-emitting firms, for every additional carbon emission, firm value decreases by 61 dollars (CAD).

Our finding is consistent with previous studies indicating the impact of industry differences on the association between firm value and environmental performance (Cohen, Fenn and Konar, 1995; Cormier and Magnan, 1997; Connors *et al.*, 2013 and Baboukardos, 2017). In specific, Baboukardos (2017) indicates that the negative association between market value and carbon emissions (mandatorily reported) is less pronounced for firms operating in energy-intensive industries.

A number of reasons can explain our finding from the test of third hypothesis. First, higher levels of GHG emissions for firms which are not known as high-GHG-emitters are unexpected for market participants, and therefore, the ethical investors tend to penalize these companies more than firms which are known as high-GHG-emitters. Second, the results imply that investors consider higher levels of implicit environmental liabilities for low-GHG-emitting firms, because these firms will face with higher pressure from governmental bodies and environmental groups to invest in pollution control equipment and activities (compliance costs). Whereas, high-GHG-emitting firms are not expected to face with additional pressures to invest their resources in pollution control activities, resulting in lower implicit environmental liabilities for these firms.

4.3 Summary of the empirical results

In summary, in this chapter, we presented the results for the tests of our hypotheses. The first hypothesis of our research assumes that there is a stock market reaction to the first public release of carbon emissions information of Canadian firms. We conducted an event study to test the first hypothesis. Our results indicate that the public provision

of Canadian firms' GHG emissions information through the website of *Environment and Climate Change Canada* in 2006, did not result in a significant reaction of stock market participants. As a result, our first hypothesis is not supported on a statistical basis. The event study is also conducted for the two subsequent releases of GHG emissions information, as sensitivity tests. However, we do not find a significant market response to the two subsequent release of the information. We consider that the firms' GHG emissions have been already integrated into their stock prices and therefore, the publication of this information did not provide new and unexpected information for investors.

The second hypothesis of our study suggests that there is a negative association between GHG emissions of public Canadian firms and their market valuation. We employed a regression analysis which was based on Ohlson's market-valuation model. The results of the regression analysis show that there is a significant negative relationship between carbon emissions and firm value, supporting our second hypothesis. Our findings suggest that the Canadian investors use the GHG emissions information as the proxy for future environmental liabilities (consistent with the literature). Moreover, our results indicate that, on average, for every additional tonne of GHG emissions, the firm value decreases by 71 dollars (CAD).

The third hypothesis proposes that the firms' sector of activity affects the relationship between GHG emissions and market value of firms. In order to test this hypothesis, we incorporated a moderator variable ($IND * EMIS$) in the market-valuation model. The results of the estimated model confirm our third hypothesis and show that the negative association between GHG emissions and firm value is more pronounced for low-GHG-emitting firms. On average, for every additional tonne of GHG emissions in low-GHG-emitters, the market value decreases by 1010 dollars, while for the high-emitting firms, the market value decreases by 61 dollars, suggesting a considerable economic consequence and a higher market penalization for the low-GHG-emitting firms.

Table 4.6 Summary of main findings

Hypothesis	Result	Confirm or reject
H_1: There is a stock market reaction to the first release of carbon emissions information of Canadian firms through the GHGPR in 2006.	Public provision of Canadian firms' GHG emissions information through the website of Environment and Climate Change Canada in 2006, did not result in a significant reaction of stock market participants	The first hypothesis is rejected
H_2: There is a negative relationship between carbon emissions and the stock market value of public Canadian firms.	There is a significant negative relationship between carbon emissions and firm value and on average, for every additional tonne of GHG emissions, the firm value decreases by 71 dollars	The second hypothesis is confirmed
H3: Companies' sector of activity changes the relationship between GHG emissions and the stock market value of public Canadian firms.	The negative association between GHG emissions and firm value is more pronounced for low-GHG-emitting firms	The third hypothesis is confirmed

CONCLUSION

This research attempted to examine whether Canadian investors care about the greenhouse gas (GHG) emissions of publicly-traded firms. More specifically, the objective of our research was to empirically assess the stock market effects of public Canadian firms' carbon emissions. To this end, we developed three research hypotheses which were drawn from previous related studies and the theoretical argument.

Our first hypothesis was proposed based on the efficient market hypothesis (EMH) (Fama, 1970). Since 2004, the government of Canada required all facilities, emitting 50000 tonnes or more of carbon and carbon equivalents, to report their total emissions to the government. The GHG emissions of all reporting facilities are then organized and publicized annually on the website of *Environment and Climate Change Canada*. We hypothesized that the disclosure of firms' GHG emissions, at the first year (2006), provided new and unexpected information for stock market participants and therefore affected the share prices of public firms (consistent with assumption of the EMH). We undertook an event study to analyze whether the release of GHG emissions information created abnormal returns for a sample of 47 reporting firms. The results of the event study do not indicate statistically significant abnormal returns around the day of the release of information. We predict that the public provision of GHG emissions did not provide new and unpredicted information for investors. The results of the event studies (as sensitivity tests) for the two subsequent releases of emissions information were consistent with the finding of the first event study.

At the second stage, the valuation-relevance of GHG emissions information for the Canadian investors was examined. We proposed that the GHG emissions were negatively associated with the firm value. In order to test our second hypothesis, we employed a market-valuation analysis for the GHG emissions of 2014, 2015 and 2016. The results of our valuation model for a pooled sample of 182 firm-year observations indicate that there is a strong and negative relationship between the GHG emissions and the firm value. Our empirical findings indicate that for every additional tonne of GHG emissions, the market value of firms decreases by 71 dollars.

Our third hypothesis assumed that the industry type of firms had a moderating role on the negative association between GHG emissions and the market value of firms. To test this hypothesis, we examined whether there was a difference in the valuation-relevance of GHG emissions between firms known as high-GHG-emitters (firms operating in the sectors of oil and gas and electricity) and low-GHG-emitting companies. Our results reveal that the negative association between GHG emissions and the market value of firms is more pronounced for low-GHG-emitting firms, suggesting higher penalties from stock market participants for these firms (a decrease of 1010 dollars for every additional tonne of emissions).

In conclusion, we find that the GHG emissions of Canadian firms are value-relevant and the negative association between emissions and firm value suggests that investors use the level of GHG emissions as the proxy for future environmental liabilities.

5.1 Implications of our study

The findings of our study have practical implications for managers of public Canadian firms and for the accounting standard setters. First of all, the negative association found between GHG emissions and firm value implies that managers should consider the

economic consequences of high levels of emissions and try to undertake measurements to reduce their total GHG emissions. Managers could also take into consideration of providing more detailed voluntary information about the monitoring, measuring and reducing carbon emissions to minimize the negative valuation impact of their GHG emissions' level. Moreover, based on the considerable amount of penalty for high levels of GHG emissions of low-emitting firms, managers of such firms need to take more serious decisions to control the carbon emissions of firms.

Our results have also implications for the accounting standard setters. The empirically significant value-relevance of GHG emissions indicates that stock market participants use the level of GHG emissions in their valuation analysis. Hence, there is a demand from the users of financial statements for the complete and reliable information about carbon performance of firms. However, the information on GHG emissions and carbon performance of firms are not mandated to be reported in the current financial statements. Accounting regulators would therefore, consider setting the carbon-related accounting standards. As a result, financial statements would provide more relevant information for market participants and other stakeholders. Additionally, our results imply that investors use the level of GHG emissions to estimate future environmental liabilities. In order to have more precise estimates of carbon liabilities, clear guidelines for the environmental liabilities could be prepared form the accounting standard setters. Consequently, managers can provide their own estimates of future environmental liabilities in the current financial statements, and therefore, investors won't need to invest additional time in evaluating implicit environmental liabilities.

5.2 Limits of our study and recommendations for future works

Our research has some limitations that we suggest possible solutions for them to be considered in future research. First, as elaborated in previous chapters, we have used

the level of GHG emissions of firms as the proxy for non-accounting information in our market-valuation model. However, the level of emissions, solely, cannot reflect the carbon performance of firms. Companies' carbon reduction policies and plans, as well as carbon risk management practices, should also be considered in the assessment of firms' carbon performance. Therefore, future research could incorporate companies' carbon policies and carbon management activities in the market valuation analysis.

Second, the GHG emissions of firms were reported to the Canadian government under a mandatory program, which provided us with a reliable and coherent set of data on the emissions. However, this source of carbon emissions information limited the number of our sample firms for each year. We suggest that future works take additional sources of information to have a relatively larger number of firms.

Third, the Canadian firms' GHG emissions information of each year is published with a lag of 12-18 months by the *Environment and Climate Change Canada*. Therefore, for our event study, the event day has been determined with a long delay. As a result, the investors may have already obtained their needed information from other sources. We suggest that future event studies consider a data source which publishes the information on firms' carbon performance with a shorter time delay.

Future research can also examine the valuation-relevance of Canadian firms' carbon emissions which are announced under voluntary reporting systems, such as the Carbon Disclosure Project (CDP), to be able to compare the impact of different reporting regimes on the valuation-relevance of carbon emissions. Moreover, using the emissions information reported to the CDP, there is the possibility of comparing the Canadian evidence with other countries examining the same kind of data.

Finally, we have examined the moderating role of industry type on the relationship between GHG emissions and firm value. Future research in the context of Canadian

firms could assess the impacts of corporate governance or other factors on the association between GHG emissions and market value of firms.

ANNEX A

SUMMARY OF ENVIRONMENTAL DISCLOSURE LITERATURE

Table A.1 Summary of voluntary environmental disclosure articles

Study	Environmental variable	Method	Main findings
Campbell *et al.* (2003)	Environmental liabilities in the financial statements (footnotes and accrual)	Regression analysis	Valuation-relevance of environmental liabilities information available in accruals and footnotes
Freedman and Patten (2004)	Environmental disclosure in 10-K reports	Regression analysis	Mitigating role of voluntary disclosure on the negative market effects of pollution performance of firms
Clarkson *et al.* (2013)	Environmental disclosure reported by firms	Regression analysis	Incremental valuation-relevance of voluntary disclosure of firms over pollution performance
Schadewitz and Niskala (2010)	Corporates responsibility reporting based on Global Reporting Initiatives (GRI)	Regression analysis	Valuation-relevance of GRI responsibility reporting
Murray *et al.* (2006)	Environmental disclosure in annual reports	Regression analysis	No association between voluntary disclosure and firm value

Moneva and Cuellar (2009)	Financial and non-financial environmental information in annual reports	Regression analysis	Valuation-relevance of financial environmental information only (negative association between financial indicators and the firm value)
Cormier and Magnan (2007)	Environmental disclosure in financial statements	Regression analysis	Impact of voluntary disclosure on the valuation of earnings based on country-specific context
De Klerk and De Villiers (2012)	Environmental disclosure in corporate responsibility reporting (CRR)	Regression analysis	Positive relationship between CRR and firm value (valuation-relevance of CRR)

Table A.2 Summary of externally environmental disclosure articles

Study	Environmental variable	Method	Main findings
Hamilton (1995)	Toxic Release Inventory (TRI) information	Event study	Negative impact of TRI information on firm value, at the first year of information release
Konar and Cohen (1997)	Toxic Release Inventory (TRI) information	Event study	Negative impact of TRI information on firm value of firms and the subsequent reduction of emissions by firms
Khanna *et al.* (1998)	Toxic Release Inventory (TRI) information	Event study	Negative abnormal returns as a result of repeated provision of TRI information
Cohen, Fenn and Konar (1995)	Environmental disclosure in governmental reports (like TRI) and 10-K reports	Regression analysis	Negative association between TRI information and stock prices
Connors *et al.* (2013)	Toxic Release Inventory (TRI) information	Event study	Different market response to the TRI information according to the industry type
Cormier *et al.* (1993)	Water pollution performance of firms	Regression analysis	Negative association between pollution performance and firms' market value

Cormier and Magnan (1997)	Water pollution performance of firms	Regression analysis	Negative association between pollution performance and stock market value of firms in particular for polluting firms
Lanoie *et al.* (1998)	Pollution performance of firms	Event study	No association between the disclosure of pollution performance and stock market value of firms
Hassel *et al.* (2005)	Environmental index developed by *Caring Company*	Regression analysis	Negative association between environmental performance and market value of firms
Semenova *et al.* (2009)	Environmental performance of firms published by *Global Ethical Standard Investment Services Risk*	Regression analysis	Positive association between environmental performance and market value of firms
Lorraine *et al.* (2004)	News on the environmental fines and rewards of firms	Event study	Negative stock market response to bad news

Table A.3 Summary of mandatory environmental disclosure articles

Study	Environmental variable	Method	Main findings
Li and McConomy (1990)	Accrued liabilities for future site restoration and removal costs	Regression analysis	Valuation-relevance of future environmental liabilities for investors
Hughes (2000)	SO_2 emissions disclosure	Regression analysis	Valuation-relevance of SO_2 emissions reporting for investors
Bewley (2005)	Environmental liabilities	Regression analysis	Valuation-relevance of environmental liabilities
Clarkson *et al.* (2004)	Environmental capital expenditures	Regression analysis	Positive association between environmental capital expenditures (ECE) and firm value in low-polluting firms

ANNEX B

SUMMARY OF CARBON DISCLOSURE LITERATURE

Table B.1 Summary of mandatory carbon disclosure articles

Study	Environmental variable	Method	Main findings
Clarkson *et al.* (2015)	Actual CO_2 emissions and CO_2 emission allowances	Regression analysis	Negative association between carbon emissions and firm value, and between allowance shortages and firm value
Brouwers *et al.* (2016)	Verified CO_2 emissions and CO_2 emission allowances	Event study	Negative association between CO_2 emission allowance shortages and firm value
Johnstone *et al.* (2008)	SO_2 (as a proxy for GHG emissions) emission allowances and actual SO_2 emission levels	Regression analysis	Positive association between SO_2 emission allowance bank of firms and their stock market value
Chapple *et al.* (2013)	Carbon emissions	Event study	Negative stock market impact of carbon emissions under a proposed emissions trading scheme
Baboukar dos (2017)	GHG emissions	Regression analysis	Negative relationship between GHG emissions and firm value and the mitigating impact of a mandatory GHG reporting regulation on this relationship

Table B.2 Summary of voluntary carbon disclosure articles

Study	Environmental variable	Method	Main findings
Kim and Lyon (2011)	Carbon emissions	Event study	Positive impact of carbon emissions disclosure on shareholder value of firms under the increased probability of environmental regulations
Lee *et al.* (2015)	Carbon emissions	Event study	Negative association between voluntary carbon disclosure and market value of firms and the mitigating impact of regular carbon communication on this association
Matsumura *et al.* (2014)	Carbon emissions	Regression analysis	Negative association between carbon emission levels and market value of firms
Griffin *et al.* (2010)	Carbon emissions	Regression analysis	Negative association between reported and non-reported carbon emissions and firm value
Choi and Luo (2017)	Carbon emissions	Regression analysis	Negative relationship between carbon emissions and the stock market value of firms

Table B.3 Summary of externally carbon disclosure articles

Study	Environmental variable	Method	Main findings
Beatty and Shimshack (2010)	Firms' response to climate-change, published by *Climate Counts*	Regression analysis	Negative market reactions (punishment) for firms with lower climate-change-actions
Hsu and Wang (2012)	Firms' responses to climate change, covered by *Wall Street Journal*	Event study	Positive stock market reaction for firms' negative coverage in the journal

ANNEX C

Table C.1 Sample firms for the second event study (GICS numbers are presented for each company)

Company	GIC Numbers	Company	GIC Numbers	Company	GIC Numbers
1. Abitibi-Consolidated	151050	18. Fording	151040	35. PrimeWest Energy	101020
2. Agrium	151010	19. Hudbay Minerals	151040	36. Shell Canada	101020
3. Alcan	151040	20. Husky energy	101020	37. Sherritt International	151040
4. ATCO Group	551030	21. Imperial Oil	101020	38. St Lawrence Cement	151020
5. Boralex	551050	22. INCO	151040	39. Suncor Energy	101020
6. Bonavista Petroleum	101020	23. Inter Pipeline	101020	40. Talisman Energy	101020
7. Canadian Natural Resources	101020	24. IPSCO	151040	41. Teck Comminco Metals	151040
8. Canadian Oil Sands	101020	25. Keyera	101020	42. Stelco	151040
9. Canadian Utilities (CU)	551030	26. Maxim Power	551050	43. Timminco	151040
10. CANFOR	151050	27. Methanex	151010	44. TransAlta	551050
11. Cascades	151030	28. Nexen	101020	45. TransCanada	101020
12. Domtar	151050	29. Northland Power	551050	46. Gerdau AmeriSteel	151040
13. Emera	551010	30. NOVA Chemicals	151010	47. West Fraser Timber	151050
14. Enbridge	101020	31. Pengrowth	101020	48. Westcoast Energy	551010
15. EnCana	101020	32. Penn West Petroleum	101020	49. Taylor NGL	151010
16. Fraser Paper	151040	33. Petro Canada	101020		
17. Brookfield Power	551050	34. Catalyst Paper	151050		

- Sectors of activity according to GIC numbers: 101020: oil, gas and consumable fuels; 151010: chemicals; 151020: construction materials; 151030: containers and packaging; 151040: metals and mining; 151050: paper and forest products; 551010: electric utilities; 551030: multi-utilities and 551050: power and renewable electricity.

ANNEX D

Table D.1 Sample firms for the third event study (GICS numbers are presented for each company)

Company	GIC Numbers	Company	GIC Numbers	Company	GIC Numbers
1. Agrium	151010	16. Fording	151040	31. PrimeWest Energy	101020
2. Alcan	151040	17. Hudbay Minerals	151040	32. Petro Canada	101020
3. ATCO Group	551030	18. Husky energy	101020	33. Sherritt International	151040
4. Boralex	551050	19. Imperial Oil	101020	34. Taylor NGL	151010
5. Bonavista Petroleum	101020	20. Inter Pipeline	101020	35. Suncor Energy	101020
6. Brookfield Power	551050	21. Keyera	101020	36. Talisman Energy	101020
7. Canadian Natural Resources	101020	22. Maxim Power	551050	37. Teck Comminco Metals	151040
8. Canadian Oil Sands	101020	23. Western Canadian Coal	151040	38. Tembec	151050
9. Canadian Utilities (CU)	551030	24. Nexen	101020	39. Timminco	151040
10. CANFOR	151050	25. Northland Power	551050	40. TransAlta	551050
11. Cascades	151030	26. Fraser Paper	151040	41. TransCanada	101020
12. Domtar	151050	27. Catalyst Paper	151050	42. Gerdau AmeriSteel	151040
13. Emera	551010	28. NOVA Chemicals	151010	43. West Fraser Timber	151050
14. Enbridge	101020	29. Pengrowth	101020	44. Westcoast Energy	551010
15. EnCana	101020	30. Penn West Petroleum	101020		

- Sectors of activity according to GICS numbers: 101020: oil, gas and consumable fuels; 151010: chemicals; 151030: containers and packaging; 151040: metals and mining; 151050: paper and forest products; 551010: electric utilities; 551030: multi-utilities, and 551050: power and renewable electricity.

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