Greenhouse Gas Performance and Accounting Disclosure: Global Commonalities and Differences

by

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Intellectual Property Statement

The candidate confirms that the work submitted is his/her/their own and that appropriate credit has been given where reference has been made to the work of others.

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Abstract

This thesis investigates the relationship between firms' underlying carbon footprints and the corresponding corporate carbon disclosure strategies for developed economies, developing economies, and internationally as a whole. Evidence shows that there are systematic differences in society between developing economies and developed economies. Consequently, firms' general carbon disclosure strategies based on their underlying carbon footprints are expected to differ between developing economies and developed economies. The investigations employ an international dataset of firm-level carbon emission and disclosure data from the recently available Carbon Disclosure Project database, as well as other complementary and supplementary data sources.

Specifically, for years 2009-2014, the overall global evidence indicates that heavy carbon emitters disclose significantly more extensively about their carbon emission-related information (negative association between corporate carbon performance and carbon disclosure). Moreover, it is identified that such evidence is driven by developed economies. In developing economies, however, firms' carbon disclosure is not associated with firms' underlying carbon footprints.

After controlling potential endogeneity and data-trending problems, for the same period under investigation, the overall global evidence shows that a decrease of firms' underlying carbon footprints causes a subsequent decrease in firms' carbon disclosure extensiveness. This global evidence is again driven by developed economies. In developing economies, the changes in firms' underlying carbon footprints do not contain any information on firms' subsequent carbon disclosure strategy changes. The evidence obtained in this thesis suggests that the relationship of interest could be associated with the different social characteristics (carbon awareness level, carbon disclosure regulatory environment, stakeholders' carbon information demands, etc) regarding corporate carbon emission issues in different societies. This, in turn, provides a plausible rationale to connect the chronologically conflicting evidence in the extant literature that investigates the association pattern (no association; negative association; positive association) between firms' underlying environmental impact level and firms' environmental disclosure extensiveness level.

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List of Abbreviations

CSR	Corporate Social Responsibility
CEP	Council on Economic Priorities
CDLI	Carbon Disclosure Leadership Index
CDP	Carbon Disclosure Project
CDM	Clean Development Mechanism
DAC	Development Assistance Committee
ETS	Emissions Trading Scheme
EU	European Union
ESG	Environmental, Social and Governance
GHG	Greenhouse Gas
GRI	Global Reporting Initiative
GHGRP	Greenhouse Gas Reporting Program
GICS	Global Industry Classification Standard
GDP	Gross Domestic Product
GNP	Gross National Product
GLS	Generalised Least Squares
GMM	Generalised Method of Moments
IMF	International Monetary Fund
IRRC	Investor Responsibility Research Centre
JI	Joint Implementation
MSCI	Morgan Stanley Capital International
NPV	Net Present Value
OLS	Ordinary Least Squares
OECD	Organisation for Economic Co-operation and Development
R&D	Research and Development
SEA	Social and Environmental Accounting
SEC	Securities and Exchange Commission

S&P	Standard and Poor's
TRI	Toxics Release Inventory
UNFCCC	United Nations Framework Convention on Climate Change
US	United States
UK	United Kingdom
USD	United States Dollar
UN HDI	United Nations Human Development Index
2SLS	Two-Stage Least Squares

1. Introduction

The thesis focuses on the relationship between firms' greenhouse gas (GHG; alternatively, carbon equivalents) performance[1] and the corresponding accounting disclosure. However, GHG emission issues are only an aspect of the wider corporate environmental issues. The introduction starts with introducing prior studies and the corresponding evidence as regards the relationship between firms' environmental performance and corporate environmental disclosure. Following which, the necessity and practical significance of the investigations included in this thesis would be given. The introduction chapter concludes with an induction of the research questions being studied in each empirical chapter of the thesis and the structure of the rest of the thesis.

1.1 Focus of the Investigation

Environmental issues arising from firms' business operations are important drivers for accounting disclosure (Ingram and Frazier, 1980; Ullmann, 1985; Clarkson et al., 2008; Luo, 2019). The degree of the environmental impact of firms' business activities on the environment where firms operate is considered firms' environmental performance (Freedman and Jaggi, 1982; Patten, 2002; Clarkson et al., 2008). One may intuitively think that firms' environmental disclosure should be based on firms' underlying environmental performance and change in the same direction with firms' environmental performance, as this is good practice with consistent integrity. However, the empirical evidence from prior studies suggests otherwise. In section1.1, first an induction of the extant literature that investigates the association between firms' environmental performance and corporate environmental disclosure would be given. Subsequently, the gaps and problems of the extant literature would be highlighted, leading to the necessity of the investigations included in this thesis as regards the relationship between firms' GHG performance and the corresponding accounting disclosure.

[1] Firms' environmental performance refers to the extent to which firms' business activities affect the environment where firms' activities happen. In the practice of academic research, prior studies widely use the amount and/or the scaled amount of pollutants and/or toxics generated by firms or environmental issue related scores produced by third party research institutions to proxy for firms' environmental performance. This also applies to firms' GHG (carbon) performance.

1.1.1 The Research Problem

The social and environmental accounting (SEA) literature has seen an abiding but contradictory discussion on the relationship between firms' environmental performance and corporate environmental disclosure. For those studies that identify association between firms' environmental performance and corporate environmental disclosure, whether good [2] environmental performers or bad environmental performers tend to disclose more extensively about their environmental information is a focus of contention (Clarkson et al., 2008; Qian and Schaltegger, 2017). Specifically, early research generally finds no significant association between firms' environmental performance and the extensiveness of corporate environmental disclosure (Ingram and Frazier, 1980; Wiseman, 1982; Freedman and Wasley, 1990). Later studies find that bad environmental performers tend to disclose more extensively about their environmental related information (negative association) (Bewley and Li, 2000; Hughes et al., 2001; Patten, 2002). Most recent studies, however, generally identify that good environmental performers tend to disclose more extensively about their environmental related information (positive association) (Al-Tuwaijri et al., 2004; Clarkson et al., 2008). Those studies which discover no association or a negative association between environmental performance and environmental disclosure generally corresponds to legitimacy theory's prediction (Patten, 2002; Cho and Patten, 2007). And studies that find a positive association between environmental performance and environmental disclosure generally accords with discretionary disclosure theory's prediction (Clarkson et al., 2008).

Legitimacy theory argues that those whose social legitimacy and public image are more threatened tend to disclose more environmental information. This is because such disclosure could serve as their reaction to social pressures and a measure that may help them reduce expected losses elicited from threatened social legitimacy and damaged public image (Bewley and Li, 2000; Patten, 2002). While discretionary disclosure theory argues that good environmental performers tend to disclose more extensively about their environmental information. This is because they intend to communicate their superior environmental performance status among investors and potential stakeholders to establish the corresponding good environmental public image and obtain potential financial and non-

[2] In the related extant literature, good environmental performers and bad environmental performers are relatively defined based on specific firms' negative influence on the environment where they operate. Specifically, insignificant or low releases of pollutants and/or toxics are a sign of good environmental performers [See: Al-Tuwaijri, S.A., Christensen, T.E. and Hughes, K.E. 2004. The relations among environmental disclosure, environmental performance, and economic performance: a simultaneous equations approach. *Accounting, Organizations and Society.* **29**(5-6), pp.447-471.; Clarkson, P.M., Li, Y., Richardson, G.D. and Vasvari, F.P. 2008. Revisiting the relation between environmental performance and environmental disclosure: An empirical analysis. Ibid.**33**(4-5), pp.303-327.].

financial benefits in the long run (Dye, 1985; Navarro, 1988). These two different theoretical predictions are totally exclusive to each other, combined with the empirical evidence that respectively supports each other's theoretical prediction. The literature regarding this research topic is split and conflicting.

Since the end of the 20th century, "GHG emission issues" and related "climate change risks" have been brought to more and more people's attention, initiating from the world's most advanced economies (UNFCCC, 2014), in the wake of the successful convention of the United Nations Framework Convention on Climate Change (UNFCCC) in 1992 and the subsequent formation of Kyoto Protocol in 1997. Recently, reports and surveys (KPMG, 2015; KPMG, 2017) find that world's largest companies have been proactively responding to public concerns over climate change risks by setting up carbon reduction targets and integrating "low-carbon" business concepts into their daily operations. In fixed-income financial market, climate change mitigation aligned bonds have seen rapid growth over the past two decades, the issuance of climate bonds has reached $223bn as of 2019 (Climate Bonds Initiative, 2019). Government-led regulatory and market based instruments like carbon taxes, carbon emissions trading schemes etc., have also been implemented to help build the sustainable future of human society (Downar et al., 2019). In line with which situation, adding to the literature that studies the relationship between firms' environmental performance and firms' environmental disclosure, a group of studies particularly investigate the relationship between GHG disclosure and GHG performance drawing on data from the world's largest companies that are predominantly from developed economies (Luo and Tang, 2014; Qian and Schaltegger, 2017; Luo, 2019).

Nevertheless, these studies examining the association between GHG disclosure and GHG performance mainly just repeated what prior studies have done to investigate the relationship between firms' environmental performance and corporate environmental disclosure, using GHG emissions and disclosure data. The results obtained are still contradictory, further adding to the conflicting and jumbled landscape of the research issue. The extant literature regarding this research issue has stepped into a dead loop of arguing which condition of association, namely, no association, negative association, positive association, between firms' environmental performance and corporate environmental disclosure should be, based on newer and newer data.

1.1.2 Directing Attention to Macro Environmental Disclosure Circumstance

However, an important situation has been ignored in this thinking pattern. That is, the association pattern between firms' environmental performance and corporate environmental disclosure could be changing over time[3] under different macro environmental disclosure circumstances (as is mentioned in the abstract, these circumstances refer to different overall social institutions and regulatory environments regarding corporate environmental disclosure over time) in society. Then the identified no association, negative association, and positive association as regards the relationship of interest could be all true but under different macro environmental disclosure circumstances over time. Specifically, prior empirical evidence as regards the relationship between firms' environmental performance and corporate environmental disclosure is predominantly from North America. And the conflicting evidence as regards the relationship of interest clusters in different periods of North American society chronologically. For an intuitive understanding of the clustering phenomenon of the North American empirical evidence as regards the relationship of interest, please see Table 1-1[4].

We could see from Table 1-1 that studies drawing on North American data in the 1970s predominantly find "no association" as regards the relationship of interest. Studies drawing on North American data after 1970s and before 1994 predominantly find "negative association" as regards the relationship of interest. And studies drawing on North American data after 1994 (inclusive) predominantly find "positive association" as regards the relationship of interest.

[3] Note that prior studies that investigate the relationship between firms' environmental performance and corporate environmental disclosure predominantly use cross-sectional research design.

[4] The papers included in Table 1-1 are selected from prior empirical studies that investigate firms' environmental disclosure-performance relationship, as they draw on North American data. Only North American studies are selected because the evidence regarding this research issue is predominantly based on data from North America. The evidence from North America is continuous. If there is any pattern of the empirical evidence regarding the relationship of interest over time, it is much easier to see by eliminating the noises generated by the discontinuous evidence from other regions. These papers would be reviewed in detail in chapter 2. Specifically, review pieces and meta-analyses on this research topic are not included in Table 1-1, as review pieces and meta-analyses are also based on the empirical evidence from these empirical studies. For an intuitive presentation of the plausible story-line, these papers are excluded. In addition, there are only two empirical papers included for Phase3, because research regarding this research topic employing North American data has plateaued in the old thinking pattern after decades' academic discussions.

Table 1-1: The chronological shifts of North American empirical evidence as regards the association between firms' environmental performance and corporate environmental disclosure

Paper Title	Publication Year	Authors	Data Year	Research Design and Findings regarding the association between environmental disclosure and environmental performance	Phases	Journal
Environmental performance and corporate disclosure.	1980	Ingram, Robert W. Frazier, Katherine Beal	1977	Cross-sectional design; No association		Journal of Accounting Research
An evaluation of environmental disclosures made in corporate annual reports.	1982	Wiseman, Joanne	1972, 1974, 1976	Cross-sectional design; No association	**Phase1**	Accounting, Organizations and Society
The association between environmental performance and environmental disclosure in annual reports and 10Ks.	1990	Freedman, Martin Wasley, Charles	1972, 1974, 1975, 1976	Cross-sectional design; No association		Advances in Public Interest Accounting
Disclosure of environmental information by Canadian manufacturing companies: a voluntary disclosure perspective.	2000	Bewley, Kathryn Li, Yue	1993	Cross-sectional design; Negative association		Advances in Environmental Accounting and Management
Corporate environmental disclosures: Are they useful in determining environmental performance?	2001	Hughes, Susan B. Anderson, Allison Golden, Sarah	1992, 1993	Cross-sectional design; Negative association	**Phase2**	Journal of Accounting and Public Policy
The relation between environmental performance and environmental disclosure: a research note.	2002	Patten, Dennis M.	1990	Cross-sectional design; Negative association		Accounting, Organizations and Society
The relations among environmental disclosure, environmental performance, and economic performance: a simultaneous equations approach.	2004	Al-Tuwaijri, Sulaiman A. Christensen, Theodore E. Hughes, K. E.	1994	Cross-sectional design; Positive association		Accounting, Organizations and Society
Revisiting the relation between environmental performance and environmental disclosure: An empirical analysis.	2008	Clarkson, Peter M. Li, Yue Richardson, Gordon D. Vasvari, Florin P.	2003	Cross-sectional design; Positive association	**Phase3**	Accounting, Organizations and Society

It should be noted that corporate environmental issues started to become a material social concern together with and under the wider concept of corporate social responsibility[5] (CSR) in the 1960s-1970s in developed economies, although Chester Bernard and Theodore Kreps initiated the advocacy for socially responsible business early in the 1930s-1940s of the US (Thinkingshift, 2007). Since 1960s-1970s, corporate environmental issues together with other general CSR related issues have been steadily gaining more and more stakeholders' serious concern from developed economies to the rest of the world. Accordingly, vast research on CSR related issues started to sprout from the 1970s and has prospered thereafter (Thinkingshift, 2007).

Because CSR related (environmental) issues are not, from the beginning, considered a naturally integrated part of businesses, it is after decades' propaganda and education that CSR (corporate environmental issues) gradually became a serious concern of businesses and their stakeholders globally (Deegan, 2017). Since the point (the 1960s-1970s) when corporate environmental issues started to become a material social concern, it is reasonable to contend that the macro corporate environmental disclosure circumstance changes and develops as *the importance of corporate environmental issues and related risks spreads and sediments* in the society of developed economies and then in the society of developing economies. And *the spreading and sedimentation of the importance of corporate environmental issues and related risks* are coupled with the corresponding propaganda and education efforts in different societies (Deegan, 2002; Cowan and Deegan, 2011).

It then follows that, during *the whole spreading and sedimentation process of the importance of corporate environmental issues and related risks* in society, the types and numbers of stakeholders requiring corporate environmental information would gradually change and increase. Because different stakeholders have different influencing abilities on their interested firms (Deegan, 2002; Cooper and Owen, 2007; Chang et al., 2014), the changes and increases of stakeholders requiring corporate environmental information over time would eventually lead to changes of the macro environmental disclosure circumstances in society over time. Simultaneously and consequentially, corresponding to stakeholders' environmental information requirement changes, the types and the numbers of firms that make corporate environmental disclosure would change under the different macro environmental disclosure circumstances in society over time. Speaking of the different types of firms, according to the

[5] "*Corporate social responsibility (CSR) is generally considered a self-regulating business model that shapes a company to be socially accountable—to itself, its stakeholders, and the public. By practicing corporate social responsibility, also called corporate citizenship, companies can be conscious of the kind of impact they are having on all aspects of society, including economic, social, and environmental.*" {See James, C. and Gordon, S. 2020. *Corporate social responsibility (CSR)* [Online]. Available from: https://www.investopedia.com/terms/c/corp-social-responsibility.asp}.

degree of the average environmental impact of a specific industry regarding environmental issues, firms could be categorised into low-profile firms, average firms and high-profile firms (Clarkson et al., 2008; Cheng et al., 2014). For example, chemical firms are generally considered high-profile firms regarding corporate environmental issues, because they have on average high volumes of toxics and pollutants releases .

Particularly, take *the spreading and sedimentation process of the importance of corporate environmental issues and related risks* in North American society for example. When corporate environmental issues started to become a material social concern in the 1960s-1970s of North American society, the concerned entities in society regarding corporate environmental issues tend to be mainly academics, related promoting non-governmental organisations etc. (Opinion Research Corporation, 1974; Duff And Phelps Inc, 1976). It is possible that only those high-profile firms regarding corporate environmental issues would start to respond to the environmental information demand from such concerned entities. This speculation also coincides with the fact that the North American studies included in **Phase1** of Table 1-1 only draw on environmental data from high-profile firms monitored by the Council on Economic Priorities[6] (CEP). At this stage, the management of the responding firms only starts to realise the importance and relevance of corporate environmental issues to their businesses. And it's barely possible for them to substantially manage their environmental impact. Thus, studies drawing on data from this stage would most likely to find the result of no association regarding the relationship of interest, as the environmental disclosure data at this stage does not contain any information of firms' real environmental performance. Firms purely use corporate environmental disclosure as a device to alleviate their threatened legitimacy and a substitute for material environmental impact mitigation activities at this stage. Legitimacy theory has a predominant explanatory power over the observed no-association phenomenon between firms' environmental performance and corporate environmental disclosure in **Phase1** in Table 1-1.

Along with *the degree to which the importance of corporate environmental issues and related risks is accepted by North American society* increasing, it would reach a stage where the concerned entities in society have also increased to include political lobbying groups, regulators, governments and some concerned investors and customers. At this stage, firms with a significant environmental impact would all feel urged to materially manage and disclose their environmental information. This is because if firms ignore relevant environmental

[6] The Council on Economic Priorities is a non-profit institution dedicated to analysing and rating corporate social and environmental activities in the US.

regulations or/and guidance, governments and/or regulators could impose the corresponding punishments and/or initiate prosecutions. If firms ignore the environmental information demands from concerned investors and customers, investors could impose higher financing costs on these firms or even withdraw investments. Customers may stop buying from such firms. Firms certainly do not want to experience any of the situations above.

Accordingly, on the one hand, environmental disclosure produced by such firms at this stage tends to reflect or partially reflect such firms' material environmental mitigation activities. On the other hand, firms that have little environmental impact from their operations would be very unlikely to produce detailed environmental disclosure. This is because they are not regulated by regulators and governments regarding key environmental issues and are not monitored by those concerned investors, customers regarding key environmental issues. Producing detailed environmental disclosure would be pure costs for them. Or if mandatory environmental disclosure is required by regulators and governments at this stage, bad environmental performers would have to discuss in detail how they manage their environmental impact and risks in regulated channels. However, good environmental performers would again disclose much less extensively, as they have little material environmental impact and have less to say. Extensive unnecessary disclosure would add to unnecessary costs. Consequently, at this stage, studies tend to find a negative association as regards the relationship of interest. Legitimacy theory again has strong explanatory power over the relationship of interest at this stage (**Phase2** in Table 1-1).

When it develops to the stage where *the importance of corporate environmental issues and related risks is accepted by the vast majority of society*, in addition to the interest groups like academics, related non-governmental promoting organisations, political lobbying groups, regulators and governments, most investors, customers and the wider stakeholders are concerned with their interested firms' environmental impact. At this stage, even firms with little environmental impact and risks (i.e. good environmental performers) pervasively produce detailed environmental disclosure, backed up with good statistics and their ingrained sustainable operating patterns. In contrast, firms with significant environmental impact and risks would tend to disclose in a less detailed way (usually with more soft claims and less material statistics and measures) or be silent (where mandatory environmental disclosure is not required) to mix with those average performers (Clarkson et al., 2008). This is because their statistics and business patterns are by any means no match for those good environmental performers. Studies at this stage in North America have a much-improved access to environmental disclosure and performance data from a much wider range of firms, with good environmental

performers disclosing more extensively. Consequentially, the empirical evidence obtained as regards the relationship of interest tends to be positive. At this stage (**Phase3** in Table 1-1), discretionary disclosure theory has strong explanatory power over the relationship of interest.

The arguments above provide a possible rationale to connect the seemingly contradictory empirical evidence as regards the association patten between firms' environmental performance and corporate environmental disclosure in the extant literature. That is, both legitimacy theory's prediction and discretionary disclosure theory's prediction over the association pattern of the relationship of interest could be true under the corresponding macro corporate environmental disclosure circumstances. The shifts of the empirically observed association patten between firms' environmental performance and corporate environmental disclosure in different phases of Table 1-1 may simply reflect the changes and developments of the macro corporate environmental disclosure circumstance in North America over time. In addition, it is worth noting that the three macro environmental disclosure circumstances above are only some possible speculations that help clarify the argument that *the different association patterns between firms' environmental performance and corporate environmental disclosure could be associated with the respective macro environmental disclosure circumstances in society over time*. Thus, the conditions specified in these different macro environmental disclosure circumstances above are by no means prescriptive.

However, it could also be that the clustering of the same empirical evidence regarding the relationship of interest from North America results from the similarity of data and methodologies used by the studies in the same phase and major differences of the data and methodologies used by the studies in different phases. Most importantly, because the existing evidence is predominantly from North American studies, we do not know whether the global evidence on the association pattern between firms' environmental performance and corporate environmental disclosure would also point to the possibility *that the different association patterns of the relationship of interest are associated with the respective macro disclosure circumstances*. Thus, the investigations in this thesis as regards the relationship between firms' GHG performance and corporate GHG disclosure intend to provide some new evidence on whether global evidence also points to the possibility *that the different association patterns of the relationship of interest are associated with the respective macro disclosure circumstances in society*, using consistent research design for the same period under investigation on a global basis.

1.2 Research Questions and Thesis Structure

The previous section presents the focus of the investigations of the thesis and the gaps in the literature on which the thesis intends to build on. This section introduces the research questions examined in each empirical chapter of the thesis and how these research questions relate with the gaps in the literature. At the end of the section, the structure of the rest of the thesis would be given to guide readers through the thesis.

1.2.1 The First Empirical Chapter

Although GHG emission issues and related climate change risks are subsumed by corporate environmental issues, the major difference between GHG emission issues and other corporate environmental issues is that, as is mentioned earlier, GHG emission issues have been only brought to public attention at the end of the 20th century by the world's most advanced economies (Thinkingshift, 2007). While other general corporate environmental issues started to become a material social concern in the 1960s-1970s (Thinkingshift, 2007). A commonality that GHG emission issues share with other coproate environmental issues is that, like other corporate environmental issues, GHG emission issues are not originally considered a naturally integrated part of businesses. A high level of GHG emission awareness and concern in society is coupled with the corresponding propaganda and education efforts over time in society. In other words, it takes a significant period of time to reach a high level of GHG emission awareness and concern in society.

Given the above arguments and the fact that, at current stage, only world's largest companies have been proactively responding to public concerns over climate change risks (KPMG, 2015; KPMG, 2017). Global GHG awareness is significantly lower than the global awareness of other CSR related issues (KPMG, 2015; KPMG, 2017). The global GHG disclosure circumstance is different from the global disclosure circumstance as regards other environmental issues at current stage. In addition, prior studies find that there are significant differences between developed economies and developing economies regarding the drivers, determinants and impact of corporate environmentally related disclosure (Belal, 2000; Islam and Deegan, 2008; Islam and McPhail, 2011; Ali and Rizwan, 2013; Ali et al., 2017). And the advacacy of the importance of GHG emission issues and related climate change risks initiated from developed economies and then, spread to the rest of the world (Thinkingshift, 2007).

These situations also lead to a difference between developed economies and developing economies as regards their respective GHG disclosure circumstances at current stage.

Particularly, the first empirical study (chapter 4) investigates the research question **(1)** "For years 2009-2014, would the observed association pattern between firms' GHG performance and corporate GHG disclosure on a global basis be different from the most recently observed positive association (**Phase3** in Table 1-1) between firms' environmental performance and corporate environmental disclosure?" If it is different, then, this would add to the possibility of the speculation based on North American evidence *that the different association patterns of the relationship of interest are associated with the respective macro disclosure circumstances in society*. Subsequently, this chapter also investigates the research question **(2)** "For the same period under investigation, would the association pattern between firms' GHG performance and corporate GHG disclosure in developed economies be different from that in developing economies?" If the difference is again observed, then, this would further add to the viability of the speculation above based on North American evidence. Most importantly, because the analyses proposed above are conducted under the same research design, if the expected differences are observed, it would be much safer to say that the differences regarding the relationship of interest are there, as the data obtained under different macro disclsoure circumstances speaks for itself.

1.2.2 The Second Empirical Chapter

Most studies in the literature that investigate the environmental disclosure-performance relationship stop at only claiming possible association between firms' environmental performance and corporate environmental disclosure. Little evidence has been provided on whether firms' environmental disclosure strategy would change according to the historical changes in firms' underlying environmental performance. Subsequent to chapter 4 that strives to provide new evidence on the possibility of a framework to connect and unify the conflicting evidence in the extant literature that investigates the environmental disclosure-performance association problem, the second empirical study (chapter 5) pushes the issue one step further to investigate whether there is any evidence that would suggest a causal relationship between the changes in firms' historical GHG performance and the subsequent changes in firms' GHG disclosure strategy on a global basis after controlling for potential impact of endogeneity and the impact of data trending problem on the results.

The research question that chapter 5 investigates is **(3)** "Globally speaking, for years 2009-2014, would firms' GHG disclosure strategy change according to firms' historical

GHG performance changes over time?" (or alternatively, "Globally speaking, , for years 2009-2014, would changes in firms' GHG performance cause any subsequent changes in firms' GHG disclosure strategy?") This research question is examined based on two competing theoretical predictions from the "inside-out"[7] management perspectives and legitimacy theory. Specifically, the "inside-out" management perspectives argue that, to report any information from inside a firm to outside information users, there is always a process of "involvement-achievement-disclosure" (Burritt and Schaltegger, 2010; Burritt et al., 2010). Regardless of whether CSR related disclosure is originally used just as a tool to react to outside expectations on firms or not, with continual involvement in a specific CSR related issue, corporate CSR disclosure tends to adjust in line with a firm's CSR performance changes through the course of time. This is because the risk of "being busted" together with the corresponding costs would be growing to uncontrollable if a firm always uses CSR disclosure that constantly dissociates with its real CSR performance history (Schaltegger and Csutora, 2012). From which point of view, firms' GHG disclosure would change to promote climate information transparency as a result of the changes in firms' GHG mitigating performance trajectory.

However, according to the argument from legitimacy theory, maintaining firms' legitimacy is a priority in maintaining the sustainable existence of firms, as firms only exist to the extent that society considers them to be legitimate (Aerts and Cormier, 2009; Hawn et al., 2011). Corporate activities should be regarded as firms' reflection towards various social expectations (Lindblom, 1983; Deegan, 2002; Law, 2010). Intuitively, corporate decisions as regards CSR related issues should also be considered a kind of reactive behaviour from the management of a firm to cater to social expectations on a firm. Following this line of thinking, corporate GHG disclosure is only a legitimising tool, and it does not necessarily have to be based on firms' underlying GHG performance. Thus, the changes in firms' GHG disclosure do not have to contain any information of firms' GHG mitigating performance change trajectory. Or if the corporate GHG disclosure of a firm is based on firms' underlying GHG performance, firms tend to see a decreasing tendency in GHG disclosure following an improving tendency in firms' historical GHG performance. This is because firms may well reduce the non-trivial cost-eliciting GHG disclosure activities if they feel that their legitimacy

[7] Although the investigation in chapter 5 is still on the relationship between firms' GHG performance and corporate GHG disclosure, the focus has shifted to the possible implications of firms' historical GHG performance changes on firms' subsequent GHG disclosure strategy changes. The prediction of "inside-out" management perspectives is that firms' GHG disclosure strategy (extensiveness) would move in the same direction with the changes in firms' historical GHG mitigating performance. This prediction coincides with discretionary disclosure theory's prediction that the association pattern between firms' GHG performance and corporate GHG disclosure should be positive, in a different context.

is less threatened or is sufficiently maintained with achieved historical GHG performance improvement. From this point of view, firms' GHG disclosure would not change to promote climate information transparency as a result of the changes in firms' GHG mitigating performance trajectory.

1.2.3 The Third Empirical Chapter

Subsequent to chapter 5 which investigates the overall global evidence as regards the research question "Would firms' GHG disclosure change to promote climate information transparency as a result of the changes in firms' GHG mitigating performance trajectory?" Given there is a significant difference between developed economies and developing economies as regards their respective GHG disclosure circumstances for the period under investigation, the third empirical study (chapter 6) further examines the research question **(4)** "For the same period under investigation, would there be any difference of the evidence regarding the research question in chapter 5 between developing economies and developed economies?" The nature of the investigation of this research question in chapter 6 is to identify whether it is the developing economies, or it is the developed economies that drive the overall global evidence obtained in chapter 5. Understanding the research question in chapter 6 helps us know if there is any difference between developing economies and developed economies as regards the general GHG disclosure strategies that firms in developing economies and firms in developed economies respectively take under their respective GHG disclosure circumstances for the period under investigation.

The difference of the evidence regarding the problem "whether firms' GHG disclosure would change to promote climate information transparency as a result of the changes in firms' GHG mitigating performance trajectory" between developing economies and developed economies is expected, because *the importance and relevance of GHG emission issues and related climate change risks* were initiated and promoted by the world's most advanced economies. Thus, it is expected that there is a difference as regards *the degree to which the importance of GHG emission issues and related climate change risks is accepted by society* between developing economies and developed economies for the same period under investigation. Consequentially, as regards the same research question in chapter 5, a difference of the empirical evidence between developing economies and developed economies is expected for the same period under investigation.

In addition, prior studies have identified that the concerns level as regards the impact of climate change risks and GHG emission issues on firms from shareholders and the wider stakeholders in developed economies is higher than that in developing economies (Belal, 2000; Luo et al., 2013; Ali et al., 2017). Also, the impact of strength of social contracts on firms in developed economies is much stronger than that in developing economies (Ali and Rizwan, 2013; Luo et al., 2013; Ali et al., 2017). Relatedly, there is evidence suggesting that local stakeholders' concerns regarding CSR related issues are often ignored in developing economies (Beddewela and Herzig, 2013). All this evidence leads to significant difference as regards the GHG disclosure circumstance between developing economies and developed economies. Going back to the proposed possibility to connect and unify the conflicting evidence in the extant literature that investigates the environmental disclosure-performance association problem, the results obtained for the research question in chapter 6 would also potentially add to the possibility or militate against the possibility *that the relationship between firms' environmental performance and corporate environmental disclosure is associated with the respective macro disclosure circumstances in society*.

1.2.4 The Structure of the Thesis

The rest of the thesis unfolds firstly with a review of the theories that inform the thesis in chapter 2. The relevant literature and hypotheses examined in each empirical chapter would then be presented respectively in chapter 2. Following which, the data used in this thesis together with the data sources, empirical models in each empirical chapter, variables used in these empirical models would be introduced and explained in chapter 3. I choose to introduce the empirical models and variables employed in each empirical chapter of the thesis together in chapter 3 as there is a high degree of overlap of the empirical models and the variables included in these models between each empirical chapter, due to consistent research design. Subsequently, the main body of the thesis, empirical chapter 4, empirical chapter 5, empirical chapter 6 follow in turn. The thesis concludes with chapter 7, which summarises and discusses the findings and contributions of the thesis. In addition, the limitations of the empirical studies included in this thesis and suggestions for future research would also be given at the end of chapter 7.

2. Theories, Literature and Hypotheses

This thesis starts from the possibility *that the different association patterns between firms' environmental performance and corporate environmental disclosure are associated with the respective macro environmental disclosure circumstances in society*, derived from North American evidence. Based on which, the thesis intends to provide new global evidence that could either add to the possibility or go against the possibility. Specifically, each different association pattern as regards the relationship of interest corresponds to a different macro environmental disclosure circumstance. And there are different theories that respectively have strong explanatory power over the different association patterns as regards the relationship of interest. In chapter 2, firstly, these theories that inform different association patterns as regards the relationship of interest would be reviewed. Subsequently, the related literature for each of the empirical chapter would be reviewed and the hypotheses examined in each of the empirical chapter would be given drawing on the literature and these theories' specific predictions respectively.

2.1 Theories Informing the Thesis

Although this thesis contends that the literature that investigates the disclosure-performance association problem as regards corporate environmental issues should jump out of the dead loop of arguing whether legitimacy theory's prediction as regards the relationship of interest is right or discretionary disclosure theory's prediction as regards the relationship of interest is right from a static point of view, the association pattern between firms' environmental performance and corporate environmental disclosure under different macro environmental disclosure circumstances actually corresponds to either legitimacy theory's prediction or discretionary disclosure theory's prediction. Thus, the contents of these two theories needs to be reviewed and discussed to have a better understanding of the situations of different macro environmental disclosure circumstances. In addition, informing chapter 5 and chapter 6, the "inside-out" management perspectives play a key role in deducing the hypotheses of interest in these two chapters, a review of the "inside-out" management perspectives would also be given following the review of legitimacy theory and discretionary disclosure theory.

2.1.1 A Review of Legitimacy Theory

To better understand the concept of legitimacy theory and its theoretical implications, it is necessary to review several related theories, as there is a degree of overlap, speaking of connotation and extension, between these theories. First what we need to understand is the argument from the "political economy theory". This is because the perspectives that legitimacy theory provide are based on those provided in political economy theory.

2.1.1.1 Political Economy Theory and Legitimacy Theory

Gray et al. (1996) define the term "political economy" as "the social, political and economic framework where human life happens". Political economy theory indicates that society, politics, and economics are overlappingly connected and integrated together. Economic issues cannot be fully understood without their social and political backdrop. Specifically, in the accounting research area, accounting disclosures are considered, from the political economy point of view, social, political, and economic documents, which are a tool to contribute to firms' private interests by legitimising corporate operations. Thus, accounting disclosures are able to communicate social, political, and economic information to targeted audience and shape their related perceptions (Guthrie and Parker, 1990). These insights are in line with what is argued in legitimacy theory.

It should be noted that both legitimacy theory and political economy theory are systems-based theories, which indicates that an entity or institution is both influenced and exerting influences on the larger system where it exists (Deegan, 2002). As is argued by Gray et al. (1996), a system-based view of institution and society allows for a focus on the role of the information conveyed by institutional disclosure in the examination of the relationships between individuals, groups, organisations, and society. From which point of view, firms are part of a larger society, legitimacy theory argues that neither firms have access to resources in society, nor do they have to exist as a matter of course (Bitektine, 2011). Firms only exist to the extent society considers them to be legitimate, put it another way, the larger society system where firms operate decides whether the operations and existence of a firm are legitimate (Deegan, 2002).

Lindblom (1994) defines the concept of "legitimacy" as a condition or status that only exists when an entity's value system conforms to that of the social system where this entity exists. This is consistent with the systems-based argument of legitimacy theory and

political economy theory. Particularly, from Lindblom's "legitimacy" definition, legitimacy should be regarded as a resource which is necessary for firms' continued operations and existence. As is argued earlier, firms do not have an inherent access to any resource in the larger system in which they operate (Barney, 1991; McWilliams and Siegel, 2011). Legitimacy theory suggests that the management of a firm would take any necessary action to ensure the sustainable procurement of a resource that is critical to the survival of the firm (Deegan et al., 2002). This implicates that firms would pursue strategies to gain, extend, and maintain their legitimacy, when their legitimacy is threatened. This is because, as is argued earlier, firms only exist to the extent society considers them to be legitimate. The strategies when firms intend to ensure their legitimacy may incorporate corporate accounting disclosure, and controlling or collaborating with other legitimate firms (Deegan et al., 2002; Law, 2010). From a legitimacy theory's perspective, a possible strategy for firms to defend their threatened legitimacy is fashioning accounting disclosure to allay their threatened "legitimacy status".

2.1.1.2 Stakeholder Theory and Legitimacy Theory

Ramifying from the argument in political economy theory, stakeholder theory provides similar but differentially different insights, compared with legitimacy theory. According to Gray et al. (1995), it is incorrect to consider legitimacy theory and stakeholder theory as two different theories. In fact, there is a significant degree of overlap between them. Specifically, as is identified in earlier research (Deegan, 2002; Freedman and Wasley, 1990; Freedman and Jaggi, 1992), there are two branches of stakeholder theory: One is the ethical, also known as the normative branch of stakeholder theory, which provides various prescriptions on how should firms deal with their stakeholders. This branch of stakeholder theory focuses on firms' responsibility towards their stakeholders. It tells management what they should do to stakeholders. However, it does not give suggestions to management on how they should react towards various stakeholders' changing demands. Thus, this branch of stakeholder theory does not involve predictions in management's behaviour.

The other branch of the stakeholder theory is the managerial, or alternatively, the positive branch of stakeholder theory (Deegan, 2002). This branch of stakeholder theory focuses on the necessity for firms' management to manage their relationship with different stakeholder groups, especially those stakeholder groups that control the necessary resources for firms to sustainably operate and exist (Ullmann, 1985). According to Gray et al. (1996),

from the perspective of the managerial branch of stakeholder theory, firms divide stakeholders into different categories based on the degree to which firms consider the relationship with each stakeholder group needs to be managed to ensure firms' continued operation and existence. The more important a stakeholder (group) is considered by a firm, the more resources would be invested to manage the relationship with it by a firm. It is also argued by Gray and Laughlin (2012) that firm-specific information disclosure is a major strategy for firms to employ to either get stakeholders' financial and non-financial support or deflect stakeholders' opposition and disapproval.

From both the legitimacy theory's point of view and the managerial stakeholder theory's point of view, firm-specific information disclosure is a reactive other than proactive behaviour made by firms due to strategic reasons. Specifically, firm-specific CSR related information disclosure is made out of management's judgement on how much pressure a firm faces regarding a specific CSR related issue other than any potential responsibilities. Firms' management has the incentive to voluntarily disclose firms' CSR related information to various (powerful) stakeholder groups to show that they are trying to meet these stakeholder groups' expectations (Deegan, 2002). The subtle difference between legitimacy theory and managerial stakeholder theory, however, is that managerial stakeholder theory admits that different stakeholders (be it an individual or an interest-group) have different opinions on how firms should operate legitimately, and those different stakeholders have different degrees of influences on firms because of their different power and abilities related to different firms (Deegan, 2002; Deegan et al., 2002). Nevertheless, legitimacy theory talks about "society" and how firms react to various expectations from society.

Speaking of the compatibility with the proposed possibility *that the different association patterns between firms' environmental performance and corporate environmental disclosure are associated with the respective macro environmental disclosure circumstances in society*, it is argued that legitimacy theory is a better choice over the managerial stakeholder theory. This is because the possibility talks about how *the degree to which the importance of corporate environmental issues is accepted by society* precipitates the formation of different macro environmental disclosure circumstances. Legitimacy theory considers the expectations from the group/groups of stakeholders that has/have the behaviour-changing power towards their interested firms the expectations from society. This perspective provides a panoramic depiction of different macro environmental disclosure circumstances.

2.1.1.3 Social Contract and Legitimacy Theory

"Social contract" is another key concept for legitimacy theory to be able to predict management's reactions to society's expectations on firms' legitimate operations. According to Mathews (2003), social contracts exist between firms and individuals in society, in turn, because society is comprised of individuals, social contracts exist between firms in society and the society where firms are embedded. Society grants the legal authority to firms to give them access to various resources to provide society-expected ends. When society deems that a firm is not operating in a legitimate way that is acceptable to society, society would retract firms' social contract, ceasing the existence of such firms (Deegan, 2002). It should be noted that, because the concept of "social contract" is only a social construct, we could not know the specific terms within social contracts with accuracy. As Gray et al. (1996) contend that various legal and regulatory clauses could be considered the explicit part of a social contract, those non-prescriptive expectations, however, from various stakeholders are the implicit part of a social contract. The implicit part of a social contract varies significantly depending on different managers' different perceptions.

Social contract is also crucial to the notion of corporate legitimacy. As Shocker and Sethi (1973) argue that, because society is dynamically changing all the time, the continued survival of a firm requires that the firm should meet the constant tests of legitimacy by successfully maintaining the social contract between the firm and society. A firm's operation and existence may not be deemed legitimate suddenly as society's expectations to it suddenly have changed (Lindblom, 1994). One possible situation would be that the corporate behaviour that was once considered legitimate by society turns illegitimate as society's non-prescriptive expectations towards firms have changed. Alternatively, major adverse events which relate to what once was considered legitimate practice in a firm or in an industry would significantly threaten the legitimacy status of the firm or the industry implementing the problematic used-to-be legitimate, but now illegitimate practice (Patten, 1992).

Taking the formation of the social concern regarding GHG emission issues and related climate change risks for example. Before the convention of the United Nations Framework Convention on Climate Change in 1992, society did not consider anthropogenic GHG emissions a threat to its sustainable development. The behaviour of firms with significant GHG emissions impact not controlling their carbon footprints are legitimate at that time. However, following the successful convention of the UNFCCC in 1992 and the subsequent formation of Kyoto Protocol in 1997, it is believed by a wider and wider range of people that anthropogenic GHG emissions could cause a serious problem to the

sustainable development of society. Originally, concerned interest groups may not include any entities that have enforcing power over firms' operation patterns, like academics, related promoting non-governmental organisations etc. However, the implicit part of social contracts regarding GHG emission issues has already started changing. When the concerned interest groups have grown to include regulators, governments etc, the explicit part of social contracts regarding GHG emission issues would also change. In the end, the behaviour of not managing firms' GHG footprints would be considered illegitimate.

As is argued by Deegan (2002), it should be pointed out that whether or how a firm may react to a perceived threatened legitimacy problem is dependent on the management's perception of whether the firms' legitimacy status is threatened in the first place. This means, when firms are faced with the same social propaganda from a lobbying group for the same period under investigation, some firms' management may effectively react to this social propaganda, as the management perceives that their firm's legitimacy is threatened. However, other firms' management may not be responding to the same social propaganda, as they perceive that the propaganda is irrelevant to their firm's operations. Arguments from legitimacy theory could well accommodate the different macro environmental (GHG) disclosure circumstances in **Phase1** and **Phase2** illustrated in Table 1-1.

2.1.2 A Review of Discretionary Disclosure Theory

However, when it comes to the macro environmental (GHG) disclosure circumstance in **Phase3** of Table1-1, legitimacy theory could not explain why high-profile firms as regards a specific environmental issue would disclose less or be silent (where mandatory disclosure regarding this specific environmental issue is not required) about their information regarding this specific environmental issue. Especially, when it is in a period (**Phase3** of Table 1-1) where the vast majority of society accepts the importance and relevance of this specific environmental issue. And it is a common practice under this specific macro disclosure circumstance for various firms and organisations to produce environmental disclosure regarding this specific environmental issue. This is where discretionary disclosure theory could step in.

2.1.2.1 Arguments from Discretionary Disclosure Theory

The discretionary disclosure theory (or alternatively, voluntary disclosure theory) develops from a group of studies in economic literature. This group of studies investigates the possible discretion that a firm or a manager could practice as regards the disclosure of non-compulsory information which is known to the firm or the manager and could affect the firm's valuation (Verrecchia, 2001). The early evidence identified in this stream of economic literature finds that, in a situation where a manager plans to sell an asset to a buyer, at the same time, he has concealed information regarding the asset's quality, the high probability of adverse selection from the buyer would always drive the manager to fully disclose the previously concealed information to the buyer (Grossman and Hart, 1980; Grossman, 1981; Milgrom, 1981; Milgrom and Roberts, 1986). It should be noted that this evidence is reliant on the assumption that the buyer is sane and rational to expect that the concealed information by the manager is value-reducing as regards the asset for sale (Beyer et al., 2010). With which assumption, the buyer would discount the asset for sale to the extent that only full disclosure of the concealed information is in the manager's best interest, irrespective of how value-reducing this concealed information could be regarding the asset for sale (Grossman and Hart, 1980; Grossman, 1981; Milgrom, 1981; Milgrom and Roberts, 1986; Verrecchia, 1990; Verrecchia, 2001).

Later studies apply the above idea to discretionary disclosure research in financial accounting literature. The general setting of decision making of such financial accounting research is that managers have extra information apart from those included in mandatory financial accounting disclosure that is associated with the valuation of firms' assets (Jovanovic, 1982; Verrecchia, 1983; Lanen and Verrecchia, 1987; Verrecchia, 1990; Verrecchia, 2001). This group of studies investigate under what kind of conditions managers would withhold such information and under what kind of conditions managers would disclose such information. Specifically, these studies argue that the existence of *disclosure related costs* would elicit situations where managers would even conceal value-boosting information (Jovanovic, 1982; Verrecchia, 1983; Lanen and Verrecchia, 1987). This situation would militate against the assumption in prior economic studies that *the buyer is sane and rational to expect that the concealed information by the manager is clearly value-reducing as regards the asset for sale (which means bad news for the asset for sale).* The possibility of managers could even conceal value-boosting information because of the existence of *disclosure related costs* disables rational buyers from believing the concealed information is definitely bad news exists. This defies the assumption in prior economic studies *that the sane and rational buyer would always believe that any*

concealed information would be bad news. This situation, in turn, gives the discretion to managers to conceal bad news because the buyer could not tell whether the concealed news is bad or good due to the existence of *disclosure related costs*. Also, because the buyer could not tell whether the concealed news is bad or good, the buyer could not discount a manger's or a firm's related assets to the degree that only full disclosure of the concealed information is in the manager's best interest, irrespective of how value-reducing this concealed information could be (Grossman and Hart, 1980; Grossman, 1981; Milgrom, 1981; Milgrom and Roberts, 1986; Verrecchia, 1990; Dye, 2001).

The key factor that turns the table from the full disclosure model in the economic literature to partial disclosure model in the financial accounting literature is the existence of *disclosure related costs*. As regards the *disclosure related costs* discussed above, it is argued that the *disclosure related costs* not only include the costs of preparing the disclosure and disseminating the information (Verrecchia, 1983; Dye, 2001; Beyer et al., 2010; Glaeser et al., 2020) but also the costs that are proprietary to the behaviour of disclosure itself (Arya et al., 2010; Bens et al., 2011; Berger, 2011; Arya and Mittendorf, 2013). Specifically, the behaviour of disclosure of the statistics and decisions of a firm itself could assist other firms' decision-making process, which is harmful to the disclosing firm even if the disclosed information is good news (Verrecchia, 1983; Verrecchia, 2001; Dye, 2001; Beyer et al., 2010).

For example, suppose a situation where a firm has good news regarding their earnings in a sunrise industry. Although the news itself is good, communicating positive information to the market, the news could also attract potential competitors to enter the sunrise industry, thus, posing a significant threat to the disclosing firm's prospects in the future (Nagar et al., 2003; Bens et al., 2011). In which case, to ensure a firm's long-term benefits in this sunrise industry, the managers of the firm may choose to withhold a part of the good news, which results in a partial disclosure equilibrium (Richarson, 2001; Merkl-Davies and Brennan, 2007; Arya et al., 2010). Accordingly, investors could not tell whether the concealed information is definitely good or bad, thus, they could not discount the firm's related assets to the level that makes the managers of the firm to fully disclose their information.

This, in turn, also gives the discretion of concealing bad news to managers, because if the managers of a firm fully disclose their bad news, investors would discount the firm's related assets to the lowest they could. If the managers of a firm conceal the bad news, because investors could not tell whether the concealed news is bad or good, they could not discount the firm's related assets to the lowest they could. In which case, concealing bad news is loss-reducing to the firm (Verrecchia, 1983; Lang and Lundholm, 1996; Verrecchia,

2001; Berger, 2011; Pae, 2002; Aobdia and Cheng, 2018). The next section would discuss how the discussed arguments from discretionary disclosure theory could be fitted to predict the association pattern between firms' environmental performance and corporate environmental disclosure that informs the macro environmental disclosure circumstance in **Phase3** of Table 1-1.

2.1.2.2 Implications of Discretionary Disclosure Theory

As is discussed above, the arguments from discretionary disclosure theory pertain to the economic literature and financial accounting literature. However, Li et al. (1997) and Bewley and Li (Bewley and Li, 2000) first apply discretionary disclosure theory's arguments to the SEA literature (Clarkson et al., 2008) in their investigations of factors that would affect firms' choices to disclose environmental information and related extensiveness problem of the disclosure of environmental information. Their findings indicate that when firms' pollution propensity increases, outside information demanders' knowledge of firms' environmental risks increases and the proprietary costs of disclosing environmental information to the public decrease, firms are more likely to disclose their environmental information to the public (Li et al., 1997). Additionally, firms with higher pollution propensity, more media exposure of their environmental risks and more social and political pressures would be more likely to make more extensive environmental information disclosure (Bewley and Li, 2000). They use the models advanced in discretionary disclosure theory to conduct their empirical analysis, however, their results reveal that it is the threatened legitimacy that drives firms to make more extensive environmental disclosure. Regardless of where their investigating methodology comes from, the data at that time supports legitimacy theory's prediction. This, in turn, adds to the possibility *that the different association patterns between firms' environmental performance and corporate environmental disclosure are associated with the respective macro environmental disclosure circumstances in society*.

Going back to the macro environmental disclosure circumstance in **Phase3** of Table 1-1, it should be noted that it is a period where *the importance of corporate environmental is accepted by the vast majority of society*, and most of the investors in the market would consider corporate environmental issues to be value relevant. Thus, it is reasonable to believe that the expected short-term and long-term benefits of disclosing corporate environmental information outweighs *the disclosure-related costs* for those good performers. In this situation, the management of good performers is forthcoming to disclose their superior environmental

performance status to the public to distinguish themselves with others and impound as much as inflow of benefits (Aobdia and Cheng, 2018; Glaeser et al., 2020). However, for those bad environmental performers, they would choose to disclose in a less detailed way or be silent where compulsory environmental disclosure is not required so that they could be possibly considered by investors and the wider stakeholders as average performers (Clarkson et al., 2008) to obtain loss-reduction. This is because investors and the wider stakeholders could not discount the value of this kind of firms to the lowest they could, in the presence of the uncertainty resulting from the *disclosure-related costs* that would also cause firms to conceal good news (Verrecchia, 1983; Dye, 1985; Verrecchia, 2001; Clarkson et al., 2008). Based on which argument, discretionary disclosure theory offers a way to explain why those bad environmental performers would choose to disclose less than those good environmental performers under the macro environmental disclosure circumstance in **Phase3** of Table 1-1.

2.1.3 A Review of "Inside-out" Management Perspectives

Focusing on the relationship between firms' GHG performance and corporate GHG disclosure, the thesis not only examines the potential association pattern that could be observed (chapter 4), but also intends to further provide evidence on whether firms' GHG disclosure strategy would change according to firms' historical GHG mitigating performance changes (chapter 5 and chapter 6). In the latter case, the "inside-out" management perspectives provide a competing prediction as regards the relationship of interest, contrasting legitimacy theory's prediction. Thus, it is necessary to review the arguments presented in the "inside-out" management perspectives, before deducing the corresponding hypotheses for chapter 5 and chapter 6 according to the "inside-out" management perspectives.

2.1.3.1 Arguments from "Inside-out" Management Perspectives

Along with the deepening of the concept and practices as regards CSR and related sustainability development[8] issues over multiple social scales (Bebbington and Larrinaga, 2014), a group of research theoretically discusses how sustainability development could be

[8] *"Sustainable development could be argued to be the unifying theme/normative ideal that is being used to motivate and integrate social/environment/ethical concerns within corporate social responsibility and social accounting*" [see Bebbington, J. 2009. Measuring sustainable development performance: Possibilities and issues. *Accounting Forum.* **33**(3), pp.189-193.; Bebbington, J. 2014. *Sustainability accounting and accountability.* Routledge.]

materially practiced and integrated in the extant social and economic establishment (Ball and Bebbington, 2008). Studies regarding this research topic generally take either an overall management point of view or corporate accounting point of view (Bebbington and Larrinaga, 2014; Hörisch et al., 2015). Specifically, the former flavour of these studies emphasises the importance and benefits of management integrity when making the shift from traditional business patterns to a sustainable one (Schaltegger and Synnestvedt, 2002; Schaltegger and Burritt, 2005; Schaltegger and Wagner, 2006; Burritt et al., 2010; Hörisch et al., 2015). The latter flavour of these studies focuses on visualising and consequently how to develop a reliable system of measurement and reporting of sustainability development from the point of view of corporate accounting system construction (Bebbington and Thomson, 1996; Gray and Bebbington, 2000; Bebbington et al., 2007; Bebbington, 2009; Bebbington, 2014; Bebbington and Larrinaga, 2014). The "inside-out" management perspectives relate to the management stream of discussions regarding sustainability development.

From the management point of view, there are generally two approaches to assimilate sustainability development concept and sustainability development practices into a firm's existing establishment (Isenmann and Lenz, 2002; Isenmann, 2005; Wagner and Schaltegger, 2003). One is to start from the stage of corporate strategic formation and all the way down to the stage of corporate business operations (Bennett, 2000; Bennett et al., 2002; Bennett et al., 2003). This approach integrates sustainability development into a firm's business operation models completely from a firm's strategy level to a firm's daily operation level with the monitoring, measuring and reporting system of sustainability development naturally imbedded into a firm's business structures (the proactive approach) (Kaplan and Norton, 2001; Kaplan et al., 2004; Gaiser and Wunder, 2004), however, the costs of establishing such an integrated sustainability development system within a firm are usually significantly high (Epstein, 2008).

Another is to start from collecting information demands from a firm's concerned shareholders and the wider stakeholders to establish a set of management structure , parallel to a firm's existing structure, specifically attending to sustainability development management, measurement and disclosure within a firm (the reactive approach) (Carroll, 1999; Schaltegger and Wagner, 2006). The proactive approach features a lower maintenance costs of the sustainability management, accounting and reporting system of a firm because of the integrated alignment of firms' sustainability development initiatives and firms' main business activities (Burritt et al., 2002; Figge et al., 2002). The reactive approach features a lower sustainability development structure establishment costs, which is more cost-effective for firms in the beginning (Burritt et al., 2002; Schaltegger and Burritt, 2005; Burritt and

Schaltegger, 2010). However, firms taking this this approach is highly susceptible to "greenwashing" motivations in different stages of firm's development, especially in the time of financial strain. This is because the motivation of a firm that takes a reactive approach towards corporate sustainability development is its threatened legitimacy, and firms' sustainability development activities are more likely to be in contradiction with firms' main business activities, in which condition, firms' sustainability development activities would be often sacrificed (Schaltegger and Wagner, 2006; Schaltegger and Burritt, 2010).

Specifically, based on the proactive approach of adopting sustainability development in firms, Schaltegger and Wagner (2006) propose an integrative management model of sustainability development transformation in firms, featuring a Sustainability Balanced Scorecard approach motivating sustainability development in the strategy formation stage of a firm, a corresponding sustainability measurement and accounting system monitoring sustainability development in firms' daily operations and a sustainability information disclosure system that communicates firm's sustainability development efforts and achievement to the public. This model forms an inherently consistent process of "involvement-achievement-disclosure" within firms (Schaltegger and Wagner, 2006). They argue that the integrity and consistency of the sustainability development management in a firm is an overarching issue in a firm's material shift to a sustainable business operation pattern (Schaltegger and Wagner, 2006). By integrating sustainability concept and sustainable operation paradigms in a firm's long-term strategy, corporate culture and the daily work of each faculty of a firm, different faculties of a firm and various levels of management of a firm tend to be chained consistently together to substantially manage their sustainability impact and sustainability development (Schaltegger and Wagner, 2006; Schaltegger and Burritt, 2017).

Also, such sustainability development consistency is key to reliable monitoring, measuring and reporting of corporate sustainability development issues (Burritt et al., 2010; Schaltegger et al., 2017). The proactive approach towards corporate sustainability development issues represents the "inside-out" logic of corporate sustainability management (Schaltegger and Wagner, 2006; Qian and Schaltegger, 2017). And because of the structural consistency between firms' sustainability development initiatives and firms' main business activities following the "inside-out" logic of corporate sustainability management, firms' sustainability management activities are unlikely to be in contradiction with the traditional financial side of firms' businesses (Figge et al., 2002; Schaltegger and Burritt, 2005; Schaltegger and Wagner, 2006). The ingrained alignment between sustainability management and firms' daily operations within firms that undertake the proactive approach towards

sustainability development issues would create a convergence tendency between firms' actual sustainability involvement and firms' sustainability disclosure in the long run.

2.1.3.2 Implications of "Inside-out" Management Perspectives

Applying the above arguments regarding firms' adoption approaches of sustainability development management from the management literature to firms' adoption approaches as regards GHG impact control and management, it is reasonable to argue that, in a period where *the importance and relevance of GHG emission issues and related climate change risks are not highly and widely accepted by society*, firms would tend to adopt GHG impact control and management activities reactively according to concerned shareholders and the wider stakeholders' GHG information needs. In such a condition, it is highly likely that firms' threatened legitimacy and the related costs resulting from their threatened legitimacy are main drivers that drive them to control their GHG emissions and manage their GHG impact. Following this line of thinking, corporate GHG disclosure is only a legitimising tool, and it does not necessarily have to be based on firms' underlying GHG performance. Thus, the changes in firms' GHG disclosure do not have to contain any information of firms' GHG mitigating performance change trajectory. Or if the corporate GHG disclosure of a firm is based on firms' underlying GHG performance, firms tend to see a decreasing tendency in GHG disclosure following an improving tendency in firms' historical GHG performance. This is because once firms feel their legitimacy is less threatened or sufficiently maintained, they tend to cut extra costs that is negatively affecting their financial conditions. The situations above respectively correspond to the macro GHG disclosure circumstance in **Phase1** of Table 1-1 and **Phase2** of Table 1-1.

However, when it comes to a period, where *the importance and relevance of GHG emission issues and related climate change risks are highly and widely accepted by society,* firms under this macro GHG disclosure circumstance would have incentives to adopt GHG impact control and management activities proactively by integrating GHG monitoring, measuring and reporting into their basic business models, as this approach has the advantage of a lower maintenance costs as regards the GHG monitoring, measuring and reporting system (Burritt et al., 2002; Figge et al., 2002), compared with the reactive approach to adopting GHG impact control and management activities in their business models. This follows the "inside-out" management perspectives. In which condition, regardless of whether GHG related disclosure is originally used just as a tool to react to outside expectations on firms as regards

firms' GHG related risks or not, with continual and consistent involvement in managing firms' GHG impact, firms' GHG disclosure tends to adjust in line with a firm's underlying GHG performance change through the course of time. This is because the risk of "being busted" together with the corresponding costs would be growing to uncontrollable if a firm always uses GHG disclosure that constantly dissociates with its real GHG performance history (Schaltegger and Csutora, 2012). From which perspective, firms' GHG disclosure would change to promote climate information transparency as a result of the changes in firms' GHG mitigating performance trajectory. This situation corresponds to the macro GHG disclosure circumstance in **Phase3** of Table 1-1.

The above situations inform the investigations and analyses conducted in chapter 5 and chapter 6. Depending on the findings, we could see whether the results obtained in chapter 5 and chapter 6 are in line with the evidence obtained in chapter 4 as regards the association pattern between GHG performance and the extensiveness of GHG disclosure. Thus, the results obtained in chapter 5 and chapter 6 would either further add to the possibility *that the relationship between firms' environmental performance and corporate environmental disclosure is associated with the respective macro environmental disclosure circumstances in society* or go against to it.

2.2 Literature and Hypotheses for Each Empirical Chapter

The previous section reviews the theories that inform the thesis. In this section, firstly, the literature relating to the research questions in each empirical chapter would be reviewed in detail. Following which, the hypotheses tested in each empirical chapter would be deduced, combining the relevant theoretical predictions and the corresponding evidence in the literature.

2.2.1 Literature and Hypotheses for Chapter 4

The first empirical study (chapter 4) firstly reviews the relevant literature that investigates the association between firms' environmental performance and corporate environmental disclosure from North America. Subsequently, a possible storyline to connect these conflicting evidence as regards the relationship of interest would be formally deduced, focusing on the possibility that the observed conflicting evidence on the relationship of interest could be associated with different macro disclosure circumstances in society over

time. Then, the chapter examines the association pattern between firms' GHG performance and the extensiveness of firms' GHG disclosure on a global basis to see if the global evidence adds to the possibility or militates against the possibility.

Specifically, prior North American studies that investigate the relationship between firms' environmental performance and the extensiveness of corporate environmental disclosure focus on how to produce a reliable disclosure proxy using different "disclosure content analysis" methodologies based on firms' cross-sectional environmental disclosure. Then they associate these disclosure proxies with "a third-party environmental performance score" or "revenue scaled water, soil or toxic substance releases amount in the same cross-section" to see the direction of association of the two. These cross-sectional studies produce conflicting results regarding the relationship of interest in different periods of North American society.

Based on these studies, the possibility that *the different association patterns between firms' environmental performance and corporate environmental disclosure could be associated with the respective macro environmental disclosure circumstances in society* would be formally advanced. To help understand this possibility, three possible macro environmental disclosure circumstances that feature the corresponding association patterns between firms' environmental performance and corporate environmental disclosure are also given for reference. Again, note that these three possible macro environmental disclosure circumstances are only inferences based on known information, thus, are by no means prescriptive. Their function is to help clarify the possibility that *the different association patterns between firms' environmental performance and corporate environmental disclosure could be associated with the respective macro environmental disclosure circumstances in society*.

In addition, recently, there is also a group of studies that examine the relationship between GHG performance and GHG disclosure. However, these studies all ignore a major fact that the importance of "GHG emission issues" and "climate change risks" was only brought to public attention and became a social concern at the end of the 20th century. Given which condition, these studies all consider the investigation of the relationship between GHG performance and GHG disclosure an alternative of the investigation of the association between firms' environmental performance and corporate environmental disclosure in the old thinking pattern. These studies again provide mixed evidence, adding to the conflicts in the literature further. Following the literature review as regards the investigation of the association between firms' environmental performance and corporate environmental disclosure, recent studies that examine the relationship between GHG performance and GHG disclosure would also be reviewed in this section.

2.2.1.1 Studies that Find No Relationship between Firms' Environmental Performance and Corporate Environmental Disclosure

The debates about the relationship between firms' environmental performance and corporate environmental disclosure start from 1970s, when a group of studies documents that there is a lack of demand for environmental disclosure of companies from stakeholders (Opinion Research Corporation, 1974; Duff And Phelps Inc, 1976; Buzby and Falk, 1979). These studies argue that the lack of demand for corporate environmental disclosure may result from the fact that self-reported corporate environmental disclosure is lacking in due quality or the situation that corporate environmental disclosure is irrelevant to investors' and stakeholders' decision models. Further, Ingram and Frazier (1980) contend that environmental disclosure is important to investors and the wider stakeholders, however, it is the lack of due quality of corporate environmental disclosure at that time that keeps external information users' demand for such disclosure low.

Specifically, Ingram and Frazier (1980) investigate the relationship between voluntary corporate environmental disclosure in annual reports and corporate environmental performance, using a sample of 40 US firms that conform to the regulation of the CEP[9] for the year 1977 in the US. They employ content-analysis based disclosure scores to proxy for environmental disclosure. The disclosure content analysis is conducted based on a set of criteria that rate the quality of environmental disclosure in 20 prescriptive categories under four dimensions, namely, theme, specificity, observable evidence, and time. They use the social and environmental performance scores of their sample companies provided by the CEP to proxy for corporate environmental performance. The results of their study fail to find a statistically significant association between firms' environmental performance and corporate environmental disclosure. And this supports their argument that the environmental disclosure in annual reports at that time lacks the necessary quality based on which outside information users would believe it. This study is widely considered a seminal paper employing content-analysis based disclosure scores as the proxy for environmental disclosure, which has a profound influence on future research.

Building on the work of Ingram and Frazier (1980), Wiseman (1982) attempts to evaluate the quality and accuracy of environmental disclosures in corporate annual reports of 26 US firms conforming to the regulation of the CEP in several high-pollution industries (1972 for pulp and paper industry; 1974 for oil industry; 1972 and 1976 for steel industry).

[9] See footnote 6 in section1.1.2.

This study uses a similar content-analysis method based on Ingram and Frazier (1980)'s environmental disclosure indexing method. Particularly, Wiseman developed an environmental disclosure index by classifying different environmental disclosure contents into 18 items that fall under 4 dimensions, that is, 1) Economic factors; 2) environmental litigation; 3) pollution alleviating behaviour; 4) other disclosures that do not pertain to the other 3 dimensions. One important improvement the Wiseman index makes to Ingram and Frazier's disclosure index is that the Wiseman index values quantitative disclosures more over qualitative disclosure, based on the argument that quantitative data is much harder to be mimicked and manipulated (Dye, 1985). The Wiseman index allocates 3 points to quantitative disclosure, 2 points for qualitative disclosure, 1 point for general mentioning of environmental information, and 0 point for no disclosure. The CEP's social and environmental performance scores are, again used as the proxy for corporate environmental performance. The findings reveal that corporate environmental disclosures in the annual reports of companies suffer from many informational gaps, and there is no association between firms' environmental disclosure and the underlying environmental performance of firms.

Criticising the insufficient disclosure sample selection in prior research, Freedman and Wasley (1990) include companies' SEC filings as an additional source of environmental disclosure under examination. They use a sample of 50 US companies across 4 high-profile industries, namely, electric utilities (1975), pulp and paper (1972), steel (1972 and 1976), and oil (1974), to revisit the relationship between firms' environmental performance and corporate environmental disclosure. Drawing on the Wiseman (1982) disclosure index, they respectively correlate the environmental disclosure scores of the annual reports and that of the 10-K files with the CEP's social and environmental performance rankings, using Spearman rank order correlation tests. Their results indicate no statistically significant relationship between corporate environmental disclosure and firms' environmental performance. The studies that find no association between firms' environmental performance and corporate environmental disclosure suggest that firms only use corporate environmental disclosure as a pure legitimising tool. And maintaining firms' legitimacy and related interests is the reason why such disclosure is produced.

2.2.1.2 Studies that Find Negative Disclosure-Performance Association as Regards Corporate Environmental Issues

Instead of directly investigating the relationship between firms' environmental performance and corporate environmental disclosure, Bewley and Li (2000) examine the factors that affect management's environmental disclosure decisions-making process, based on the discretionary disclosure theory. Specifically, their sample consists of 188 Canadian firms in the manufacturing industry for the year of 1993. They use environmental disclosure scores based on the Wiseman (1982) index, to measure the extensiveness of companies' environmental disclosure. However, they do not directly measure firms' environmental performance, instead, they measure firms' pollution propensity. They alternatively use firms' industry membership and whether firms are regulated by the Canadian Ministry of Environment under the National Pollution Release Inventory program to proxy for firms' pollution propensity. Their findings reveal that wider social factors such as press coverage, governmental pressure as well as stakeholders' environmental expectations play an important role in affecting corporate voluntary environmental disclosure. In which case, environmental underperformers tend to disclose more environmental information than good environmental performers do. This corresponds to legitimacy theory's prediction.

Congruent with Bewley and Li (2000)'s findings, Hughes et al. (2001) investigate the association between companies' environmental disclosure scores and their environmental performance category, using a sample of 51 US companies in the environmentally-sensitive manufacturing industry for the years of 1992 and 1993. Particularly, they use the CEP's environmental performance rankings (good, mixed, and poor) to proxy for companies' performance category. Based on a modified Wiseman (1982) index, they score firms' environmental disclosures in the President's letter, Management Discussion & Analysis section, and note section of their annual reports. They use the obtained scores to proxy for companies' environmental disclosure. Their results show that there is no statistically significant difference between the environmental disclosure scores for firms in the good band and firms in the mixed band. However, firms in the poor performance band have significantly higher environmental disclosure scores, compared with those in the good and mixed bands. The authors also argue that this finding may be related with enhanced requirement on corporate environmental sustainability by the Financial Accounting Standards Board and Securities and Exchange Commission during the period under investigation. Poor environmental performers are faced with extra pressures from society to disclose more environmental information in order to change outsiders' perceptions about

their environmental performance status and make up for their tarnished public environmental images (Clarkson et al., 2008)

Early studies that look into the relationship between firms' environmental performance and corporate environmental disclosure rely heavily on the CEP's social and environmental performance rankings. However, the CEP only monitor 50 environmentally sensitive firms in four major polluting industries in the US, their data coverage is very limited (Al-Tuwaijri et al., 2004). Another problem with the CEP data is that the CEP does not take industry-specific differences into consideration when gauging the social and environmental performance of firms under its regulation. This may render the findings of studies that use the CEP statistics to proxy for environmental performance ungrounded and inconsistent with each other (Patten, 2002). The above situations severely weaken the validity and the generalizability of findings of previous research. Later studies with wider data accessibility, improved research design and alternative proxies of variables under examination, strive to remedy the defects of these prior studies.

Patten (2002) contends that prior studies that investigate the relationship between firms' environmental performance and corporate environmental disclosure suffer from three major problems: 1) there are omitted variables that should be controlled; 2) the sample used is not adequate; 3) inaccurate and biased measures for environmental performance. In the light of the problems of the CEP data, Patten uses Toxic Release Inventory (TRI) data scaled by sales as the proxy for corporate environmental performance. In addition to the Wiseman (1982) environmental disclosure index, Patten also introduces line count of environmental disclosure as a supplement to the Wiseman index. Based on the analyses of the environmental disclosure in the 1990 annual reports of 131 US firms from 24 industries, Patten identifies that the TRI intensity measure is positively associated with both disclosure scores, indicating a negative association between firms' environmental performance and corporate environmental disclosure.

These studies that find a negative association between firms' environmental performance and corporate environmental disclosure correspond to legitimacy theory's predictions. This is because legitimacy theory argues CSR related issues are a kind of social pressure that firms are faced with, thus, the corresponding disclosure is a passive reaction towards such pressure (Bewley and Li, 2000; Patten, 2002; Cho and Patten, 2007). Bad environmental performers' social legitimacy and public image are more threatened, and they are faced with more pressure from a wide range of stakeholders, e.g. governments, lobbying groups, current and potential investors (Friede et al., 2015; Shaukat et al., 2016; Yu et al.,

2018). Thus, bad environmental performers tend to disclose more extensively about their environmental information to react to such pressure. In addition, bad environmental performers' extensive environmental disclosure could also help them to gain financial favour from socially and environmentally responsible investors. This is because consecutive environmental disclosure could signal to such investors that they have been proactively managing their environmental impact and risks (Kapstein, 2001; Toms, 2002; Clarkson et al., 2013; Ascui, 2014).

2.2.1.3 Studies that Find Positive Disclosure-Performance Association as Regards Corporate Environmental Issues

Al-Tuwaijri et al. (2004) investigate the relations among environmental disclosure, environmental performance and economic performance drawing on a simultaneous equations approach. Instead of using toxic release intensity data, they use the ratio of recycled toxic waste over total toxic waste generated to proxy for environmental performance. Environmental disclosure is measured as the scores based on analysing environmental disclosure in SEC form 10-K that is related to potentially responsible parties' designation for clean-up responsibility of hazardous-waste sites, toxic waste information, oil and chemical leaks information, and fines or penalties as on environmental issues. Specifically, their sample comprises 198 S&P 500 firms included in the 1994 Investor Responsibility Research Centre (IRRC)'s environmental profile directory. The results of their study reveal that good environmental performance is significantly related with more detailed and extensive quantifiable environmental disclosure of toxic waste measures and occurrences. This suggests a positive relation between firms' environmental performance and corporate environmental disclosure.

Clarkson et al. (2008) revisit the relation between firms' environmental performance and corporate environmental disclosure, focusing purely on firm-specific environmental disclosures in all available voluntary channels, such as stand-alone environmental reports or web pages, for 191 US firms from 5 high-polluting industries of the fiscal year 2003. Particularly, they argue that prior mixed findings in this area result from using environmental disclosures from regulated channels such as annual reports and SEC filings. This is because bad environmental performers are required to provide more environmental information that would result in financial results to the SEC. Also, because both discretionary disclosure

theory and socio-political theories[10] (which subsume legitimacy theories) relate to voluntary environmental disclosures, using environmental disclosure from regulated channels is academically lax. Based on the Global Reporting Initiative (GRI) sustainability reporting guidelines, they develop a new set of environmental disclosure index of 45 items that correspond to both hard disclosure items (disclosures that are substantiated by material evidence or assurance) and soft disclosure items (ordinary claims or statements). They argue that this set of environmental disclosure index sees beyond financial consequences of environmental activities and stresses companies' environmental disclosure that reflect their true environmental performance. In addition, they use two alternative measures, namely the percentage of recycled toxic waste out of total toxic waste generated and the ratio of toxic waste generated over sales, to proxy for environmental performance. They find a positive connection between firms' environmental performance and the extensiveness of voluntary environmental disclosure.

These studies that find a positive association between firms' environmental performance and corporate environmental disclosure draw on discretionary disclosure theory to rationalise their findings. This is because discretionary disclosure theory argues that good environmental performers have incentives to inform investors of their performance status by using more quantitative and objective disclosure measures, as this kind of disclosure is not easily imitated by those bad performers. With more extensive and detailed disclosure characterized by hard-to-imitate measures, good environmental performers intend to signal their superior performance type to related parties to gain potential managerial and financial benefits (Verrecchia, 1983; Dye, 1985; Burritt and Schaltegger, 2010; Martin and Moser, 2016; Yu et al., 2018). Bad environmental performers, however, would disclose less or do not disclose. This is because, for one thing, faking or distorting their environmental performance information is faced with potential non-trivial litigation and regulation costs, as well as long-term public image and goodwill damage. For another, disclosing less or being silent on their environmental performance may also make investors lump them into the category of "average performers". This is because the existence of *disclosure related costs* may also prevent firms from disclosing "not-so-bad" environmental information to the public (Dye, 1985; Ullmann, 1985; Clarkson et al., 2008; Fatemi et al., 2017). Intuitively, discretionary disclosure

[10] The socio-political theories include political economy theory, stakeholder theory, social contract theory and legitimacy theory. [See: Clarkson, P.M., Li, Y., Richardson, G.D. and Vasvari, F.P. 2008. Revisiting the relation between environmental performance and environmental disclosure: An empirical analysis. *Accounting, Organizations and Society*. **33**(4-5), pp.303-327.].

theory predicts a positive association between firms' environmental performance and corporate environmental disclosure.

2.2.1.4 The Disclosure-Performance Association as Regards GHG Emission Issues

Most recently, there have been studies that investigate the association between firms' GHG performance and the extensiveness of firms' voluntary GHG disclosure. Luo and Tang (2014) investigate whether voluntary carbon disclosure reflects the underlying corporate carbon performance. Specifically, they use the CDP's[11] Carbon Disclosure Leadership Index (CDLI) scores to proxy for the extent of corporate voluntary carbon disclosures through the CDP's climate change project. The ratio of yearly total scope1[12] and scope2 carbon emissions over yearly total sales is used as the proxy for carbon performance. Using a cross-section of 474 companies from the US, the UK and Australia for the year 2010, their results show that the extent of carbon information disclosure is positively associated with corporate carbon performance. This study, however, suffers from a very limited sample selection, and the evidence they get is only based on one year's data, firm-specific heterogeneities and country-fixed heterogeneities across years are not controlled.

Qian and Schaltegger (2017) examine how the changes of the extensiveness of carbon disclosures at "t" affect the subsequent changes of carbon performance at "t+1". In line with Luo and Tang (2014)'s work, they use firm-specific carbon emissions (scope1+scope2) scaled by total revenue to proxy for carbon performance. The CDP's climate change questionnaire disclosure scores are used to proxy for firms' carbon disclosure extensiveness. Their sample consists of global 500 companies which at least voluntarily disclosed their carbon emission related information to the CDP once for the years 2008-2012. They argue that self-reported carbon information disclosure could serve as an internal mechanism that monitors and improves firms' subsequent carbon performance. Their results show that the carbon disclosure increment at "t" is positively associated with the subsequent carbon intensity decrement at "t+1". This study changes the focus of the investigation of the association between GHG performance and GHG disclosure to how changes in disclosure could lead to changes in future performance. However, it does not provide any "in levels" evidence. The impact of potential endogeneity problem arising from omitted time-variant

[11] CDP stands for Carbon Disclosure Project. It is a non-profit organisation that encourages GHG information disclosure on a global basis. More information regarding this organisation would be introduced in chapter 3, as this thesis also uses GHG related data from this organisation.

[12] For definitions of different scopes of carbon emissions, please refer to footnotes 14, 15, 16 in section3.1.1

variables on their results is not controlled for. In addition, Global 500 companies are mostly from the world's top ten largest economies, thus, the representation is very limited.

Luo (2019) re-investigates the association between firms' GHG performance level and the extensiveness of firms' voluntary GHG disclosure with a focus on how institutional factors affect the relationship of interest. The study uses Global 500 firms that participated in the CDP's climate change project from 2008 to 2015 as the sample. Specifically, it uses both "sales scaled firm-specific total scope1 and scope2 carbon emission intensity" and, alternatively an "industry sectors carbon intensity means adjusted indicator" to proxy for carbon performance. The Carbon Disclosure Leadership Index (CDLI) scores produced by the CDP are used to proxy for the extensiveness of voluntary carbon disclosure. Overall, their results indicate a negative association between firms' GHG performance level and the extensiveness of firms' voluntary GHG disclosure. However, there are obvious weaknesses for the sample selection and research design. Again, Global 500 companies' representation is very limited, as they are all the world's largest companies from the world's largest economy. Further, the study neither controls for country nor region fixed heterogeneities across years throughout their "in level" analyses, although the study emphasizes that its data is from different countries.

As is mentioned earlier, the studies that examine the relationship between GHG performance and GHG disclosure all ignore the fact that the importance of "GHG emission issues" and "climate change risks" was only brought to public attention and became a social concern at the end of the 20th century by the world's most advanced economies. The authors all regard these studies as an alternative variation of prior studies that investigate the relationhsip between firms' environmental performance and corporate environmental disclosure. The potential association between the relationship of interest and the corresponding macro GHG dislcosure circumstance is consistently neglected. Thus, the evidence provided by these studies further adds to the jumbled and contradictory landscape in the extant literature. In the following section, based on the chronologically continuous North American evidence as regards the association between firms' environmental performance and corporate environmental disclosure, the possibility *that the different association patterns between firms' environmental performance and corporate environmental disclosure could be associated with the respective macro environmental disclosure circumstances in society* would be formally advanced. The results of the investigations included in chapter 4 would either add to this possibility or militate against this possibility.

2.2.1.5 A Possibility to Connect and Explain the Contradiction

Looking at the reviewed prior North American studies that investigate the relationship between firms' environmental performance and corporate environmental disclosure from a chronological point of view, we could see that consistent empirical evidence of the direction of association between firms' environmental performance and corporate environmental disclosure clusters over time. In other words, we could observe "periodization" of the extant empirical evidence as regards the relationship of interest in North American setting.

Specifically, the cross-sectional studies that draw on North American data before the year 1980 generally find no association between firms' environmental performance and corporate environmental disclosure. The cross-sectional studies that draw on North American data before the year 1994 generally find a negative association between firms' environmental performance and corporate environmental disclosure. The cross-sectional studies that draw on North American data after the year 1994 (inclusive) generally find a positive association between firms' environmental performance and corporate environmental disclosure. The cross-sectional evidence in different phases as is shown in Table 1-1 could be possibly connected through the course of time.

Particularly, considering that reaching a high level of environmental awareness and concern is coupled with the corresponding propaganda and education efforts in society over time (Deegan, 2017). And, in the meanwhile, as different stakeholders with different firm-behaviour-affecting power gradually become environmentally aware and concerned, the overall social expectations on firms regarding corporate environmental issues would also change over time (Deegan, 2002; Cowan and Deegan, 2011). This gives rise to the possibility that *the different association patterns between firms' environmental performance and corporate environmental disclosure could be associated with the respective macro environmental disclosure circumstances in society*. And the different observation of the direction of association regarding the relationship of interest could be all true under different macro environmental disclosure circumstances in society. Specifically, to assist the understanding of this possibility, the possible situations of different macro environmental disclosure circumstances could be as follows (**N.B.**: the situations specified below are only instruments to assist understanding of possible different macro environmental disclosure circumstances, these situations are not prescriptive):

Phase1: When the importance and risks related to corporate environmental issues are introduced and publicised by only academics and related non-governmental promoting organisations. These entities advocate that firms' business operations should take into considerations their environmental consequences and aim to develop sustainably. However, only those companies that have the heaviest environmental impact get involved in corporate environmental disclosure due to the pressure from academics and related non-governmental promoting organisations, and their incentives to brand themselves as leaders in managing corporate environmental issues. The management of such firms only starts to consider corporate environmental issues as relevant to their businesses and show their concerns over corporate environmental issues through environmental disclosure, with no material actions.

Firms with insignificant environmental consequences would refrain from producing such disclosure, as the costs of producing such disclosure outweigh the expected benefits (Cahan et al., 2016; Griffin et al., 2017). So, in this phase, although companies with most significant environmental exposure do start making disclosure, their actual performance does not change materially. Thus, a non-association observation between firms' environmental performance and corporate environmental disclosure could be identified by empirical studies in this phase. Because firms with the most significant environmental impact in this phase purely use environmental disclosure as a tool to legitimise their business operations. And such disclosure does not reflect any of firms' underlying environmental performance. This phase corresponds to legitimacy theory's prediction.

Phase2: When the importance of and risks related to environmental issues continue to deepen in various levels of society, an increasingly significant number of investors and consumers together with political lobbying groups, regulators, governments are becoming concerned about potential environmental risks that firms with significant environmental impact are exposed to. Such firms with significant environmental impact would have to make material reactions to their investors', consumers', regulators', and government's environmental concerns. Their material reactions would be to invest in environmental aspects within their operations to monitor, report and try to reduce the corresponding environmental risks that they are exposed to. Again, firms with insignificant environmental consequences would refrain from producing such reports or disclose in a general way if mandatory disclosure regarding environmental issues is required, because the costs of producing corporate disclosure regarding environmental issues that they have little impact on outweigh the expected benefits. Thus, a negative-association observation between firms' environmental performance and corporate environmental disclosure could be identified by empirical studies in this phase. This is because bad environmental performers tend to use

more extensive environmental disclosure to tell the concerned powerful stakeholders that they are trying to control their environmental impact, thus, possibly reducing the corresponding risks related to corporate environmental issues. This phase also corresponds to legitimacy theory's prediction.

Phase3: As the importance and risks related to corporate environmental issues gets to be accepted and believed by the majority of society, the overall social value system regarding corporate environmental issues has completely changed (Lindblom, 1994; Blacconiere and Patten, 1994; Deegan, 2002). Society expects that corporate environmental issues should be integrated into operations of every company. Even the firms with the least environmental impact would produce environmental reports to meet such social expectations. A positive association between firms' environmental performance and corporate environmental disclosure could be empirically observed. This is because, given that the environmental statistics of bad environmental performers is no match for good environmental performers, when environmental disclosure becomes a common practice among various firms in society, it forms "peer pressure" to all firms in the same social system (Barney et al., 2011; Buchner et al., 2012; Hartmann et al., 2013). Good environmental performers would like to communicate their superior environmental performance status to society to distinct themselves with those bad environmental performers through more extensive and detailed environmental disclosure with good statistics. This would help them gain as much financial (e.g. long-run investment preference from investors) and non-financial benefits (e.g. good CSR reputation) as possible. Whereas, firms with inferior environmental performance status would seek to mix with those firms considered by society as "average type" to reduce as much loss as possible through less environmental disclosure or being silent on their environmental performance, where there is no requirement of mandatory environmental disclosure (Clarkson et al., 2008; Bénabou and Tirole, 2010; Stanny, 2013; Jaggi et al., 2018). This phase corresponds to discretionary disclosure theory's prediction.

2.2.1.6 Hypotheses of Interest for Chapter 4

As is reviewed in the previous section, recent research that examines the association between firms' GHG performance and firms' GHG disclosure all share a commonality that they regard the examination of the association between firms' GHG performance and firms' GHG disclosure as an alternative variation of the examination of the association between firms' environmental performance and corporate environmental disclosure. In other words, these studies consider that the examination of the association between firms' GHG performance and firms' GHG disclosure interchangeable with prior cross-sectional studies that investigate the association between firms' environmental performance and corporate environmental disclosure. However, this conduct could be problematic according to the argument *that the association pattern between firms' environmental performance and corporate environmental disclosure could be associated with the respective macro environmental disclosure circumstances in society*.

Specifically, although GHG emission issues and related climate change risks are subsumed by corporate environmental issues, the investigation of the association between firms' GHG performance and firms' GHG disclosure should not be considered alternative to the investigation of the relationship between firms' environmental performance and corporate environmental disclosure, according to the argument above. This is because *the importance of GHG emission issues and related climate change crisis* was advanced and diffused amongst different countries and regions much later than that of other general corporate environmental issues. Given that general corporate environmental issues became a formal concept and advocacy in the 1960-1970s, initiating from developed economies (Thinkingshift, 2007), however, the introduction of the importance of "climate change risks" and "global warming crisis" is hallmarked by the 1992 United Nations Framework Convention on Climate Change and the subsequent Kyoto Protocol in 1997 (UNFCCC, 2014). *The time length of the social propaganda and education efforts to diffuse the importance of other general environmental issues in global society* is much longer than that of *the importance of GHG emission issues and related climate change risks in global society*. Also, as reports find that global GHG awareness is significantly lower than the global awareness of other CSR related issues (KPMG, 2015; KPMG, 2017), it then follows that *the global macro disclosure circumstance regarding general environmental issues* and *the global macro disclosure circumstance regarding GHG emission issues* have a significant difference for the same recent period under investigation (in the case of this thesis, the period under investigation is years 2009-2014).

If the possibility *that the different association patterns between firms' environmental performance and corporate environmental disclosure are associated with the respective macro environmental disclosure circumstances in society* is true. Then, if one conducts a study that investigates *the global association pattern between firms' GHG performance and the extensiveness of firms' GHG disclosure* for a recent period under investigation, say years 2009-2014, the results obtained could be very different from the most recent positive (Al-Tuwaijri et al., 2004; Clarkson et al., 2008) association observation *between firms' other environmental performance and corporate environmental disclosure regarding other environmental issues*. If the evidence regarding *the global association pattern between firms' GHG performance and the extensiveness of firms' GHG disclosure* for a recent period under investigation is observed to be corresponding to "**Phase1** of Table 1-1" or "**Phase2** of Table 1-1" through empirical analysis, then such evidence would add to the possibility *that the different association patterns between firms' environmental performance and corporate environmental disclosure are associated with the respective macro environmental disclosure circumstances in society.* As such, the re-investigation of the association between firms' GHG performance and the extensiveness of GHG disclosure has its own specific significance.

Given that the most recent studies that investigate the association between firms' environmental performance and corporate environmental disclosure identify results that correspond to "**Phase3** of Table 1-1" (Al-Tuwaijri et al., 2004; Clarkson et al., 2008), it would be of interest to investigate the global association between firms' GHG performance and the extensiveness of GHG disclosure to see which phase of Table 1-1 it corresponds to. In addition, prior studies argue that using environmental disclosure in "regulated channels" like "annual reports", "10-K filings" to investigate the relationship between firms' environmental performance and corporate environmental disclosure would introduce regulatory interfering factors to the extensiveness of firms' environmental disclosure, because bad environmental performers have greater exposure to corporate environmental risks and must discuss, in detail, relevant information in "regulated channels" like "annual reports", "10-K filings" [see paragraph 4 on page 304 of (Clarkson et al., 2008)]. I apply this argument to the tests in this thesis and use GHG disclosure information from the voluntary channel of Carbon Disclosure Project (CDP)'s climate change questionnaires to control for regulatory interfering factors in the GHG disclosure data I use. Thus, the first set of hypotheses that this study investigates are:

H1: Firms' GHG performance and the extensiveness of voluntary GHG disclosure are not associated with each other on a global basis for the period under investigation.

H2: The direction of association between firms' GHG performance and the extensiveness of voluntary GHG disclosure is negative on a global basis for the period under investigation.

H3: The direction of association between firms' GHG performance and the extensiveness of voluntary GHG disclosure is positive on a global basis for the period under investigation.

In addition, the evidence regarding CSR related disclosure and performance documented in the social and environmental accounting literature so far predominantly comes from developed economies (Brooks and Oikonomou, 2018). Also, prior studies have documented significant differences as regards the drivers, determinants, and impact of CSR related disclosure in both developed and developing economies. Specifically, the environmental disclosure of companies in developing economies tends to focus on the disclosure of energy and resources expenditure rather than the disclosure of firms' proactive activities to mitigate firms' environmental impact driven by firms' environmental strategy (Belal, 2000). CSR disclosure in developed economies tends to include more CSR themes (environment; energy; health; humanity; community; fairness) and have more disclosure locations (such as a specific section in firms' annual reports; stand-alone CSR reports; firms' webpages) than CSR disclosure in developing economies. The differences of social and economic development level between developed economies and developing economies fundamentally lead to these differences in CSR disclosure (Xiao et al., 2005; Tsamenyi et al., 2007).

Further, in developing economies, the adoption of social and environmental disclosure is found to be mainly resulting from external coercive forces like governmental regulations and legal judgments (Jackson et al., 2006; Parker, 2011; Luo et al., 2013). The general practice in firms' own industry sector also creates motivations for firms to voluntarily disclose their social and environmental information (Martinsson et al., 2013; Luo et al., 2013; Ali et al., 2017). Although inter-governmental and non-governmental organisations that promote GHG measurement and reporting are active in making firms in developing economies to voluntarily disclose CSR related information to shareholders and the wider stakeholders, there is a lack of evidence that the propaganda from such organisations improves firms' CSR disclosure in developing economies (Ali and Frynas, 2018). In addition, other public interest pressure (pressure from lobbyists, media and concerned stakeholders), however, forms little motivation on firms' decision to make CSR related disclosure. (Ali and Rizwan, 2013; Luo et al., 2013; Ali et al., 2017). Moreover, financial resource constraints

(profitability, leverage and sales growth rate) are significantly associated with firms' decisions to adopt social and environmental disclosure (Luo et al., 2013). Whereas, in developed economies, not only firms' economic scale, financial capability and corporate governance characteristics but also social, political and cultural factors drive firms' social and environmental disclosure agenda (Ali et al., 2017). Specifically, social pressure from regulators, governments, CSR-reporting-promoting entities and media plays a key role in persuading firms into adopting proactive social and environmental mitigating strategies, practices, and disclosure in developed economies (Ali et al., 2017; Ali and Frynas, 2018).

Going back to the investigation of GHG disclosure-performance association, as is mentioned earlier, both the advocacy of *the importance of general environmental related issues* and the advocacy of *the importance of GHG emission issues and related climate change risks* were initiated in the world's most developed economies. *The time length of the social propaganda and education efforts to diffuse the importance of GHG emission issues and related climate change risks* in the society of developed economies is longer than that in the society of developing economies. Also, as is the literature reviewed above, there are significant differences between developed economies and developing economies regarding the drivers, determinants and impact of social and environmental disclosure (Frynas and Yamahaki, 2016; Ali et al., 2017; Ali and Frynas, 2018). Given these existing differences between developed economies and developing economies regarding macro social and environmental disclosure circumstance, if one investigates the association between firms' GHG performance level and the extensiveness of voluntary GHG disclosure in both developed economies and developing economies for the same recent period under investigation (in this thesis, the period under investigation is years 2009-2014), it could be that the observed evidence as regards the relationship of interest would be different between developed economies and developing economies. If the expected difference is observed, then, it would further add to the possibility *that the different association patterns between firms' environmental performance and corporate environmental disclosure are associated with the respective macro environmental disclosure circumstances in society.* Thus, another hypothesis worth investigating would be:

H4: For the same period under investigation, the observed association pattern between firms' GHG performance and the extensiveness of voluntary GHG disclosure in developing economies is different from that in developed economies.

2.2.2 Literature and Hypotheses for Chapter 5

Subsequent to the investigations in chapter 4, chapter 5 intends to investigate "whether firms' GHG disclosure would change to promote climate information transparency according to the changes in firms' historical GHG mitigating performance trajectory, globally speaking" (or alternatively, "whether changes in GHG performance would cause any subsequent changes in firms' GHG disclosure strategy, globally speaking"). This investigation strives to provide further evidence on claimable causal relationship between firms' underlying GHG performance and firms' GHG disclosure on a global basis. In the following sections, related literature based on which the investigation is generated would be reviewed. The hypotheses of interest would then be given after presenting the theoretical predictions from related theories.

2.2.2.1 Evidence on the Disclosure-Performance Association as Regards General CSR/Environmental Issues

The investigation of the relationship between firms' environmental performance and firms' environmental disclosure starts with some evidence in professional literature claiming that there is an insignificant demand for environmental disclosure information from investors and other outside stakeholders (Opinion Research Corporation, 1974; Duff And Phelps Inc, 1976; Buzby and Falk, 1979) in the 1970s of the US. Ingram and Frazier (1980) argue that this situation may be because there is a lack of quality for such disclosure at that time or because corporate environmental involvement information is not relevant to external information users' decision models. To test the possible cause of the insignificant demand for environmental disclosure from shareholders and the wider stakeholders, they investigate the association between corporate environmental disclosure and corporate environmental performance in 40 US firms under the regulation of the Council on Economic Priorities. Their results find that there is no significant association between corporate environmental disclosure and firms' environmental performance. Thus, they argue that it is the lack of quality in corporate environmental disclosure that keeps the demand of a wide range of stakeholders for such disclosure low. Following their studies, subsequent studies focus on the disclosure-performance gap and provide conflicting results about the relationship of interest.

Subsequent to Ingram and Frazier (1980)'s seminal work, studies in this research area predominantly provide "in levels" North American evidence based on cross-sectional research design. The nature of their research question is to examine the direction of association (no association; negative association; positive association) between firms'

environmental performance level and the extensiveness of corporate environmental disclosure. Specifically, studies that use North American data before the year 1980 primarily identify no association between firms' environmental performance level and the extensiveness of corporate environmental disclosure [These studies have been reviewed in detail in section2.2.1.1, see (Ingram and Frazier, 1980; Wiseman, 1982; Freedman and Wasley, 1990)]. Studies that use North American data after the year 1980 (inclusive) before the year 1994 primarily identify a negative association between firms' environmental performance level and the extensiveness of corporate environmental disclosure [These studies again have been reviewed in section2.2.1.2, see (Bewley and Li, 2000; Hughes et al., 2001; Patten, 2002)]. Studies that use North American data after the year 1994 (inclusive) primarily identify a positive association between firms' environmental performance level and the extensiveness of corporate environmental disclosure [These studies also have been reviewed in detail in section2.2.1.3, see (Al-Tuwaijri et al., 2004; Clarkson et al., 2008)].

In addition to the evidence as regards the relationship between firms' environmental performance level and the extensiveness of corporate environmental disclosure from North America. Later studies also provide additional "in levels" evidence regarding the relationship between firms' CSR/environmental performance level and the extensiveness of CSR/environmental disclosure from specific industries and other regions. Font et al. (2012) investigate the influence of the reliability of corporate disclosure system on the gap between CSR claims and CSR practices in the tourism industry. By benchmarking CSR claims and CSR practices of 10 most important multinational hotel groups in the European tourism market, they find that firm size is a major mediating factor on the size of the gap between CSR claims and the underlying CSR practices.

Sutantoputra et al. (2012) revisit the association between environmental disclosure and environmental performance using data from 53 ASX200 listed firms for the year 2006, based on the disclosure content analysis methodology introduced by Clarkson et al. (2008). Specifically, they analyse the environmental disclosure in these large firms' annual report. They find that larger firms in high-polluting industries tend to disclose more environmental information, indicating a negative association between firms' environmental performance and firms' environmental disclosure. This is in contradiction with the latest evidence as regards the association between environmental disclosure and environmental performance from North America. However, given that they only analyse the environmental disclosure in 53 large listed Australian firms' annual reports for only one year's data, it is expectable that the results would be biased and inaccurate. This is because, as is argued by Clarkson (2008),

large firms with high environmental exposure must discuss in detail any environmental risks that are related with firms' financial status in regulatory filings like annual reports.

2.2.2.2 Evidence on the Disclosure-Performance Association as Regards GHG Emission Issues

In the wake of the successful convention of the United Nations Framework Convention on Climate Change in 1992 and the formation of Kyoto Protocol in 1997, another group of studies ramifies from prior research to specifically examine GHG disclosure, GHG performance and the relationship between GHG disclosure and GHG performance. Specifically, Freedman and Jaggi (2004) investigate how effective US electric utilities have been reducing GHG emissions, they find that for years 1990-1998, although total carbon emissions have increased by 35%, carbon emissions per million British Thermal Unit has decreased, and US electric utilities do not disclose much about GHG related information. Following which, Freedman and Jaggi (2005) compare the pollution and GHG disclosure made in annual reports of high-GHG exposure firms from countries that ratified the Kyoto Protocol and that of high-GHG exposure firms from countries that did not ratify the Kyoto Protocol. Later, Freedman and Jaggi (2009) compare GHG disclosure extensiveness from the EU with that from Japan and Canada. These studies identify variation of GHG disclosure among different industries and countries. This series of studies conducted by Freedman and Jaggi do not differentiate themselves from prior similar research as regards general CSR or environmental disclosure and performance, as the focus of these studies is still on "disclosure content analyses" and ended up with mixed evidence.

Most recently, Luo and Tang (2014) and Luo (2019) revisit the "in levels" disclosure-performance association problem in the climate change mitigation area specifically using the newer GHG emissions data from the CDP database. Particularly, Luo and Tang (2014) draw on GHG emissions data of the US, UK and Australia from the CDP database and use a cross-sectional design to test the direction of association between firms' GHG performance level and the extensiveness of firms' voluntary GHG disclosure, they find a positive association between GHG disclosure and GHG performance. Taking one step further, Luo (2019) re-investigates the same question using GHG emissions data of Global 500 constituents from the CDP database for 8 years in a row from 2008-2015, with a focus on the influence of institutional context on the relationship of interest. They identify a negative association between firms' GHG performance level and the extensiveness of firms' voluntary GHG disclosure. These studies again focus on the "in levels" evidence of who would disclose

more and who would disclose less. The results still provide mixed perspectives that leave the literature split and contradictory.

Closely related to chapter 5, Qian and Schaltegger (2017) investigate whether improvement in GHG disclosure could lead to improvement in subsequent GHG performance. They employ a changes analysis of Global 500 firms drawing on the corresponding GHG emissions data from the CDP database for years 2008-2012. Their results find that increment in GHG disclosure is significantly associated with a subsequent improvement in the underlying GHG performance. Although their investigation does not consider the influence of endogeneity problem resulting from omitted time-variant variables on their empirical evidence obtained, their results, in turn, indicates that there may also be some association between changes in firms' underlying GHG performance and subsequent changes in the extensiveness of firms' GHG disclosure.

In the previous chapter, regarding the contradictory "in levels" evidence as regards the association between firms' environmental performance and corporate environmental disclosure in the extant literature, the possibility *that the different association patterns between firms' environmental performance and corporate environmental disclosure could be associated with the respective macro environmental disclosure circumstances in society* is advanced. The investigations conducted in chapter 4 intend to provide new international evidence that could either further point to the possibility or militate against the possibility. In this empirical chapter, following Qian and Schaltegger (2017)'s seminal work, using a similar changes research design, I intend to investigate whether changes in firms' underlying GHG performance would cause any subsequent changes in the extensiveness of firms' GHG disclosure employing international data. Specifically, although this chapter does not explore any "in levels" evidence of association between GHG disclosure and GHG performance, the theoretical arguments presented in prior studies provide good theoretical start-points for this piece of research.

2.2.2.3 Hypotheses of Interest for Chapter 5

As is mentioned in section2.1.1, the legitimacy theory argues that CSR is a kind of social pressure that firms are faced with, thus, the corresponding disclosure is a passive reaction towards such pressure (Bewley and Li, 2000; Patten, 2002; Cho and Patten, 2007). Following legitimacy theory's argument, the sole drive for firms to make GHG disclosure is because management expects a negative impact on the firms' interest if climate change risks are not attended to. And "to say" is always much cheaper and easier than "to act". If GHG disclosure

is used purely as a legitimisation tool that loses track of firms' GHG mitigating performance trajectory, then changes in firms' GHG performance would not cause any substantial changes in firms' subsequent GHG disclosure extensiveness (Cho et al., 2012; Phillips, 2013; Patten, 2015). In addition, from legitimacy theory's perspective, firms get involved in GHG mitigating activities out of their threatened legitimacy, firms then may well reduce GHG mitigating investment and GHG disclosure if they feel that their legitimacy is less threatened or is sufficiently maintained with achieved GHG performance improvement. Extra finance saved from original climate change mitigating activities could be utilised in other direct profit-making activities. In this case, firms would see a subsequent negative change in the improvement of the extensiveness of their GHG disclosure, if they have a positive change in the improvement of firms' underlying GHG performance (Milne and Gray, 2013; Qian and Schaltegger, 2017). Thus, the first two hypotheses would be:

H5: Changes in GHG performance do not contain any information of subsequent changes in GHG disclosure.

H6: Improvement in GHG performance leads to negative changes in subsequent GHG disclosure.

In contrast, according to the arguments from the "inside-out" management perspectives, when the management of firms decides to get involved in CSR related issues, such as climate change mitigating activities, firstly it indicates that the management in these firms expects an inflow of monetary or/and intangible benefits in the short-run or/and in the long-run. Secondly, it indicates that the "inside-out" management process of "involvement-achievement-disclosure" entails the existence or development of a system of measurement and corporate management infrastructure of the specific CSR concerns (Burritt and Schaltegger, 2010; Burritt et al., 2010). The final stage of the "inside-out" management process is communicating their CSR involvement and related achievement to outside information users (shareholders and the wider stakeholders) through corporate disclosure (Burritt et al., 2010). Relatedly, GHG disclosure, in the beginning, could be just a device to educate shareholders and the wider stakeholders about firms' climate change mitigating involvement and achievement (Schaltegger and Wagner, 2006). However, for firms that are continually involved in climate change mitigating activities, their GHG disclosure tends to change to converge with their GHG performance change trajectory. It means that there is a tendency for GHG disclosure to adjust in tandem with firms' historical GHG performance change (Qiu et al., 2016; Hassan et al., 2018). This is because using GHG disclosure that constantly dissociates with firms' GHG performance trajectory would expose the disclosing

firms to increasingly higher social and political costs. And firms do not want to see their established GHG related public image and reputation be busted (Schaltegger and Burritt, 2010; Qian and Schaltegger, 2017).

In line with which argument, prior studies find that firms with good environmental performance history tend to have more achievement to disclose in a variety of forms, however, firms with bad environmental performance history predominantly use a more narrative and claims focused way to disclose their environmental information (Clarkson et al., 2008; Hassan et al., 2018; Hassan, 2018). Environmental disclosure is associated with motivations, such as creating value from involving in environmental impact mitigating activities by establishing or/and fortifying good environmental image and reputation among shareholders and the wider stakeholders (Hasseldine et al., 2005; Toms, 2010). In addition, there is recent evidence suggesting that CSR related/environmental disclosure and performance is also associated with firm valuation (Matsumura et al., 2014; Cheng et al., 2014). However, it should be noted that all these benefits associated with CSR related disclosure need to be backed up by the underlying CSR performance, so that what has been established would not be debunked. Following this line of thinking, continual CSR related disclosure needs to maintain the consistency with firms' gradually changing CSR related performance history to secure the corresponding benefits. Similarly, this creates a possibility for firms' GHG mitigating performance change to shape the change of subsequent GHG disclosure accordingly (Matsumura et al., 2014; Clarkson et al., 2015).

Climate change risks and GHG emissions control have attracted increasing attention from governments, investors and the wider social mass over the past few decades (Ernst&Young, 2012; Downar et al., 2019). Although GHG emissions have been monetized in a lot of leading economies through Emissions Trading Scheme [ETS, the most famous and the first regional carbon ETS is the EU ETS (Chapple et al., 2013)], Clean Development Mechanism (CDM) and Joint Implementation (JI) following the Kyoto Protocol in 1997 (UNFCCC, 2014), disclosure of GHG information stays largely voluntary and unregulated in most countries of the world (Yu et al., 2018). In addition, society, especially large institutional investors and lenders across the world are becoming increasingly concerned over climate change risks related with their interested investees (CDP, 2019a), this indicates an ever increasing demand for GHG disclosure from firms. However, the premise of "GHG disclosure" is "involvement in GHG mitigating activities". From the "inside-out" management perspective, GHG performance is expected to shape management's subsequent GHG disclosure strategies to converge with firms' historical performance change trajectory, so that targeted benefits and established reputation would be secured in the long run

(Topping, 2012; Plumlee et al., 2015). As such, another hypothesis that is worth investigating is:

H7: Improvement in GHG performance leads to positive changes in subsequent GHG disclosure.

2.2.3 Literature and Hypotheses for Chapter 6

As is mentioned earlier, although the investigation of environmental disclosure-performance relationship has been an abiding discussion within the SEA literature, no evidence has been provided on whether firms' GHG disclosure would change to promote climate information transparency as a result of the changes in firms' GHG mitigating performance trajectory. Subsequent to Chapter 5 that provides overall international empirical evidence as regards the research question "Would firms' GHG disclosure change to promote climate information transparency as a result of the changes in firms' GHG mitigating performance trajectory?", chapter 6 strives to explore if there is a significant difference as regards the evidence of the research question of interest in chapter 5 between developing economies and developed economies.

This is because if the proposed possibility *that the different association patterns between firms' environmental performance and corporate environmental disclosure could be associated with the respective macro environmental disclosure circumstances in society* is true, then there should also be observable evidence between developing economies and developed economies that points to this proposed possibility for the same period under investigation, regarding the research question "Would firms' GHG disclosure change to promote climate information transparency as a result of the changes in firms' GHG mitigating performance trajectory?" This is because prior studies have documented that there are many existing differences as regards the various dimensions of CSR related disclosure circumstance between developing economies and developed economies. This also beckons a difference between developing economies and developed economies regarding the empirical evidence of the research question of interest in chapter 5.

2.2.3.1 Evidence and the Hypothesis for Developing Economies

Specifically, GHG related disclosure is largely voluntary[13] globally speaking. The different concern levels as regards the impact of CSR related issues on firms from shareholders and the wider stakeholders between developing economies and developed economies and the difference of the impact of strength of social contracts on firms between developing economies and developed economies are argued to create significant differences between the respective GHG disclosure circumstances in developing economies and developed economies. Although little evidence has been provided on direct comparison of the macro GHG disclosure circumstances between developing economies and developed economies, prior studies that investigate general CSR or/and environmental disclosure drivers/characteristics adopting a single country (region)-specific or a similar social and economic development level-specific point of view could provide helpful empirical evidence that leads to the differences of macro GHG disclosure circumstances between developing economies and developed economies.

Particularly, Belal (2000) examines the environmental disclosure characteristics in the annual reports of 30 Bangladeshi companies for the year 1996. This study was conducted in the backdrop of the situation in the SEA literature in late 1990s that the majority of environmental studies at that time were focused on developed countries. Specifically, compared with the prior empirical evidence from developed countries, the results obtained suggest that very limited useful information has been made in the environmental disclosure within firms' annual reports. Particularly, statistics backed up environmental disclosure is rare to be found, the author concludes that quality of environmental disclosure in developing economies is at a low level in the period under investigation. Consistent with Belal (2000)'s findings, Tsamenyi et al. (2007) find that corporate information transparency level cannot be reliably gauged based on corporate disclosure produced by the firms in developing economies.

Later Islam and McPhail (2011) document that developing countries have structural dependencies on foreign aid and investments through multinational corporations and joint ventures from developed countries. This situation makes developing countries, which typically have cheap labour, underdeveloped markets, and rich natural resources, susceptible

[13] Although it should be noted that GHG disclosure is now mandatory for firms with significant social and climate change impact in some of the world's most advanced economies, for example, as is mentioned earlier, the US Environment Protection Agency requires firms that meet certain carbon emissions threshold to report carbon emissions information at facility level from 2010 onwards; The UK requires that listed firms report their GHG emissions information in firms' annual directors' report from 2013 onwards, globally speaking, GHG disclosure is still predominantly produced on a voluntary basis.

to developed countries' exploitation on them. Such a social-economic situation in developing countries contributes to the ignorance of the weaker local stakeholders' concerns and needs by the firms in developing nations. Adding to which, Beddewela and Herzig (2013) document that the priority of the South Asian subsidiaries of large multinational corporations that incorporated in developed countries in CSR related areas is to satisfy their headquarters in developed countries. This process is often coupled with sacrificing local stakeholders' CSR related concerns. In addition, Sierra-García et al. (2015) find that firms that integrate CSR related disclosure in their annual report from developing regions are less likely to have their disclosed information assured, compared with their counterpart from developed regions. This evidence together indicates that the local stakeholders in developing economies have limited influence on firms, relatedly, the social contracts between firms and the societies in developed nations also tend to be weak. This indication is further evidenced in subsequent studies that, in developing economies, the adoption of social and environmental disclosure is found to be mainly resulting from external coercive forces like governmental orders and legal judgments (Martinsson et al., 2013; Luo et al., 2013; Ali et al., 2017), other public interest pressure (pressure from lobbyists, media and concerned stakeholders), however, forms little motivation on firms' decision to make social and environmental disclosure. (Ali and Rizwan, 2013; Luo et al., 2013; Ali et al., 2017).

The above evidence indicates that the local stakeholders in developing economies have limited influence on firms, the social contracts between firms and the societies in developing nations also tend to be weak. Given that general CSR issues (which subsumes general environmental issues) have long been a material social concern since the 1960-1970s globally speaking (Thinkingshift, 2007), however, the general social concern level regarding CSR related issues are still low, based on the above evidence. For the much later advanced GHG emission issues and related climate change risks, it then follows that the social awareness and concern level of GHG emission control would also be low overall in developing economies. Relatedly, the general GHG disclosure circumstance in developing economies tends to be at the initiating stage (**Phase1** of Table 1-1), where GHG disclosure is used just as a tool to react to the external social and political pressures that firms are faced with. This kind of disclosure does not have to contain the true information of firms' underlying GHG performance. Going back to legitimacy theory's point of view, maintaining corporate legitimacy is the priority over other issues, "to say" is always much cheaper and easier than "to do". For the research question of interest "Would changes in GHG performance cause any subsequent changes in GHG disclosure?", it is likely that changes in firms' GHG performance would not cause any substantial changes in firms' subsequent

GHG disclosure extensiveness in developing economies, thus, the hypothesis as regards the research question of interest for the developing economies is that:

H8: Changes in GHG performance do not contain any information of subsequent changes in GHG disclosure in developing economies.

2.2.3.2 Evidence and the Hypothesis for Developed Economies

In contrast with those evidence presented in developing countries, a number of prior studies show that stakeholders' pressure could also effectively affect firms' CSR related strategies and practices, along with other firm-specific internal factors like firms' economic scale, financial capability and corporate governance characteristics etc in developed economies (Xiao et al., 2005; Branco and Rodrigues, 2008; Reverte, 2009; Luo et al., 2013). In addition, CSR related disclosure produced by firms from developed economies has a higher probability to be assured by a third party, compared with their counterpart from developing economies. This is related with the fact that firms in developing economies are subject to more stringent financial constraints overall compared with their counterpart from developed economies, and firm-specific resources are predominantly allocated to growth related corporate activities in developing economies (Luo et al., 2013; Sierra-García et al., 2015). These evidence indicates that firms from developed economies are subject to higher level of pressure from society (Ali et al., 2017) and the strength of social contracts are stronger in the societies of developed economies, compared with the strength of social contracts in the societies of developing economies (Jamali and Karam, 2016; Jamali and Karam, 2018). Thus, the degree of supervision that firms in developed economies receive from society is stronger than the degree of supervision that firms in developing economies receive from society.

In addition, because *the time length of the social propaganda and education efforts to diffuse the importance of GHG emission issues and related climate change risks* in the society of developed economies is longer than that in the society of developing economies, *the degree to which the importance and relevance of GHG emission issues and related climate change risks are accepted and believed by the society* of developed economies is expected higher than that of developing economies. If the macro GHG disclosure circumstance in developing economies is expected to correspond to **Phase1** of Table 1-1, then the macro GHG disclosure circumstance in developed economies should be expected to correspond to the **Phase2** of Table 1-1, when firms with significant climate change impact take material measures to respond to their

investors' and consumers' ever-increasing concerns over the climate change related risks such firms are exposed to.

In this phase, on the one hand, firms in developed economies do not tend to use GHG disclosure that totally loses track of firms' underlying GHG performance, as the supervision from society is strong, which makes the cost of "being busted" very high; on the other hand, from legitimacy theory's perspective, firms get involved in GHG mitigating activities out of their threatened legitimacy, firms then may well reduce GHG mitigating investment and GHG disclosure if they feel that their legitimacy is less threatened or is sufficiently maintained with continuously achieved GHG performance improvement, so that any extra finance saved from climate change mitigating activities and disclosure could be used in other direct profit-making activities. In this case, firms in developed economies would see subsequent negative changes in the improvement of the extensiveness of their GHG disclosure, if they have continuously positive historical changes in the improvement of firms' underlying GHG performance (Milne and Gray, 2013; Qian and Schaltegger, 2017). Thus, the hypothesis as regards the research question of interest for the developed economies is that:

H9: Improvement in GHG performance leads to negative changes in subsequent GHG disclosure in developed economies.

3. Methodology

Chapter 3 intends to lead readers from the theoretical discussions to the research data and models used for the investigations in this thesis. Specifically, the first empirical study (chapter 4) strives to find if there is any global evidence that could add to the possibility *that the different association patterns between firms' environmental performance and corporate environmental disclosure are associated with the respective macro environmental disclosure circumstances in society,* which is obtained based on North American evidence. The investigations in chapter 4 is focused on the association pattern between firms' GHG performance and the extensiveness of corporate GHG disclosure for a recent period under investigation (years 2009-2014). These investigations in chapter 4 take advantage of the natural setting that the global macro GHG disclosure circumstance for years 2009-2014 is different from the global macro general environmental disclosure circumstance for years 2009-2014, and that the macro GHG disclosure circumstance in developing economies is different from that in developed economies for years 2009-2014.

Subsequent to chapter 4, chapter 5 intends to provide overall international evidence as regards the research question "Globally speaking, would firms' GHG disclosure change to promote climate information transparency as a result of the changes in firms' GHG mitigating performance trajectory?" (or alternatively, "Globally speaking, would changes in GHG performance cause any subsequent changes in firms' GHG disclosure strategy?") after controlling for potential impact of endogeneity and the impact of data trending problem on the results. Chapter 6 further intends to provide evidence on whether developing economies or developed economies drive the international evidence obtained in chapter 5 regarding the same research question. The evidence obtained in chapter 5 and chapter 6 could further add to the possibility *that the different association patterns between firms' environmental performance and corporate environmental disclosure are associated with the respective macro environmental disclosure circumstances in society* or militate against it. There is significant overlap between the three empirical chapters as regards the empirical models and the data used. Thus, chapter 3 firstly introduces the main database-the CDP database-that the investigations in the thesis use and the sample selection process for the investigations in the thesis. Subsequently, the empirical models and variables included in the empirical models would be presented and explained in turn.

3.1 The CDP Database and Data

The CDP, formerly "Carbon Disclosure Project", is a non-profit organization. It focuses on encouraging companies, cities, states, and regions to measure and understand their environmental impact. The CDP runs a global disclosure system. Companies, cities, states, and regions could voluntarily disclose related information by answering CDP's "climate change questionnaire", "forests questionnaire" and "water security questionnaire" in the system. The CDP collects above environmental information on behalf of the world's largest institutional investors and institutional customers. In 2014, there are more than 760 institutional investors and customers, representing about 92 trillion US dollars, endorsing CDP's climate change project (Rivers, 2014). The number has increased to 100 trillion US dollars as of 2019 (CDP, 2019c).

Responding to the CDP's climate change questionnaire is not compulsory, although the CDP has a list of requested companies to send their climate change questionnaire to each year. The CDP's list of requested companies for their climate change questionnaire each year is selected by the world's largest institutional investors and customers that back up the CDP. If a firm is requested by the CDP to respond to the CDP's climate change questionnaire, it could choose to respond or not according to its management's judgement. Also, if a firm decides to decline the CDP's request or does not respond to the climate change questionnaire, it will have potential financial indications from those institutional investors or/and institutional customers that request such information from it. In addition, firms that are not included in the CDP's climate change questionnaire requesting list could self-select themselves to report to the CDP through the climate change questionnaire.

In this thesis, because I use firm-specific carbon emissions and disclosure related information collected through the CDP's climate change questionnaire, it is necessary to understand the contents and structure of the CDP's climate change questionnaire and how the CDP scores the extensiveness and completeness of firms' responses to the climate change questionnaire. The CDP revises its climate change questionnaire as regards the questions presented, answer choices and answer routes in the questionnaire partially on a yearly basis to improve the reliability of carbon-related information collected. This makes a lot of information provided (excluding carbon emissions figures) in the questionnaire incomparable vertically. However, for years 2010-2015 (collecting carbon related data for years 2009-2014), the CDP's climate change questionnaires and the corresponding firm response scoring methodology stay largely consistent.

3.1.1 Climate Change Survey Structure for Years 2010-2015

As is mentioned earlier, the wording and answer choices of questions presented in the questionnaire and the position questions appear in the questionnaire may change from year to year. However, for years 2010-2015, all the questions appear in the climate change questionnaire could be categorised into three sections, namely, 1) management as regards confronting climate change within a firm; 2) identified risks and opportunities as regards climate change within a firm; 3) Carbon emissions-related information within a firm. (CDP, 2013b; CDP, 2013a). Specifically, within section 1), respondents are asked to answer if there is any corporate governance structure responsible for climate change issues within a firm, any strategy regarding climate change management in place within a firm, any carbon emission reduction targets or initiatives completed or underway for the reporting period, and whether a firm publish firm-specific climate-change related disclosure in other places other than the CDP's climate change questionnaire. The questions in this section ask respondents to provide the climate change management infrastructure information within a company.

Section 2) asks respondents to provide information on any identified physical or/and regulatory risks and opportunities with regards to climate change. This section provides information on how reporting firms understand the relevance of climate change issues to the firm. Section 3) asks respondents to provide information about how firms measure and identify their carbon emissions quantity in scope1[14], scope2[15] , and scope3[16]. If possible, firms should also break down scope1 and scope2 emissions by emission sources and by business sectors. Particularly, because of the extensiveness of the sources of scope3 emissions, firms are asked to provide scope3 emissions only by sources for the reporting period (For an intuitive understanding of the structure of the CDP's climate change questionnaire, see Table 3-1).

[14] Scope1 includes direct carbon emissions from owned or controlled sources (fuel combustion, company vehicles, fugitive emissions).United States Environmental Protection Agency. 2016. *Learn about the greenhouse gas reporting program (ghgrp).* [Online]. Available from: https://www.epa.gov/ghgreporting/learn-about-greenhouse-gas-reporting-program-ghgrp.

[15] Scope2 includes indirect emissions from purchased electricity, heat, steam, and cooling. (reference ibid)

[16]Scope3 includes all other indirect emissions within a firm's value chain (reference ibid)

Table 3-1: Question structure and distribution of attainable scores across sections for 2010-2015 climate change surveys-Example

	Denominator range - disclosure		Denominator range - performance	
	Min	**Max**	**Min**	**Max**
Management				
Governance	2	4	5	5
Strategy	5	11	9	9
Targets & Initiatives	7.5	14	7	8
Communications	1	1	3	3
Risks and Opportunities				
Climate change risks (regulatory, physical, other)	30	36	0	9
Climate change opportunities (regulatory, physical, other)	30	36	0	9
Emissions				
Emissions methodology	3	4	0	0
Emissions data	33	36	7	7
Scope 1 breakdown	1	2	0	0
Scope 2 breakdown	1	2	0	0
Scope 2 contractual	1.5	2.5	0	0
Energy	4.5	4.5	0	0
Emissions performance	5.5	9.5	9	10
Emissions trading	2	8	1	1
Scope 3	13.5	16.5	5	5
Overall total	**140.5**	**187**	**46**	**66**

This table provides an example of the different sections of the CDP's climate change questionnaire for years 2010-2015. Each section of the questionnaire carries a certain number of attainable scores for firms' responses. A lot of questions in each section have different answer routes, after choosing "Yes" or "No". This leads to different attainable scores. As we could see, only several specific sections of the questionnaire simultaneously carry attainable performance scores. A respondent would only be accessible to get performance scores after obtaining the corresponding disclosure scores for a question. Overall, for the whole questionnaire, a respondent has to be scored at least 50 percent for disclosure in order to be scored for performance band. However, note that the performance band provided by the CDP is not a metric that gauges the degree to which a firm's operations are low-carbon based, it only indicates the level of actions taken by a firm to manage its climate-change related impact (CDP, 2011).

For the 2010 climate change questionnaire, if it is the first time that a firm participates in the CDP's climate change project, the CDP asks firms to provide scope1 and scope2 emissions-related information for three years prior to the reporting period (which is financial year 2009) (CDP, 2010). As for the climate change questionnaires for years 2011-2015, firms are not asked to provide scope1 and scope2 emissions for previous years, however, firms could choose to do so. In fact, in each year's climate change questionnaire responses, there is always a very small proportion of firms that only report carbon emissions information for past years prior to the current reporting year (e.g. in the 2013 climate change questionnaire, the vast majority of firms provide carbon information for 2012, as data for 2012 is the most recent data available. However, some firms only provide data for 2010 and 2011). When

cleaning data, for consistency of sample screening assumption and analysis purposes, the data of firms that only provide previous years' information other than the current reporting year is dropped.

In addition to the emissions information that firms are asked to provide above. In section 3), firms are also asked to provide any purchased electricity, heat, steam, and cooling to back up their reported scope2 emissions. Based on the data from the carbon emissions management and monitoring system within a firm, firms are requested to provide how their combined scope1 and scope2 emissions change (decreased or increased) compared to the previous year. A firm-activity based intensity of carbon emissions and a corporate finance intensity of carbon emissions for the current reporting year are also requested. In addition, firms should also disclose information about any emissions trading scheme that they are involved in and any sales or/and purchases of carbon credits within the scheme. For firms in some specific industries [2010, 2011: electric utilities, oil and gas companies, auto manufacturers; 2012, 2013, 2014: information and communications technology companies are added (CDP, 2014b; CDP, 2012); 2015: food, beverage and tobacco companies are added (CDP, 2015b)], they are requested to respond to some additional industry-specific modules when responding to the main questions in the climate change questionnaire (CDP, 2014a; CDP, 2015a). For example, oil and gas companies are requested to report their climate change sensitive assets by sources and by business sectors when reporting their climate-change related physical or regulatory risks and opportunities. Electric utilities are directed to industry-specific response table when reporting their scope1 emissions information, etc. If the questions in the industry-specific modules coincide with those in the main questionnaire, these companies could choose to only respond in the industry-specific modules instead of responding in the main questionnaire.

It should be noted that, if a firm chooses to respond to the CDP's climate change questionnaire, it does not have to finish all the questions in the questionnaire. And regardless of the level of completion of the questionnaire, firms could choose to make their questionnaire response to be publicly available through CDP's website or not. For years 2010-2015, the deadline for the submission of the response to the CDP's climate change questionnaire is the end of May, firms' climate change responses submitted by the end of May would automatically be scored for the level of comprehensiveness and details of a firm's response to the CDP's climate change questionnaire. Firms that submit their responses after the deadline would not be automatically scored, however, these firms could contact the CDP to ask to be scored. Regardless of whether a firm has received a disclosure score, firms could choose to make their disclosure score status (specific scores or the status of "not scored") to

be publicly available through the CDP's website or not[17]. Because all responding firms are given this scoring eligibility information before they respond to the climate change questionnaire, whether a firm receives a disclosure score and whether the disclosure score would be publicly available depend on the choice of the specific firm's management.

3.1.2 Disclosure Scoring Methodology for Climate Change Responses 2010-2015

Scoring is closely aligned with CDP's vision and missions (CDP, 2019a). For years 2010 to 2015, firms that submit their response before the deadline of submission for the climate change questionnaire each year would automatically be scored for the level of details and comprehensiveness of a response. For years 2010-2015, the disclosure score is an integer number ranging between 0 and 100 inclusive. Like firms' responses to the climate change questionnaire, firms could choose to make their disclosure score status publicly available through the CDP's website or not, regardless of whether a firm receives a disclosure score or not. Again, it should be noted that the CDP suggests all firms that decide to respond to the climate change questionnaire read the scoring methodology before they respond to the questionnaire so that they know whether firms would be scored and how firms would be scored. Thus, whether a firm would have a disclosure score and whether a firm would make its disclosure score status publicly available through the CDP's website depend on the judgement and decision of the management of the firm.

For the purpose of disclosure scoring, a few attainable points are allocated to each question in the climate change questionnaire (to see how these attainable points spread in each section of the questionnaire, see Table 3-1 for example). Note that, for questions that require information of high importance, e.g. emission figures in different scopes, more attainable scores are allocated. Also, all the answers and data provided in the additional industry-specific modules are not scored, unless there is overlap between the information requested by the questions in the main climate change questionnaire and the information requested by the questions in the industry-specific modules, and the respondent only responded to the questions in the industry-specific modules. In this case, respondents should direct scorers to the answers in the industry-specific modules. To calculate the final disclosure score for a responding firm, the CDP divides all the disclosure points obtained by

[17] Please note that the CDP's firm listing and score listing policies on their website has changed since 2016, to *"1) Companies who are requested to submit a response to investors will be listed on the CDP website regardless of whether a response is submitted or not; 2) Company scores are made publicly available, regardless of whether the response itself is public or non-public. For companies responding to a questionnaire for the first time, CDP offers the option to keep this score private for the first year."* {CDP. 2019b. *How will my company be listed on the CDP website?* [Online]. [Accessed 02/07/2019]. Available from: https://www.cdp.net/en/guidance#13}

the firm in its response by all the attainable disclosure points given the firm's chosen answer routes in the questionnaire, and then multiply the fraction by 100 to generate an integer disclosure score ranging from 0 to 100. That is, "**(disclosure points obtained / disclosure points attainable) x 100 = disclosure score**".

Although the total disclosure points attainable vary between different firms' different choices of answer routes, their disclosure scores are always comparable using this disclosure score calculation formula. In addition, the minimum and maximum disclosure scores attainable of the climate change questionnaire vary between years, because the questions included in the climate change questionnaire vary between years. Using this disclosure scoring methodology also creates vertically comparable disclosure scores, regardless of the specific changes of questions in each year's climate change questionnaire. If a firm chooses to only respond to certain questions in the climate change questionnaire, the firm's disclosure score would be biased down by the scoring rules. This is because, many questions have different answer routes after choosing "Yes", "No" or "Not relevant", each answer route has different attainable disclosure points, if a respondent leaves a question unanswered, CDP would choose the maximum disclosure points that are attainable for this question as part of the denominator in the final disclosure score calculation, and "0" as part of the numerator of the final disclosure score calculation (Rivers, 2014) (See Table 3-1).

3.1.3 Overall Sample Selection

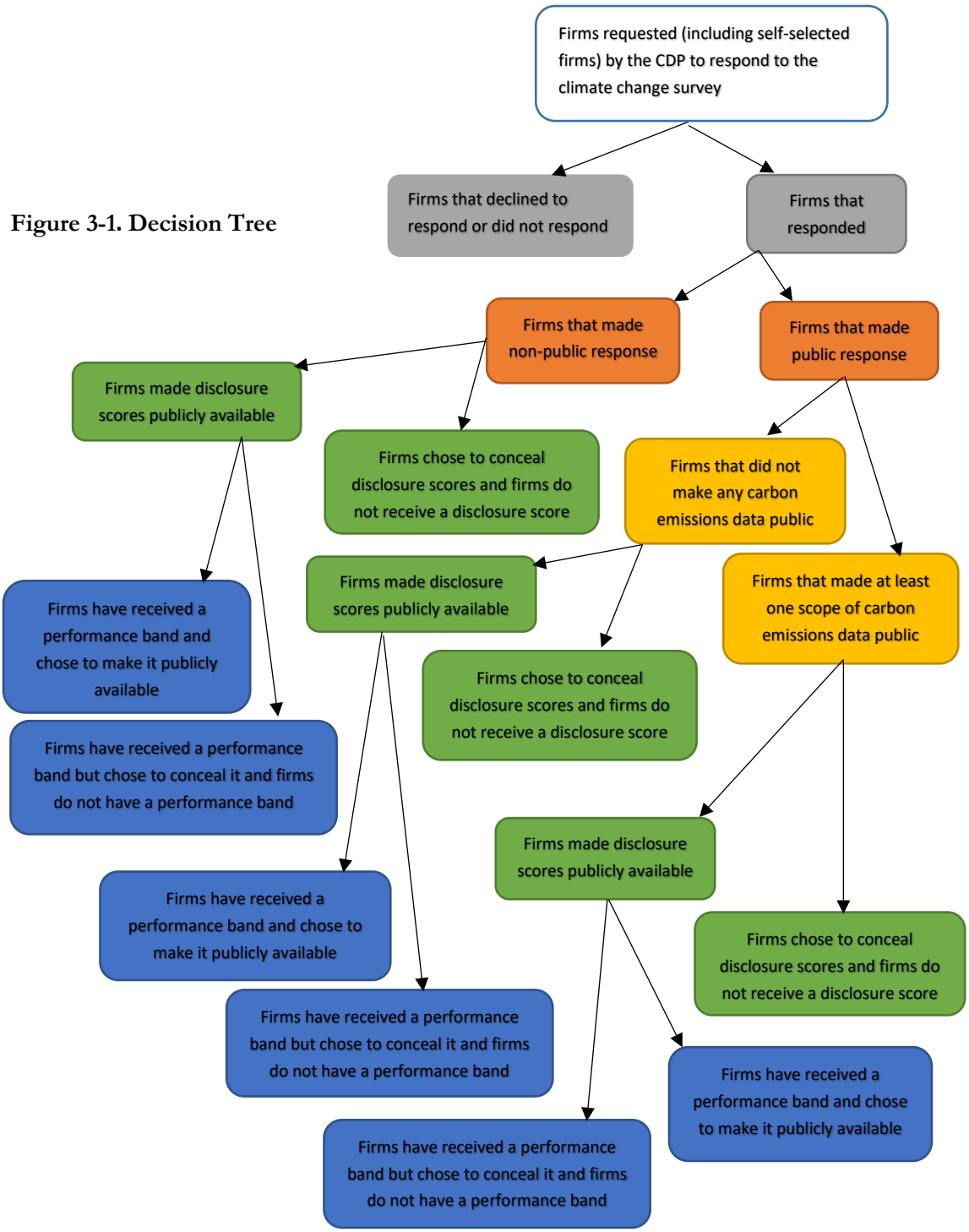
The CDP's climate change survey should be regarded as a voluntary channel for firms to discretionarily disclose their GHG emission related information to the requiring investors, customers, and the public. No matter a firm is asked by the CDP to respond to their climate change survey or a firm is self-selected to respond to the CDP's climate change survey, it could always choose to respond or not, and could subsequently choose to make its responses and scores public or not (see Figure 3-1 for the decision tree of how the management of firms that involved in the CDP's climate change questionnaire makes firms' emissions and disclosure data publicly available). Given which condition, the CDP's climate change survey is the same as other discretionary CSR disclosure channels like corporate homepage, CSR disclosure, independent CSR reports etc. The CDP's climate change survey for years 2010-2015 (submission deadline of responses is 31st May for this period) collect firm specific GHG emission related data for years 2009-2014. And as is mentioned earlier, the climate change

questionnaires and disclosure scoring methodologies for 2010-2015 stay largely consistent and comparable. Thus, I choose 2009-2014 as the period under examination.

For the following empirical studies, I use both a full sample of 25967 firm-year observations that corresponds to 5622 firms, 78 countries and 19 regions[18] and a reduced sample of 6366 firm-year observations that corresponds to 1646 firms, 44 countries and 19 regions. To be included in the full sample, firms should a) have at least participated in the

[18] The 19 regions are categorised based on cultural, lingual, geographical, political and economic similarities by the CDP.

Figure 3-1. Decision Tree



1. Blocks of the same colour are of the same decision stage.
2. Carbon emissions info of firms that made non-public response is not available through the CDP's database.
3. For years 2010-2015, firms that submitted their response by the end of May would automatically receive a disclosure score. Firms submitted after the end of May would not be automatically scored, but they could ask to be scored.
4. Firms would only be scored for performance band if they have scored at least 50 points for disclosure in the first place.

CDP's climate change project once for years 2010-2015; b) have necessary financial and accounting data available from Compustat and/or Datastream. The reduced sample is selected out of the full sample if c) firms have received a disclosure score for their responses to the CDP's climate change survey and allowed the CDP to make their disclosure scores publicly available through the CDP's website for at least one year for the 2010-2015 CDP climate change projects. The reduced 6366 firm-year observations all have a valid publicly available CDP climate change disclosure score.

Table 3-2 Panel A and Table 3-2 Panel B provide descriptive statistics for the reduced sample and for the full sample across countries, territories and across regions. The firm-year observations are originally based on countries or territories. However, it is very common for some countries or territories to have firm-year observations below 20. Thus, these firm-year observations are further categorised into different regions (there are in total 19 regions for both the full sample and the reduced sample). These region classifications are based on cultural, lingual, geographical, political, and economic similarities by the CDP.

We could see that for both the reduced sample and the full sample, I have the most firm-year observations from the US (around 26% in the reduced sample, 18% in the full sample). Out of the 4672 US firms involved in the CDP's climate change project, 1631 (around 35%) of them have publicly available CDP disclosure scores through the CDP's website. Overall, 6366 firm-year observations (around 24.5%) of all 25967 firm-year observations involved in the CDP's climate change project have publicly available CDP disclosure scores through the CDP's website. This indicates that most involved firms are not willing to make their CDP disclosure score status publicly available. On the one hand, it, in turn, may suggest that most of the management of involved firms expects a negative impact on their own firms by publishing their CDP disclosure score status through the CDP's website. On the other hand, regardless of firms' carbon performance, communicating firms' proactive posture on climate change mitigating activities to the public by making firms' CDP disclosure extensiveness information public may have significant positive financial and non-financial benefits for firms that have publicly available CDP disclosure scores through the CDP's website.

For the reduced sample, 15 out of 19 regions have more than 100 firm-year observations. For the full sample, 12 out of 19 regions have more than 1000 firm-year observations. The sample I choose has a significant improvement regarding representation

Table 3-2: Panel A. Sample observation distribution across countries, territories, and regions for the reduced sample

Countries and Territories		Regions		Countries and Territories		Regions	
South Africa	267	**Africa**	**267**	**South Korea**	163	**Korea**	**163**
Australia	217			**Israel**	10		
New Zealand	40	**Oceania**	**257**	**Turkey**	30		
Belgium	28			**UAE**	4	**M. East**	**44**
Luxembourg	6			**Denmark**	98		
Netherlands	83	**Benelux**	**117**	**Finland**	152		
Canada	397	**Canada**	**397**	**Iceland**	1		
Bermuda	5			**Norway**	113		
Mexico	20	**C. America**	**25**	**Sweden**	149	**Nordics**	**513**
P. R. China	8			**Brazil**	82		
Hong Kong	41			**Chile**	8		
Taiwan	63	**China**	**112**	**Colombia**	10	**S. America**	**100**
Austria	33			**Indonesia**	2		
Germany	256			**Malaysia**	4		
Switzerland	153	**DACH**	**442**	**Philippines**	1		
Cyprus	5			**Singapore**	9		
Czech	2			**Thailand**	10	**SE. Asia**	**26**
Italy	116			**USA**	1631	**USA**	**1631**
Portugal	43			**UK**	825	**UK**	**825**
Russia	12						
Spain	115	**E.&S. Europe**	**293**				
France	269	**France**	**269**				
India	120	**India**	**120**				
Ireland	35	**Ireland**	**35**				
Japan	730	**Japan**	**730**	**Total**			**6366**

Table 3-2: Panel B. Sample observation distribution across countries, territories, and regions for the full sample

Countries and Territories		Regions		Countries and Territories		Regions		Countries and Territories		Regions	
Egypt	42			**Czech**	45			**Qatar**	10		
Kenya	6			**Estonia**	19			**Saudi Arabia**	24		
Mauritius	4			**Greece**	32			**Turkey**	505		
Morocco	8			**Hungary**	48			**UAE**	35	**M. East**	**641**
Nigeria	12			**Italy**	373			**Denmark**	174		
South Africa	422	**Africa**	**494**	**Latvia**	10			**Finland**	265		
Australia	961			**Lithuania**	23			**Iceland**	5		
New Zealand	191	**Oceania**	**1152**	**Monaco**	3			**Norway**	314		
Belgium	180			**Poland**	256			**Sweden**	309	**Nordics**	**1067**
Luxembourg	40			**Portugal**	170			**Argentina**	12		
Netherlands	329	**Benelux**	**549**	**Romania**	24			**Brazil**	420		
Canada	1227	**Canada**	**1227**	**Russia**	347			**Chile**	120		
Bermuda	26			**Serbia**	6			**Colombia**	60		
Cayman Islands	21			**Slovakia**	12			**Peru**	45	**S. America**	**657**
Mexico	143			**Slovenia**	20			**Cambodia**	2		
Panama	11	**C. America**	**201**	**Spain**	372			**Indonesia**	278		
P.R. China	1130			**Ukraine**	22	**E.&S. Europe**	**1827**	**Malaysia**	244		
Hong Kong	352			**France**	1207	**France**	**1207**	**Papua New Guinea**	1		
Mongolia	6			**India**	1113			**Philippines**	122		
Taiwan	710	**China**	**2198**	**Pakistan**	42	**India**	**1155**	**Singapore**	108		
Austria	120			**Ireland**	157	**Ireland**	**157**	**Thailand**	155		
Germany	1022			**Japan**	2757	**Japan**	**2757**	**Vietnam**	45	**SE. Asia**	**955**
Switzerland	447	**DACH**	**1589**	**South Korea**	1389	**Korea**	**1389**	**USA**	4672	**USA**	**4672**
Bulgaria	1			**Bahrain**	6			**Channel Islands**	11		
Croatia	39			**Israel**	55			**Gibraltar**	6		
Cyprus	5			**Oman**	6			**UK**	2056	**UK**	**2073**
										Total	**25967**

compared with prior studies that use only part of S&P 500 companies or Global 500 companies as their sample. My samples are clustered at region level. To avoid potential biases, region-fixed effects need to be controlled in my analyses.

Table 3-3 Panel A and Table 3-3 Panel B present the distribution descriptive statistics for the reduced sample and the full sample across years and industries. We could see that, generally speaking, the firm-year observations across the six-year period for both the reduced sample and the full sample show a progressively increasing trend (except that for the full sample, there is a drop of firm-year observations from 4942 to 4082 between 2013 and 2014), with 634 firm-year observations in 2009 and 1327 firm-year observations in 2014 for the reduced sample, 3624 firm-year observations in 2009 and 4082 firm-year observations in 2014 for the full sample. The differences of the firm-year observations between each year are generally not huge, except that there are relatively less firm-year observations in 2009 with only 634 firm-year observations for the reduced sample, 3624 firm-year observations for the full sample. This may be related with the situation that the CDP's climate change survey structure had a major change in 2010, and the CDP has not increased their climate change project company list yet. In addition, the increasing trend of the number of participants in the CDP's climate change project also reflects that the management of an increasing number of firms considers the involvement in controlling for climate change related risks important and relevant to their firms.

The firm-year observations are categorised into 10 sectors according to the Global Industry Classification Standard (GICS) developed by Morgan Stanley Capital International (MSCI) and Standard & Poor's (S&P). I have the least firm-year observation from the "Telecommunication Services" sector (N=241, 3.8% of all firm-year observations for the reduced sample; N=686, 2.6% of all firm-year observations for the full sample), and the most firm-year observation from the "Industrials" sector (N=1399, 22% of all firm-year observations for the reduced sample; N=5064, 19.5% of all firm-year observations for the full sample). My samples are also clustered at industry level. Overall, to conduct my analysis, year-fixed effects, industry-fixed effects, and region-fixed effects need to be effectively controlled.

Table 3-3: Panel A. Sample observation distribution across years and industries for the reduced sample

	Industry1	Industry2	Industry3	Industry4	Industry5	Industry6	Industry7	Industry8	Industry9	Industry10	Total
2009	44	80	84	46	44	132	65	74	24	41	634
2010	57	127	106	77	60	204	93	139	35	62	960
2011	58	144	115	80	67	252	113	165	44	65	1103
2012	63	148	130	80	75	245	109	164	46	63	1123
2013	65	159	147	85	79	274	125	172	45	68	1219
2014	66	171	152	88	88	292	155	188	47	80	1327
Total	353	829	734	456	413	1399	660	902	241	379	**6366**

Industries are categorized according to the industry sectors of Global Industry Classification Standard (GICS) developed by "MSCI" and "Standard & Poor's".

Industry1: Financials; Industry2: Consumer Discretionary; Industry3: Consumer Staples; Industry4: Energy; Industry5: Health Care; Industry6: Industrials; Industry7: Information Technology; Industry8: Materials; Industry9: Telecommunication Services; Industry10: Utilities.

Table 3-3: Panel B. Sample observation distribution across years and industries for the full sample

	Industry1	Industry2	Industry3	Industry4	Industry5	Industry6	Industry7	Industry8	Industry9	Industry10	Total
2009	127	495	338	297	208	707	346	682	101	323	3624
2010	152	565	363	305	242	796	402	756	112	339	4032
2011	221	664	414	330	286	870	465	812	114	339	4515
2012	261	723	428	328	309	934	509	828	120	332	4772
2013	270	788	447	337	329	952	546	813	128	332	4942
2014	172	627	393	294	269	805	405	697	111	309	4082
Total	1203	3862	2383	1891	1643	5064	2673	4588	686	1974	**25967**

Industries are categorized according to the industry sectors of Global Industry Classification Standard (GICS) developed by "MSCI" and "Standard & Poor's".

Industry1: Financials; Industry2: Consumer Discretionary; Industry3: Consumer Staples; Industry4: Energy; Industry5: Health Care; Industry6: Industrials; Industry7: Information Technology; Industry8: Materials; Industry9: Telecommunication Services; Industry10: Utilities.

3.2 Research Design

After introducing the main data source and the sampling process for the thesis in the previous section. The following section specifies the empirical models used in the empirical chapters. Simultaneously, variables included in these models as well as the related literature review for these variables would be given.

3.2.1 Empirical Models for Chapter 4; Variables Included in the Models

In this section, first the main model for chapter 4, which is the GHG disclsoure-performance model, would be introduced. In addition, it should be noted that the data collecting process of the CDP involves management's discretionary selection. To correct for the impact of self-selection bias on the results obtained as regards the relationhsip of interest, the disclosure score publication model would be introduced, following the the GHG disclsoure-performance model.

3.2.1.1 Disclosure-Performance Model and Variables

In chapter 4, for the recent period 2009-2014, first I intend to identify whether the observed global association pattern between firms' GHG performance level and the extensiveness of corporate GHG disclosure would be different from the most recently observed positive association (Al-Tuwaijri et al., 2004; Clarkson et al., 2008) between firms' other environmental performance and corporate environmental disclosure regarding other environmental issues, given the existing differences between the global macro GHG disclosure circumstance and the global macro corporate environmental disclosure circumstance regarding other environmental issues. Secondly, for the same period under investigation, I intend to test whether the observed association pattern between firms' GHG performance level and the extensiveness of corporate GHG disclosure in developing economies would be different from that in developed economies, given the existing differences between developing economies and developed economies regarding their respective macro GHG disclosure circumstances. If the expected differences are observed, then, the results obtained would add to the possibility *that the different association patterns between firms' environmental performance and corporate environmental disclosure are associated with the respective macro environmental disclosure circumstances in society*.

I examine the following "in levels" model regarding voluntary GHG disclosure and GHG performance:

$$CD_{i,t} = a_0 + a_1 CP1_{i,t}\ OR\ a_1 CP2_{i,t} + a_2 ROA_{i,t} + a_3 Q_{i,t} + a_4 FR_{i,t} + a_5 CGRANK_{i,t} + a_6 SIZE_{i,t} + a_7 IO_{i,t} + a_8 SG_{i,t} + a_9 AN_{i,t} + a_{10} ESG_{i,t-1} + v_{i,t} \quad (1)$$

, where CD is a measure for the extensiveness of companies' GHG disclosure. I use the CDP's yearly climate change disclosure score to proxy for this measure, following Luo and Tang (2014), Qian and Schaltegger (2017)'s prior studies. This disclosure score is an integer mark (ranging from 0 to 100) calculated by the CDP based on the level of completion of the climate change questionnaire and the quality of the information provided in the climate change questionnaire. According to Al-Tuwaijri et al. (2004), there are generally two different ways to quantify companies' CSR/environmental disclosure. The first one is to use the number of pages or the number of sentences or words in the annual reports or stand-alone CSR/environmental reports. These measures are largely defective as they do not consider the information and the quality of information of CSR/environmental disclosure (Gray et al., 1995; Patten, 2002; Deegan, 2002; Clarkson et al., 2008).

The second one is to do content analyses of companies' CSR/environmental disclosure according to a set of self-developed scoring standards. The disclosure scores of the same CSR/environmental disclosure could vary significantly based on the set of scoring standards one chooses. Thus, the generalisability of the results is considerably problematic (Wiseman, 1982; Al-Tuwaijri et al., 2004; Chapple et al., 2013). In this study, however, I choose to use a set of scores that measure "the degree to which a company has responded to the CDP's climate change questionnaires". These scores are given by the CDP to its climate change program participants each year. The calculation process of these scores has already been introduced in previous sections. As the CDP develop the climate change questionnaire and participants can only disclose their GHG information according to the questions in the questionnaire, the scoring standards are highly consistent across different companies in different countries. This is a great improvement compared with various "CSR/environmental disclosure content analysis" standards used by prior studies.

CP is a measure for companies' GHG (carbon) performance, the proxy for this measure is the ratio of the yearly total scope1, scope2 and scope3 carbon (GHG) emissions (in thousand metric tonnes) of each sample firm over their yearly total inflation-adjusted revenue (in million USD). Specifically, as Depoers et al.(2016) find that there is a significant

difference between the reported GHG emissions in corporate reports and those reported in the CDP's climate change questionnaire based on evidence from large listed French firms. Also, because Thomson Reuters' Asset4 database collects scope1 and scope2 GHG emissions data from global media coverage (firms' annual reports, CSR reports, webpage CSR disclosure and research institutions' publications etc.), for the period under investigation[19]. To control for firms' reported carbon emissions differences from different channels, CP1 equals total scope1, scope2, scope3 carbon equivalent emissions (in thousand metric tonnes) from the CDP database over firms' yearly total inflation-adjusted revenue (in million USD). CP2 equals total scope1 and scope2 carbon emissions (in thousand metric tonnes) from Thomson Reuters' Asset4 [20] database plus scope3 carbon emissions (in thousand metric tonnes) from the CDP database over firms' yearly total inflation-adjusted revenue (in million USD).

The most important issue in social and environmental accounting studies, is about how to find a proper proxy for CSR performance/environmental performance. Extant literature has well documented the difficulties in finding such a proxy (Cheng et al., 2014). Several different measures have been used in the extant literature to gauge companies' CSR performance or environmental performance, for instance, third-party social reputational indices like the Fortune reputational and social responsibility index (McGuire et al., 1988; Preston and O'bannon, 1997); questionnaire based cognitive measures (Aupperle, 1991); third party objective performance indices like the Council on Economic Priorities environmental performance index (CEP index), Thomson Reuters ESG scores (Freedman and Jaggi, 1982; Hughes et al., 2001; Cheng et al., 2014), toxic substance emissions obtained from the Toxics Release Inventory (TRI) database (Patten, 2002; Al-Tuwaijri et al., 2004; Clarkson et al., 2008) etc.. These CSR and environmental measures all suffer from various problems, reputation-based measures are not objective, generalisability is a major issue for these measures; the CEP performance index and TRI index only cover several high pollution industries; Thomson Reuters ESG scores do not differentiate between data collected from voluntary channels and data collected from non-voluntary channels. The most important problem of these proxies is that they are made to proxy for a concept that incorporates various facets. However, in this study I use firms' annual GHG emissions in thousand metric

[19] Thomson Reuters' Asset4 database have been providing carbon emissions data obtained through its own data sources since April 2009 (See https://www.csrwire.com/press_releases/13695-ASSET4-Carbon-Data-Estimates-Available-Now).

[20] Thomson Reuters' Asset4 database only collects scope1 direct carbon equivalent emissions and scope2 indirect carbon equivalent emissions independently from global media coverage, scope3 indirect carbon equivalent emissions are not provided.

tonnes scaled by firms' total revenue in million US dollars to proxy for GHG performance itself, this proxy is indeed more academically rigorous.

ROA is a firm's return on assets, it is computed as the ratio of income before exceptional items (in million USD) of the current year over the total assets (in million USD) at the end of last year. Prior research has identified various relationship between CSR/environmental impacts of a company and its financial performance, these findings are largely contradictory with each other, characterised by positive or negative association, U shaped or Inverse-U shaped association (Margolis et al., 2007; Cheng et al., 2014). However, the direction of causality is a problem unsettled, Waddock and Graves (1997) argue that CSR is both a predictor and a result of financial performance. For one thing, firms with more slack financial resources tend to be more actively involved in CSR related investment, for another, these CSR investments, in turn, may result in huge intangibles that bring unfathomable financial benefits. In this study, I use firms' return on assets (ROA) to control for slack finance effects on firms' GHG involvement.

Q is Tobin's Q, it measures the market to book ratio of a company, calculated as the ratio of market value of common equity of a firm (in million USD) plus the book value of its common equity (in million USD) minus the book value of its total assets (in million USD) over the book value of its total assets. Prior studies identify that companies with considerable potential intangible assets and positive NPV investment opportunities tend to have a large Tobin's Q (Smith Jr and Watts, 1992; Barth et al., 1997). Firms with more positive NPV investment opportunities and extra intangible assets have been found to be associated with more proactive CSR strategies (McWilliams and Siegel, 2011; Friede et al., 2015). In addition, Hassan and Romilly (2018) found that Tobin's Q is positively associated with more extensive environmental disclosure. I control Tobin's Q for its potential effects on the extensiveness of firms' voluntary GHG disclosure.

FR measures a firm's financial risk, I use firms' leverage level to proxy for this measure. It is calculated as firms' book value of total debt including current (in million USD) over firms' book value of total assets (in million USD). Firms' leverage level has been widely used to measure firms' financial risk (FR) in prior studies. Firms' financial risk is found to be associated with management's decision to invest in CSR related issues and CSR strategy changes (Chapple et al., 2013; Benlemlih et al., 2018). There is a higher demand for information transparency when a firm increases leverage (McWilliams and Siegel, 2011). I control firms' leverage level on firms' tendency to make more extensive voluntary GHG disclosure.

CGRANK is a measure of corporate governance that is related to climate change mitigation issues. It takes on a value of "2", if the highest level of direct responsibility for climate change within a firm is a subset of the board or some committee appointed by the board; it takes on a value of "1", if the highest level of direct responsibility for climate change within a firm is a manager or an officer; it takes on a value of "0", if there is no individual or committee with overall responsibility for climate change. The information also comes from the CDP's climate change questionnaire. This measure captures the mediating effect of governance structure on environmental disclosure. The existence of a corporate position of direct responsibility for CSR related issues within the governance structure of a company reflects that the management values such issues. It may also reflect specific company's shareholders' concern over such issues. Environment-wise, a position or a committee on the board of a company for climate change and a position in management that focuses on climate change intuitively denotes how much a firm values climate-change-related risks and opportunities. In practice, with such a position in a company, the execution of climate change related strategies and production related processes are expected to be better than that of those companies without such climate change monitoring positions. I use CGRANK to control for the effects of board or management positions that are devoted to climate change mitigation activities on firms' tendency to voluntarily disclose GHG related information, as well as on firms' GHG performance.

SIZE is the size of a company, it is measured in this study as the natural log of the market value (in million USD) of the equity of a company. The majority of prior studies regarding CSR/environmental disclosure and performance control for firm size, it is argued that larger firms are subject to more social and political pressure that require them to enhance transparency and operate in a more socially and environmentally responsible manner (Lang and Lundholm, 1996; Clarkson et al., 2013). As a reaction to such pressure and in an attempt to reduce related costs, larger firms are more forthcoming to procure clean technologies and equipment and disclose more about their CSR related information (Chapple et al., 2013; Qian and Schaltegger, 2017). In addition, it is also argued that firm size is associated with firms' information environment, larger firms normally have better information environment, compared with smaller firms (Gray et al., 1995; Lang and Lundholm, 1996). Thus, I control firm size for its potential effects on firms' voluntary GHG disclosure.

IO is the institutional ownership of companies, it is constructed as the shares of a company owned by institutional investors over all shares outstanding of a company. Because the CDP collects GHG related data from global companies on behalf of a total US$100

trillion assets (as of 2019) from over 650 biggest institutional investors across the world that are "climate change crisis" concerned. Firms that have a high percentage of institutional ownership would be probably more likely to respond to the CDP's climate change survey. Also, prior research argues that the agents of a company are more forthcoming to communicate through accounting disclosure regarding the issues concerning shareholders if the ownership of the company is dispersed and diversified, as socially responsible investors would be more likely to be involved in the decision-making process of the company in this case (Roberts, 1992; Toms, 2002; Hasseldine et al., 2005). "Institutional ownership" (IO) provides a measure of the impact of ownership structure on companies' posture towards environmental issues and related risks.

SG is firms' sales growth, calculated as the difference of sales revenue in million USD at "t" and sales revenue in million USD at "t-1" over sales revenue in million USD at "t-1". This measure is included in the model, as prior studies identify that management that is capable of creating cash inflow is more prone to adopt strategies that generate benefits in the long run (De Villiers et al., 2011; Stanny, 2013; Cahan et al., 2016). To benefit from voluntary information disclosure, firms' management should be willing to take a long-term posture. In addition, prior studies argue that CSR related investments are "luxury good" associated with "slack finance" (Freedman and Jaggi, 1992; Cormier and Magnan, 1997; Aerts et al., 2008; Buchner et al., 2015). Good sales growth is often associated with better liquidity and more "slack finance" (Buchner et al., 2012; Friede et al., 2015). AN measures a firm's asset newness, calculated as the ratio of a firm's net properties, plant, and equipment (in million USD) at each year end over its gross properties, plant, and equipment (in million USD) at each year-end. Prior studies (Clarkson et al., 2011; Qian and Schaltegger, 2017) provide evidence that firms with newer equipment are more likely to use environmental and climate friendly technologies. Companies with newer assets could be associated with more extensive environmental disclosure, as they want to transform this investment into profitable intangible assets.

ESG is Thomson Reuters' firm-specific environmental, social, and governance (ESG) score for the previous year. It measures the overall balanced performance level of a firm in environmental, social, and governance areas based on firm specific ESG information captured by Thomson Reuters from global media. It is expected that firms that have already performed well in environmental, social, and governance (ESG) aspects would have more resources in monitoring their GHG footprint and are more likely to voluntarily disclose more extensively about their GHG emission related information to the public. Thomson Reuters'

ESG score provides a comprehensive evaluation on firms' historical ESG performance based on available global media coverage (Thomson Reuters, 2017). Bad ESG performers may also seek to change its established negative image reflected through Thomson Reuters' ESG score by improving its ESG performance. Thomson Reuters' ESG score could serve as an external shock for management's decision process regarding firms' involvement in climate change mitigation activities. I control for the influence of previous year's Thomson Reuters' ESG score on firms' willingness and tendency to disclose their GHG emission related information in the current year.

3.2.1.2 Disclosure Score Publication Choice Model and Variables

To control for the self-selection bias of the sample. Besides model (1), I also jointly examine the following probit model (2) with model (1) using the full sample employing the Heckman (1979) twostep regression:

$$DSPUB_t = a_0 + a_1 IR_t + a_2 SIZE_t + a_3 DSPUB_{t-1} + a_4 IO_{i,t} + a_5 VOLA_t + a_6 FR_t + a_7 AN_t + a_8 RDI_t + a_9 DEV_t + v_{i,t} \quad \mathbf{(2)}$$

, where DSPUB is a dummy variable, which equals "1", if a firm receives a disclosure score for its response to the CDP's climate change questionnaire and allows its CDP disclosure score to be publicly available through the CDP's website for year "t", and "0" otherwise.

IR is a measure for firms' propensity to have publicly available CDP disclosure scores through the CDP's website. It is calculated as the ratio of the number of those whose CDP disclosure scores are available through CDP's website in an industry in the full sample (based on the GICS industry classification) for year "t" over the number of all firms in an industry for year "t" in the full sample, excluding each focal firm's contribution in my dataset. Including this measure to predict whether firms would have publicly available CDP disclosure scores through the CDP's website is reasonable. This is because non-disclosing firms would feel "peer pressure" if lots of firms in the industry voluntarily make their disclosure scores publicly available through the CDP's website. Further, Li et al. (1997) find that stakeholders' evaluation of the magnitude of non-disclosing firms' CSR liability increases with more and more firms in the industry disclosing CSR related information. This indicates

that the costs of staying silent about firms' CSR information are more expensive when most of firms in the same industry disclose such information.

Evidence from prior studies that investigate firm-level systematic characteristics related with firms' propensity to respond to the CDP's climate change questionnaire finds that firms' size is significantly positively related with firms' responding propensity (Stanny and Ely, 2008; Stanny, 2013). SIZE is a measure for firms' economic size, calculated as the natural log of the market value (in million US dollars) of the equity of a company. $DSPUB_{t-1}$ is the lag of DSPUB , this measure is included as a predictor of whether firms would have publicly available CDP disclosure scores through the CDP's website, because prior studies find that firms that voluntarily make their carbon emission information publicly available through CDP's website would be 8 times more likely to continue to do so (Stanny, 2013; Griffin et al., 2017). IO is a measure of firms' institutional ownership, it is the percentage of firms' total shares outstanding that are owned by institutional investors. Because the CDP collects GHG related data from companies on behalf of a total US$100 trillion assets from over 650 biggest institutional investors across the world that are socially and environmentally concerned. Firms that have a high percentage of institutional ownership would be probably more likely to have publicly available CDP disclosure scores through the CDP's website.

VOLA is the standard deviation of adjusted monthly stock return based on a moving window of 12 months for years 2009-2014. I control for this factor, as prior studies in discretionary disclosure research and environmental disclosure research find that firms whose financial status is exposed to higher volatility tends to have lower quality of corporate disclosure (Verrecchia, 1983; Brooks and Oikonomou, 2018). Thus, it is expected that firms with high volatility are less likely to make high quality non-compulsory GHG disclosure, thus, less likely to have publicly available CDP disclosure scores through the CDP's website. FR measures a firm's financial risk, I use firms' leverage level to proxy for this measure. It is calculated as firms' book value of total debt including current (in million USD) over firms' book value of total assets (in million USD). Controlling for leverage level in the disclosure decision model is consistent with the evidence from discretionary disclosure research that firms with higher leverage tend to provide corporate disclosure of higher quality (Dye, 1985; Frankel et al., 1995; Dhaliwal et al., 2011).

AN denotes firms' assets newness, it is calculated as the ratio of a firm's net properties, plant, and equipment at each financial year-end over its gross properties, plant, and equipment at each financial year-end. Firms with newer equipment are argued to have cleaner production process and to be less environment-harming, as newer equipment is more likely

to be producing with stricter environmental standards (Clarkson et al., 2008; Clarkson et al., 2011). Thus, firms that have higher asset newness value tends to be associated with more environmentally friendly corporate institutions and strategies. It is expected that this kind of firms would have more resources to make quality GHG related disclosure, quality GHG disclosure would associate with higher CDP disclosure scores. Thus, firms with higher asset newness would probably be more likely to have publicly available CDP disclosure scores through the CDP's website.

RDI is a measure for firms' Research and Development (R&D) spending intensity, it is calculated as the ratio of a firm's yearly R&D spending over its total book value of assets in year "t". I control this factor in the disclosure score publication choice model, because prior studies find that firms with higher R&D expenditures tend to get involved in more long-run benefit-generating activities (Qian and Schaltegger, 2017; Brooks and Oikonomou, 2018). Management's decision to disclose non-compulsory GHG related information is associated with benefits in the long run. Besides, having publicly available CDP disclosure scores through the CDP's website is associated with the establishment of firms' climate change reputation in the long run. DEV is a dummy variable that equals "1", if a firm is a member of DAC[21]; "0", if otherwise. According to the arguments related to the possibility *that the different association patterns between firms' environmental performance and corporate environmental disclosure could be associated with the respective macro environmental disclosure circumstances in society* and the evidence presented in previous sections, there are significant differences between developing economies and developed economies regarding their respective macro GHG disclosure circumstances. So is expected the likelihood of having publicly available CDP disclosure scores through the CDP's website between developing economies and developed economies.

3.2.2 Empirical Models for Chapter 5, Chapter 6; Variables Included in the Models

To test the hypotheses advanced in chapter 5 as regards the research question "Would firms' GHG disclosure change to promote climate information transparency as a result of the changes in firms' GHG mitigating performance trajectory?" (In addition, because chapter 6

[21] *The Development Assistance Committee (DAC) is a group of the world's major donor countries that discuss issues surrounding development aid and poverty reduction in developing countries within the OECD.* For the reason why this criterion is used to differentiate between developing economies and developed economies, please go to section4.3.1. { see "Organisation for Economic Co-operation and Development (OECD). 2008. *About the Development Assistance Committee (DAC).* [Online]. [Accessed 15 Mar. 2019]. Available from: http://www.oecd.org/dac/"}.

examines whether it is the developing economies or it is the developed economies that drive the overall international evidence obtained in chapter 5 as regards the same research question, chapter 6 shares the same empirical model with chapter 5), the following empirical model is employed:

$$\Delta CD_{i,t+1} = a_0 + a_1 \Delta CI_{i,t}(-) + a_2 \Delta ROA_{i,t} + a_3 \Delta Q_{i,t} + a_4 \Delta FR_{i,t} + a_5 CGRANK_{i,t} + a_6 \Delta SIZE_{i,t} + a_7 \Delta IO_{i,t} + a_8 \Delta SG_{i,t} + a_9 \Delta AN_{i,t} + a_{10} \Delta ESG_{i,t} + v_{i,t}$$

, where CD denotes the extensiveness of firms' voluntary GHG disclosure. It is measured by the CDP's climate change questionnaire disclosure scores. As is shown in Table 3-1 in section3.1, the structure of the CDP's climate change questionnaire stays the same for years 2010-2015, the whole questionnaire could be broken down to 3 sections and 12 categories, and each category carries a certain amount of attainable disclosure scores. The CDP's climate change questionnaire disclosure score measures firms' completion level of the CDP's climate change questionnaire, and because scoring is based on firms' answers towards the same questionnaire, the scoring standards are highly consistent across different firms from different countries. As is introduced in section3.1.2, the CDP's climate change disclosure score is an integer number that ranges from 0 to 100 inclusive. For the convenience of interpretation, when calculating the changes of CD, after taking the difference of the CD for two consecutive years, the difference is divided by 100. For example, if the disclosure score of a firm for 2010 is 68, and that for 2011 is 70, the changes of disclosure score for this firm in 2011 is (70-68)/100=0.02 or 2%. Measuring changes of disclosure scores this way is consistent with the practice of Qian and Schaltegger (2017).

CI is firms' GHG emissions intensity, it is calculated as firms' "scope1", "scope1+scope2" (in thousand metric tonnes) over firms' yearly total inflation-adjusted revenue (in million USD) respectively. For the purpose of identification, "scope1" GHG intensity using data from the CDP data base is denoted as A1CI, "scope1+scope2" GHG intensity using data from the CDP data base is denoted as A2CI. "Scope1" GHG intensity is examined independently because GHG Emission Trading Schemes all over the world at current stage only include scope1 GHG emissions, thus, scope1 GHG emissions get a significant amount of attention and management within firms (Cooper, 2015; Qian and Schaltegger, 2017). Prior studies predominantly use scope1 direct GHG emissions plus scope2 indirect emissions to proxy for firms' overall[22] GHG emissions (Qian and Schaltegger, 2017; Jaggi et al., 2018; Hassan et al., 2018; Luo, 2019), thus A2CI is also examined in this study.

In addition, as Depoers et al. (2016) identify that there is a significant difference between the reported GHG emissions in corporate reports and those reported in the CDP's climate change questionnaire using data form large listed French firms. Although we do not know whether the evidence could be extended to the wider international firms, it is better that I control for the impact of potential differences of reported GHG emissions from different channels on the results I obtain, a parallel set of GHG intensity proxies are produced drawing on GHG emissions data from Thomson Reuters' Asset4 database. This is because Thomson Reuters' Asset4 database independently collect firms' scope1 direct and scope2 indirect GHG emissions from global media coverage (firms' annual reports, CSR reports, webpage CSR disclosure and research institutions' publications etc.). B1CI and B2CI are calculated respectively using "scope1" GHG emissions (in thousand metric tonnes) from Thomson Reuters' Asset4 database, "scope1+scope2" GHG emissions (in thousand metric tonnes) from Thomson Reuters' Asset4 database over firms' yearly total inflation-adjusted revenue (in million USD). Using revenue scaled GHG emissions to proxy for firms' GHG performance is consistent with prior studies (Luo and Tang, 2014; Depoers et al., 2016; Qian and Schaltegger, 2017; Luo, 2019). Also, because the proxies for GHG performance are intensity measures, following Qian and Schaltegger (2017), I inversed the signs of ΔCI, so

[22] Unlike the case in chapter 4, "scope1+scope2+scope3" emissions are not used to proxy for firms' overall GHG emissions, this is because chapter 5 and chapter 6 investigate how firms' voluntary GHG disclosure strategies change as a result of the changes in firms' realised GHG mitigating achievement trajectory. However, the realisation of scope3 emissions may spread into a few periods in the future including the current period, for example, the realisation of scope3 GHG emissions resulting from sold vehicles of a firm could take a few years following the year when the vehicles were sold. To avoid the impact of "look-ahead bias" on the results obtained in this chapter, scope3 GHG emissions are not examined. Whereas, chapter 4 only investigates the association between GHG performance and the extensiveness of firms' voluntary GHG disclosure, the "look-ahead bias" is irrelevant in that context.

that ΔCI(-) could be intuitively explained as the improvement of GHG performance (decrease of GHG intensity).

A few other factors documented in prior studies that are associated with CSR related disclosure and CSR related performance are controlled in the empirical model, and the changes form of these factors are calculated accordingly. ROA denotes firms' return on assets, it is calculated as the ratio of income before exceptional items (in million USD) of the current year over the total assets (in million USD) at the end of last year. Prior studies have documented that there is a relationship between firms' financial performance and CSR related involvement and performance, however, the results are mixed (Schnietz and Epstein, 2005; Wahba, 2008; Hassan et al., 2018). Some studies find that firms with good financial performance in fact take an economic focused approach in their business operations and observe negative association between financial performance and CSR involvement (Margolis et al., 2007; Hassan et al., 2018). However, others find that adequate financial resources are associated with good social and environmental involvement and performance (Waddock and Graves, 1997; Lo and Sheu, 2007; Nakao et al., 2007; Cheng et al., 2014). Firms' return on assets is controlled for its potential effects on GHG disclosure.

Q denotes Tobin's Q, which is a measure for firms' market to book ratio. This measure is calculated as the ratio of the market value of the common equity of a firm (in million USD) plus the book value of its common equity (in million USD) minus the book value of its total assets (in million USD) over the book value of its total assets. This factor is controlled in the empirical model as evidence suggests that firms with higher Tobin's Q are associated with more employable intangible assets, more positive NPV investment opportunities and more proactive CSR strategies (Barth et al., 1997; McWilliams and Siegel, 2011; Friede et al., 2015). In addition, recent studies identify that environmental disclosure is positively associated with Tobin's Q (Hassan, 2018; Hassan et al., 2018). FR denotes firms' financial risk, this measure is calculated as firms' leverage level, which equals firms' book value of total debt including current (in million USD) over firms' book value of total assets (in million USD). Using firms' leverage level to catch firms' financial risk is consistent with several prior studies (Beck, 1992; Fama and French, 1993; Bansal and Clelland, 2004; Mulhall and Bryson, 2013). In addition, evidence shows that when firms raise leverage level, the demand of better information transparency from shareholders and the wider stakeholders would also increase (McWilliams and Siegel, 2011), leverage level is associated with firms' posture towards CSR related issues and firms' CSR disclosure (Chapple et al., 2013; Benlemlih et al., 2018).

CGRANK measures corporate management infrastructure construction level related to climate change mitigation within a firm. Specifically, it equals "2" if the highest level of direct responsibility for climate change mitigation in a firm is a subset of the board or some committee appointed by the board; it equals "1" if the highest level of direct responsibility for climate change mitigation in a firm is a manager or an officer; it equals "0" if there is no management establishment of overall responsibility for climate change mitigation in a firm. This factor is controlled for its potential effect on firms' willingness and tendency to get involved in GHG mitigating activities and disclosure, as prior studies find that firms with a position on the board or in the management that takes overall responsibility for CSR related issues tend to perform overall better in CSR than firms without such a position (Stanny and Ely, 2008; Brooks and Oikonomou, 2018). This measure is not in differenced form because in a period of 6 years in a row, firms' GHG related management setting barely changes. SIZE denotes the economic scale of firms, it is calculated as the natural log of the market value (in million USD) of the equity of a firm. Firms' size has been constantly controlled in prior CSR disclosure and performance related research, as it is argued that larger firms are exposed to stronger social and political pressure, this, in turn, motivates firms to perform better in CSR related areas, and provide better CSR related information transparency through corporate disclosure (Clarkson et al., 2013; Chapple et al., 2013).

IO denotes the institutional ownership of companies, it is calculated as the shares of a company owned by institutional investors over all shares outstanding of a company. Because CDP's climate change project is backed up by total US$100 trillion assets (as of 2019) from over 650 biggest institutional investors across the world that are "climate change crisis" concerned. For firms that take part in the CDP's climate change questionnaire, firms' institutional ownership may, to some degree, drive management's decision to participate. Also, for regular participants, large institutional owners may drive these firms to perform better and better in GHG emissions reduction and disclosure in order to excel among peer firms that are regular participants of the CDP's climate change project. SG denotes firms' sales growth, it is calculated as the difference of sales revenue in million USD at "t" and sales revenue in million USD at "t-1" over sales revenue in million USD at "t-1". I control for this factor in this model as prior evidence shows that management that is good at creating cash flow from sales tends to adopt proactive strategies in CSR related issues (De Villiers et al., 2011; Stanny, 2013; Cahan et al., 2016). In addition, firms with good sales growth tend to have good liquidity, prior studies also argue that CSR related investments are "luxury good" associated with "slack finance" (Freedman and Jaggi, 1992; Cormier and Magnan, 1997; Aerts

et al., 2008; Buchner et al., 2015). Thus, firms' sales growth may have potential effect on firms' GHG mitigating activities involvement and GHG disclosure.

AN denotes the newness of firms' properties, plants, and equipment, it is calculated as the ratio of a firm's net properties, plant, and equipment (in million USD) at each year end over its gross properties, plant, and equipment (in million USD) at each year-end. This factor is controlled as prior evidence shows that firms with newer properties, plants, and equipment are more likely to use clean technologies that are environmentally and climate friendly (Clarkson et al., 2011; Qian and Schaltegger, 2017). Thus, firms with newer properties, plants, and equipment are expected to have higher level of environmental and GHG mitigating activities involvement than firms with older properties, plants, and equipment. ESG denotes Thomson Reuters' firm-specific environmental, social, and governance (ESG) score. Thomson Reuters' ESG score measures the overall balanced performance level of a firm in environmental, social, and governance areas based on firm-specific ESG information captured by Thomson Reuters from global media coverage (Thomson Reuters, 2017). It is expected that firms with good overall ESG scores would also perform well in GHG emissions reduction activities and disclosure.

4. Behind the Contradiction: GHG Performance and Disclosure-New Evidence

4.1 Introduction

The disclosure-performance association as regards corporate environmental issues has been a long-standing inconclusive discussion in social and environmental accounting literature. Specifically, a major focus of argument is whether corporate environmental disclosure adheres to firms' real environmental performance. In other words, whether there is a reliable association between firms' environmental performance and corporate environmental disclosure. And if there is association between firms' environmental performance and corporate environmental disclosure, whether good environmental performers tend to have more extensive environmental disclosure or bad environmental performers tend to have more extensive environmental disclosure. The evidence presented in prior studies as regards this research topic is mixed and contradictory, leaving the literature jumbled and split. In the light of this situation, this study strives to provide global evidence on a potential rationale to connect the mixed evidence so far and offer new evidence to this research topic.

The investigation of the association between firms' environmental performance and corporate environmental disclosure originates from a group of papers in early social accounting literature that attempts to examine the problem of whether investors really need corporate environmental disclosure to make investment decisions or not. This is because there is research at that time identifying some evidence that doubts investors' need for such reports against professional predictions that corporate environmental reporting is useful to investors (Ingram and Frazier, 1980; Trotman and Bradley, 1981). Ingram and Frazier (1980) first investigate the association between firms' environmental performance and corporate environmental disclosure and find that firms' environmental disclosure is not associated with firms' environmental performance. They then argue that investors' insufficient need for corporate environmental reports results from the fact that the quality of corporate environmental disclosure is low and such disclosure does not contain the information of firms' underlying environmental performance. Following their seminal work, later studies identify inconsistent results (no association; negative association; positive association) about the relationship of interest (Wiseman, 1982; Freedman and Jaggi, 1982; Patten, 2002; Clarkson et al., 2008; Clarkson et al., 2013; Luo and Tang, 2014).

Despite the conflicting evidence as regards the association between firms' environmental performance and corporate environmental disclosure, there is little evidence provided on whether the seemingly contradictory evidence could be connected and unified. By reviewing the extant literature that studies the relationship between firms' environmental performance and corporate environmental disclosure, it is identified that the evidence on this research topic is predominantly from North America (especially the US) based on cross-sectional data. Further revealed is that this contradictory evidence clusters in different periods of North American society in a chronological manner. That is, the earliest studies on the research topic of interest primarily identify no association between firms' environmental performance and corporate environmental disclosure (Ingram and Frazier, 1980; Wiseman, 1982; Freedman and Wasley, 1990), later studies primarily identify negative association between firms' environmental performance and corporate environmental disclosure (Bewley and Li, 2000; Hughes et al., 2001; Patten, 2002), and most recently studies primarily identify positive association between firms' environmental performance and corporate environmental disclosure (Al-Tuwaijri et al., 2004; Clarkson et al., 2008).

Starting from the chronologically-clustering contradictory evidence in North America on this research topic and the fact that corporate environmental issues are not originally considered an integrated part of businesses. Making society accept and believe that corporate environmental isssues should be sufficiently managed in firms' daily operations, and thus, making most firms integrate corproate emnvironmental management into their busienss models are a long-term cause (Deegan, 2017). And this process is coupled with the corresponding propaganda and education efforts in society (Deegan, 2002; Cowan and Deegan, 2011). It then follows that the macro environmental dislcosure circumstance in society would gradually change in the process to diffuse and sediment the importance of corporate environmental issues in society. There is a possibility *that the different association patterns between firms' environmental performance and corporate environmental disclosure could be associated with the respective macro environmental disclosure circumstances in society* over time.

Specifically, given that firms could always make environmental disclosure to react to society's increasing concern over corporate environmental risks, regardless of whether firms have really improved their environmental performance[23], it then follows that corporate environmental disclosure could be used as an instrument of "greenwashing" to restore firms' public image and reputation in early stages when the management of a firm only starts to realise the relevance of corporate environmental issues to its business. In this case, firms have not really improved their environmental performance, the extensiveness of corporate environmental disclosure does not contain any information about firms' true environmental performance, or even worse, corporate environmental disclosure is used to conceal firms' bad performance on corporate environmental issues (Wiseman, 1982; Griffin et al., 2017; Cooper et al., 2018). Under this situation, no association or negative association between firms' environmental performance and corporate environmental disclosure could be empirically observed by cross-sectional studies in society.

However, when *the importance and relevance of corporate environmental issues* get deep and rooted in society, and corporate environmental impact mitigating activities become a normality in firms, good environmental performers are typically forthcoming to disclose extensively about their real environmental achievement, backed up by solid statistics and monitoring process. While bad environmental performers would be conservative on their de facto environmental performance or be silent (where no compulsory environmental reporting is required), as their data is by any means no match for those good performers. This is because statistics, real environmental strategy, and existing environmental monitoring infrastructure in place are hard to imitate, and vary between different firms (Clarkson et al., 2008; Yu et al., 2018). In addition, falsification of such data would expose the corresponding firms to high social and political costs and unrecoverable reputation and public image damage (Bebbington and Larrinaga, 2014; Downar et al., 2019). In this case, the extensiveness of corporate environmental disclosure adheres to firms' real environmental performance. Positive association between firms' environmental performance and corporate environmental disclosure could be empirically observed by cross-sectional studies in society.

[23] When firms use environmental disclosure as a pure instrument of "greenwashing", while they have not actually improved their environmental performance, rhetoric texts about firms' ambitions and dedication towards corporate environmental issues are largely drawn on. This kind of environmental disclosure is classified as "soft" disclosure. "Soft" environmental disclosure with little statistics and process depiction could be easily replicated by competitors.[see "Clarkson, P.M., Li, Y., Richardson, G.D. and Vasvari, F.P. 2008. Revisiting the relation between environmental performance and environmental disclosure: An empirical analysis. *Accounting, Organizations and Society*. **33**(4-5), pp.303-327."; Hassan, O.A. 2018. The impact of voluntary environmental disclosure on firm value: Does organizational visibility play a mediation role? *Business Strategy*. **27**(8), pp.1569-1582.]

The above arguments offer a plausible rationale to connect the conflicting evidence documented in the research area that investigates the association between firms' environmental performance and corporate environmental disclosure. In line with the possible rationale argued above, it should be noted that the advent of socially responsible business could be dated back to Chester Barnard's publication of "*The Functions of the Executive*" in the 1930s of the US and Theodore Kreps' publication of "*Measurement of the Social Performance of Business*" in the 1940s of the US (Thinkingshift, 2007). Further, corporate social responsibility (which subsumes corporate environmental responsibility) became a formal concept and social concern in the 1960-1970s in developed economies (Thinkingshift, 2007). In contrast, although "GHG emission issues" and related "climate change risks" are also subsumed by the wider environmental concept, they only came into public attention and became a social concern at the end of the 20th century following the convention of the 1992 United Nations Framework Convention on Climate Change and the subsequent Kyoto Protocol in 1997. Thus, *the diffusion and sedimentation of the importance of GHG emission issues and related climate change risks* in global society as a whole started roughly 3 decades later than that of the general CSR and environmental issues, globally speaking.

As a result, *the time length of the corresponding social propaganda and education efforts to diffuse and sediment the importance of GHG emission issues and related climate change risks in global society* (starting from the 1990s) is much shorter than *that of the general CSR and environmental issues in global society* (starting from the 1960s). The global macro GHG disclosure environment is different from the global macro disclosure circumstance regarding general CSR or environmental issues at current stage (KPMG, 2015; KPMG, 2017). Consequentially, it would be of interest to empirically test the association pattern between firms' GHG performance and the extensiveness of firms' GHG disclosure for a recent period under investigation. Through the test, we could see whether the international evidence obtained would add to the possibility *that the different association patterns between firms' environmental performance and corporate environmental disclosure are associated with the respective macro environmental disclosure circumstances in society* or not. To do the test, I use a panel dataset of 5622 firms from 78 countries that are involved in the Carbon Disclosure Project (CDP) for years 2010-2015(carbon emissions related data for years 2009-2014). I intend to introduce new global evidence [24], compared with prior studies that provide predominantly North American evidence, as a potential contribution to the research topic using this dataset.

[24] Note that there have been recent studies using Global 500 companies' data to investigate the relationship between carbon performance and carbon disclosure [see "Qian, W. and Schaltegger, S. 2017. Revisiting carbon disclosure and performance: Legitimacy and management views. *The British Accounting Review*. **49**(4),

In addition, because the advocacy of mitigating climate change risks through GHG emission control is initiated by the world's most developed countries (UNFCCC, 2014), *the time length of the corresponding social propaganda and education efforts to diffuse and sediment the importance of GHG emission issues and related climate change risks in the society of developing economies* is shorter than that in the society of developed economies. Prior studies also identify that there are significant differences as regards the respective environmental disclosure circumstances between developing economies and developed economies. It is expected that relationship between firms' GHG performance and the extensiveness of firms' GHG disclosure in developing economies would also be different from that in developed economies for the same period under investigation.

Depending on whether the expected difference as regards the relationship of interest between developing economies and developed economies could be observed or not, it would potentially either further add to or again go against the proposed possibility *that the different association patterns between firms' environmental performance and corporate environmental disclosure are associated with the respective macro environmental disclosure circumstances in society*. The rest of this study is arranged as follows. Section4.2 reviews extant relevant literature and presents the consequent hypotheses. Sections4.3 specifies the research design, data selection and variables measurement. Section4.4 analyses the obtained evidence, followed by the conclusions in section4.5.

4.2 Literature Review and Hypotheses

For the literature review and hypotheses of chapter 4, please refer back to section2.2.1.

4.3 Research Design

The previous section focuses on the literature related to the investigations conducted in this chapter and the hypotheses to be tested. In this section, to start with, the data and the source of the data for the investigations in this chapter would be introduced together with the

pp.365-379."; "Luo, L. 2019. The influence of institutional contexts on the relationship between voluntary carbon disclosure and carbon emission performance. *Accounting and Finance.* **59**(2), pp.1235-1264."]. These studies contribute to the literature in different ways and would be discussed in the literature review section. Most importantly, Global 500 companies are highly clustered in the world's largest and/or most developed economies. Thus, the representation is quite limited, neither could their results be considered truly international.

corresponding sampling process. Following which, the empirical models employed, and the variables included in these models would be specified.

4.3.1 Sample and Data

To test the hypotheses advanced above, I divide the sample selected in section3.1.3 further into the "developing economies group" and the "developed economies group". The generally accepted criteria to decide whether a country or territory could be classified as a developed economy include but not limited to "gross domestic product (GDP)", "gross national product (GNP)", "per capita income", "industrialization level", "widespread infrastructure level" and "general living standard" (Investopedia, 2019). However, there is no unique methodology about how to synthesise data from various sources to generate a list of developed countries and territories. The United Nations Human Development Index (UN HDI)[25], the Organisation for Economic Co-operation and Development (OECD)[26], the World Bank[27] and the International Monetary Fund (IMF)[28] have their own specific list of develped (advanced; high-income) countries and territories, using different methodologies (UNDP, 2010; Organisation for Economic Co-operation and Development (OECD), 2010; International Monetary Fund, 2016; World Bank, 2018).

There are overlap and differences between different lists of develped (advanced; high-income) countries and territories. However, the countries in the Development Assistance Committee (DAC)[29] of the OECD are constantly listed in different lists of

[25] *The United Nations Human Development Index (UN HDI) is a statistical tool used to measure a country's overall achievement in its social and economic dimensions. The social and economic dimensions of a country are based on the health of people, their level of education attainment and their standard of living.*{see "The Economic Times. 2017. *The definition of human development index*. [Accessed 23 Nov. 2019]. Available from: https://economictimes.indiatimes.com/definition/human-development-index"}.

[26] *The Organisation for Economic Co-operation and Development (OECD) is an international organisation that works to build better policies for better lives. Their goal is to shape policies that foster prosperity, equality, opportunity and well-being for all.* {see "Organisation for Economic Co-operation and Development (OECD). 1961. *Who we are.* [Online]. [Accessed 23 Nov. 2019]. Available from: http://www.oecd.org/about/"}.

[27] *The World Bank is an international financial institution that provides loans and grants to the governments of poorer countries for the purpose of pursuing capital projects.* {see "World Bank. 2008. *About the World Bank.* [Online]. [Accessed 23 Jul. 2019]. Available from: https://www.worldbank.org/en/about"}.

[28] *The International Monetary Fund (IMF) is an organization of 189 countries, working to foster global monetary cooperation, secure financial stability, facilitate international trade, promote high employment and sustainable economic growth, and reduce poverty around the world.* { see "International Monetary Fund. 1945. *About the IMF.* [Online]. [Accessed 12 Apr. 2019]. Available from: https://www.imf.org/en/About"}.

[29] *The Development Assistance Committee (DAC) is a group of the world's major donor countries that discuss issues surrounding development aid and poverty reduction in developing countries within the OECD.* { see "Organisation for Economic Co-operation and Development (OECD). 2008. *About the Development Assistance Committee (DAC).* [Online]. [Accessed 15 Mar. 2019]. Available from: http://www.oecd.org/dac/"}.

develped (advanced; high-income) countries and territories. For the purpose of consistency in criteria, countries in my sample that are memebers of the DAC are categorised as "developed countries". The full sample (see section3.1.3) is further divided into a subsample of developed economies (corresponding to 19150 firm-year observations, 4188 firms, 29 countries) and a subsample of developing economies (corresponding to 6817 firm-year observations, 1424 firms, 49 countries); the reduced sample (see section3.1.3) is further divided into a subsample of developed economies (corresponding to 5655 firm-year observations, 1409 firms, 24 countries) and a subsample of developing economies (corresponding to 711 firm-year observations, 237 firms, 20 countries).

4.3.2 Empirical Models and Variables

For the explanation of empirical models used to examine the hypotheses advanced in this chapter and the variables included in these empirical models, please refer back to section3.2.1.

4.4 Results

This section presents the empirical results obtained for the research questions of interest in this chapter. Specifically, the analyses of the results start with analysing and summarising the information obtained from summary statistics. Following which, the tests for hypotheses 1-3 would be conducted through baseline-model regression, negative binomial regression and Heckman twpstep regression controlling for self-selection bias. Finally, the tests for hypothesis 4 would also be conducted through the above regression models.

4.4.1 Implications from Summary Statistics

Table 4-1 Panel A and Table 4-1 Panel B provide the descriptive statistics of the main variables in the disclosure-performance model and the disclosure score publication choice model for the full sample[30] and the breakdown of the full sample by development level group and by CDP disclosure score availability group. $CP1_t$, $CP2_t$, ROA_t, Q_t, FR_t, IO_t, SG_t are

[30] It should be noted that the "full sample" here means the full sample in each of the two models in this chapter. The "full sample" in the disclosure-performance model is the "reduced sample" mentioned in "3.1.3 Overall Sample Selection". And the "full sample" in the disclosure score publication choice model is the "full sample" of the chapter mentioned in "3.1.3 Overall Sample Selection".

winsorised at 0.05 level to avoid the impact of extreme values. Specifically, in Table 4-1 Panel A, I conduct a univariate analysis on the means and medians of the variables in the two models of this chapter by development group.

The mean for all the firm-year observations that have a publicly available CDP disclosure score is 75.99, while the standard deviation is only 19.7, the variation of the dependent variable in the disclosure-performance model is not huge. On the 100-point disclosure score scale, this means that firms that have publicly available CDP disclosure scores are on the high end of all the firms that have received a disclosure score. Out of the 6366 firm-year observations that have a publicly available CDP disclosure score, only 711 observations come from the developing economies group. This number is only around 1/8 of the 5655 observations with a publicly available CDP disclosure score from the developed economies group. However, on average, firms that have a publicly available CDP disclosure score from developing economies have significantly (t-stat $p<0.01$, Wilcoxon $p<0.01$) more extensive voluntary CDP disclosure (mean=79.64, median=83) than firms that have a publicly available CDP disclosure score (mean=75.53, median=79) from developed economies. Considering that around 10.4% (711/6817) of all observations from developing economies and around 29.5% (5655/19150) of all observations from developed economies chose to make their CDP disclosure scores publicly available, it may indicate that the threshold for firms to make their CDP voluntary disclosure scores publicly available in developing economies is higher than that in developed economies.

Consistent with the evidence of CDP disclosure score between developing economies and developed economies, we could see that firms that have a publicly available

Table 4-1: Panel A. Descriptive statistics for the full sample and breakdown of sample by development level group

	Full Sample					DEV=0		DEV=1			
Variable	**Mean**	**Q1**	**Median**	**Q3**	**Std.Dev.**	**Mean**	**Median**	**Mean**	**Median**	**t-stat p-value**	**Wilcoxon p-value**
Disclosure-Performance Model (**n=6366**)						**n=711**		**n=5655**			
CD_t	75.99	65.00	80.00	92.00	19.7	79.64	83.00	75.53	79.00	p<0.01	p<0.01
$CP1_t$	0.44	0.02	0.07	0.39	0.85	0.81	0.25	0.40	0.06	p<0.01	p<0.01
$CP2_t$	0.43	0.02	0.07	0.39	0.81	0.70	0.20	0.39	0.06	p<0.01	p<0.01
ROA_t	0.05	0.02	0.04	0.08	0.06	0.08	0.06	0.05	0.04	p<0.01	p<0.01
Q_t	0.42	-0.23	0.21	0.83	0.90	0.79	0.53	0.38	0.19	p<0.01	p<0.01
FR_t	0.47	0.28	0.49	0.65	0.22	0.51	0.51	0.46	0.48	p<0.01	p<0.01
$CGRANK_t$	1.79	2.00	2.00	2.00	0.46	1.78	2.00	1.85	2.00	p<0.01	insig
$SIZE_t$	8.92	7.90	8.98	9.91	1.47	8.36	8.34	8.99	9.04	p<0.01	p<0.01
IO_t	0.55	0.26	0.54	0.85	0.32	0.47	0.47	0.55	0.55	p<0.01	p<0.01
SG_t	0.04	-0.06	0.03	0.10	0.15	0.05	0.02	0.04	0.03	p<0.05	insig
AN_t	0.50	0.38	0.48	0.61	0.16	0.60	0.61	0.49	0.47	p<0.01	p<0.01
ESG_{t-1}	52.93	40.99	50.16	65.36	15.34	54.71	55.22	52.74	49.71	p<0.01	p<0.01
Disclosure Score Publication Choice Model (**n=25967**)						**n=6817**		**n=19150**			
IR_t	0.25	0.20	0.24	0.28	0.06	0.24	0.23	0.25	0.24	p<0.01	p<0.01
$SIZE_t$	7.80	6.81	7.86	8.90	1.67	7.62	7.69	7.86	7.92	p<0.01	p<0.01
$DSPUB_{t-1}$	0.25	0.00	0.00	0.00	0.43	0.10	0.00	0.30	0.00	p<0.01	p<0.01
IO_t	0.50	0.21	0.47	0.78	0.32	0.43	0.38	0.52	0.50	p<0.01	p<0.01
$VOLA_t$	0.10	0.06	0.09	0.12	0.04	0.11	0.10	0.10	0.09	p<0.01	p<0.01
FR_t	0.46	0.29	0.48	0.63	0.22	0.51	0.52	0.45	0.46	p<0.01	p<0.01
AN_t	0.54	0.40	0.53	0.68	0.19	0.63	0.65	0.51	0.49	p<0.01	p<0.01
RDI_t	0.03	0.00	0.01	0.04	0.03	0.01	0.00	0.03	0.02	p<0.01	p<0.01

"**CD**" is the CDP's climate change questionnaire disclosure score; "**CP1**" is a GHG intensity measure that uses all emission data from the CDP; "**CP2**" is an alternative GHG intensity measure that draws on data from Asset4 database; "**ROA**" is firms' return on assets; "**Q**" is firms' market to book ratio; "**FR**" measures firms' financial risk, calculated as firms' leverage level; "**CGRANK**" equals "2" if the highest level of direct responsibility for climate change mitigation in a firm is a subset of the board or some committee appointed by the board, it equals "1" if the highest level of direct responsibility for climate change mitigation in a firm is a manager or an officer, "0" otherwise; "**SIZE**" measures the economic scale of firms; "**IO**" is the institutional ownership of companies; "**SG**" is firms' sales growth; "**AN**" measures the newness of firms' properties, plants and equipment; "**ESG**" denotes Thomson Reuters' firm-specific environmental, social and governance (ESG) score. "**IR**" measures firms' propensity to have a publicly available CDP disclosure scores through the CDP's website; "**DSPUB**" is a dummy variable, which equals "1" if a firm has a publicly available CDP disclosure scores through the CDP's website; "**VOLA**" is the standard deviation of adjusted monthly stock return based on a moving window of 12 months for years 2009-2014; "**RDI**" measures firms' Research and Development spending intensity; "**DEV**" is a dummy that equals "1" if a country is a member of "DAC", "0" otherwise.

CDP disclosure score from developing economies also on average have significantly (t-stat $p<0.01$, Wilcoxon $p<0.01$) higher Thomson Reuters' ESG scores (mean=54.71, median=55.22) than firms that have a publicly available CDP disclosure score (mean=52.74, median=49.71) from developed economies. For carbon emission intensity measures CP1 and CP2, we could see that, on average, CP1 (mean=0.44) is slightly higher than CP2 (mean=0.43), the variation of CP1 (standard deviation=0.85) is also higher than that of CP2 (standard deviation=0.81). Note that the carbon emissions amount used to calculate CP1 is all from the CDP's voluntary climate change questionnaire, however, for CP2, scope1 and scope2 carbon emissions amount is independently collected from global media coverage and corporate reports by Thomson Reuters' Asset4 database, only scope3 carbon emissions amount is from the CDP. This means that there is a difference in the carbon emissions amount reported by firms in different channels. This is consistent with Depoers et al (2016)'s finding that there is a difference between the reported GHG emissions in corporate reports and those reported in the CDP's climate change. Given this condition, it is necessary, in this study, to use the two measures of carbon intensity alternatively in the disclosure-performance model to see whether the results obtained are sensitive to carbon emissions data collected from different channels.

In addition, we could see that, for both CP1 and CP2, firms from developing economies have a much higher average carbon intensity (CP1=0.81; CP2=0.70) than firms from developed economies (CP1=0.40; CP2=0.39) do. Combining which with the evidence that firms that have a publicly available CDP disclosure score from developing economies also have significantly more extensive voluntary CDP disclosure than firms that have a publicly available CDP disclosure score from developed economies, it is consistent with legitimacy theory's argument that bad environmental performers tend to disclose more extensively about their environmental information, even with "not-so-good" figures, to react to social pressure (Lindblom, 1983; Clarkson et al., 2008; Clarkson et al., 2013). This piece of univariate evidence indicates that the association between firms' GHG performance and the extensiveness of voluntary GHG disclosure for the period under investigation may correspond to **Phase2** of Table 1-1.

The return on assets (ROA) from firms in developing economies (mean=0.08; median=0.06) is on average significantly (t-stat $p<0.01$, Wilcoxon $p<0.01$) higher than that (mean=0.05; median=0.04) in developed economies. This is consistent with the documented evidence in prior studies (Burtraw et al., 2005; Jamali and Mirshak, 2007; Investopedia, 2019) that developing economies usually have a higher economic growth momentum, but a lower

economic amount and quality, compared with developed economies whose economic conditions are of a higher level in amount and quality, but a lower growth rate and momentum. This is also consistent with the univariate evidence of asset newness (AN) in this table.

We could see that the asset newness (AN) level (mean=0.60, median=0.61 in the disclosure-performance model; mean=0.63, median=0.65 in the disclosure score publication choice model) of firms in developing economies is also significantly (t-stat $p<0.01$, Wilcoxon $p<0.01$) higher on average than that (mean=0.49, median=0.47 in the disclosure-performance model; mean=0.51, median=0.49 in the disclosure score publication choice model) of firms in developed economies. This is probably associated with the situation that firms in developed economies are often with a much longer history than firms in developing economies (Keasey et al., 2015). Thus, firms in developed economies have long passed their fast-growing stage and are focused on stable growth and quality expansion (Pindado et al., 2015; Accenture, 2016). Consequently, they update their properties, plant, and equipment at a lower rate, compared with those firms in developing economies, who are at their fast-growing stage. The argument that firms in developing economies are at their fast-growing stage is also consistent with the sales growth (SG) evidence in this table. We could see the sales growth rate (mean=0.05) of firms from developing economies is significantly (t-stat $p<0.05$) higher than that (mean=0.04) of firms from developed economies.

In the sample for disclosure-performance model, firms from developing economies also overall have substantially (t-stat $p<0.01$, Wilcoxon $p<0.01$) higher Tobin's Q (market to book ratio) value (mean=0.79; median=0.53) than firms from developed economies (mean=0.38; median=0.19). This indicates that the level of market over-valuation of firm values in developing economies is greater than that in developed economies. This is also consistent with the evidence of ROA and SG in this table. Together, the evidence suggests that the economic growth momentum in developing economies appears to be significantly stronger, when compared with that in developed economies for the period under investigation. This is also reflected in the leverage level, as we could see that firms from developing economies tend to be less risk-averse with an overall significantly (t-stat $p<0.01$, Wilcoxon $p<0.01$) higher leverage level (mean=0.51, median=0.51 in the disclosure-performance model; mean=0.51, median=0.52 in the disclosure score publication choice model) than their counterparts from developed economies (mean=0.46, median=0.48; in the disclosure-performance model; mean=0.45, median=0.46 in the disclosure score publication choice model).

For the financial indicators above that could be aligned with economic growth momentum, the univariate evidence indicates that firms in developing economies out-perform their counterparts in developed economies. However, speaking of achieved economic scale (SIZE), overall, firms from developed economies (mean=8.99, median=9.04 in the disclosure-performance model; mean=7.86, median=7.92 in the disclosure score publication choice model) substantially (t-stat $p<0.01$, Wilcoxon $p<0.01$) out-perform their counterparts from developing economies (mean=8.36, median=8.34 in the disclosure-performance model; mean=7.62, median=7.69 in the disclosure score publication choice model). Speaking of climate change mitigating management infrastructure construction level (CGRANK), we could also see that firms from developed economies (mean=1.85) overall significantly (t-stat $p<0.01$) out-perform firms from developing economies (mean=1.78). Firms from developed economies (mean=0.55, median=0.55 in the disclosure-performance model; mean=0.52, median=0.50 in the disclosure score publication choice model) consistently have significantly (t-stat $p<0.01$, Wilcoxon $p<0.01$) higher overall institutional ownership (IO) percentage than firms from developing economies (mean=0.47, median=0.47 in the disclosure-performance model; mean=0.43, median=0.38 in the disclosure score publication choice model).

Also, firms from developed economies (mean=0.25; median=0.24), on average, have significantly (t-stat $p<0.01$, Wilcoxon $p<0.01$) stronger propensity (IR) to have publicly available CDP disclosure scores through the CDP's website than firms from developing economies (mean=0.24; median=0.23) do. Consistent with the aforementioned evidence that firms from developing economies have higher overall leverage level, thus, less risk-averse than firms from developed economies, firms from developing economies have, on average, substantially (t-stat $p<0.01$, Wilcoxon $p<0.01$) slightly higher level of stock return volatility (VOLA, mean=0.11; median=0.10) than firms from developed economies (mean=0.10; median=0.09). In line with the findings in prior studies that innovation is a key driver of the economic growth in developed nations (Hull and Rothenberg, 2008; De Villiers et al., 2011), firms from developed economies generally have materially (t-stat $p<0.01$) higher level of research and development expenditure intensity (RDI, mean=0.03) than firms from developing economies (mean=0.01). Overall, we could see that the means of the variables in these two models for developing economies are significantly different from those for the developed economies. This suggests that besides the analyses using the full sample, it would be of interest and necessity to see if there is any significant difference for my results respectively using the subsamples (developing economies subsample; developed economies subsample) to run the models.

Table 4-1: Panel B. Descriptive statistics for the full sample and breakdown of sample by CDP disclosure score public availability group

Variable	DSPUB=0		DSPUB=1		t-stat p-value	Wilcoxon p-value
	Mean	Median	Mean	Median		
Disclosure-Performance Model	n=19601		n=6366			
CD_t	-	-	75.99	80.00	-	-
$CP1_t$	0.53	0.08	0.44	0.07	p<0.01	insig
$CP2_t$	0.45	0.07	0.43	0.07	insig	insig
ROA_t	0.05	0.04	0.05	0.04	insig	insig
Q_t	0.51	0.24	0.42	0.21	p<0.01	insig
FR_t	0.46	0.48	0.47	0.49	insig	insig
$CGRANK_t$	1.66	2.00	1.79	2.00	p<0.01	insig
$SIZE_t$	7.41	7.55	8.92	8.98	p<0.01	p<0.01
IO_t	0.48	0.45	0.55	0.54	p<0.01	p<0.01
SG_t	0.07	0.05	0.04	0.03	p<0.01	p<0.01
AN_t	0.56	0.55	0.50	0.48	p<0.01	p<0.01
ESG_{t-1}	41.56	39.81	52.93	50.16	p<0.01	p<0.01
Disclosure Score Publication Choice Model						
IR_t	0.24	0.24	0.26	0.25	p<0.01	p<0.01
$SIZE_t$	7.41	7.55	8.92	8.98	p<0.01	p<0.01
$DSPUB_{t-1}$	0.03	0.00	0.80	1.00	p<0.01	p<0.01
IO_t	0.48	0.45	0.55	0.54	p<0.01	p<0.01
$VOLA_t$	0.10	0.09	0.08	0.08	p<0.01	p<0.01
FR_t	0.46	0.48	0.47	0.49	insig	insig
AN_t	0.56	0.55	0.50	0.48	p<0.01	p<0.01
RDI_t	0.03	0.01	0.03	0.02	insig	p<0.01

"**CD**" is the CDP climate change questionnaire disclosure score; "**CP1**" is a GHG intensity measure that uses all emission data from the CDP; "**CP2**" is an alternative GHG intensity measure that draws on data from Thomson Reuters' Asset4 database; "**ROA**" is firms' return on assets; "**Q**" is firms' market to book ratio; "**FR**" measures firms' financial risk, calculated as firms' leverage level; "**CGRANK**" equals "2" if the highest level of direct responsibility for climate change mitigation in a firm is a subset of the board or some committee appointed by the board, it equals "1" if the highest level of direct responsibility for climate change mitigation in a firm is a manager or an officer, "0" otherwise; "**SIZE**" measures the economic scale of firms; "**IO**" is the institutional ownership of companies; "**SG**" is firms' sales growth; "**AN**" measures the newness of firms' properties, plants and equipment; "**ESG**" denotes Thomson Reuters' firm-specific environmental, social and governance (ESG) score. "**IR**" measures firms' propensity to have a publicly available CDP disclosure scores through the CDP's website; "**DSPUB**" is a dummy variable, which equals "1" if a firm has a publicly available CDP disclosure scores through the CDP's website; "**VOLA**" is the standard deviation of adjusted monthly stock return based on a moving window of 12 months for years 2009-2014; "**RDI**" measures firms' Research and Development spending intensity.

In Table 4-1 Panel B, I conduct a univariate analysis on the means and medians of the variables in the two models of this chapter by CDP disclosure score public availability group. We could see that firms that do not have publicly available CDP disclosure scores overall have significantly (t-stat $p<0.01$) higher CP1 carbon intensity (mean=0.53) than firms that have publicly available CDP disclosure scores (mean=0.44). However, there is no significant difference as regards CP2 carbon intensity between the two groups. This could be because carbon emissions data disclosed in corporate reports are intentionally changed to smaller amount to reduce losses associated with disclosed carbon emissions information, thus, the carbon emissions amount disclosed in corporate reports could not reliably reflect the underlying true carbon emissions amount of corresponding firms (Depoers et al., 2016).

For other variables included in both models, we could see that, for the period under investigation, firms that do not have publicly available CDP disclosure scores tend to have significantly (t-stat $p<0.01$) higher market to book ratio (Q) (mean=0.51; median=0.24), sales growth (SG) (mean=0.07; median=0.05), asset newness (AN) (mean=0.56; median=0.55) and monthly stock return volatility (VOLA) (mean=0.10; median=0.09) than firms that have publicly available CDP disclosure scores do (where, Q mean=0.42, median=0.21; SG mean=0.04, median=0.03; AN mean=0.50, median=0.48; VOLA mean=0.08, median=0.08). As these variables are often found associated with firms' economic growth in prior studies (Anwar and Sun, 2011; Fatas and Mihov, 2013; Ductor and Grechyna, 2015), higher values of these variables for firms that do not have publicly available CDP disclosure scores through the CDP's website may suggest that these firms are more focused on economic growth. This speculation is also consistent with the evidence that, for the period under investigation, firms that do not have publicly available CDP disclosure scores tend to have significantly (t-stat $p<0.01$) lower climate change mitigating management infrastructure construction level (CGRANK, mean=1.66), overall environmental, social, and governance scores for the previous year (ESG_{t-1}, mean=41.56, median=39.81), propensity to have publicly available CDP disclosure scores (IR, mean=0.24, median=0.24) than firms that have publicly available CDP disclosure scores (CGRANK, mean=1.79; ESG_{t-1}, mean=52.93, median=50.16; IR, mean=0.26, median=0.25) do.

Table 4-1: Panel C. Correlation coefficients for variables in the disclosure-performance model

	CD_t	$CP1_t$	$CP2_t$	ROA_t	Q_t	FR_t	$CGRANK_t$	$SIZE_t$	IO_t	SG_t	AN_t	ESG_{t-1}
CD_t		**0.098**	**0.099**	**-0.041**	**-0.041**	**0.118**	**0.262**	**0.243**	0.019	**-0.156**	*-0.029*	**0.098**
$CP1_t$	**0.133**		**0.967**	**-0.111**	**-0.111**	**0.045**	**0.079**	0.027	**-0.075**	**-0.042**	**0.211**	-0.009
$CP2_t$	**0.126**	**0.972**		**-0.111**	**-0.128**	**0.047**	**0.081**	**0.044**	**-0.071**	**-0.044**	**0.213**	-0.008
ROA_t	**-0.064**	**-0.158**	**-0.148**		**0.708**	**-0.273**	**-0.062**	**0.225**	**0.117**	**0.274**	*0.025*	*0.029*
Q_t	**-0.056**	**-0.128**	**-0.123**	**0.735**		**-0.405**	**-0.097**	**0.166**	**0.101**	**0.167**	**0.041**	*0.036*
FR_t	**0.084**	**0.085**	**0.088**	**-0.327**	**-0.501**		**0.212**	**-0.289**	**-0.212**	**-0.096**	**-0.066**	**0.098**
$CGRANK_t$	**0.131**	**0.133**	**0.135**	**-0.109**	**-0.144**	**0.265**		**-0.037**	**-0.095**	**-0.066**	0.001	**0.128**
$SIZE_t$	**0.255**	*0.025*	0.029	**0.288**	**0.241**	**-0.274**	**-0.065**		**0.125**	*0.031*	**0.048**	**-0.079**
IO_t	*0.041*	**-0.104**	**-0.099**	**0.191**	**0.158**	**-0.169**	**-0.106**	*0.043*		0.021	0.023	**-0.111**
SG_t	**-0.229**	**-0.048**	*-0.038*	**0.335**	**0.209**	**-0.164**	**-0.116**	**0.082**	**0.045**		**0.161**	-0.017
AN_t	-0.001	**0.241**	**0.234**	**0.067**	**0.063**	**-0.082**	-0.018	**0.078**	*0.026*	**0.184**		**-0.081**
ESG_{t-1}	*0.027*	-0.011	-0.001	-0.005	*0.038*	**0.087**	**0.111**	**-0.109**	**-0.129**	*-0.044*	**-0.129**	

"**CD**" is the CDP's climate change questionnaire disclosure score; "**CP1**" equals total scope1, scope2, scope3 carbon equivalent emissions (in thousand metric tonnes) from the CDP database over firms' yearly total inflation-adjusted revenue (in million USD); "**CP2**" equals total scope1 and scope2 carbon emissions (in thousand metric tonnes) from Thomson Reuters' Asset4 database plus scope3 carbon emissions (in thousand metric tonnes) from the CDP database over firms' yearly total inflation-adjusted revenue (in million USD); "**ROA**" is firms' return on assets, calculated as the ratio of income before extraordinary items (in million USD) of the current year over the total assets (in million USD) at the end of last year; "**Q**" is firms' market to book ratio, calculated as the ratio of market value of common equity of a firm (in million USD) plus the book value of its common equity (in million USD) minus the book value of its total assets (in million USD) over the book value of its total assets; "**FR**" measures firms' financial risk, calculated as firms' leverage level, which equals firms' book value of total debt including current (in million USD) over firms' book value of total assets (in million USD); "**CGRANK**" equals "2" if the highest level of direct responsibility for climate change mitigation in a firm is a subset of the board or some committee appointed by the board, it equals "1" if the highest level of direct responsibility for climate change mitigation in a firm is a manager or an officer, "0" otherwise; "**SIZE**" measures the economic scale of firms, calculated as the natural log of the market value (in million USD) of the equity of a firm; "**IO**" is the institutional ownership of companies, calculated as the shares of a company owned by institutional investors over all shares outstanding of a company; "**SG**" is firms' sales growth, it is calculated as the difference of sales revenue in million USD at "t" and sales revenue in million USD at "t-1" over sales revenue in million USD at "t-1"; "**AN**" measures the newness of firms' properties, plants and equipment, calculated as the ratio of a firm's net properties, plant and equipment (in million USD) at each year end over its gross properties, plant and equipment (in million USD) at each year-end; "**ESG**" denotes Thomson Reuters' firm-specific environmental, social and governance (ESG) score.

Spearman rank correlation coefficients are below the diagonal, Pearson correlation coefficients are above the diagonal.

Coefficients in bold are significant at p<0.01; Coefficients in italic are significant at p<0.05; Coefficients with underscore are significant at p<0.1.

Table 4-1 Panel C shows the pair-wise correlations between the variables used in the disclosure-performance model. Spearman rank (Pearson) correlation coefficients are provided below (above) the diagonal. We could see that CP1 and CP2 are positively related with CD (Spearman rank: CP1&CD coefficient=0.133, $p<0.01$; CP2&CD coefficient=0.126, $p<0.01$. Pearson: CP1&CD coefficient=0.098, $p<0.01$; CP2&CD coefficient=0.099, $p<0.01$).This indicates that firms that have higher carbon emissions intensity tend to have more extensive voluntary GHG disclosure. The univariate correlation test between firms' GHG performance and the extensiveness of firms' voluntary GHG disclosure points to legitimacy theory's prediction for the period under investigation. However, this needs to be further confirmed considering other related factors.

Firms' return on assets (ROA, Spearman rank: ROA&CD coefficient=-0.064. Pearson: ROA&CD coefficient=-0.041, $p<0.01$), market to book ratio (Q, Spearman rank: Q&CD coefficient=-0.056, $p<0.01$. Pearson: Q&CD coefficient=-0.041, $p<0.01$) and sales growth (SG, Spearman rank: SG&CD coefficient=-0.229, $p<0.01$. Pearson: SG&CD coefficient=-0.156, $p<0.01$) are consistently negatively associated with the extensiveness of firms' voluntary GHG disclosure in both Spearman rank and Pearson correlation tests, however, leverage level (FR, Spearman rank: FR&CD coefficient=0.084, $p<0.01$. Pearson: FR&CD coefficient=0.118, $p<0.01$) is consistently positively associated with the extensiveness of firms' voluntary GHG disclosure. This indicates that firms that are in a good financial situation tend to be associated with less extensive voluntary GHG disclosure. However, firms that are more financially restricted with higher leverage level tend to be associated with more extensive voluntary GHG disclosure. Because firms that are more financially restricted are more prone to be associated with threatened legitimacy (Hawn et al., 2011; Qian and Schaltegger, 2017), this observation again points to legitimacy theory's prediction as regards the relationship of interest. Firms' climate change mitigation management infrastructure (CGRANK, Spearman rank: CGRANK&CD coefficient=0.131, $p<0.01$. Pearson: CGRANK&CD coefficient=0.262, $p<0.01$) and economic scale (SIZE, Spearman rank: SIZE&CD coefficient=0.255, $p<0.01$. Pearson: SIZE&CD coefficient=0.243, $p<0.01$) are both positively associated with the extensiveness of firms' voluntary GHG disclosure. This is probably because larger firms are faced with stronger social pressure from society and, thus, tend to have more developed climate change management infrastructure. This, in turn, enables them to report their climate change mitigating achievement with better and more extensive GHG disclosure.

4.4.2 Tests for Hypotheses 1-3: Baseline Models and GLS Models

Table 4-2 Panel A presents the OLS regression results and the firm-fixed effects GLS (The Hausman test determines that I should use fixed-effects model to run GLS regression.) results for the disclosure-performance model employing the reduced sample (self-selection bias is not controlled for the OLS, GLS models), using CP1 and CP2 respectively as the proxy for GHG performance. I impose robust standard errors to allow for potential heteroscedasticity in my dataset. In column 1 and column 6, I do not control for any year, industry or region fixed characteristics, the results in these columns present a crude relationship description between the extensiveness of voluntary GHG disclosure ("CD") and all the right-hand-side predictors. We could see that the GHG performance measure of total carbon equivalent emission intensity is significantly positively associated with the CDP's climate change disclosure score. If the yearly total carbon equivalent emissions increase by one metric ton for every thousand USD revenue, the extensiveness of companies' voluntary GHG disclosure tends to increase by around 2 disclosure points (coefficient=1.823, $p<0.01$ in column 1; coefficient=1.933, $p<0.01$ in column 6). This is consistent with the situation of **Phase2** of Table 1-1, when legitimacy theory has significant explanatory power over the association pattern between GHG performance and the extensiveness of voluntary GHG disclosure.

For the control variables in column 1 and column 6, we could see that "SIZE" is significantly positively related with the extensiveness of firms' voluntary GHG disclosure (coefficient=3.875, $p<0.01$ in column 1; coefficient=3.801, $p<0.01$ in column 6), indicating that firms with a larger economic scale tend to invest more in climate change mitigating activities and related disclosure. "CGRANK" is also significantly positively associated with firms' voluntary GHG disclosure (coefficient=4.240, $p<0.01$ in column 1; coefficient=4.396, $p<0.01$ in column 6), implying that the higher level the position in charge of climate change mitigating activities is situated in a company's governance structure, the more likely that the company is willing to disclose more detailed GHG emission related information. Firms' financial risk is significantly positively associated with firms' voluntary GHG disclosures (coefficient=8.702, $p<0.01$ in column 1; coefficient=8.238, $p<0.01$ in column 6). This is congruent with the previous finding that there is a higher demand for information transparency when a firm increases leverage (McWilliams and Siegel, 2011), and firms tend to respond to the heightened transparency demand with more extensive voluntary GHG emission-related information disclosure.

The significantly negative associations between firms' return on assets, sales growth, and the extensiveness of firms' voluntary GHG disclosure in column 1 and column 6 are consistent with the legitimacy theory. As is identified by prior studies, firms whose financial status become stringent because of threatened legitimacy tends to use more extensive corporate disclosure to explain and communicate to stakeholders their efforts on reducing negative social and environmental impact to reduce as much loss as possible (Hassan, 2018; Jaggi et al., 2018). There is a significant positive relationship between firms' Institutional Ownership and the extensiveness of firms' voluntary disclosure (coefficient=4.505, $p<0.01$ in column 1; coefficient=4.278, $p<0.01$ in column 6). This corresponds to the fact that the CDP is backed up by the world's largest institutional investors and customers. Thomson Reuters' ESG score in previous year is significantly positively associated with the extensiveness of firms' voluntary GHG disclosure (coefficient=0.064, $p<0.01$ in column 1; coefficient=0.052, $p<0.01$ in column 6). Although the impact is marginal, this means that firms that have invested dedication and excellence in ESG areas tend to make more extensive voluntary GHG related disclosure in the following period.

In column 2 and column 7, I introduce the control for year-fixed effects. We could see that firms' revenue scaled GHG emission is still significantly positively associated with the extensiveness of firms' voluntary GHG disclosure. Larger economic scale still positively correlates with the extensiveness of voluntary GHG disclosures after controlling for year fixed effects. However, this association is slightly weakened, as the regression coefficients drop from 3.875 ($p<0.01$, column 1) to 3.594 ($p<0.01$, column 2), from 3.801 ($p<0.01$, in column 6) to 3.436 ($p<0.01$, in column 7) respectively. The relationship between corporate governance characteristics devoted to climate change mitigating activities and GHG disclosure has been weakened with the regression coefficients decreasing from 4.240 ($p<0.01$, in column 1) to 3.705 ($p<0.01$, in column 2), from 4.396 ($p<0.01$, in column 6) to 3.640 ($p<0.01$, in column 7) respectively. Firms' financial risk level consistently associates with more extensive voluntary GHG disclosure, this association is also slightly weakened by controlling year-fixed effects, with the coefficient decreasing from 8.702 ($p<0.01$, in column 1) to 7.626 ($p<0.01$, in column 2), from 8.238 ($p<0.01$, in column 6) to 6.192 ($p<0.01$, in column 7) respectively. The positive association between preceding years' Thomson Reuters' ESG score and the extensiveness of voluntary GHG disclosure stays almost at the same level even after controlling year-fixed effects. Firms' return on assets is not significantly associated with the extensiveness of firms' voluntary GHG disclosure after controlling for year-fixed effects. However, overall, the results in column 2, and column 7 stay highly consistent with those in column 1 and column 6.

In columns 3 and 4 and columns 8 and 9, I subsequently add control for industry-fixed effects and region-fixed effects. We could see that, by additionally controlling for industry-fixed effects and region-fixed effects, the results I obtain are still consistent with those from the previous four models. Particularly, the negative association between firms' GHG performance and the extensiveness of firms' voluntary GHG disclosure is still significant (coefficient=1.970, $p<0.01$ in column 3; coefficient=2.146, $p<0.01$ in column 4; coefficient=2.105, $p<0.01$ in column 8; coefficient=2.324, $p<0.01$ in column 9). The identified associations between firms' level of voluntary GHG disclosure and firms' size, firms' climate change related governance characteristics, firms' financial risks and firms' Thomson Reuters' ESG scores in the previous year stay roughly at the same level, compared with those identified in the prior four models in columns1 and 2 and in columns 6 and 7. In column 5 and column 10, I use firm-fixed effects GLS regressions to test whether the results obtained in OLS regressions would be sensitive to firm-fixed characteristics across the period under investigation, the results stay consistent with those obtained from the OLS models.

Overall, the results from my OLS regression models and firm-fixed effects GLS regression models are consistent with each other, indicating that firms with higher yearly total carbon emission intensity (i.e. bad GHG performance) tend to disclose more extensively about their climate change mitigating information. Specifically, firms' economic scale, the existence of a position devoted to climate change mitigating activities in the governance structure of a firm, firms' leverage level, and firms' institutional ownership are consistently positively associated with firms' voluntary GHG disclosure throughout all OLS and firm-fixed effects GLS models. The results suggest that, for years 2009-2014, the association between firms' GHG performance and the extensiveness of firms' voluntary GHG disclosure corresponds to a global macro GHG disclosure circumstance that is similar to **Phase2** of Table 1-1. This is consistent with the fact that the time of the diffusion and sedimentation of the importance and relevance of general environmental issues in global society is much longer than that of the importance and relevance of GHG emission issues and related climate change crisis in global society. This, in turn, may indicate that *the degree to which the importance and relevance of general environmental issues is accepted and believed by global society as a whole* and *the degree to which the importance and relevance of GHG emission issues and related climate change crisis is accepted and believed by global society as a whole* have a significant difference.

Table 4-2: Panel A. The results of disclosure-performance model from OLS and fixed-effects GLS regressions using the reduced sample

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
VARIABLES	CD_t	CD_t	CD_t	CD_t	CD_t	CD_t	CD_t	CD_t	CD_t	CD_t
$CP1_t$	1.823***	1.493***	1.970***	2.146***	2.595***	-	-	-	-	-
	(0.398)	(0.356)	(0.391)	(0.406)	(0.565)	-	-	-	-	-
$CP2_t$	-	-	-	-	-	1.933***	1.475***	2.105***	2.324***	3.184***
	-	-	-	-	-	(0.417)	(0.369)	(0.400)	(0.418)	(0.600)
ROA_t	-29.759***	-7.614	-9.613	-10.999	-34.238***	-25.914***	-2.240	-4.239	-5.458	-34.238***
	(7.619)	(7.097)	(6.973)	(7.082)	(9.169)	(7.662)	(7.022)	(6.912)	(6.997)	(9.376)
Q_t	1.431***	-0.694*	-0.544	-0.480	-4.051***	1.383***	-0.901**	-0.798*	-0.573	-3.895***
	(0.453)	(0.420)	(0.434)	(0.449)	(1.174)	(0.466)	(0.420)	(0.437)	(0.453)	(1.220)
FR_t	8.702***	7.626***	7.792***	8.755***	13.737**	8.238***	6.192***	6.564***	8.707***	12.345**
	(1.382)	(1.252)	(1.329)	(1.685)	(5.734)	(1.435)	(1.271)	(1.354)	(1.723)	(5.961)
$CGRANK_t$	4.240***	3.705***	3.845***	4.219***	4.100***	4.396***	3.640***	3.856***	4.367***	3.738***
	(0.722)	(0.681)	(0.676)	(0.701)	(0.886)	(0.741)	(0.697)	(0.693)	(0.719)	(0.929)
$SIZE_t$	3.875***	3.594***	3.709***	3.664***	15.762***	3.801***	3.436***	3.507***	3.347***	15.567***
	(0.213)	(0.191)	(0.200)	(0.218)	(1.113)	(0.220)	(0.195)	(0.203)	(0.218)	(1.145)
IO_t	4.505***	2.581***	2.378***	2.387**	4.248**	4.278***	2.279***	2.156***	1.985**	3.731**
	(0.890)	(0.796)	(0.792)	(0.960)	(1.805)	(0.914)	(0.810)	(0.807)	(0.973)	(1.838)
SG_t	-23.468***	-7.121***	-6.421***	-6.390***	-25.473***	-24.620***	-7.319***	-6.540***	-6.421***	-25.335***
	(2.151)	(2.024)	(2.031)	(2.026)	(1.909)	(2.185)	(2.036)	(2.047)	(2.039)	(1.937)
AN_t	-0.407	-1.628	-0.283	-0.563	-35.968***	0.182	-0.583	1.303	1.583	-36.059***
	(1.836)	(1.684)	(1.831)	(1.994)	(5.422)	(1.855)	(1.689)	(1.822)	(1.967)	(5.745)
ESG_{t-1}	0.064***	0.068***	0.066***	0.067***	0.025	0.052***	0.050***	0.048***	0.049***	0.021
	(0.018)	(0.016)	(0.016)	(0.016)	(0.021)	(0.018)	(0.016)	(0.016)	(0.017)	(0.022)

Constant	26.908***	16.758***	17.926***	19.252***	-61.205***	27.932***	19.724***	21.150***	21.444***	-58.018***
	(2.768)	(2.929)	(3.180)	(3.388)	(9.820)	(2.860)	(3.024)	(3.262)	(3.470)	(10.139)
Year FE	NO	YES	YES	YES	NO	NO	YES	YES	YES	NO
Industry FE	NO	NO	YES	YES	NO	NO	NO	YES	YES	NO
Region FE	NO	NO	NO	YES	NO	NO	NO	NO	YES	NO
Firm FE	NO	NO	NO	NO	YES	NO	NO	NO	NO	YES
F-Stat	69.020	134.370	89.440	70.130	62.77	64.94	140.91	94.66	70.120	58.090
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	6366	6366	6366	6366	6366	6366	6366	6366	6366	6366
R-squared	0.161	0.330	0.343	0.352	0.211	0.160	0.342	0.355	0.364	0.206

"**CD**" is the CDP climate change questionnaire disclosure score; "**CP1**" is a GHG intensity measure that uses all emission data from the CDP; "**CP2**" is an alternative GHG intensity measure that draws on data from Thomson Reuters' Asset4 database; "**ROA**" is firms' return on assets; "**Q**" is firms' market to book ratio; "**FR**" measures firms' financial risk, calculated as firms' leverage level; "**CGRANK**" equals "2" if the highest level of direct responsibility for climate change mitigation in a firm is a subset of the board or some committee appointed by the board, it equals "1" if the highest level of direct responsibility for climate change mitigation in a firm is a manager or an officer, "0" otherwise; "**SIZE**" measures the economic scale of firms; "**IO**" is the institutional ownership of companies; "**SG**" is firms' sales growth; "**AN**" measures the newness of firms' properties, plants and equipment; "**ESG**" denotes Thomson Reuters' firm-specific environmental, social and governance (ESG) score.

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
For F-Stat, the number in parentheses is the level of significance

4.4.3 Tests for Hypotheses 1-3: Negative Binomial Models

As the CDP's yearly climate change questionnaire disclosure scores only take on non-negative integer values, ranging from "0" to "100", the dependent variable "CD" is count data. Because discontinuous data violates the assumptions of OLS and GLS, these models are not the best to process such data. I also use log-linear models to see if the results are consistent with those obtained from OLS regression and GLS regression. Specifically, I use negative binomial regression to perform this analysis. This is because over-dispersion is identified for the CDP's GHG disclosure scores. Over-dispersion means that the variance of "CD" is significantly different from its mean. Negative binomial regression models loosen the assumption of "variance should be equal to mean" in Poisson regression models, thus it is a better fit for the over-dispersed GHG disclosure scores.

Table 4-2 Panel B presents the negative binomial regression results and fixed-effects negative binomial regression results for the disclosure-performance model employing the reduced sample, using CP1 and CP2 respectively as the proxy for GHG performance. In column 1 and column 6, I do not control for year-fixed effects, industry-fixed effects or region-fixed effects, the control for these three factors is sequentially introduced in columns 2, 3, 4 and columns 7, 8, 9. We could see that the association between the extensiveness of companies' voluntary GHG disclosure ("CD") and companies' GHG emission intensity ("CP1" and "CP2") is consistently found to be significantly positive (the coefficient of "CP1" = 0.022 in column 1, $p<0.01$; 0.018 in column 2, $p<0.01$; 0.024 in column 3, $p<0.01$; 0.027 in column 4, $p<0.01$; the coefficient of "CP2" = 0.023 in column 6, $p<0.01$; 0.018 in column 7, $p<0.01$; 0.026 in column 8, $p<0.01$; 0.029 in column 9, $p<0.01$). Specifically, if the GHG emission amount per thousand USD of a company increases by one metric ton, the CDP's disclosure score of this company is expected to increase by 2.2% in column 1 (2.3% in column 6) without controlling for year, industry and region-fixed effects, 1.8% in column 2 (1.8% in column 7) controlling for year-fixed effects, 2.4% in column 3 (2.6% in column 8) controlling for both year and industry-fixed effects, 2.7% in column 4 (2.9% in column 9) controlling for year, industry and region-fixed effects. In addition, I control for firm-fixed effects in column 5 and column 10 to see if the results would be sensitive to firm-level heterogeneity across years, the results still stay consistent with other models. Congruous with the results from OLS and GLS models, firms' economic scale ("$SIZE_t$"), the existence of a position in charge of climate change issues within a firm ("$CGRANK_t$"), firms' financial risks ("FR_t") and Thomson

Table 4-2: Panel B. The results of disclosure-performance model from negative binomial and fixed-effects negative binomial regressions using the reduced sample

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
VARIABLES	CD_t	CD_t	CD_t	CD_t	CD_t	CD_t	CD_t	CD_t	CD_t	CD_t
$CP1_t$	0.022***	0.018***	0.024***	0.027***	0.032***	-	-	-	-	-
	(0.005)	(0.005)	(0.005)	(0.005)	(0.007)	-	-	-	-	-
$CP2_t$	-	-	-	-	-	0.023***	0.018***	0.026***	0.029***	0.038***
	-	-	-	-	-	(0.005)	(0.005)	(0.005)	(0.005)	(0.008)
ROA_t	-0.386***	-0.094	-0.121	-0.143	-0.455***	-0.330***	-0.022	-0.047	-0.067	-0.443***
	(0.102)	(0.097)	(0.095)	(0.096)	(0.124)	(0.102)	(0.095)	(0.094)	(0.095)	(0.126)
Q_t	0.018***	-0.009*	-0.007	-0.006	-0.054***	0.017***	-0.012**	-0.011*	-0.008	-0.049***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.016)	(0.006)	(0.006)	(0.006)	(0.006)	(0.016)
FR_t	0.108***	0.097***	0.100***	0.120***	0.163**	0.102***	0.080***	0.086***	0.119***	0.163**
	(0.018)	(0.017)	(0.018)	(0.022)	(0.074)	(0.019)	(0.017)	(0.018)	(0.023)	(0.076)
$CGRANK_t$	0.059***	0.051***	0.053***	0.060***	0.057***	0.061***	0.050***	0.053***	0.061***	0.051***
	(0.010)	(0.010)	(0.010)	(0.010)	(0.012)	(0.010)	(0.010)	(0.010)	(0.010)	(0.013)
$SIZE_t$	0.050***	0.047***	0.048***	0.047***	0.214***	0.049***	0.044***	0.046***	0.043***	0.207***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.015)	(0.003)	(0.003)	(0.003)	(0.003)	(0.015)
IO_t	0.058***	0.034***	0.031***	0.029**	0.068***	0.055***	0.030***	0.028***	0.024*	0.060**
	(0.012)	(0.011)	(0.011)	(0.013)	(0.024)	(0.012)	(0.011)	(0.011)	(0.013)	(0.024)
SG_t	-0.308***	-0.096***	-0.088***	-0.089***	-0.344***	-0.323***	-0.101***	-0.092***	-0.092***	-0.344***
	(0.030)	(0.028)	(0.028)	(0.028)	(0.026)	(0.030)	(0.028)	(0.028)	(0.028)	(0.026)
AN_t	-0.010	-0.024	-0.006	-0.010	-0.410***	-0.001	-0.010	0.016	0.019	-0.387***
	(0.024)	(0.023)	(0.025)	(0.027)	(0.073)	(0.025)	(0.023)	(0.024)	(0.026)	(0.076)
ESG_{t-1}	0.001***	0.001***	0.001***	0.001***	0.000	0.001***	0.001***	0.001***	0.001***	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Constant	3.688***	3.544***	3.554***	3.569***	2.697***	3.703***	3.583***	3.598***	3.599***	2.809***
	(0.038)	(0.041)	(0.045)	(0.047)	(0.151)	(0.039)	(0.043)	(0.046)	(0.048)	(0.157)
Year FE	NO	YES	YES	YES	NO	NO	YES	YES	YES	NO
Industry FE	NO	NO	YES	YES	NO	NO	NO	YES	YES	NO
Region FE	NO	NO	NO	YES	NO	NO	NO	NO	YES	NO
Firm FE	NO	NO	NO	NO	YES	NO	NO	NO	NO	YES
LR Chi^2	619.230	1724.620	1820.040	1920.01	615.42	582.610	1814.030	1919.230	1971.560	562.020
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Pseudo R^2	0.018	0.040	0.042	0.043	-	0.016	0.041	0.043	0.048	-
LnAlpha	-3.369***	-3.670***	-3.699***	-3.718***	-	-3.373***	-3.699***	-3.729***	-3.751***	-
	(0.051)	(0.063)	(0.063)	(0.063)	-	(0.055)	(0.070)	(0.070)	(0.071)	-
Alpha	0.034	0.026	0.025	0.024	-	0.034	0.025	0.024	0.024	-
	(0.002)	(0.002)	(0.002)	(0.002)	-	(0.002)	(0.002)	(0.002)	(0.002)	-
Observations	6366	6366	6366	6366	6366	6366	6366	6366	6366	6366

"**CD**" is the CDP climate change questionnaire disclosure score; "**CP1**" is a GHG intensity measure that uses all emission data from the CDP; "**CP2**" is an alternative GHG intensity measure that draws on data from Thomson Reuters' Asset4 database; "**ROA**" is firms' return on assets; "**Q**" is firms' market to book ratio; "**FR**" measures firms' financial risk, calculated as firms' leverage level; "**CGRANK**" equals "2" if the highest level of direct responsibility for climate change mitigation in a firm is a subset of the board or some committee appointed by the board, it equals "1" if the highest level of direct responsibility for climate change mitigation in a firm is a manager or an officer, "0" otherwise; "**SIZE**" measures the economic scale of firms; "**IO**" is the institutional ownership of companies; "**SG**" is firms' sales growth; "**AN**" measures the newness of firms' properties, plants and equipment; "**ESG**" denotes Thomson Reuters' firm-specific environmental, social and governance (ESG) score.

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
For LR Chi^2 the number in parentheses
is the level of significance

Reuters' ESG score ("ESG_{t-1}") in the previous year are significantly positively associated with the extensiveness of firms' voluntary GHG disclosure.

4.4.4 Robust Tests for Hypotheses 1-3: Heckman Twostep Models

Table 4-3 Panel A and Table 4-3 Panel B present the results of the Heckman (1979) twostep regression to correct for self-selection bias of the data from the CDP database, drawing on the "disclosure score publication choice model" in the first step. The first step probit model correctly classifies the observations at 92.07% level. Table 4-3 Panel A. uses "CP1" as the GHG performance proxy, Table 4-3 Panel B. uses "CP2" as the GHG performance proxy. The control for year-fixed effects, industry-fixed effects and region-fixed effects is added to the models progressively. We could see that the results I get from these 8 Heckman twostep models are highly consistent with each other. The association between firms' GHG performance and the extensiveness of voluntary GHG disclosure is significantly negative. In line with the evidence obtained in the OLS and GLS models, firms' economic scale ("$SIZE_t$"), the existence of a position in charge of climate change issues within a firm ("$CGRANK_t$"), firms' financial risks ("FR_t") and Thomson Reuters' ESG score ("ESG_{t-1}") in the previous year are significantly positively associated with the extensiveness of firms' voluntary GHG disclosure.

So far, all the empirical evidence supports that, for years 2009-2014, the global association pattern between firms' GHG performance and the extensiveness of voluntary GHG disclosure is negative. Bad GHG emission performers tend to disclose more extensively about their GHG emission related information. Firms whose financial status is more stringent with more threatened legitimacy are associated with more extensive GHG information disclosure. This corresponds to a macro GHG disclosure circumstance that is similar to **Phase2** of Table 1-1. However, the results of the latest studies that investigate the association between firms' environmental performance and corporate environmental disclosure correspond to **Phase3** of Table 1-1. Given that the global GHG disclosure circumstance is different from the global disclosure circumstance as regards other environmental issues at current stage (KPMG, 2015; KPMG, 2017), the results obtained as regards research question **(1)** adds to the possibility *that the different association patterns between firms' environmental performance and corporate environmental disclosure are associated with the respective macro environmental disclosure circumstances in society.* Thus, **H2** is true. However, the story does not end here.

Table 4-3: Panel A. The results of disclosure-performance model from Heckman twostep regressions using the full sample and CP1 as GHG performance proxy

VARIABLES	(1) CD_t	(2) $DSPUB_t$	(3) CD_t	(4) $DSPUB_t$	(5) CD_t	(6) $DSPUB_t$	(7) CD_t	(8) $DSPUB_t$
$CP1_t$	2.578***		2.260***		2.560***		2.673***	
	(0.487)		(0.449)		(0.482)		(0.492)	
ROA_t	-32.720***		-8.168		-7.021		-3.594	
	(9.846)		(9.172)		(9.155)		(9.427)	
Q_t	3.105***		0.451		0.156		0.048	
	(0.594)		(0.565)		(0.584)		(0.603)	
FR_t	11.008***	0.696***	8.671***	0.696***	8.777***	0.696***	8.514***	0.696***
	(1.885)	(0.132)	(1.742)	(0.132)	(1.803)	(0.132)	(2.420)	(0.132)
$CGRANK_t$	2.581***		1.963**		1.931**		2.210***	
	(0.844)		(0.778)		(0.778)		(0.815)	
$SIZE_t$	2.915***	0.308***	2.760***	0.308***	3.039***	0.308***	3.076***	0.308***
	(0.290)	(0.022)	(0.269)	(0.022)	(0.280)	(0.022)	(0.299)	(0.022)
IO_t	3.537***	0.163*	1.945*	0.163*	1.758*	0.163*	3.309**	0.163*
	(1.147)	(0.086)	(1.062)	(0.086)	(1.065)	(0.086)	(1.287)	(0.086)
SG_t	-29.717***		-9.868***		-9.971***		-10.133***	
	(2.792)		(2.808)		(2.826)		(2.822)	
AN_t	4.706*	-0.433**	4.042*	-0.433**	6.160**	-0.433**	6.202**	-0.433**
	(2.560)	(0.185)	(2.360)	(0.185)	(2.470)	(0.185)	(2.758)	(0.185)
ESG_{t-1}	0.066***		0.060***		0.059***		0.055***	
	(0.022)		(0.021)		(0.021)		(0.021)	
IR_t		0.522		0.522		0.522		0.522
		(0.460)		(0.460)		(0.460)		(0.460)
$DSPUB_{t-1}$		2.663***		2.663***		2.663***		2.663***
		(0.057)		(0.057)		(0.057)		(0.057)
$VOLA_t$		1.002		1.002		1.002		1.002
		(0.770)		(0.770)		(0.770)		(0.770)
RDI_t		0.862		0.862		0.862		0.862
		(0.804)		(0.804)		(0.804)		(0.804)
DEV_t		0.417***		0.417***		0.417***		0.417***
		(0.082)		(0.082)		(0.082)		(0.082)
Year FE	NO		YES		YES		YES	
Industry FE	NO		NO		YES		YES	
Region FE	NO		NO		NO		YES	
lambda		-4.186***		-3.809***		-3.865***		-3.830***
		(0.607)		(0.564)		(0.563)		(0.576)
Constant	37.341***	-4.765***	32.294***	-4.765***	25.221***	-4.765***	27.365***	-4.765***
	(3.858)	(0.291)	(3.652)	(0.291)	(5.313)	(0.291)	(5.876)	(0.291)
Observations	25967		25967		25967		25967	
Uncensored	6366		6366		6366		6366	

"**CD**" is the CDP climate change questionnaire disclosure score; "**CP1**" is a GHG intensity measure that uses all emission data from the CDP; "**ROA**" is firms' return on assets; "**Q**" is firms' market to book ratio; "**FR**" measures firms' financial risk, calculated as firms' leverage level; "**CGRANK**" equals "2" if the highest level of direct responsibility for climate change mitigation in a firm is a subset of the board or some committee appointed by the board, it equals "1" if the highest level of direct responsibility for climate change mitigation in a firm is a manager or an officer, "0" otherwise; "**SIZE**" measures the economic scale of firms; "**IO**" is the institutional ownership of companies; "**SG**" is firms' sales growth; "**AN**" measures the newness of firms' properties, plants and equipment; "**ESG**" denotes Thomson Reuters' firm-specific environmental, social and governance (ESG) score. "**IR**" measures firms' propensity to have a publicly available CDP disclosure scores through the CDP's website; "**DSPUB**" is a dummy variable, which equals "1" if a firm has a publicly available CDP disclosure scores through the CDP's website; "**VOLA**" is the standard deviation of adjusted monthly stock return based on a moving window of 12 months for years 2009-2014; "**RDI**" measures firms' Research and Development spending intensity. "**DEV**" is a dummy that equals "1" if a country is a member of "DAC", "0" otherwise.

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4-3: Panel B. The results of disclosure-performance model from Heckman twostep regressions using the full sample and CP2 as GHG performance proxy

VARIABLES	(1) CD_t	(2) $DSPUB_t$	(3) CD_t	(4) $DSPUB_t$	(5) CD_t	(6) $DSPUB_t$	(7) CD_t	(8) $DSPUB_t$
$CP2_t$	2.814***		2.257***		2.704***		2.828***	
	(0.515)		(0.470)		(0.506)		(0.518)	
ROA_t	-30.353***		-5.273		-4.079		-0.270	
	(10.051)		(9.264)		(9.248)		(9.513)	
Q_t	3.058***		0.231		-0.090		-0.149	
	(0.615)		(0.578)		(0.598)		(0.622)	
FR_t	10.177***	0.776***	7.037***	0.776***	7.228***	0.776***	7.803***	0.776***
	(1.928)	(0.135)	(1.767)	(0.135)	(1.825)	(0.135)	(2.451)	(0.135)
$CGRANK_t$	2.818***		2.068***		2.097***		2.470***	
	(0.865)		(0.789)		(0.789)		(0.828)	
$SIZE_t$	2.870***	0.317***	2.671***	0.317***	2.903***	0.317***	2.870***	0.317***
	(0.297)	(0.022)	(0.272)	(0.022)	(0.285)	(0.022)	(0.304)	(0.022)
IO_t	3.299***	0.135	1.624	0.135	1.679	0.135	2.970**	0.135
	(1.170)	(0.088)	(1.073)	(0.088)	(1.078)	(0.088)	(1.301)	(0.088)
SG_t	-29.826***		-8.542***		-8.493***		-8.582***	
	(2.816)		(2.815)		(2.835)		(2.833)	
AN_t	5.308**	-0.503***	4.953**	-0.503***	7.183***	-0.503***	7.809***	-0.503***
	(2.615)	(0.190)	(2.386)	(0.190)	(2.500)	(0.190)	(2.797)	(0.190)
ESG_{t-1}	0.054**		0.043**		0.042**		0.038*	
	(0.023)		(0.021)		(0.021)		(0.021)	
IR_t		0.129		0.129		0.129		0.129
		(0.475)		(0.475)		(0.475)		(0.475)
$DSPUB_{t-1}$		2.691***		2.691***		2.691***		2.691***
		(0.058)		(0.058)		(0.058)		(0.058)
$VOLA_t$		1.344*		1.344*		1.344*		1.344*
		(0.785)		(0.785)		(0.785)		(0.785)
RDI_t		0.596		0.596		0.596		0.596
		(0.829)		(0.829)		(0.829)		(0.829)
DEV_t		0.437***		0.437***		0.437***		0.437***
		(0.084)		(0.084)		(0.084)		(0.084)
Year FE	NO		YES		YES		YES	
Industry FE	NO		NO		YES		YES	
Region FE	NO		NO		NO		YES	
lambda		-3.658***		-3.129***		-3.199***		-3.086***
		(0.621)		(0.572)		(0.570)		(0.586)
Constant	37.974***	-4.807***	33.799***	-4.807***	29.612***	-4.807***	29.169***	-4.807***
	(3.964)	(0.300)	(3.717)	(0.300)	(5.461)	(0.300)	(6.051)	(0.300)
Observations	25967		25967		25967		25967	
Uncensored	6366		6366		6366		6366	

"**CD**" is the CDP climate change questionnaire disclosure score; "**CP2**" is an alternative GHG intensity measure that draws on data from Thomson Reuters' Asset4 database; "**ROA**" is firms' return on assets; "**Q**" is firms' market to book ratio; "**FR**" measures firms' financial risk, calculated as firms' leverage level; "**CGRANK**" equals "2" if the highest level of direct responsibility for climate change mitigation in a firm is a subset of the board or some committee appointed by the board, it equals "1" if the highest level of direct responsibility for climate change mitigation in a firm is a manager or an officer, "0" otherwise; "**SIZE**" measures the economic scale of firms; "**IO**" is the institutional ownership of companies; "**SG**" is firms' sales growth; "**AN**" measures the newness of firms' properties, plants and equipment; "**ESG**" denotes Thomson Reuters' firm-specific environmental, social and governance (ESG) score. "**IR**" measures firms' propensity to have a publicly available CDP disclosure scores through the CDP's website; "**DSPUB**" is a dummy variable, which equals "1" if a firm has a publicly available CDP disclosure scores through the CDP's website; "**VOLA**" is the standard deviation of adjusted monthly stock return based on a moving window of 12 months for years 2009-2014; "**RDI**" measures firms' Research and Development spending intensity; "**DEV**" is a dummy that equals "1" if a country is a member of "DAC", "0" otherwise.

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

4.4.5 Tests for Hypothesis 4

To test **H4**, I split both the full (25967 firm-year observations) sample and the reduced (6366 firm-year observations) sample into subsamples as "developing economies" and "developed economies" based on the criterion specified in section 4.3.1. Table 4-4 Panel A presents a comparison of the results obtained for the disclosure-performance model using firm-fixed effects GLS regression, based on the reduced sample, the developing economies subsample of the reduced sample, and the developed economies subsample of the reduced sample. We could see that there is a significantly positive association between firms' GHG emission intensity and the extensiveness of voluntary GHG disclosure (indicating a significantly negative association between firms' GHG performance and the extensiveness of voluntary GHG disclosure) for the full reduced sample and the developed economies subsample of the reduced sample in the same period under investigation. However, there is no statistically significant association between firms' GHG emission intensity and the extensiveness of voluntary GHG disclosure for the developing economies subsample of the reduced sample in the same period under investigation. The results are consistent, no matter "CP1" is used as the proxy for GHG emission intensity or "CP2" is used as the proxy for GHG emission intensity.

Table 4-4 Panel B presents a comparison of the results obtained for the disclosure-performance model using firm-fixed effects negative binomial regression, based on the reduced sample, the developing economies subsample of the reduced sample, the developed economies subsample of the reduced sample. The same result is identified, there is a significantly positive association between firms' GHG emission intensity and the extensiveness of voluntary GHG disclosure (indicating a significantly negative association between firms' GHG performance and the extensiveness of voluntary GHG disclosure) for the full reduced sample and the developed economies subsample of the reduced sample in the same period under investigation. However, there is no statistically significant association between firms' GHG emission intensity and the extensiveness of voluntary GHG disclosure for the developing economies subsample of the reduced sample in the same period under investigation. The results are again consistent, no matter "CP1" is used as the proxy for GHG emission intensity or "CP2" is used as the proxy for GHG emission intensity. Overall, the results obtained from negative binomial regressions are consistent with those obtained from GLS regressions in the test for **H4**.

Table 4-4: Panel A. A comparison of the results obtained for the disclosure-performance model using firm-fixed effects GLS regression, based on the reduced sample, the developing economies subsample of the reduced sample, the developed economies subsample of the reduced sample

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	CD_t	CD_t	CD_t	CD_t	CD_t	CD_t
	Reduced Sample	**DEV=0**	**DEV=1**	**Reduced Sample**	**DEV=0**	**DEV=1**
$CP1_t$	2.595***	0.581	2.694***	-	-	-
	(0.565)	(2.164)	(0.591)	-	-	-
$CP2_t$	-	-	-	3.184***	1.742	3.277***
	-	-	-	(0.600)	(2.207)	(0.631)
ROA_t	-34.238***	-60.218	-32.864***	-34.238***	-59.112	-32.468***
	(9.169)	(48.090)	(9.402)	(9.376)	(50.695)	(9.594)
Q_t	-4.051***	-5.998	-3.675***	-3.895***	-4.889	-3.494***
	(1.174)	(6.890)	(1.202)	(1.220)	(7.166)	(1.251)
FR_t	13.737**	19.471	13.683**	12.345**	25.038	12.072**
	(5.734)	(38.927)	(5.806)	(5.961)	(39.264)	(6.042)
$CGRANK_t$	4.100***	8.227	3.991***	3.738***	10.386	3.541***
	(0.886)	(5.653)	(0.898)	(0.929)	(6.627)	(0.938)
$SIZE_t$	15.762***	21.691***	15.342***	15.567***	20.644***	15.095***
	(1.113)	(5.648)	(1.141)	(1.145)	(5.791)	(1.177)
IO_t	4.248**	7.519	3.885**	3.731**	7.786	3.333*
	(1.805)	(8.499)	(1.856)	(1.838)	(8.560)	(1.891)
SG_t	-25.473***	-24.486***	-25.460***	-25.335***	-23.754***	-25.400***
	(1.909)	(8.537)	(1.976)	(1.937)	(8.612)	(2.006)
AN_t	-35.968***	-66.646***	-33.749***	-36.059***	-55.217**	-34.965***
	(5.422)	(20.715)	(5.687)	(5.745)	(23.452)	(5.988)
ESG_{t-1}	0.025	0.034	0.025	0.021	0.011	0.022
	(0.021)	(0.100)	(0.022)	(0.022)	(0.102)	(0.022)
Constant	-61.205***	-99.187**	-58.620***	-58.018***	-104.429**	-54.180***
	(9.820)	(46.501)	(10.131)	(10.139)	(47.421)	(10.476)
Firm FE	YES	YES	YES	YES	YES	YES
F-Stat	62.770	5.470	57.240	58.090	5.140	52.790
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	6366	711	5655	6366	711	5655
R-squared	0.211	0.347	0.204	0.206	0.344	0.199

"**CD**" is the CDP climate change questionnaire disclosure score; "**CP1**" is a GHG intensity measure that uses all emission data from the CDP; "**CP2**" is an alternative GHG intensity measure that draws on data from Thomson Reuters' Asset4 database; "**ROA**" is firms' return on assets; "**Q**" is firms' market to book ratio; "**FR**" measures firms' financial risk, calculated as firms' leverage level; "**CGRANK**" equals "2" if the highest level of direct responsibility for climate change mitigation in a firm is a subset of the board or some committee appointed by the board, it equals "1" if the highest level of direct responsibility for climate change mitigation in a firm is a manager or an officer, "0" otherwise; "**SIZE**" measures the economic scale of firms; "**IO**" is the institutional ownership of companies; "**SG**" is firms' sales growth; "**AN**" measures the newness of firms' properties, plants and equipment; "**ESG**" denotes Thomson Reuters' firm-specific environmental, social and governance (ESG) score. "**DEV**" is a dummy that equals "1" if a country is a member of "DAC", "0" otherwise.

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
For F-Stat, the number in parentheses is the level of significance

Table 4-4: Panel B. A comparison of the results obtained for the disclosure-performance model using firm-fixed effects negative binomial regression, based on the reduced sample, the developing economies subsample of the reduced sample, the developed economies subsample of the reduced sample

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	CD_t	CD_t	CD_t	CD_t	CD_t	CD_t
	Reduced Sample	**DEV=0**	**DEV=1**	**Reduced Sample**	**DEV=0**	**DEV=1**
$CP1_t$	0.032***	0.011	0.033***	-	-	-
	(0.007)	(0.026)	(0.008)	-	-	-
$CP2_t$	-	-	-	0.038***	0.026	0.039***
	-	-	-	(0.008)	(0.026)	(0.008)
ROA_t	-0.455***	-1.308**	-0.426***	-0.443***	-1.289**	-0.409***
	(0.124)	(0.627)	(0.127)	(0.126)	(0.642)	(0.129)
Q_t	-0.054***	-0.059	-0.049***	-0.049***	-0.045	-0.043***
	(0.016)	(0.086)	(0.016)	(0.016)	(0.086)	(0.017)
FR_t	0.163**	0.083	0.172**	0.163**	0.122	0.170**
	(0.074)	(0.493)	(0.075)	(0.076)	(0.496)	(0.077)
$CGRANK_t$	0.057***	0.136*	0.055***	0.051***	0.191**	0.048***
	(0.012)	(0.081)	(0.012)	(0.013)	(0.093)	(0.013)
$SIZE_t$	0.214***	0.322***	0.208***	0.207***	0.305***	0.200***
	(0.015)	(0.071)	(0.015)	(0.015)	(0.072)	(0.016)
IO_t	0.068***	0.053	0.065***	0.060**	0.058	0.056**
	(0.024)	(0.107)	(0.025)	(0.024)	(0.106)	(0.025)
SG_t	-0.344***	-0.322***	-0.344***	-0.344***	-0.311***	-0.345***
	(0.026)	(0.111)	(0.027)	(0.026)	(0.111)	(0.027)
AN_t	-0.410***	-0.940***	-0.374***	-0.387***	-0.728**	-0.369***
	(0.073)	(0.275)	(0.077)	(0.076)	(0.305)	(0.080)
ESG_{t-1}	0.000	0.001	0.000	0.000	0.001	0.000
	(0.000)	(0.001)	(0.000)	(0.000)	(0.001)	(0.000)
Constant	2.697***	1.770**	2.755***	2.809***	1.692**	2.892***
	(0.151)	(0.688)	(0.156)	(0.157)	(0.700)	(0.162)
Firm FE	YES	YES	YES	YES	YES	YES
LR Chi^2	615.420	63.160	559.600	562.020	60.260	508.640
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	6366	711	5655	6366	711	5655

"**CD**" is the CDP climate change questionnaire disclosure score; "**CP1**" is a GHG intensity measure that uses all emission data from the CDP; "**CP2**" is an alternative GHG intensity measure that draws on data from Thomson Reuters' Asset4 database; "**ROA**" is firms' return on assets; "**Q**" is firms' market to book ratio; "**FR**" measures firms' financial risk, calculated as firms' leverage level; "**CGRANK**" equals "2" if the highest level of direct responsibility for climate change mitigation in a firm is a subset of the board or some committee appointed by the board, it equals "1" if the highest level of direct responsibility for climate change mitigation in a firm is a manager or an officer, "0" otherwise; "**SIZE**" measures the economic scale of firms; "**IO**" is the institutional ownership of companies; "**SG**" is firms' sales growth; "**AN**" measures the newness of firms' properties, plants and equipment; "**ESG**" denotes Thomson Reuters' firm-specific environmental, social and governance (ESG) score. "**DEV**" is a dummy that equals "1" if a country is a member of "DAC", "0" otherwise.

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
For LR Chi^2 the number in parentheses
is the level of significance

Table 4-4 Panel C presents a comparison of the results obtained for the disclosure-performance model using Heckman twostep regression to correct for self-selection bias of the data from the CDP using "CP1" as the proxy for GHG emission intensity, based on the full sample, the developing economies subsample of the full sample, and the developed economies subsample of the full sample. Table 4-4 Panel D presents a comparison of the results obtained for the disclosure-performance model using Heckman twostep regression to correct for self-selection bias of the data from the CDP using "CP2" as the proxy for GHG emission intensity, based on the full sample, the developing economies subsample of the full sample, the developed economies subsample of the full sample. Again, we could observe that there is a significantly positive association between firms' GHG emission intensity and the extensiveness of voluntary GHG disclosure (suggesting a significantly negative association between firms' GHG performance and the extensiveness of voluntary GHG disclosure) for the full reduced sample and the developed economies subsample of the reduced sample in the same period under investigation. Again, there is no statistically significant association between firms' GHG emission intensity and the extensiveness of voluntary GHG disclosure for the developing economies subsample of the reduced sample in the same period under investigation.

Through the results above, we could see that, for the same period under investigation (years 2009-2014), *the association between firms' GHG emission intensity and the extensiveness of voluntary GHG disclosure for developed economies* and *the association between firms' GHG emission intensity and the extensiveness of voluntary GHG disclosure for developing economies* correspond to the a macro GHG disclosure circumstance that is similar to **Phase2** of Table 1-1, and a macro GHG disclosure circumstance that is similar to **Phase1** of Table 1-1 respectively. This is consistent with the evidence that there are existing differences between developed economies and developing economies regarding macro social and environmental (GHG) disclosure circumstance at current stage (Ali and Rizwan, 2013; Luo et al., 2013; Frynas and Yamahaki, 2016; Ali et al., 2017; Ali and Frynas, 2018). Thus, **H4** is true. The evidence obtained as regards research question **(2)** further adds to the possibility *that the different association patterns between firms' environmental performance and corporate environmental disclosure are associated with the respective macro environmental disclosure circumstances in society.*

Table 4-4: Panel C. A comparison of the results obtained for the disclosure-performance model using Heckman twostep regression, based on the full sample, the developing economies subsample of the full sample, the developed economies subsample of the full sample, using "CP1" as the proxy for GHG emission intensity

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	CD_t	$DSPUB_t$	CD_t	$DSPUB_t$	CD_t	$DSPUB_t$
	Full Sample		**DEV=0**		**DEV=1**	
$CP1_t$	2.578***		2.259		2.265***	
	(0.487)		(1.425)		(0.526)	
ROA_t	-32.720***		-21.042***		-29.407***	
	(9.846)		(59.974)		(9.964)	
Q_t	3.105***		13.445***		2.778***	
	(0.594)		(2.890)		(0.611)	
FR_t	11.008***	0.696***	27.027**	1.049**	10.000***	0.659***
	(1.885)	(0.132)	(12.324)	(0.434)	(1.914)	(0.140)
$CGRANK_t$	2.581***		5.402		2.548***	
	(0.844)		(4.437)		(0.859)	
$SIZE_t$	2.915***	0.308***	1.929	0.353***	2.888***	0.305***
	(0.290)	(0.022)	(2.059)	(0.066)	(0.293)	(0.023)
IO_t	3.537***	0.163*	5.082	0.198	3.465***	0.140
	(1.147)	(0.086)	(5.241)	(0.228)	(1.181)	(0.094)
SG_t	-29.717***		1.202		-31.643***	
	(2.792)		(11.603)		(2.879)	
AN_t	4.706*	-0.433**	-29.454**	-1.296***	5.690**	-0.315
	(2.560)	(0.185)	(11.956)	(0.486)	(2.639)	(0.202)
ESG_{t-1}	0.066***		0.161*		0.057**	
	(0.022)		(0.096)		(0.023)	
IR_t		0.522		-0.068		0.544
		(0.460)		(1.178)		(0.503)
$DSPUB_{t-1}$		2.663***		2.523***		2.673***
		(0.057)		(0.201)		(0.060)
$VOLA_t$		1.002		0.135		1.203
		(0.770)		(2.054)		(0.840)
RDI_t		0.862		8.936***		0.352
		(0.804)		(2.889)		(0.840)
DEV_t		0.417***		-		-
		(0.082)		-		-
lambda		-4.186***		-5.700***		-4.585***
		(0.607)		(2.136)		(0.653)
Constant	37.341***	-4.765***	54.652**	-4.752***	38.259***	-4.360***
	(3.858)	(0.291)	(23.227)	(0.789)	(3.929)	(0.289)
Observations	25967		6817		19150	
Uncensored	6366		711		5655	

"**CD**" is the CDP climate change questionnaire disclosure score; "**CP1**" is a GHG intensity measure that uses all emission data from the CDP; "**ROA**" is firms' return on assets; "**Q**" is firms' market to book ratio; "**FR**" measures firms' financial risk, calculated as firms' leverage level; "**CGRANK**" equals "2" if the highest level of direct responsibility for climate change mitigation in a firm is a subset of the board or some committee appointed by the board, it equals "1" if the highest level of direct responsibility for climate change mitigation in a firm is a manager or an officer, "0" otherwise; "**SIZE**" measures the economic scale of firms; "**IO**" is the institutional ownership of companies; "**SG**" is firms' sales growth; "**AN**" measures the newness of firms' properties, plants and equipment; "**ESG**" denotes Thomson Reuters' firm-specific environmental, social and governance (ESG) score. "**IR**" measures firms' propensity to have a publicly available CDP disclosure scores through the CDP's website; "**DSPUB**" is a dummy variable, which equals "1" if a firm has a publicly available CDP disclosure scores through the CDP's website; "**VOLA**" is the standard deviation of adjusted monthly stock return based on a moving window of 12 months for years 2009-2014; "**RDI**" measures firms' Research and Development spending intensity; "**DEV**" is a dummy that equals "1" if a country is a member of "DAC", "0" otherwise.

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4-4: Panel D. A comparison of the results obtained for the disclosure-performance model using Heckman twostep regression, based on the full sample, the developing economies subsample of the full sample, the developed economies subsample of the full sample, using "CP2" as the proxy for GHG emission intensity

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	CD_t	$DSPUB_t$	CD_t	$DSPUB_t$	CD_t	$DSPUB_t$
	Full Sample		**DEV=0**		**DEV=1**	
$CP2_t$	2.814***		2.006		2.514***	
	(0.515)		(1.555)		(0.557)	
ROA_t	-30.353***		-28.417***		-28.129***	
	(10.051)		(72.668)		(10.135)	
Q_t	3.058***		15.440***		2.836***	
	(0.615)		(3.685)		(0.631)	
FR_t	10.177***	0.776***	25.886*	1.350***	9.472***	0.726***
	(1.928)	(0.135)	(14.185)	(0.468)	(1.955)	(0.143)
$CGRANK_t$	2.818***		4.355		2.842***	
	(0.865)		(4.649)		(0.879)	
$SIZE_t$	2.870***	0.317***	2.133	0.391***	2.848***	0.311***
	(0.297)	(0.022)	(2.285)	(0.071)	(0.299)	(0.024)
IO_t	3.299***	0.135	4.290	0.297	3.404***	0.093
	(1.170)	(0.088)	(5.704)	(0.239)	(1.201)	(0.096)
SG_t	-29.826***		3.074		-31.568***	
	(2.816)		(12.091)		(2.905)	
AN_t	5.308**	-0.503***	-30.205**	-1.760***	5.974**	-0.336
	(2.615)	(0.190)	(13.297)	(0.525)	(2.690)	(0.206)
ESG_{t-1}	0.054**		0.168*		0.046**	
	(0.023)		(0.102)		(0.023)	
IR_t		0.129		-0.678		0.154
		(0.475)		(1.244)		(0.518)
$DSPUB_{t-1}$		2.690***		2.567***		2.701***
		(0.058)		(0.205)		(0.061)
$VOLA_t$		1.344*		0.941		1.415*
		(0.785)		(2.143)		(0.854)
RDI_t		0.596		9.073***		0.164
		(0.829)		(3.100)		(0.862)
DEV_t		0.437***		-		-
		(0.084)		-		-
lambda		-3.658***		-5.096**		-4.092***
		(0.621)		(2.229)		(0.667)
Constant	37.974***	-4.807***	57.622**	-5.002***	38.611***	-4.358***
	(3.964)	(0.300)	(26.992)	(0.837)	(4.031)	(0.296)
Observations	25967		6817		19150	
Uncensored	6366		711		5655	

"**CD**" is the CDP climate change questionnaire disclosure score; "**CP2**" is an alternative GHG intensity measure that draws on data from Thomson Reuters' Asset4 database; "**ROA**" is firms' return on assets; "**Q**" is firms' market to book ratio; "**FR**" measures firms' financial risk, calculated as firms' leverage level; "**CGRANK**" equals "2" if the highest level of direct responsibility for climate change mitigation in a firm is a subset of the board or some committee appointed by the board, it equals "1" if the highest level of direct responsibility for climate change mitigation in a firm is a manager or an officer, "0" otherwise; "**SIZE**" measures the economic scale of firms; "**IO**" is the institutional ownership of companies; "**SG**" is firms' sales growth; "**AN**" measures the newness of firms' properties, plants and equipment; "**ESG**" denotes Thomson Reuters' firm-specific environmental, social and governance (ESG) score. "**IR**" measures firms' propensity to have a publicly available CDP disclosure scores through the CDP's website; "**DSPUB**" is a dummy variable, which equals "1" if a firm has a publicly available CDP disclosure scores through the CDP's website; "**VOLA**" is the standard deviation of adjusted monthly stock return based on a moving window of 12 months for years 2009-2014; "**RDI**" measures firms' Research and Development spending intensity; "**DEV**" is a dummy that equals "1" if a country is a member of "DAC", "0" otherwise.

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

4.5 Conclusions

The extant literature that investigates the association pattern between firms' environmental performance and corporate environmental disclosure provides contradictory evidence regarding the relationship of interest, making this literature split and conflicting. Prior studies on this research topic focus on which association pattern (namely, no association; negative association; positive association) as regards the relationhsip of interest should be, from a static point of view, based on relevant theoretical predictions. Little evidence has been provided on how to connect and unify the conflicting evidence in the extant literature.

By reviewing the extant literature on this research topic from a chronological point of view, it is identified that the evidence regarding the association pattern between firms' environmental performance and corporate environmental disclosure is predominantly from North America. The evidence on this research topic from North America is continuous over a few decades. Excluding the noises generated from the incontinuous evidence from other regions, further revealed is that the conflicting empirical evidence on this research topic from North America clusters in different periods of North American society, since corporate environmental issues became a material social concern in the 1960s-1970s (Thinkingshift, 2007) in developed world. This gives rise to the possibility *that the different association patterns between firms' environmental performance and corporate environmental disclosure could be associated with the respective macro environmental disclosure circumstances in society.*

The above possibility could provide a potentially plausible rationale to connect and unify the contradictory evidence on this research topic over time. Making use of the natural setting that, at current stage, the global macro GHG disclosure circumstance is different from the global macro disclosure circumstance regarding other general CSR or environmental issues (KPMG, 2015; KPMG, 2017). And the macro GHG disclosure circumstance in developing economies is different from that in developed economies (Ali and Rizwan, 2013; Luo et al., 2013; Frynas and Yamahaki, 2016; Ali et al., 2017; Ali and Frynas, 2018). The investigations included in this empirical chapter strives to provide potential global evidence, using consistent research design, that would either add to or militate against the proposed possibility above.

The results in this chapter find that, for the same rencent period under investigation (years 2009-2014), The identified global association pattern between firms' GHG performance and corporate voluntary GHG disclosure extensiveness is negative, in line with legitimacy theory's prediction. This is different from the most recently observed positive (Al-Tuwaijri et al., 2004; Clarkson et al., 2008) association pattern between firms' environmental

performance and corporate environmental disclosure. In addition, for the same period under investigation, the observed association pattern between firms' GHG performance and corporate voluntary GHG disclosure extensiveness in developed economies is negative, consistent with the overall global evidence. However, the volunary GHG disclosure in developing economies does not contain any information about firms' underlying GHG performance (no association) in developing economies. Given the consistent research design for the investigations in this chapter, the evidence obtained in this chapter further adds to the possibility *that the different association patterns between firms' environmental performance and corporate environmental disclosure are associated with the respective macro environmental disclosure circumstances in society.*

However, the investigations in this chapter only provide some rudimentary global evidence that further points to the possibility *that the different association patterns between firms' environmental performance and corporate environmental disclosure are associated with the respective macro environmental disclosure circumstances in society.* The mechanism of how macro disclosure circumstance affects the relationship of interest is not explored. Another problem with this chapter is that , as we could see from Table 3-3 Panel A. and Table 3-3 Panel B., both the firms that are involved in the CDP's climate change project and the firms that chose to make their disclosure scores publicly available are increasing over the period under investigation. This potentially gives rise to problem of trending or/and seasonality in the data , which may threaten the reliability of the results obtained in this chapter. In the next chapter, further evidence regarding the relationship between GHG performance and GHG disclosure would be provided employing the first differenced form of the data. Differencing the data once would potentially wipe out or difference out most of the trend or/and seasonality in the data used, thus, making the corresponding empirical results more reliable (Wooldridge, 2010).

5. Divergence or Convergence? Further Evidence on GHG Disclosure-Performance Relationship

5.1 Introduction

As regards the investigation of the association between firms' environmental performance and corporate environmental disclosure, prior studies predominantly focus on "who tends to disclose and how extensive the disclosure tends to be" using cross-sectional research design (Qian and Schaltegger, 2017; Griffin et al., 2017; Hassan, 2018). No evidence, however, to the best of my knowledge, has been provided on whether firms' GHG disclosure would change to promote climate information transparency as a result of the changes in firms' GHG mitigating performance trajectory. On the one hand, according to legitimacy theory, firms exist to the extent society considers them to be legitimate (Aerts and Cormier, 2009; Hawn et al., 2011), corporate activities are reactive behaviour to meet social expectations, firms' involvement in CSR related issues is merely a reaction to alleviate firms' threatened legitimacy (Lindblom, 1983; Deegan, 2002; Law, 2010). From this perspective, maintaining firms' legitimacy is the priority over all other issues (Clarkson et al., 2008; Cho et al., 2012). It would then be possible that changes in firms' GHG performance would not cause any substantial changes in firms' subsequent GHG disclosure. This is because GHG disclosure is used only as a legitimizing tool that does not necessarily has to be based on firms' real performance. Moreover, it could also be possible that firms will see a subsequent decrease tendency in the extensiveness of their GHG disclosure if they have an improvement tendency in the underlying GHG performance. This is because, under legitimacy theory's prediction, firms get involved in GHG mitigating activities out of their threatened legitimacy, firms then may well reduce GHG mitigating investment and GHG disclosure if they feel that their legitimacy is less threatened or is sufficiently maintained with achieved GHG performance improvement. Based on legitimacy theory's argument, firms' GHG disclosure changes tend to dissociate with the underlying GHG performance changes and would not change to promote climate information transparency as a result of the changes in firms' GHG mitigating performance.

On the other hand, for firms that are continually involved in climate change mitigating activities, their GHG disclosure tends to adjust in line with their historical GHG performance change through the course of time. This is because the cost of "being busted" would be increasing to uncontrollable, if firms constantly use GHG disclosure that

dissociates with firms' GHG performance history (Schaltegger and Csutora, 2012). As is argued by Schaltegger and Wagner (2006), corporate disclosure, in the beginning, could be just a tool to react to outside pressures that does not reflect or reflects little of firms' underlying CSR related performance. However, as firms continually get involved in CSR related activities, CSR related disclosure needs to grow convergent with firms' CSR involvement history and performance trajectory. From this perspective, adjusting firms' GHG disclosure in tandem with firms' underlying GHG performance change should be the tendency in management's process of reconciling GHG mitigating activities and subsequent GHG disclosure (Schaltegger and Wagner, 2006; Schaltegger and Csutora, 2012; Qian and Schaltegger, 2017). According to the "inside-out" management view (Schaltegger and Wagner, 2006; Qian and Schaltegger, 2017), as firms' GHG mitigating performance changes, firms' subsequent GHG disclosure tends to converge with firms' GHG performance change trajectory as a result, so that the established public image and reputation regarding climate change mitigating activities are not harmed. That is, there is a possibility for firms to improve climate information transparency as GHG disclosure converges (changes in line) with firms' historical GHG performance change trajectory through the course of time.

The situations above respectively have their own reasonable arguments and standing. Thus, subsequent to the previous empirical chapter that explore "in levels" evidence regarding the relationship between GHG performance and GHG disclosure for the period under investigation, this chapter investigates whether changes in GHG performance would cause any subsequent changes in firms' GHG disclosure strategy, drawing on the reduced sample (see Table 3-2 Panel A., Section3.1.3) of 4562 firm-year observations (after first differencing of the original 6366 firm-year observations) that correspond to 1646 firms, 44 countries for years 2009-2014 and "changes" research design. Depending on the findings of this empirical study, outside GHG information demanders like shareholders and the wider stakeholders, could have a better understanding of what's behind firms' GHG mitigating activities involvement, and whether continual improvement in GHG mitigating activities could have any substantial implications on the changes of firms' GHG disclosure strategy and climate information transparency. Also as is mentioned in the conclusion section of last chapter, the empirical evidence obtained in the previous chapter could be weakened by potential trending and/or seasonality in the data used. By employing the first differenced form of the data used, this chapter could also test if the direction of association between GHG performance and the extensiveness of firms' voluntary GHG disclosure observed in the previous chapter would persist after differencing out potential trend and/or seasonality in the data used. The rest of the chapter is arranged as follows: section5.2 goes through

relevant literature and theoretical predictions, at the end of which the hypotheses would be given, section5.3 introduces the data employed, the sampling method, the empirical model and the variables used in this chapter, section5.4 analyses the empirical evidence obtained to test the hypotheses advanced. Following which, conclusions of this chapter would be given in section5.5.

5.2 Literature Review and Hypotheses

For the literature review and hypotheses of chapter 5, please refer back to section2.2.2.

5.3 Research Design

Consistent with the previous empirical chapter, this section starts with specifying the data used for the investigations conducted in this chapter, together with the corresponding data source. Then the sampling process would be introduced. Following which, the section finishes with the introduction of the empirical model used to conduct the investigations in this chapter, as well as the relevant variables.

5.3.1 Sample and Data

To conduct the analyses in this chapter, I use firm-specific "carbon emissions amounts", "carbon disclosure scores" and "climate change mitigation related management levels within firms" that measure where the highest level of direct responsibility for climate change mitigation is positioned, from the CDP's climate change database. The sample is selected from all the firms that have been involved in the CDP's climate change project for years 2010-2015 (the CDP's climate change projects for 2010-2015 collect GHG emissions related data from involved firms for years 2009-2014; "involvement" means a firm has either been asked by the CDP to participate in the voluntary CDP climate change questionnaire or self-selected itself to participate in the CDP's voluntary climate change questionnaire. See section3.1 for details of how the CDP's climate change project works, and Figure 3-1 for the decision making process of involved firms) if firms have a publicly available CDP questionnaire disclosure score for at least one year for years 2009-2014. This ensures that every firm-year observation included in the sample has a valid CDP disclosure score. The period 2009-2014 is selected as the period under investigation because the CDP's climate

change questionnaire stays largely consistent, thus the information collected through these questionnaires provides good horizontal and vertical comparability across firms and between years.

This sample selection process gives a sample of 6366 firm-year observations that corresponds to 1646 firms, 44 countries (corresponding to the reduced sample mentioned in Table 3-2 Panel A., section3.1.3). Because this research uses changes analysis, by taking the first difference of the CDP's climate change disclosure scores and other variables included in the original sample data, I get a sample of 4562 firm-year observations that corresponds to 1646 firms, 44 countries. In addition, according to the 1646 firms included in the sample, scope1 and scope2 carbon emissions data of these firms from Thomson Reuters' Asset4 database are also added, carbon emissions data from different channels are used in the analyses to alternatively create a set of proxies for GHG performance, besides those created using GHG emissions data from the CDP's database (the reason why alternative GHG emissions data are used is explained in section5.3.2).

5.3.2 Empirical Model and Variables

For the explanation of empirical model used to examine the hypotheses advanced in this chapter and the variables included in the empirical model, please refer back to section3.2.2.

5.4 Results

The analyses of the results obtained in this chapter start with summarising the implications from summary statistics. Then, the results obtained from baseline models would be presented and analysed. Further, taking into consideration of the imapct of potential endogeneity problems on the results obtained from baseline models, the results obtained from two-stage least squares models would be presented and analysed.

5.4.1 Implications from Summary Statistics

Table 5-1 Panel A presents the descriptive statistics of undifferenced CDP climate change disclosure scores, the undifferenced four measures of GHG intensity for the sample. We could see that the standard deviation of the CDP's disclosure score (19.696) is much lower than the mean (75.992) of it, this indicates that the variations between different

observations of this variable is not large. On a 100 points scale, given that firms which chose to disclose their disclosure scores to the public have a mean score of 75.992, a median of "80", this shows that generally firms that have a relatively high disclosure score tend to make their disclosure scores public. The standard deviation of all four GHG intensity measures are all larger than their respective means (A1CI: mean=0.190, SD=0.408; B1CI: mean=0.215, SD=0.457; A2CI: mean=0.256, SD=0.473; B2CI: mean=0.275, SD=0.530), there is considerable variation of these GHG intensity measures. In addition, we could see that the disclosed carbon intensity from the CDP's climate change project (A1CI: mean=0.190, median=0.015; A2CI: mean=0.256, median=0.048) is on average slightly lower than those (B1CI: mean=0.215, median=0.017; B2CI: mean=0.275, median=0.051) from other channels (corporate reports, webpages, online media etc.). The differences of the same scope of GHG intensity from different channels indicate that it is necessary to see if the obtained regression results would be sensitive to these identified differences.

Table 5-1 Panel B presents the descriptive for variables in their first differenced form. The signs of the changes of all four first-differenced GHG intensity measures are reversed, so that they could be intuitively explained as improvement in GHG performance, and the higher the value of the sign-inversed first-differenced GHG intensity is, the better the improvement in GHG performance. In contrast with the undifferenced GHG intensity measures, we could see that, for the changes of "scope1", "scope1+scope2" GHG intensity measures, the improvement of GHG performance reported in the CDP's voluntary climate change questionnaire [ΔA1CI(-): mean=-0.001; ΔA2CI(-): mean=-0.002] is on average lower than that [ΔB1CI(-): mean=0.004; ΔB2CI(-): mean=0.000] reported through other channels (corporate reports, webpages, online media etc.). This indicates that firms tend to exaggerate their performance improvement in channels like corporate reports, webpages, online media etc. at incremental (changes) level to give better impressions on outside information users (shareholders and the wider stakeholders).

Table 5-1: Panel A. Descriptive statistics of overall corporate GHG profile for the sample

Variable	Mean	Q1	Median	Q3	Std.Dev.
			n=6366 (1646 firms)		
CD_t	75.992	65.000	80.000	92.000	19.696
$A1CI_t$	0.190	0.004	0.015	0.140	0.408
$B1CI_t$	0.215	0.004	0.017	0.180	0.457
$A2CI_t$	0.256	0.018	0.048	0.247	0.473
$B2CI_t$	0.275	0.019	0.051	0.263	0.530

"**CD**" is the CDP's climate change questionnaire disclosure score; "**A1CI**" is the ratio of "scope1" carbon emissions (in thousand metric tonnes) from the CDP over firms' inflation-adjusted sales revenue (in million USD); "**B1CI**" is the ratio of "scope1" carbon emissions (in thousand metric tonnes) from Thomson Reuters' Asset4 database over firms' inflation-adjusted sales revenue (in million USD); "**A2CI**" is the ratio of "scope1+scope2" carbon emissions (in thousand metric tonnes) from the CDP over firms' inflation-adjusted sales revenue (in million USD); "**B2CI**" is the ratio of "scope1+scope2" carbon emissions (in thousand metric tonnes) from Thomson Reuters' Asset4 database over firms' inflation-adjusted sales revenue (in million USD).

Table 5-1: Panel B. Descriptive statistics of variables for the sample

Variable	Mean	Q1	Median	Q3	Std.Dev.
			n=4562 (1646 firms)		
ΔCD_t	0.059	0.000	0.040	0.110	0.102
$\Delta A1CI_t(-)$	-0.001	-0.001	0.000	0.001	0.112
$\Delta B1CI_t(-)$	0.004	-0.001	0.000	0.002	0.114
$\Delta A2CI_t(-)$	-0.002	-0.004	0.000	0.003	0.137
$\Delta B2CI_t(-)$	0.000	-0.004	0.000	0.004	0.141
CGRANK	1.778	2.000	2.000	2.000	0.463
ΔQ_t	0.030	-0.091	0.025	0.163	0.399
ΔROA_t	-0.001	-0.014	0.000	0.014	0.039
ΔFR_t	0.001	-0.020	0.000	0.018	0.050
ΔAN_t	-0.007	-0.021	-0.007	0.007	0.047
ΔSG_t	-0.010	-0.118	-0.014	0.080	0.195
$\Delta SIZE_t$	0.071	-0.084	0.085	0.239	0.302
ΔIO_t	0.003	-0.002	0.000	0.003	0.055
ΔESG_t	0.485	-4.480	0.340	5.710	14.620

"**CD**" is the CDP's climate change questionnaire disclosure score; "**A1CI**" is the ratio of "scope1" carbon emissions (in thousand metric tonnes) from the CDP over firms' inflation-adjusted sales revenue (in million USD); "**B1CI**" is the ratio of "scope1" carbon emissions (in thousand metric tonnes) from Thomson Reuters' Asset4 database over firms' inflation-adjusted sales revenue (in million USD); "**A2CI**" is the ratio of "scope1+scope2" carbon emissions (in thousand metric tonnes) from the CDP over firms' inflation-adjusted sales revenue (in million USD); "**B2CI**" is the ratio of "scope1+scope2" carbon emissions (in thousand metric tonnes) from Thomson Reuters' Asset4 database over firms' inflation-adjusted sales revenue (in million USD); "**CGRANK**" equals "2" if the highest level of direct responsibility for climate change mitigation in a firm is a subset of the board or some committee appointed by the board, it equals "1" if the highest level of direct responsibility for climate change mitigation in a firm is a manager or an officer, "0" otherwise; "**Q**" is firms' market to book ratio, calculated as the ratio of market value of common equity of a firm (in million USD) plus the book value of its common equity (in million USD) minus the book value of its total assets (in million USD) over the book value of its total assets; "**ROA**" is firms' return on assets, calculated as the ratio of income before extraordinary items (in million USD) of the current year over the total assets (in million USD) at the end of last year; "**FR**" measures firms' financial risk, calculated as firms' leverage level, which equals firms' book value of total debt including current (in million USD) over firms' book value of total assets (in million USD); "**AN**" measures the newness of firms' properties, plants and equipment, calculated as the ratio of a firm's net properties, plant and equipment (in million USD) at each year end over its gross properties, plant and equipment (in million USD) at each year-end; "**SG**" is firms' sales growth, it is calculated as the difference of sales revenue in million USD at "t" and sales revenue in million USD at "t-1" over sales revenue in million USD at "t-1"; "**SIZE**" measures the economic scale of firms, calculated as the natural log of the market value (in million USD) of the equity of a firm; "**IO**" is the institutional ownership of companies, calculated as the shares of a company owned by institutional investors over all shares outstanding of a company; "**ESG**" denotes Thomson Reuters' firm-specific environmental, social and governance (ESG) score.

Table 5-1: Panel C. Correlation coefficients

	ΔCD_{t+1}	$\Delta A1CI_t(-)$	$\Delta A2CI_t(-)$	$\Delta B1CI_t(-)$	$\Delta B2CI_t(-)$	ΔQ_t	ΔFR_t	CGRANK	$\Delta SIZE_t$	ΔIO_t	ΔROA_t	ΔSG_t	ΔAN_t	ΔESG_t
ΔCD_{t+1}		0.005	0.013	0.015	0.003	0.032	-0.019	-0.014	*0.045*	-0.004	*0.039*	*0.041*	-0.027	-0.012
$\Delta A1CI_t(-)$	-0.044		**0.901**	**0.603**	**0.414**	0.001	**-0.043**	-0.008	*0.037*	-0.005	**0.084**	**0.093**	0.026	0.019
$\Delta A2CI_t(-)$	-0.034	**0.815**		**0.582**	**0.491**	-0.001	-0.028	-0.009	**0.045**	-0.004	**0.078**	**0.105**	0.017	0.011
$\Delta B1CI_t(-)$	*-0.057*	**0.762**	**0.674**		**0.882**	0.005	-0.012	-0.019	**0.064**	0.002	**0.107**	**0.134**	*0.037*	0.004
$\Delta B2CI_t(-)$	-0.031	**0.643**	**0.782**	**0.775**		0.014	-0.003	-0.017	**0.073**	-0.014	**0.094**	**0.147**	**0.043**	0.001
ΔQ_t	*0.053*	0.026	0.049	0.042	0.047		**-0.287**	0.014	**0.585**	**-0.071**	**0.186**	**0.085**	**-0.051**	-0.007
ΔFR_t	-0.012	-0.044	-0.033	-0.047	-0.045	**-0.361**		-0.024	**-0.147**	0.012	**-0.246**	-0.005	-0.021	-0.026
CGRANK	-0.041	-0.024	-0.026	-0.034	-0.028	0.007	-0.047		**-0.046**	-0.004	-0.005	-0.017	-0.004	-0.003
$\Delta SIZE_t$	*0.051*	**0.108**	**0.159**	**0.122**	**0.161**	**0.799**	**-0.194**	-0.022		-0.029	**0.297**	**0.234**	**0.076**	0.012
ΔIO_t	0.016	-0.019	0.008	-0.006	0.006	0.011	0.008	0.021	0.028		-0.018	0.019	0.014	-0.016
ΔROA_t	0.023	**0.152**	**0.196**	**0.181**	**0.199**	**0.306**	**-0.239**	-0.019	**0.337**	*-0.061*		**0.333**	**0.067**	0.013
ΔSG_t	0.039	**0.241**	**0.302**	**0.289**	**0.329**	**0.147**	*-0.061*	-0.011	**0.271**	-0.027	**0.381**		0.024	-0.027
ΔAN_t	-0.046	0.034	0.044	0.044	0.039	**-0.127**	**0.071**	0.032	0.011	-0.007	0.029	0.001		0.025
ΔESG_t	0.005	0.018	0.007	0.026	0.013	-0.026	-0.011	-0.019	0.003	0.011	0.016	-0.011	0.033	

"**CD**" is the CDP's climate change questionnaire disclosure score; "**A1CI**" is the ratio of "scope1" carbon emissions (in thousand metric tonnes) from the CDP over firms' inflation-adjusted sales revenue (in million USD); "**A2CI**" is the ratio of "scope1+scope2" carbon emissions (in thousand metric tonnes) from the CDP over firms' inflation-adjusted sales revenue (in million USD); "**B1CI**" is the ratio of "scope1" carbon emissions (in thousand metric tonnes) from Thomson Reuters' Asset4 database over firms' inflation-adjusted sales revenue (in million USD); "**B2CI**" is the ratio of "scope1+scope2" carbon emissions (in thousand metric tonnes) from Thomson Reuters' Asset4 database over firms' inflation-adjusted sales revenue (in million USD); "**Q**" is firms' market to book ratio, calculated as the ratio of market value of common equity of a firm (in million USD) plus the book value of its common equity (in million USD) minus the book value of its total assets (in million USD) over the book value of its total assets; "**FR**" measures firms' financial risk, calculated as firms' leverage level, which equals firms' book value of total debt including current (in million USD) over firms' book value of total assets (in million USD); "**CGRANK**" equals "2" if the highest level of direct responsibility for climate change mitigation in a firm is a subset of the board or some committee appointed by the board, it equals "1" if the highest level of direct responsibility for climate change mitigation in a firm is a manager or an officer, "0" otherwise; "**SIZE**" measures the economic scale of firms, calculated as the natural log of the market value (in million USD) of the equity of a firm; "**IO**" is the institutional ownership of companies, calculated as the shares of a company owned by institutional investors over all shares outstanding of a company; "**ROA**" is firms' return on assets, calculated as the ratio of income before extraordinary items (in million USD) of the current year over the total assets (in million USD) at the end of last year; "**SG**" is firms' sales growth, it is calculated as the difference of sales revenue in million USD at "t" and sales revenue in million USD at "t-1" over sales revenue in million USD at "t-1"; "**AN**" measures the newness of firms' properties, plants and equipment, calculated as the ratio of a firm's net properties, plant and equipment (in million USD) at each year end over its gross properties, plant and equipment (in million USD) at each year-end; "**ESG**" denotes Thomson Reuters' firm-specific environmental, social and governance (ESG) score.

Spearman rank correlation coefficients are below the diagonal, Pearson correlation coefficients are above the diagonal.

Coefficients in bold are significant at p<0.01; Coefficients in italic are significant at p<0.05; Coefficients with underscore are significant at p<0.1.

The GHG performance improvement data presented in the channels like corporate reports, webpages, online media etc. are largely beautified , compared with the GHG performance improvement data disclosed through the CDP's voluntary climate change questionnaire. This is also consistent with what Depoers et al. (2016) find that large firms in France tend to downplay their climate change impact in corporate reports. This is probably because corporate reports, website disclosure or online media disclosure are literally the most accessible and cost-effective ways for shareholders and the wider stakeholders who are climate change concerned to know how firms manage their GHG impact. Firms take advantage of this fact and intentionally beautify the disclosed data to let shareholders and the wider stakeholders have a better impression on firms' GHG management and performance. These differences in reported changes of GHG emission intensity could also be reflected in the regression results.

The sample firms have seen an average decrement of sales growth (ΔSG: mean=-0.010) for the period under investigation. In addition, there is an overall increment (ΔSIZE: mean=0.071) of firms' economic scale on average for the period under investigation. Overall, the descriptive statistics of GHG performance measures in their first differenced form is consistent with that in the undifferenced form.

Table 5-1 Panel C presents the pair-wise correlation coefficients between the variables used in the empirical model. Above (Below) the diagonal are the Pearson (Spearman rank) correlation coefficients. Although, in the Pearson correlation test, no significant correlation between the GHG intensity changes measures and the GHG disclosure extensiveness changes measures has been identified, scope1 GHG emissions changes measures (Spearman rank: $\Delta A1CI_t(-)\&\Delta CD_{t+1}$ correlation coefficient=-0.044, $p<0.1$; $\Delta B1CI_t(-)\&\Delta CD_{t+1}$ correlation coefficient=-0.057, $p<0.05$) have been found to be significantly negatively correlated with the GHG disclosure extensiveness changes measures in Spearman rank correlation test. It should be noted that both no correlation and negative correlation between the GHG intensity changes measures and the GHG disclosure extensiveness changes measures conform to legitimacy theory's prediction. This could be further tested in regression tests. In addition, the increment of firms' economic size is positively (Spearman rank: $\Delta SIZE_t(-)\&\Delta CD_{t+1}$ correlation coefficient= 0.051, $p<0.05$; Pearson: $\Delta SIZE_t(-)\&\Delta CD_{t+1}$ correlation coefficient= 0.045, $p<0.05$) associated with the increment of firms' GHG disclosure extensiveness, this is probably because firms are faced with increasing social pressure regarding climate changes mitigation activities as their economic scale grows.

5.4.2 Baseline Models Tests for the Hypotheses Using OLS

Table 5-2 presents the pooled OLS [31] regression results of the empirical model that investigates the association between changes of firms' GHG performance and the subsequent changes in firms' voluntary GHG disclosure extensiveness, using "scope1" [$\Delta A1CI_t(-)$, $\Delta B1CI_t(-)$] and "scope1+scope2" [$\Delta A2CI_t(-)$, $\Delta B2CI_t(-)$] GHG emissions intensity for the period under investigation. The process of differencing the data once could potentially wipe out or difference out most of the trend or/and seasonality in the data used, it means that first differencing does not always make the data completely stationary (Wooldridge, 2010). As Wooldridge (2010) argues that empirical models could have both an additive industry (country or region) effect and an industry (country or region) specific trend effect, first differencing could partial out the additive effect and leaves the trend effect. Differencing the data could remove the additive industry (country or region) effect, simultaneously, controlling for industry (country or region) fixed effects in pooled OLS regression drawing on first differenced data could remove industry (country or region) specific trend effect in the data. Following which argument, I also control for industry and region fixed effects in the baseline models.

Specifically, we could see that, for the period under investigation, changes of the improvement in firms' GHG performance does not contain any information of the subsequent changes in the improvement of firms' voluntary GHG disclosure extensiveness. This is consistent with legitimacy theory's prediction and indicates that, for the period under investigation, firms' GHG disclosure is largely manipulated for the maintenance of firms' legitimacy. This kind of GHG disclosure loses track of firms' GHG mitigating achievement trajectory, and it is the reason why changes in firms' GHG performance do not contain any information of the subsequent changes of firms' GHG disclosure extensiveness. In addition, from column 2 to column 8, for every one-unit increase in the improvement in firms' sales growth, there is an increase of the subsequent improvement in firms' voluntary GHG disclosure extensiveness by around 2% ($p<0.1$).

[31] OLS stands for Ordinary Least Squares. Because I use changes analyses to investigate the relationship of interest, for one thing, Random Effects Generalised Least Squares equals OLS in this study, as there is lots of negative serial correlation in my data due to the process of differencing my data, for another, first differenced data has already differenced out time-invariant factors using repeated observations over time, using first-differenced data has similar effect of using Fixed Effects Generalised Least Squares [see, Wooldridge, J.M. 2010. *Econometric analysis of cross section and panel data.* MIT press.]. Thus, for baseline models, I only report results from OLS regression.

Table 5-2: The results of OLS regression using A1CI, A2CI, B1CI and B2CI as the GHG performance proxy respectively

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	ΔCD_{t+1}	ΔCD_{t+1}	ΔCD_{t+1}	ΔCD_{t+1}	ΔCD_{t+1}	ΔCD_{t+1}	ΔCD_{t+1}	ΔCD_{t+1}
$\Delta A1CI_t(-)$	-0.016	-0.017	-	-	-	-	-	-
	(0.017)	(0.018)	-	-	-	-	-	-
$\Delta A2CI_t(-)$	-	-	-0.010	-0.011	-	-	-	-
	-	-	(0.013)	(0.014)	-	-	-	-
$\Delta B1CI_t(-)$	-	-	-	-	-0.021	-0.021	-	-
	-	-	-	-	(0.023)	(0.023)	-	-
$\Delta B2CI_t(-)$	-	-	-	-	-	-	-0.010	-0.010
	-	-	-	-	-	-	(0.016)	(0.016)
ΔQ_t	0.003	0.004	0.003	0.004	0.001	0.001	0.001	0.002
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
ΔFR_t	-0.035	-0.034	-0.032	-0.032	-0.047	-0.045	-0.041	-0.029
	(0.051)	(0.052)	(0.051)	(0.052)	(0.050)	(0.051)	(0.050)	(0.051)
CGRANK	-0.006	-0.008	-0.006	-0.008	-0.006	-0.008	-0.006	-0.010
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
$\Delta SIZE_t$	0.007	0.009	0.007	0.010	0.012	0.013	0.009	0.011
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
ΔIO_t	-0.023	-0.026	-0.023	-0.026	-0.005	-0.006	-0.016	-0.017
	(0.030)	(0.031)	(0.030)	(0.031)	(0.036)	(0.037)	(0.034)	(0.036)
ΔROA_t	0.009	0.004	0.015	0.010	-0.003	0.001	0.022	0.025
	(0.065)	(0.065)	(0.065)	(0.065)	(0.064)	(0.065)	(0.064)	(0.065)
ΔSG_t	0.021	0.023*	0.021*	0.023*	0.027**	0.029**	0.024*	0.024*
	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)
ΔAN_t	-0.051	-0.050	-0.053	-0.052	-0.073	-0.076	-0.079	-0.081
	(0.054)	(0.055)	(0.054)	(0.055)	(0.055)	(0.056)	(0.057)	(0.057)
ΔESG_t	-0.001	-0.000	-0.001	-0.000	-0.001	-0.000	-0.001	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Constant	0.069***	0.078***	0.069***	0.079***	0.069***	0.067***	0.073***	0.078***
	(0.009)	(0.017)	(0.009)	(0.017)	(0.010)	(0.017)	(0.009)	(0.017)
Industry FE	NO	YES	NO	YES	NO	YES	NO	YES
Region FE	NO	YES	NO	YES	NO	YES	NO	YES
Observations	4,562	4,562	4,562	4,562	4,562	4,562	4,562	4,562
R-squared	0.006	0.017	0.006	0.017	0.008	0.019	0.007	0.018

"**CD**" is the CDP's climate change questionnaire disclosure score; "**A1CI**" is the ratio of "scope1" carbon emissions (in thousand metric tonnes) from the CDP over firms' inflation-adjusted sales revenue (in million USD); "**A2CI**" is the ratio of "(scope1+scope2" carbon emissions (in thousand metric tonnes) from the CDP over firms' inflation-adjusted sales revenue (in million USD); "**B1CI**" is the ratio of "scope1" carbon emissions (in thousand metric tonnes) from Thomson Reuters' Asset4 database over firms' inflation-adjusted sales revenue (in million USD); "**B2CI**" is the ratio of "scope1+scope2" carbon emissions (in thousand metric tonnes) from Thomson Reuters' Asset4 database over firms' inflation-adjusted sales revenue (in million USD); "**Q**" is firms' market to book ratio; "**FR**" measures firms' financial risk, calculated as firms' leverage level; "**CGRANK**" equals "2" if the highest level of direct responsibility for climate change mitigation in a firm is a subset of the board or some committee appointed by the board, it equals "1" if the highest level of direct responsibility for climate change mitigation in a firm is a manager or an officer, "0" otherwise; "**SIZE**" measures the economic scale of firms; "**IO**" is the institutional ownership of companies; "**SG**" is firms' sales growth; "**AN**" measures the newness of firms' properties, plants and equipment; "**ESG**" denotes Thomson Reuters' firm-specific environmental, social and governance (ESG) score.

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

In chapter 4, the "in levels" evidence indicates that firms with lower return on assets, lower sales growth rate, higher leverage levels tend to be associated with more extensive voluntary GHG disclosure. This suggests that the "slack finance" and "luxury good" arguments of CSR are not supported by the empirical evidence for the period under investigation. However, the evidence identified in Table 5-2 provides grounds for the "slack finance" and "luxury good" arguments of CSR in a different way that the increasing tendency of the improvement of firms' sales growth in the current period would enable firms to have an increasing tendency of the improvement of firms' voluntary GHG disclosure extensiveness in the next period. The findings in Table 5-2 generally are consistent with the findings of the "in-levels" evidence as regards the association between GHG performance and the extensiveness of firms' voluntary GHG disclosure in chapter4 that legitimacy theory has predominant explanatory power over the disclosure-performance association in corporate GHG mitigating activities for the period under investigation. However, it should be noted that the results reported in Table 5-2 suffer from endogeneity problems. This is detected by the Durbin-Wu-Hausman test of endogeneity (Wooldridge, 2010). Thus. In the next section, the results obtained after controlling for endogeneity would be reported and discussed.

5.4.3.Controlling for Endogeneity, Results from Two-Stage Least Squares (2SLS) Regression

In addition to the main results reported from OLS models above, I use instrumental variable models to control for potential endogeneity problems, which would threaten the validity of the results reported. Endogeneity occurs when one or more independent variables of interest (excluding control variables) on the right-hand side is/are correlated with the error term in an empirical model (Wooldridge, 2010). This situation would cause OLS estimates to be biased. This is because one important assumption of using OLS estimates is that the right-hand-side independent variable(s) of interest should not contain information about the mean of the error term in the empirical model, which means that the covariance between the error term and the explanatory variable(s) of interest should be zero. If the covariance between the error term and the independent variable(s) of interest is not zero, then the OLS estimates of the coefficients of the independent variable(s) of interest cannot be regarded as Best Linear Unbiased Estimates of the population parameters.

It should be noted that there are overall three sources of endogeneity identified in prior studies, namely, 1) omitted independent variable(s); 2) measurement errors in

independent variable(s) of interest; 3) causal loop (simultaneity) between the dependent variable and the independent variable(s) of interest. The three situations mentioned above cause the independent variable(s) of interest to be correlated with the error term in an empirical model, thus, giving rise to endogeneity. Because the relationship that I investigate in this chapter is between the changes of firms' GHG performance at "t" and the changes of firms' voluntary GHG disclosure extensiveness at "t+1", there would be no potential endogeneity from causal loop. This is because future events cannot affect anything that has already happened in the past. Also, given that I use GHG emissions data from different channels to control for measurement errors, the probable source of endogeneity in the empirical model would be from "omitted variables". Relatedly, prior studies also identify other firm-level factors that could effectively affect firms' CSR related disclosure. For example, board independence and board size are found to be positively associated with corporate CSR disclosure (Jizi et al., 2014). However, these corporate governance related factors are not included in the empirical model of this chapter.

Specifically, although first-differenced estimators (changes analyses) are commonly used in econometrics to control for omitted variables, first-differenced estimators could only difference out omitted time-invariant variables. There is a possibility of endogeneity rising from omitted time-variant variables. Thus, I use the "instrumental variables" method to separate the part of the variation of "ΔCI_t" that is not associated with the error term in the empirical model. A key advantage of using instrumental variables to control for endogeneity problems is that the coefficient estimate(s) of the endogenous independent variable(s) of interest is(are) more likely to be consistent (Wooldridge, 2010). The consistency of estimates in regression analysis is a priority over efficiency (Wooldridge, 2010). Also, as heteroscedasticity is detected in the data I use, GMM is implemented in the two-stage least squares regression process to allow for reliable inference [see (Cheng et al., 2014)].

Particularly, the sign-inversed first-differenced form of region-industry average of "ΔCI_t" ($\Delta CIRIM_t(-)$), excluding each firm's contribution to the average, is used as an instrument for the endogenous variable of interest, which is "ΔCI_t". By excluding each firm's contribution to the average, each firm's region-industry average of "ΔCI_t" differs from each other, enough variation of the instrument is secured. Using region-industry average of the independent variable of interest as its instrument is consistent with a few prior studies (Lev and Sougiannis, 1996; Friedberg, 2003; Hanlon et al., 2003; Cheng et al., 2014). The reason of using the region-industry average of the changes of firms' GHG performance is that the changes of firms' GHG performance is systematically affected by that of other firms within the same industry in the same region (Cheng et al., 2014). Using this instrumental variable is

also in line with prior evidence that firms' CSR related performance and disclosure are driven by social, political and industrial characteristics (Ioannou and Serafeim, 2012; Luo et al., 2013).

Table 5-3 Panel A presents the two-stage least squares regression results (imposing GMM option to allow for heteroscedasticity in the data) of the empirical model using A1CI to proxy for firms' GHG performance, drawing on $\Delta A1CIRIM_t(-)$ as the instrument for the independent variable of interest "$\Delta A1CI_t$". After factoring out the endogenous disturbances in the independent variable of interest, we could see that if the improvement of firms' "scope1" GHG performance increases by one metric ton per thousand revenue in USD, the subsequent improvement in firms' GHG disclosure extensiveness tends to decrease by around 5%. This observed negative association is consistent after controlling for industry-fixed effects and region-fixed effects in regression to factor out, in the second stage regression, any residual industry or/and region-specific trend effect in the first differenced dataset. Table 5-3 Panel B presents the two-stage least squares regression results (imposing GMM option to allow for heteroscedasticity in the data) of the empirical model using A2CI to proxy for firms' GHG performance, drawing on $\Delta A2CIRIM_t(-)$ as the instrument for the independent variable of interest "$\Delta A1CI_t$". The results obtained are consistent with those reported in Table 5-3 Panel A. For every 1 metric ton per thousand USD revenue increase in the improvement of firms' "scope1+scope2" GHG performance, there is around 4% decrease in the subsequent improvement of firms' voluntary GHG disclosure extensiveness.

Table 5-3: Panel A. The results of the empirical model using A1CI as the GHG performance proxy-instrumental variables

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	First stage	ΔCD_{t+1}	First stage	ΔCD_{t+1}	First stage	ΔCD_{t+1}
$\Delta A1CI_t(-)$	-	-0.046***	-	-0.053***	-	-0.052***
	-	(0.017)	-	(0.020)	-	(0.020)
$\Delta A1CIRIM_t(-)$	-22.708***	-	-22.800***	-	-22.835***	-
	(0.449)	-	(0.452)	-	(0.455)	-
ΔQ_t	-0.005	-0.001	-0.005	0.001	-0.005	0.001
	(0.005)	(0.007)	(0.005)	(0.007)	(0.005)	(0.007)
ΔFR_t	-0.080**	-0.026	-0.078**	-0.032	-0.080**	-0.031
	(0.037)	(0.053)	(0.037)	(0.053)	(0.037)	(0.054)
CGRANK	-0.002	-0.007	-0.002	-0.006	-0.001	0.010*
	(0.004)	(0.005)	(0.004)	(0.005)	(0.004)	(0.006)
$\Delta SIZE_t$	0.001	0.012	-0.000	0.014	-0.000	0.015
	(0.007)	(0.010)	(0.007)	(0.010)	(0.007)	(0.009)
ΔIO_t	-0.022	-0.025	-0.022	-0.029	-0.022	-0.028
	(0.028)	(0.031)	(0.028)	(0.031)	(0.028)	(0.031)
ΔROA_t	0.091*	-0.006	0.090*	-0.013	0.088*	-0.016
	(0.047)	(0.069)	(0.047)	(0.068)	(0.047)	(0.068)
ΔSG_t	0.033***	0.021	0.034***	0.022	0.034***	0.025*
	(0.009)	(0.014)	(0.009)	(0.014)	(0.009)	(0.014)
ΔAN_t	0.047	-0.056	0.049	-0.055	0.047	-0.047
	(0.037)	(0.056)	(0.037)	(0.056)	(0.038)	(0.056)
ΔESG_t	0.000	-0.000	0.000	-0.000	0.000	-0.000
	(0.000)	(0.000)	-0.005	0.001	(0.000)	(0.000)
Constant	0.004	0.071***	0.004	0.069***	0.004	0.078***
	(0.007)	(0.010)	(0.009)	(0.013)	(0.012)	(0.015)
Industry FE		NO		YES		YES
Region FE		NO		NO		YES
Observations	4,562	4,562	4,562	4,562	4,562	4,562
R-squared	0.515	0.004	0.516	0.013	0.517	0.019
Kleigergen-Raap rk Wald F (Weak instruments test)		12.539		12.779		12.605

"**CD**" is the CDP's climate change questionnaire disclosure score; "**A1CI**" is the ratio of scope1 carbon emissions (in thousand metric tonnes) from the CDP over firms' inflation-adjusted sales revenue (in million USD); "**$A1CIRIM_t(-)$**" is the region-industry mean of "$A1CI_t(-)$", excluding each firm's contribution to the mean; "**Q**" is firms' market to book ratio; "**FR**" measures firms' financial risk, calculated as firms' leverage level; "**CGRANK**" equals "2" if the highest level of direct responsibility for climate change mitigation in a firm is a subset of the board or some committee appointed by the board, it equals "1" if the highest level of direct responsibility for climate change mitigation in a firm is a manager or an officer, "0" otherwise; "**SIZE**" measures the economic scale of firms; "**IO**" is the institutional ownership of companies; "**SG**" is firms' sales growth; "**AN**" measures the newness of firms' properties, plants and equipment; "**ESG**" denotes Thomson Reuters' firm-specific environmental, social and governance (ESG) score.

Robust Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 5-3: Panel B. The results of the empirical model using A2CI as the GHG performance proxy-instrumental variables

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	First stage	ΔCD_{t+1}	First stage	ΔCD_{t+1}	First stage	ΔCD_{t+1}
$\Delta A2CI_t(-)$	-	-0.034**	-	-0.040**	-	-0.039**
	-	(0.015)	-	(0.017)	-	(0.017)
$\Delta A2CIRIM_t(-)$	-22.756***	-	-22.848***	-	-22.896***	-
	(0.494)	-	(0.498)	-	(0.501)	-
ΔQ_t	-0.007	-0.000	-0.007	0.001	-0.008	0.002
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
ΔFR_t	-0.083*	-0.023	-0.080*	-0.029	-0.085*	-0.029
	(0.048)	(0.052)	(0.048)	(0.053)	(0.049)	(0.054)
CGRANK	-0.001	-0.007	-0.002	-0.006	-0.000	0.009*
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.006)
$\Delta SIZE_t$	0.003	0.012	0.002	0.014	0.002	0.015
	(0.009)	(0.010)	(0.009)	(0.009)	(0.009)	(0.009)
ΔIO_t	-0.016	-0.025	-0.017	-0.029	-0.015	-0.028
	(0.036)	(0.030)	(0.037)	(0.031)	(0.037)	(0.031)
ΔROA_t	0.109*	0.002	0.110*	-0.004	0.109*	-0.008
	(0.061)	(0.069)	(0.062)	(0.068)	(0.062)	(0.068)
ΔSG_t	0.042***	0.022	0.042***	0.023	0.041***	0.025*
	(0.012)	(0.014)	(0.012)	(0.014)	(0.012)	(0.014)
ΔAN_t	0.059	-0.057	0.060	-0.056	0.061	-0.049
	(0.049)	(0.056)	(0.049)	(0.056)	(0.049)	(0.057)
ΔESG_t	0.000	-0.000	0.000	-0.000	0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Constant	0.004	0.071***	0.004	0.069***	0.002	0.077***
	(0.009)	(0.010)	(0.012)	(0.013)	(0.016)	(0.015)
Industry FE		NO		YES		YES
Region FE		NO		NO		YES
Observations	4,562	4,562	4,562	4,562	4,562	4,562
R-squared	0.471	0.004	0.472	0.013	0.473	0.019
Kleigergen-Raap rk Wald F (Weak instruments test)		12.779		12.876		12.403

"**CD**" is the CDP's climate change questionnaire disclosure score; "**A2CI**" is the ratio of "scope1+scope2" carbon emissions (in thousand metric tonnes) from the CDP over firms' inflation-adjusted sales revenue (in million USD); "**$A2CIRIM_t(-)$**" is the region-industry mean of "$A2CI_t(-)$", excluding each firm's contribution to the mean; "**Q**" is firms' market to book ratio; "**FR**" measures firms' financial risk, calculated as firms' leverage level; "**CGRANK**" equals "2" if the highest level of direct responsibility for climate change mitigation in a firm is a subset of the board or some committee appointed by the board, it equals "1" if the highest level of direct responsibility for climate change mitigation in a firm is a manager or an officer, "0" otherwise; "**SIZE**" measures the economic scale of firms; "**IO**" is the institutional ownership of companies; "**SG**" is firms' sales growth; "**AN**" measures the newness of firms' properties, plants and equipment; "**ESG**" denotes Thomson Reuters' firm-specific environmental, social and governance (ESG) score.

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Overall, the results obtained in Table 5-3 after controlling for endogeneity suggest that, for the period under investigation, the increasing tendency in the improvement of firms' GHG performance causes a decreasing tendency in the subsequent improvement of the extensiveness of firms' voluntary GHG disclosure. This corresponds to the second theoretical prediction under legitimacy theory that firms would subsequently reduce GHG mitigating investment and GHG disclosure if they feel that their legitimacy is less threatened or is sufficiently maintained with achieved GHG performance improvement. The finding indicates that, for the period under investigation, firms' GHG disclosure would not change to promote firms' climate information transparency as a result of firms' continual involvement in GHG mitigating activities and firms' GHG mitigating performance improvement trajectory. Thus, **H6** is supported. It should be noted that this finding is also consistent with the global GHG disclosure-performance association evidence obtained in chapter 4. This further adds to the possibility *that the relationship between firms' environmental performance and corporate environmental disclosure is associated with the respective macro environmental disclosure circumstances in society*

Table 5-4 Panel A and Table 5-4 Panel B present the two-stage least squares regression results (imposing GMM option to allow for heteroscedasticity in the data) of the empirical model using B1CI and B2CI respectively to proxy for firms' GHG performance, drawing on $\Delta B1CIRIM_t(-)$ and $\Delta B2CIRIM_t(-)$ as the instruments for the independent variables of interest, which are $\Delta B1CI_t(-)$ and $\Delta B2CI_t(-)$. As B1CI and B2CI are calculated respectively based on "scope1" GHG emissions and "scope1+scope2" GHG emissions collected from a variety of other channels (corporate reports, webpages, online media, publications of research institutions etc.) by Thomson Reuters' Asset4 database, we could examine whether the results obtained above is sensitive to measurement differences of GHG emissions from different data sources. We could see that all the results shown in Table 5-4 Panel A and Table 5-4 Panel B indicate that there is no association between changes in firms' GHG performance and the subsequent changes in firms' voluntary GHG disclosure. The finding is consistent after controlling for industry-fixed effects and region-fixed effects in regression to factor out, in the second stage regression, any residual industry or/and region-specific trend effect in the first differenced dataset.

Table 5-4: Panel A. The results of the empirical model using B1CI as the GHG performance proxy-instrumental variables

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	First stage	ΔCD_{t+1}	First stage	ΔCD_{t+1}	First stage	ΔCD_{t+1}
$\Delta B1CI_t(-)$	-	-0.017	-	-0.025	-	-0.021
	-	(0.022)	-	(0.022)	-	(0.023)
$\Delta B1CIRIM_t(-)$	-18.744***	-	-18.890***	-	-19.012***	-
	(0.407)	-	(0.410)	-	(0.413)	-
ΔQ_t	-0.004	0.001	-0.004	0.002	-0.003	0.003
	(0.005)	(0.007)	(0.005)	(0.007)	(0.005)	(0.007)
ΔFR_t	-0.070**	-0.036	-0.066*	-0.042	-0.068*	-0.041
	(0.034)	(0.051)	(0.034)	(0.051)	(0.035)	(0.052)
CGRANK	-0.003	-0.008	-0.004	-0.008	-0.003	0.011*
	(0.003)	(0.006)	(0.003)	(0.006)	(0.004)	(0.006)
$\Delta SIZE_t$	0.001	0.010	0.001	0.012	0.000	0.012
	(0.006)	(0.010)	(0.006)	(0.010)	(0.007)	(0.010)
ΔIO_t	0.004	-0.017	0.004	-0.021	0.003	-0.020
	(0.025)	(0.034)	(0.025)	(0.035)	(0.025)	(0.035)
ΔROA_t	0.075*	-0.029	0.074*	-0.028	0.069	-0.029
	(0.042)	(0.070)	(0.043)	(0.070)	(0.043)	(0.070)
ΔSG_t	0.040***	0.027*	0.041***	0.028*	0.040***	0.031**
	(0.009)	(0.014)	(0.009)	(0.014)	(0.009)	(0.014)
ΔAN_t	0.039	-0.058	0.041	-0.056	0.042	-0.051
	(0.035)	(0.065)	(0.035)	(0.065)	(0.035)	(0.065)
ΔESG_t	0.000	-0.000	0.000	-0.000	0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Constant	0.007	0.072***	0.007	0.069***	0.014	0.074***
	(0.006)	(0.010)	(0.009)	(0.013)	(0.012)	(0.016)
Industry FE		NO		YES		YES
Region FE		NO		NO		YES
Observations	4,562	4,562	4,562	4,562	4,562	4,562
R-squared	0.519	0.007	0.521	0.016	0.525	0.021
Kleigergen-Raap rk Wald F (Weak instruments test)		65.506		66.657		67.858

"**CD**" is the CDP's climate change questionnaire disclosure score; "**B1CI**" is the ratio of "scope1" carbon emissions (in thousand metric tonnes) from Thomson Reuters' Asset4 over firms' inflation-adjusted sales revenue (in million USD); "**$B1CIRIM_t(-)$**" is the region-industry mean of "$B1CI_t(-)$", excluding each firm's contribution to the mean; "**Q**" is firms' market to book ratio; "**FR**" measures firms' financial risk, calculated as firms' leverage level; "**CGRANK**" equals "2" if the highest level of direct responsibility for climate change mitigation in a firm is a subset of the board or some committee appointed by the board, it equals "1" if the highest level of direct responsibility for climate change mitigation in a firm is a manager or an officer, "0" otherwise; "**SIZE**" measures the economic scale of firms; "**IO**" is the institutional ownership of companies; "**SG**" is firms' sales growth; "**AN**" measures the newness of firms' properties, plants and equipment; "**ESG**" denotes Thomson Reuters' firm-specific environmental, social and governance (ESG) score.

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 5-4: Panel B. The results of the empirical model using B2CI as the GHG performance proxy-instrumental variables

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	First stage	ΔCD_{t+1}	First stage	ΔCD_{t+1}	First stage	ΔCD_{t+1}
$\Delta B2CI_t(-)$	-	-0.010	-	-0.017	-	-0.014
	-	(0.015)	-	(0.016)	-	(0.016)
$\Delta B2CIRIM_t(-)$	-19.963***	-	-20.039***	-	-20.199***	-
	(0.452)	-	(0.454)	-	(0.458)	-
ΔQ_t	-0.016	0.002	-0.005	0.003	-0.005	0.003
	(0.026)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
ΔFR_t	0.305	-0.018	-0.066	-0.025	-0.070	-0.022
	(0.192)	(0.050)	(0.049)	(0.051)	(0.050)	(0.051)
CGRANK	0.001	-0.007	-0.004	-0.008	-0.003	0.011*
	(0.019)	(0.005)	(0.005)	(0.005)	(0.005)	(0.006)
$\Delta SIZE_t$	0.057	0.008	0.010	0.011	0.009	0.012
	(0.036)	(0.010)	(0.009)	(0.010)	(0.009)	(0.010)
ΔIO_t	0.194	-0.012	0.001	-0.016	0.004	-0.013
	(0.144)	(0.033)	(0.037)	(0.034)	(0.037)	(0.034)
ΔROA_t	0.134	-0.001	0.008	0.001	0.007	-0.002
	(0.243)	(0.070)	(0.062)	(0.069)	(0.063)	(0.069)
ΔSG_t	0.001	0.023	0.047***	0.024*	0.046***	0.027*
	(0.047)	(0.014)	(0.012)	(0.014)	(0.012)	(0.014)
ΔAN_t	0.017	-0.074	0.040	-0.070	0.046	-0.067
	(0.201)	(0.066)	(0.052)	(0.066)	(0.052)	(0.067)
ΔESG_t	-0.000	-0.000	0.000	-0.000	0.000	-0.000
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Constant	0.007	0.073***	0.002	0.069***	0.011	0.078***
	(0.009)	(0.010)	(0.013)	(0.013)	(0.017)	(0.016)
Industry FE		NO		YES		YES
Region FE		NO		NO		YES
Observations	4,562	4,562	4,562	4,562	4,562	4,562
R-squared	0.463	0.006	0.464	0.016	0.467	0.021
Kleigergen-Raap rk Wald F (Weak instruments test)		29.778		30.621		30.338

"**CD**" is the CDP's climate change questionnaire disclosure score; "**B2CI**" is the ratio of "scope1+scope2" carbon emissions (in thousand metric tonnes) from Thomson Reuters' Asset4 over firms' inflation-adjusted sales revenue (in million USD); "**$B2CIRIM_t(-)$**" is the region-industry mean of "$B2CI_t(-)$", excluding each firm's contribution to the mean; "**Q**" is firms' market to book ratio; "**FR**" measures firms' financial risk, calculated as firms' leverage level; "**CGRANK**" equals "2" if the highest level of direct responsibility for climate change mitigation in a firm is a subset of the board or some committee appointed by the board, it equals "1" if the highest level of direct responsibility for climate change mitigation in a firm is a manager or an officer, "0" otherwise; "**SIZE**" measures the economic scale of firms; "**IO**" is the institutional ownership of companies; "**SG**" is firms' sales growth; "**AN**" measures the newness of firms' properties, plants and equipment; "**ESG**" denotes Thomson Reuters' firm-specific environmental, social and governance (ESG) score.

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Although the results are still under legitimacy theory's prediction, the probable reason for these different findings could be that the data of the improvement of firms' underlying GHG performance from channels like corporate reports, webpages, online media etc. for the period under investigation have been intentionally beautified to give better impressions on shareholders and the wider stakeholders. Because the data have been beautified, firms' voluntary GHG disclosure from these channels do not contain any information about firms' underlying GHG performance. In this case, the beautified GHG data disclosure from these channels are merely used as a legitimising tool. These regression results reflect the descriptive statistics shown in Table 5-1 Panel B, where the improvement of GHG performance reported in the CDP's voluntary climate change questionnaire [ΔA1CI(-): mean=-0.001; ΔA2CI(-): mean=-0.002] is on average lower than that [ΔB1CI(-): mean=0.004; ΔB2CI(-): mean=0.000] reported through other channels (corporate reports, webpages, online media etc.).

In sum, all the empirical evidence obtained in this chapter supports legitimacy theory's prediction over the association between changes in firms' GHG performance and the subsequent changes in the extensiveness of firms' voluntary GHG disclosure. That is, the changes in the improvement of firms' GHG performance is negatively associated with the subsequent changes in the improvement of firms' voluntary GHG disclosure extensiveness. For the period under investigation, the increasing tendency in the improvement of firms' GHG performance causes a decreasing tendency in the subsequent improvement of the extensiveness of firms' voluntary GHG disclosure. This also corresponds to the negative association "in levels" evidence in the previous chapter regarding the relationship between firms' GHG performance and the extensiveness of firms' voluntary GHG disclosure for the period under investigation. Overall, the results obtained in this chapter indicate that firms mainly use GHG disclosure as a legitimising tool for their operations and a substitute for substantial continual involvement in climate change mitigation activities for the period under investigation.

5.5 Conclusions

Using a sample of 4562 "in changes" firm-year observations that corresponds to 1646 firms, 44 countries for years 2009-2014, this chapter investigates whether there is any influence of changes in firms' GHG mitigating achievement on potential subsequent changes in firms' voluntary GHG disclosure extensiveness. By examining this research question, we could see whether firms' GHG disclosure would change to promote climate information transparency as a result of the changes in firms' GHG mitigating performance trajectory. The empirical evidence from baseline models using OLS regression suggests that changes in firms' GHG performance do not contain any information of subsequent changes in the extensiveness of firms' voluntary GHG disclosure. However, after controlling for endogeneity, when using reported GHG emissions data from the CDP database, the results obtained indicate that the increasing tendency in the improvement of firms' GHG performance causes a decreasing tendency in the subsequent improvement of the extensiveness of firms' voluntary GHG disclosure for the period under investigation.

When using reported GHG emissions data obtained by Thomson Reuters' Asset4 database from other channels like corporate reports, webpages, online media and publications of research institutions etc., nevertheless, the results, after controlling for endogeneity, suggest that there is no association between changes in firms' GHG performance and subsequent changes in firms' voluntary GHG disclosure extensiveness. The probable reason for these different findings, when compared with the results obtained using reported GHG emissions data from the CDP database, could be that the data of the improvement of firms' underlying GHG performance from channels like corporate reports, webpages, online media and publications of research institutions etc. for the period under investigation have been intentionally beautified (as is shown by the descriptive statistics in Table 5-1 Panel B) to give better impressions on shareholders and the wider stakeholders. Because the data have been beautified, the changes in firms' GHG performance do not contain any information about the subsequent changes in the extensiveness of firms' voluntary GHG disclosure from these channels. In this case, the voluntary GHG information disclosure from these channels is merely used as a substitute for firms' real GHG mitigating efforts. However, even though the results obtained using GHG emissions data from other channels have changed, compared with those obtained using GHG emissions data from the CDP database. The results are still consistent with legitimacy theory's prediction.

Overall, because of the identified negative relationship between the improvement in firms' GHG performance and the subsequent improvement in the extensiveness of firms' voluntary GHG disclosure, it suggests that firms' GHG disclosure would not change to promote climate information transparency as a result of the changes in firms' GHG mitigating performance trajectory for the period under investigation. There is a tendency for firms' voluntary GHG disclosure to dissociate with firms' underlying GHG performance for the period under investigation. In addition, it is worth noting that the "in changes" evidence regarding the global relationship between firms' GHG performance and firms' GHG disclosure identified in this chapter is consistent with the "in levels" evidence regarding the global association pattern between firms' GHG performance and firms' GHG disclosure in the previous chapter. That is, for the period under investigation, legitimacy theory has predominant explanatory power over the association between firms' GHG performance and firms' GHG disclosure. For the period under investigation, firms all over the world prevailingly use voluntary GHG disclosure as a legitimising tool, a substitute for substantial climate change mitigation activities involvement, rather than a channel that reliably communicates firms' underlying GHG performance to climate change concerned shareholders and the wider stakeholders.

So far, although we know the global evidence indicates that, for the period under investigation, firms' voluntary GHG disclosure tends to dissociate with firms' underlying GHG performance, we do not know exactly how firms from developed economies and firms from developing economies contribute to such empirical evidence. As is documented in chapter 4, the global evidence as regards the association pattern between GHG performance, and the extensiveness of firms' voluntary GHG disclosure corresponds to a macro global GHG disclosure circumstance that is similar to **Phase2** of Table 1-1. However, the global evidence in chapter 4 is driven by firms from developed economies, this is because the empirical evidence regarding the relationship of interest from developed economies is consistent with the global evidence. However, the empirical evidence regarding the relationship of interest from developing economies corresponds to a macro GHG disclosure circumstance that is similar to **Phase1** of Table 1-1. All the evidence obtained in chapter 4 adds to the possibility *that the different association patterns between firms' environmental performance and corporate environmental disclosure are associated with the respective macro environmental disclosure circumstances in society*. In line with which, it is expected that the global evidence obtained in chapter 5 could also be driven by firms from developed economies. Thus, the roles that firms from developed economies and firms from developing economies play in the contribution to the global evidence identified in chapter 5 would be explored in the next chapter.

6. GHG Disclosure and GHG Performance: Divergence or Convergence? A Comparative Analysis between Developing Economies and Developed Economies

6.1 Introduction

Social and environmental accounting (SEA) related topics have attracted a vibrant community of researchers from all over the world for the past few decades (Deegan, 2017). Particularly, the disclosure of SEA information has been a major research area of interest. One of the established interests as regards SEA information disclosure focuses on the drivers (determinants) that make firms to disclose SEA information and related reporting characteristics (Belal, 2000; Tsamenyi et al., 2007; Wanderley et al., 2008; Reverte, 2009; Martinsson et al., 2013; Ali and Frynas, 2018). Another research area of interest regarding SEA information disclosure, as is mentioned in previous chapters, focuses on the examination of the association between environmental performance and environmental disclosure to see if corporate environmental disclosure could reliably reflect firms' underlying environmental performance (Ingram and Frazier, 1980; Wiseman, 1982; Freedman and Wasley, 1990; Li et al., 1997; Bewley and Li, 2000; Al-Tuwaijri et al., 2004; Clarkson et al., 2008; Luo and Tang, 2014; Luo, 2019). The commonality of these studies is that they mainly adopt a single country (region)-specific or a similar social and economic development level-specific/similar economic scale-specific point of view, thus, the evidence obtained is largely discrete, contradictory, and not generalisable.

Recently, there have been comparative studies that compare the differences of CSR disclosure drivers (determinants) between developing economies and developed economies based on either empirical analyses (Luo et al., 2013; Sierra-García et al., 2015) or reviewing and summarising prior studies employing single country/region data (Fifka, 2013; Ali et al., 2017). However, little evidence has been provided on the differences of CSR related disclosure-performance relationship between developing economies and developed economies. In chapter 4, the differences of the non-causal GHG disclosure-performance association between developing economies and developed economies have been investigated based on the fact that there are significant differences between developed economies and developing economies as regards their respective GHG disclosure circumstances at current stage. Further in chapter 5, although the international empirical evidence suggests that, for

the period under investigation, the increasing tendency in the improvement of firms' GHG performance causes a decreasing tendency in the subsequent improvement of the extensiveness of firms' voluntary GHG disclosure, we do not know how firms from developed economies and firms from developing economies contribute to the empirical evidence. In addition, many differences haven been documented in prior studies between firms from developing economies and firms from developed economies regarding social and economic development characteristics and the consequent CSR behaviour patterns (Jamali and Karam, 2016; Jamali and Karam, 2018; Ali and Frynas, 2018). For the same research question "Would changes in GHG performance cause any subsequent changes in GHG disclosure strategy?", it is also expected that the empirical evidence obtained, for the same period under investigation, would differ between developing economies and developed economies.

This chapter investigates if there is also a significant difference of empirical evidence regarding the research question in chapter 5 between developing economies and developed economies. The data employed in this chapter is the same as the international dataset used in chapter 5. However, this global dataset is further split into 452 observations from developing economies corresponding to 237 firms and 4110 observations from developed economies corresponding to 1409 firms. Depending on the findings obtained in this chapter, we could know what kind of roles firms from developing economies and firms from developed economies respectively play in contribution to the international evidence identified as regards the research question of interest in chapter 5. The rest of the chapter would unfold as follows: section6.2 first reviews theoretical discussions and related literature, following which the hypotheses of interest would be advanced, section6.3 introduces and explains the data employed, the sampling method, the empirical model and the variables used in this chapter, section6.4 analyses the empirical evidence obtained to test the hypotheses advanced. In the end, section6.5 presents the conclusions of this chapter.

6.2 Literature Review and Hypotheses

For the literature review and hypotheses of chapter 6, please refer back to section2.2.3.

6.3 Research Design

After deducing the hypotheses in this chapter, based on the relevant evidence in the extant literature, this section guides readers from the narrative to the methods used to test the hypotheses. Again, firstly, the data used, data source and the sampling method would be specified and explained in turn. Secondly, the empirical model employed and the variables included would be presented to conclude this section.

6.3.1 Sample and Data

To test the hypotheses above, I use the same dataset that was used for the analyses in chapter 5. This dataset is selected from all the firms that have been involved in the CDP's climate change project for years 2010-2015 (N.B. the CDP collects GHG emissions related data from involved firms for years 2009-2014 through their climate change questionnaire for years 2010-2015; firms involved include those who have been asked by the CDP to participate in the CDP climate change questionnaire and those who self-selected themselves to participate in the CDP's climate change questionnaire). This time the full reduced sample (the full reduced sample is relative to the full sample of 25967 firm-year observations corresponding to 5622 firms, 78 countries in section 3.1.3) of 6366 firm-year observations corresponding to 1646 firms, 44 countries is again firstly transformed by the process of first differencing. After the process of first-differencing of the data, the first-differenced form of the full reduced sample corresponding to 4562 firm-year observation, 1644 firms, 44 countries is produced. Again, in addition to the scope1 and scope2 GHG emissions data from the CDP's database, for the 1646 firms included in the sample, alternative scope1 and scope2 GHG emissions data, collected by Thomson Reuters' Asset4 database from various other data sources are also used to create a parallel set of GHG performance proxies to control for measurement errors of GHG emissions data from different channels.

Consistent with the criterion used to divide the sample into developing economies and developed economies subsamples in chapter 4, whether a country is a member of the

OECD's Development Assistance Committee (DAC) is chosen as the criterion to split the sample. This criterion is selected, because the criteria used to gauge whether a country or territory could be considered a developed economy include but not limited to a number of different aspects, such as "gross domestic product (GDP)", "gross national product (GNP)", "per capita income", "industrialization level", "widespread infrastructure level" and "general living standard" etc.(Investopedia, 2019). And different professional entities (UN HDI; World Bank; IMF etc.) have produced their specific lists of developed economies based on various methodologies considering different set of relevant criteria. However, countries that are members of the DAC are consistently included in different lists of developed economies. Choosing this criterion to split the sample into developing economies and developed economies subgroups avoids disputes between different lists of developed economies. Consequently, the 4562 firm-year observations are further split into 452 observations from developing economies that correspond to 237 firms, and 4110 observations from developed economies that correspond to 1409 firms.

6.3.2 Empirical Model and Variables

For the explanation of empirical model used to examine the hypotheses advanced in this chapter and the variables included in the empirical model, please refer back to section3.2.2.

6.4 Results

In this section, firstly, the relevant information from summary statistics between developing economies and developed economies would be compared and analysed. Secondly, the results obtained from baseline models would be compared and analysed between developing economies and developed economies. Finally, after controlling the impact of potential endogeneity problem on the empirical evidence obtained, the major differences as regards the evidence on the research question between developing economies and developed economies would be analysed and summarised.

6.4.1 Implications from Summary Statistics

Table 6-1 Panel A presents a comparison of the descriptive statistics of undifferenced CDP climate change disclosure scores, the undifferenced four measures of GHG intensity between the developing economies subsample and the developed economies subsample. For both subsamples, we could see that the standard deviation of the CDP's disclosure score (**DEV=0**: 17.460; **DEV=1**: 19.913) is much lower than the mean (**DEV=0**: 79.643; **DEV=1**: 75.532) of it, this indicates that the variations between different observations of this variable is not large. The means (**DEV=0**: 79.643; **DEV=1**: 75.532) of both subsamples are above 75 points on a 100 points scale, indicating that both in developing economies and developed economies, overall firms that are on the high end of the disclosure score spectrum tend to make their disclosure scores public. For both subsamples, the standard deviation of all four GHG intensity measures are all larger than their respective means (**DEV=0**: A1CI: mean=0.336, SD=0.559; B1CI: mean=0.344, SD=0.597; A2CI: mean=0.512, SD=0.667; B2CI: mean=0.547, SD=0.741; **DEV=1**: A1CI: mean=0.171, SD=0.380; B1CI: mean=0.199, SD=0.435; A2CI: mean=0.223, SD=0.432; B2CI: mean=243, SD=0.490), there is considerable variation of these GHG intensity measures. Also, the values of all four GHG intensity measures for the developing economies are larger than those of all four GHG intensity measures for the developed economies. This indicates that, for the period under investigation, firms in developing economies generally have worse GHG performance, compared with their counterpart in developed economies. In addition, we could see that, for both subsamples, the disclosed carbon intensity from the CDP's climate change project (**DEV=0**: A1CI: mean=0.336, median=0.073; A2CI: mean=0.512, median=0.191; **DEV=1**: A1CI: mean=0.171, median=0.014; A2CI: mean=0.223, median=0.042) is on average slightly lower than those (**DEV=0**: B1CI: mean=0.344, median=0.086; B2CI: mean=0.547, median=0.206; **DEV=1**: B1CI: mean=0.199, median=0.016; B2CI: mean=0.243, median=0.045) from other channels (corporate reports, webpages, online media etc.). The differences of the same scope of GHG intensity from different channels indicate that it is necessary to see if the obtained regression results would be sensitive to these identified differences.

Comparing the means of disclosure scores between the developing subsample and the developed subsample, we could see that firms from developing economies generally significantly (t-stat p-value<0.01; Wilcoxon p-value<0.01) disclose more extensively (**DEV=0**: CD: mean=79.643, median=83) about their GHG emissions information than

firms from developed economies (**DEV=1**: CD: mean=75.532, median=79) through the CDP's voluntary climate change questionnaires. This disclosing pattern is coupled with the fact that for all four measures of GHG intensity, firms from developing economies on average have significantly (t-stat p-value<0.01; Wilcoxon p-value<0.01) higher GHG intensity (**DEV=0**: A1CI: mean=0.336, median=0.073; B1CI: mean=0.344, median=0.086; A2CI: mean=0.512, median=0.191; B2CI: mean=0.547, median=0.206) than firms from developed economies (**DEV=1**: A1CI: mean=0.171, median=0.014; B1CI: mean=0.199, median=0.016; A2CI: mean=0.223, median=0.042; B2CI: mean=0.243, median=0.045). For one thing, this indicates that firms with higher GHG emissions per thousand USD tend to voluntarily disclose more about their GHG information. This is consistent with legitimacy theories argument. For another, this indicates that it would be of interest and necessity to see if there is any specific characteristics for firms from developing economies and firms from developed economies respectively as regards the empirical evidence of the research question of interest.

Table 6-1 Panel B presents a comparison of the descriptive for variables in their first differenced form between developing economies and developed economies. The signs of the changes of all four first-differenced GHG intensity measures are reversed, so that they could be intuitively explained as improvement in GHG performance, and the higher the value of the sign-inversed first-differenced GHG intensity is, the better the improvement in GHG performance. Specifically, in contrast with the undifferenced GHG intensity measures in Table 6-1 Panel A, we could see that for both subsamples, the improvement of GHG performance reported in the CDP's voluntary climate change questionnaire [**DEV=0**: ΔA1CI(-): mean=-0.013; ΔA2CI(-): mean=-0.016; **DEV=1**: ΔA1CI(-): mean=-0.001; ΔA2CI(-): mean=-0.002] is on average lower than that [**DEV=0**: ΔB1CI(-): mean=-0.012; ΔB2CI(-): mean=-0.015; **DEV=1**: ΔB1CI(-): mean=0.004; ΔB2CI(-): mean=0.000] reported through other channels (corporate reports, webpages, online media etc.). Consistent with the descriptive of the full reduced sample in chapter 5, This indicates that firms tend to exaggerate their performance improvement in channels like corporate reports, webpages, online media etc. at incremental (changes) level to give better impressions on outside information users (shareholders and the wider stakeholders), regardless of their current GHG performance improvement level.

Table 6-1: Panel A. Descriptive statistics of overall corporate GHG profile for the developing economies subsample and the developed economies subsample

Variable	DEV=0					DEV=1					t-stat p-value	Wilcoxon p-value
	Mean	Q1	Median	Q3	Std.Dev.	Mean	Q1	Median	Q3	Std.Dev.		
	n=452 (237 firms)					n=4110 (1409 firms)						
CD	79.643	70.000	83.000	94.000	17.460	75.532	64.000	79.000	92.000	19.913	p<0.01	p<0.01
A1CI	0.336	0.009	0.073	0.296	0.559	0.171	0.003	0.014	0.105	0.380	p<0.01	p<0.01
B1CI	0.344	0.011	0.086	0.285	0.597	0.199	0.004	0.016	0.150	0.435	p<0.01	p<0.01
A2CI	0.512	0.049	0.191	0.669	0.667	0.223	0.016	0.042	0.197	0.432	p<0.01	p<0.01
B2CI	0.547	0.056	0.206	0.668	0.741	0.243	0.018	0.045	0.217	0.490	p<0.01	p<0.01

"**CD**" is the CDP's climate change questionnaire disclosure score; "**A1CI**" is the ratio of scope1 carbon emissions (in thousand metric tonnes) from the CDP over firms' inflation-adjusted sales revenue (in million USD); "**B1CI**" is the ratio of scope1 carbon emissions (in thousand metric tonnes) from Thomson Reuters' Asset4 database over firms' inflation-adjusted sales revenue (in million USD); "**A2CI**" is the ratio of (scope1+scope2) carbon emissions (in thousand metric tonnes) from the CDP over firms' inflation-adjusted sales revenue (in million USD); "**B2CI**" is the ratio of (scope1+scope2) carbon emissions (in thousand metric tonnes) from Thomson Reuters' Asset4 database over firms' inflation-adjusted sales revenue (in million USD); "**DEV**" is a dummy that equals "1" if a country is a member of "DAC", "0" otherwise.

Table 6-1: Panel B. Descriptive statistics of variables for the developing economies subsample and the developed economies subsample

Variable	DEV=0					DEV=1					t-stat p-value	Wilcoxon p-value
	Mean	Q1	Median	Q3	Std.Dev.	Mean	Q1	Median	Q3	Std.Dev.		
	n=452 (237 firms)					n=4110 (1409 firms)						
ΔCD	0.063	0.010	0.050	0.110	0.102	0.059	0.000	0.040	0.100	0.102	insig	insig
ΔA1CI(-)	-0.013	-0.008	-0.000	0.001	0.135	-0.001	-0.001	0.000	0.001	0.112	p<0.05	p<0.01
ΔB1CI(-)	-0.012	-0.008	0.000	0.004	0.153	0.004	-0.001	0.000	0.002	0.114	p<0.05	p<0.01
ΔA2CI(-)	-0.016	-0.022	0.000	0.006	0.190	-0.002	-0.004	0.000	0.003	0.137	p<0.05	p<0.01
ΔB2CI(-)	-0.015	-0.026	-0.001	0.006	0.203	0.000	-0.004	0.000	0.004	0.141	p<0.05	p<0.01
CGRANK	1.778	2.000	2.000	2.000	0.463	1.848	2.000	2.000	2.000	0.390	p<0.01	insig
ΔQ	-0.012	-0.177	0.001	0.166	0.582	0.030	-0.091	0.025	0.163	0.399	p<0.05	p<0.05
ΔROA	-0.006	-0.022	-0.002	0.011	0.043	-0.001	-0.014	0.000	0.014	0.039	p<0.01	p<0.01
ΔFR	0.005	-0.019	0.003	0.030	0.054	0.001	-0.020	0.000	0.018	0.050	p<0.1	p<0.01
ΔAN	-0.009	-0.026	-0.010	0.008	0.047	-0.007	-0.021	-0.007	0.007	0.047	insig	p<0.05
ΔSG	-0.030	-0.151	-0.027	0.093	0.231	-0.010	-0.118	-0.014	0.080	0.195	p<0.05	insig
ΔSIZE	0.018	-0.162	0.044	0.231	0.336	0.071	-0.084	0.085	0.239	0.302	p<0.01	p<0.01
ΔIO	-0.001	-0.002	0.000	0.001	0.085	0.003	-0.002	0.000	0.003	0.055	insig	insig
ΔESG	-0.085	-4.705	0.325	5.785	13.570	0.485	-4.480	0.340	5.710	14.620	insig	insig

"**CD**" is the CDP's climate change questionnaire disclosure score; "**A1CI**" is the ratio of "scope1" carbon emissions (in thousand metric tonnes) from the CDP over firms' inflation-adjusted sales revenue (in million USD); "**B1CI**" is the ratio of "scope1" carbon emissions (in thousand metric tonnes) from Thomson Reuters' Asset4 database over firms' inflation-adjusted sales revenue (in million USD); "**A2CI**" is the ratio of "scope1+scope2" carbon emissions (in thousand metric tonnes) from the CDP over firms' inflation-adjusted sales revenue (in million USD); "**B2CI**" is the ratio of "scope1+scope2" carbon emissions (in thousand metric tonnes) from Thomson Reuters' Asset4 database over firms' inflation-adjusted sales revenue (in million USD); "**CGRANK**" equals "2" if the highest level of direct responsibility for climate change mitigation in a firm is a subset of the board or some committee appointed by the board, it equals "1" if the highest level of direct responsibility for climate change mitigation in a firm is a manager or an officer, "0" otherwise; "**Q**" is firms' market to book ratio, calculated as the ratio of market value of common equity of a firm (in million USD) plus the book value of its common equity (in million USD) minus the book value of its total assets (in million USD) over the book value of its total assets; "**ROA**" is firms' return on assets, calculated as the ratio of income before extraordinary items (in million USD) of the current year over the total assets (in million USD) at the end of last year; "**FR**" measures firms' financial risk, calculated as firms' leverage level, which equals firms' book value of total debt including current (in million USD) over firms' book value of total assets (in million USD); "**AN**" measures the newness of firms' properties, plants and equipment, calculated as the ratio of a firm's net properties, plant and equipment (in million USD) at each year end over its gross properties, plant and equipment (in million USD) at each year-end; "**SG**" is firms' sales growth, it is calculated as the difference of sales revenue in million USD at "t" and sales revenue in million USD at "t-1" over sales revenue in million USD at "t-1"; "**SIZE**" measures the economic scale of firms, calculated as the natural log of the market value (in million USD) of the equity of a firm; "**IO**" is the institutional ownership of companies, calculated as the shares of a company owned by institutional investors over all shares outstanding of a company; "**ESG**" denotes Thomson Reuters' firm-specific environmental, social and governance (ESG) score; "**DEV**" is a dummy that is equal to "1" if a country is a member of "DAC", "0" otherwise.

The above observation is consistent with what is observed for the full reduced sample in chapter 5 that GHG performance improvement data presented in the channels like corporate reports, webpages, online media etc. are largely beautified, compared with the GHG performance improvement data disclosed through the CDP's voluntary climate change questionnaire. This further extends Depoers et al. (2016)'s finding in France that large French firms tend to downplay their climate change impact in corporate reports to firms in developing economies and firms in other developed economies. That is, for both firms in developing economies and firms in developed economies, it is a prevailing practice to beautify firms' GHG performance data at incremental (changes) level to make a better impression on shareholders and the wider stakeholders regarding firms' GHG management and performance in channels like corporate reports, website disclosure or online media. This is probably because that these channels are literally the most accessible and cost-effective ways for shareholders and the wider stakeholders who are climate change concerned to know how firms manage their GHG impact. It should be noted that this finding is consistent with legitimacy theory's argument and the differences of reported changes of GHG performance in different channels may also be reflected in the regression results for both subsamples.

Comparing the descriptive statistics of the improvement of GHG performance between developing economies and developed economies, we could see that firms from developed economies generally have significantly (t-stat p-value<0.1; Wilcoxon p-value<0.1) better improvement in GHG performance [**DEV=1**: ΔA1CI(-): mean=-0.001; ΔB1CI(-): mean=0.004; ΔA2CI(-): mean=-0.002; ΔB2CI(-): mean=0.000] for the period under investigation than firms from developing economies [**DEV=0**: ΔA1CI(-): mean=-0.013; ΔB1CI(-): mean=-0.012; ΔA2CI(-): mean=-0.016; ΔB2CI(-): mean=-0.015]. This is consistent with what is observed in Table 6-1 Panel A that firms from developing economies on average have significantly higher GHG intensity than firms from developed economies. Also, firms from developed economies on average have a significantly (t-stat p-value<0.01) higher rank of corporate management infrastructure construction level related to climate change mitigation within a firm (**DEV=1**: CGRANK: mean=1.848) than firms from developing economies do (**DEV=0**: CGRANK: mean=1.778).

For improvement in firms' market to book ratio, we could see that, for the period under investigation, the average changes of Tobin's Q of firms from developing economies is negative (**DEV=0**: ΔQ: mean=-0.012), meaning an overall decrement of firms' market to book ratio. However, the average changes of Tobin's Q of firms from developed economies is positive (**DEV=1**: ΔQ: mean=0.030), meaning an overall increment of firms' market to

book ratio. This indicates that firms' financial performance is steadier in developed economies than that in developing economies from the perspective of market valuation. Consistent with what is observed for the changes in firms' market to book ratio, although, for the period under investigation, firms' average return on assets has seen a decrement for both firms from developed economies and firms from developing economies. The degree of decrement of return on assets for firms from developed economies (**DEV=1**: ΔROA: mean=-0.001) is on average significantly (t-stat p-value<0.01) lower than that (**DEV=0**: ΔROA: mean=-0.006) for firms from developing economies. Accordingly, we could see that the average increment of financial risks for firms from developing economies (**DEV=0**: ΔFR: mean=0.005) is significantly (t-stat p-value<0.1) higher than that (**DEV=1**: ΔFR: mean=0.001) for firms from developed economies for the period under investigation.

In line with what is observed for the changes of ROA and FR, firms from developed economies have seen significantly (t-stat p-value<0.05) less decrement of sales growth (**DEV=1**: ΔSG: mean=-0.010) compared with their counterpart from developing economies (**DEV=0**: ΔSG: mean=-0.030). The average increment of economic scale for firms from developed economies (**DEV=1**: ΔSIZE: mean=0.071) is significantly (t-stat p-value<0.01) higher than that (**DEV=0**: ΔSIZE: mean=0.018) for firms from developing economies. For most variables included in the empirical model, there is a significant difference between the means of changes of the same variable between firms from developed economies and firms from developing economies.

Table 6-2: Panel A. Correlation coefficients of the variables for the developing economies subsample

	ΔCD_{t+1}	$\Delta A1CI_t(-)$	$\Delta A2CI_t(-)$	$\Delta B1CI_t(-)$	$\Delta B2CI_t(-)$	ΔQ_t	ΔFR_t	CGRANK	$\Delta SIZE_t$	ΔIO_t	ΔROA_t	ΔSG_t	ΔAN_t	ΔESG_t
ΔCD_{t+1}		0.009	0.047	0.044	-0.007	0.032	-0.042	-0.058	*0.153*	-0.003	0.065	0.003	-0.061	0.026
$\Delta A1CI_t(-)$	0.065		**0.705**	*0.128*	**0.386**	-0.016	-0.051	0.023	-0.015	-0.014	**0.158**	0.002	0.067	0.004
$\Delta A2CI_t(-)$	-0.119	**0.718**		**0.333**	**0.551**	-0.026	-0.034	-0.002	0.003	-0.031	**0.137**	*0.106*	0.054	-0.051
$\Delta B1CI_t(-)$	0.061	**0.609**	**0.365**		**0.779**	-0.021	0.012	0.011	-0.018	-0.031	**0.269**	*0.121*	*0.106*	-0.081
$\Delta B2CI_t(-)$	-0.073	**0.435**	**0.563**	**0.711**		-0.001	0.017	0.004	-0.005	-0.097	**0.274**	**0.271**	0.046	-0.082
ΔQ_t	0.147	0.108	0.104	0.091	0.144		**-0.318**	0.061	**0.592**	0.063	**0.311**	*0.105*	-0.051	-0.052
ΔFR_t	-0.167	-0.029	-0.093	0.028	-0.006	**-0.646**		-0.028	**-0.221**	-0.001	**-0.281**	0.029	**0.106**	0.001
CGRANK	0.035	-0.047	0.186	-0.069	-0.164	-0.016	0.038		0.071	-0.026	-0.018	0.059	-0.024	-0.003
$\Delta SIZE_t$	0.198	0.198	*0.266*	0.167	0.252	**0.688**	**-0.334**	0.021		0.002	0.433	0.295	0.105	-0.059
ΔIO_t	0.194	0.011	0.103	-0.002	0.016	-0.003	0.007	0.001	-0.021		-0.021	-0.049	0.006	0.013
ΔROA_t	*0.263*	0.131	*0.309*	0.183	0.211	**0.395**	**-0.334**	0.043	**0.543**	-0.066		**0.352**	0.016	-0.058
ΔSG_t	0.055	0.058	*0.266*	0.116	**0.374**	0.149	0.062	-0.016	**0.396**	-0.106	**0.421**		0.035	-0.071
ΔAN_t	-0.185	*0.291*	0.235	*0.287*	0.117	-0.203	*0.272*	0.225	0.113	-0.043	0.041	0.091		-0.029
ΔESG_t	0.158	-0.114	-0.218	-0.042	-0.087	-0.212	-0.005	*-0.268*	-0.204	-0.218	0.068	-0.125	0.043	

"**CD**" is the CDP's climate change questionnaire disclosure score; "**A1CI**" is the ratio of "scope1" carbon emissions (in thousand metric tonnes) from the CDP over firms' inflation-adjusted sales revenue (in million USD); "**A2CI**" is the ratio of "scope1+scope2" carbon emissions (in thousand metric tonnes) from the CDP over firms' inflation-adjusted sales revenue (in million USD); "**B1CI**" is the ratio of "scope1" carbon emissions (in thousand metric tonnes) from Thomson Reuters' Asset4 database over firms' inflation-adjusted sales revenue (in million USD); "**B2CI**" is the ratio of "scope1+scope2" carbon emissions (in thousand metric tonnes) from Thomson Reuters' Asset4 database over firms' inflation-adjusted sales revenue (in million USD); "**Q**" is firms' market to book ratio, calculated as the ratio of market value of common equity of a firm (in million USD) plus the book value of its common equity (in million USD) minus the book value of its total assets (in million USD) over the book value of its total assets; "**FR**" measures firms' financial risk, calculated as firms' leverage level, which equals firms' book value of total debt including current (in million USD) over firms' book value of total assets (in million USD); "**CGRANK**" equals "2" if the highest level of direct responsibility for climate change mitigation in a firm is a subset of the board or some committee appointed by the board, it equals "1" if the highest level of direct responsibility for climate change mitigation in a firm is a manager or an officer, "0" otherwise; "**SIZE**" measures the economic scale of firms, calculated as the natural log of the market value (in million USD) of the equity of a firm; "**IO**" is the institutional ownership of companies, calculated as the shares of a company owned by institutional investors over all shares outstanding of a company; "**ROA**" is firms' return on assets, calculated as the ratio of income before extraordinary items (in million USD) of the current year over the total assets (in million USD) at the end of last year; "**SG**" is firms' sales growth, it is calculated as the difference of sales revenue in million USD at "t" and sales revenue in million USD at "t-1" over sales revenue in million USD at "t-1"; "**AN**" measures the newness of firms' properties, plants and equipment, calculated as the ratio of a firm's net properties, plant and equipment (in million USD) at each year end over its gross properties, plant and equipment (in million USD) at each year-end; "**ESG**" denotes Thomson Reuters' firm-specific environmental, social and governance (ESG) score.

Spearman rank correlation coefficients are below the diagonal, Pearson correlation coefficients are above the diagonal.

Coefficients in bold are significant at p<0.01; Coefficients in italic are significant at p<0.05; Coefficients with underscore are significant at p<0.1.

Table 6-2: Panel B. Correlation coefficients of the variables for the developed economies subsample

	ΔCD_{t+1}	$\Delta A1CI_t(-)$	$\Delta A2CI_t(-)$	$\Delta B1CI_t(-)$	$\Delta B2CI_t(-)$	ΔQ_t	ΔFR_t	CGRANK	$\Delta SIZE_t$	ΔIO_t	ΔROA_t	ΔSG_t	ΔAN_t	ΔESG_t
ΔCD_{t+1}		0.005	0.008	0.012	0.004	0.032	-0.016	-0.011	0.031	-0.004	*0.038*	**0.047**	-0.023	-0.015
$\Delta A1CI_t(-)$	-0.047		**0.941**	**0.683**	**0.427**	0.004	**-0.041**	-0.011	*0.045*	-0.004	**0.071**	**0.109**	0.019	0.021
$\Delta A2CI_t(-)$	-0.029	**0.821**		**0.627**	**0.481**	0.004	-0.026	-0.008	**0.053**	-0.001	**0.065**	**0.104**	0.009	0.017
$\Delta B1CI_t(-)$	*-0.063*	**0.768**	**0.686**		**0.904**	0.009	-0.017	-0.021	**0.078**	0.004	**0.077**	**0.137**	0.026	0.017
$\Delta B2CI_t(-)$	-0.029	**0.649**	**0.791**	**0.777**		0.017	-0.006	-0.019	**0.087**	0.001	**0.061**	**0.122**	**0.043**	0.015
ΔQ_t	0.051	0.026	0.048	0.043	0.044		**-0.282**	0.012	**0.587**	**-0.095**	**0.159**	**0.079**	**-0.052**	-0.001
ΔFR_t	-0.004	-0.049	-0.032	*-0.053*	-0.047	**-0.343**		-0.025	**-0.135**	0.015	**-0.241**	-0.009	**-0.038**	-0.029
CGRANK	-0.042	-0.027	-0.032	-0.033	-0.027	0.013	*-0.053*		**-0.053**	-0.001	-0.001	-0.026	-0.001	-0.002
$\Delta SIZE_t$	0.046	**0.108**	**0.157**	**0.121**	**0.157**	**0.803**	**-0.185**	-0.018		*-0.034*	**0.274**	**0.223**	**0.071**	0.019
ΔIO_t	0.011	-0.019	0.006	-0.007	0.006	0.014	0.006	0.021	0.032		-0.018	0.028	0.015	-0.021
ΔROA_t	0.014	**0.153**	**0.191**	**0.177**	**0.196**	**0.298**	**-0.234**	-0.014	**0.325**	*-0.058*		**0.328**	**0.073**	0.021
ΔSG_t	0.037	**0.249**	**0.306**	**0.297**	**0.331**	**0.146**	*-0.063*	-0.009	**0.262**	-0.022	**0.375**		0.022	-0.022
ΔAN_t	-0.041	0.024	0.036	0.034	0.036	**-0.121**	*0.061*	0.026	0.008	-0.006	0.028	-0.001		0.031
ΔESG_t	-0.003	0.025	0.018	0.029	0.017	-0.017	-0.011	-0.014	0.011	0.019	0.011	-0.006	0.033	

"**CD**" is the CDP's climate change questionnaire disclosure score; "**A1CI**" is the ratio of "scope1" carbon emissions (in thousand metric tonnes) from the CDP over firms' inflation-adjusted sales revenue (in million USD); "**A2CI**" is the ratio of "scope1+scope2" carbon emissions (in thousand metric tonnes) from the CDP over firms' inflation-adjusted sales revenue (in million USD); "**B1CI**" is the ratio of "scope1" carbon emissions (in thousand metric tonnes) from Thomson Reuters' Asset4 database over firms' inflation-adjusted sales revenue (in million USD); "**B2CI**" is the ratio of "scope1+scope2" carbon emissions (in thousand metric tonnes) from Thomson Reuters' Asset4 database over firms' inflation-adjusted sales revenue (in million USD); "**Q**" is firms' market to book ratio, calculated as the ratio of market value of common equity of a firm (in million USD) plus the book value of its common equity (in million USD) minus the book value of its total assets (in million USD) over the book value of its total assets; "**FR**" measures firms' financial risk, calculated as firms' leverage level, which equals firms' book value of total debt including current (in million USD) over firms' book value of total assets (in million USD); "**CGRANK**" equals "2" if the highest level of direct responsibility for climate change mitigation in a firm is a subset of the board or some committee appointed by the board, it equals "1" if the highest level of direct responsibility for climate change mitigation in a firm is a manager or an officer, "0" otherwise; "**SIZE**" measures the economic scale of firms, calculated as the natural log of the market value (in million USD) of the equity of a firm; "**IO**" is the institutional ownership of companies, calculated as the shares of a company owned by institutional investors over all shares outstanding of a company; "**ROA**" is firms' return on assets, calculated as the ratio of income before extraordinary items (in million USD) of the current year over the total assets (in million USD) at the end of last year; "**SG**" is firms' sales growth, it is calculated as the difference of sales revenue in million USD at "t" and sales revenue in million USD at "t-1" over sales revenue in million USD at "t-1"; "**AN**" measures the newness of firms' properties, plants and equipment, calculated as the ratio of a firm's net properties, plant and equipment (in million USD) at each year end over its gross properties, plant and equipment (in million USD) at each year-end; "**ESG**" denotes Thomson Reuters' firm-specific environmental, social and governance (ESG) score.

Spearman rank correlation coefficients are below the diagonal, Pearson correlation coefficients are above the diagonal.

Coefficients in bold are significant at p<0.01; Coefficients in italic are significant at p<0.05; Coefficients with underscore are significant at p<0.1.

Table 6-2 Panel A and Table 6-2 Panel B present the pair-wise correlation coefficients between the variables used in the empirical model for the developing economies subsample and the developed economies subsample respectively. Above (Below) the diagonal are the Pearson (Spearman rank) correlation coefficients. Specifically, we could see that, for firms from developing economies (see Table 6-2 Panel A), there is no significant univariate correlation between the improvement of firms' GHG performance in all four measures and the subsequent improvement of the extensiveness of firms' voluntary GHG disclosure in both Pearson correlation matrix and Spearman rank correlation matrix. This indicates that **H8** could be true for the developing economies subsample. For firms from developed economies (see Table 6-2 Panel B), although, in the Pearson correlation test, no significant correlation between the improvement of firms' GHG performance and the subsequent improvement of the extensiveness of firms' voluntary GHG disclosure has been identified, scope1 GHG performance improvement (Spearman rank: $\Delta A1CI_t(-)\&\Delta CD_{t+1}$ correlation coefficient=-0.047, $p<0.1$; $\Delta B1CI_t(-)\&\Delta CD_{t+1}$ correlation coefficient=-0.063, $p<0.05$) has been found to be significantly negatively correlated with the subsequent improvement of the extensiveness of firms' voluntary GHG disclosure in Spearman rank correlation test. This indicates that **H9** could be partially true for firms from developed economies, however, the evidence needs to be further confirmed considering the influences of other related factors and potential endogeneity problems.

6.4.2 Baseline Models Tests for Hypotheses Using OLS

Table 6-3 Panel A and Table 6-3 Panel B present comparisons of the results of the empirical model between developing economies and developed economies obtained from pooled OLS[32] regression, using "scope1" [$\Delta A1CI_t(-)$, $\Delta B1CI_t(-)$] and "scope1+scope2" [$\Delta A2CI_t(-)$, $\Delta B2CI_t(-)$] GHG emissions intensity for the period under investigation. Specifically, Table 6-3 Panel A presents the group of baseline models that only control for industry fixed effects, Table 6-3 Panel B presents the group of baseline models that control for both industry fixed effects and region fixed effects. The reason for controlling industry fixed effects and region fixed effects in changes models is, as is mentioned in chapter 5, that

[32] Please refer back to footnote 31 for the reason why only results from OLS are reported.

Table 6-3: Panel A. The results of OLS regression using A1CI, A2CI, B1CI and B2CI as the GHG performance proxy respectively, controlling for industry fixed effects

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	ΔCD_{t+1}	ΔCD_{t+1}	ΔCD_{t+1}	ΔCD_{t+1}	ΔCD_{t+1}	ΔCD_{t+1}	ΔCD_{t+1}	ΔCD_{t+1}
	DEV=0	**DEV=1**	**DEV=0**	**DEV=1**	**DEV=0**	**DEV=1**	**DEV=0**	**DEV=1**
$\Delta A1CI_t(-)$	0.482	-0.019	-	-	-	-	-	-
	(0.317)	(0.018)	-	-	-	-	-	-
$\Delta A2CI_t(-)$	-	-	0.102	-0.013	-	-	-	-
	-	-	(0.188)	(0.014)	-	-	-	-
$\Delta B1CI_t(-)$	-	-	-	-	-0.016	-0.028	-	-
	-	-	-	-	(0.118)	(0.024)	-	-
$\Delta B2CI_t(-)$	-	-	-	-	-	-	0.266**	-0.017
	-	-	-	-	-	-	(0.120)	(0.017)
ΔQ_t	-0.022	0.005	-0.024	0.005	-0.032	0.004	-0.042	0.004
	(0.029)	(0.007)	(0.029)	(0.007)	(0.035)	(0.007)	(0.029)	(0.007)
ΔFR_t	0.184	-0.032	0.126	-0.030	-0.126	-0.038	-0.203	-0.031
	(0.357)	(0.052)	(0.344)	(0.052)	(0.337)	(0.051)	(0.330)	(0.051)
CGRANK	0.042	-0.006	0.038	-0.006	-0.001	-0.006	-0.010	-0.007
	(0.065)	(0.005)	(0.072)	(0.005)	(0.040)	(0.005)	(0.029)	(0.005)
$\Delta SIZE_t$	0.070	0.007	0.075	0.007	0.062	0.010	0.072	0.008
	(0.059)	(0.009)	(0.058)	(0.009)	(0.059)	(0.009)	(0.050)	(0.009)
ΔIO_t	0.737**	-0.031	0.999	-0.031	0.816*	-0.012	1.485***	-0.025
	(0.341)	(0.031)	(0.659)	(0.031)	(0.416)	(0.036)	(0.446)	(0.035)
ΔROA_t	1.364**	-0.022	1.413***	-0.015	1.443***	-0.032	1.381***	-0.004
	(0.508)	(0.065)	(0.508)	(0.065)	(0.473)	(0.065)	(0.453)	(0.065)
ΔSG_t	-0.040	0.022*	-0.031	0.022*	-0.023	0.029**	-0.087	0.025*
	(0.066)	(0.013)	(0.065)	(0.013)	(0.058)	(0.014)	(0.063)	(0.014)
ΔAN_t	-1.127**	-0.035	-1.119**	-0.036	-0.831**	-0.055	-0.774**	-0.062
	(0.435)	(0.054)	(0.445)	(0.054)	(0.377)	(0.056)	(0.330)	(0.058)
ΔESG_t	0.001	-0.000	0.001	-0.000	0.001	-0.000	0.000	-0.000
	(0.001)	(0.000)	(0.001)	(0.000)	(0.001)	(0.000)	(0.001)	(0.000)
Constant	0.045	0.071***	0.055	0.071***	0.122	0.063***	0.139*	0.066***
	(0.134)	(0.012)	(0.150)	(0.012)	(0.090)	(0.013)	(0.072)	(0.013)
Industry FE	YES	YES	YES	YES	YES	YES	YES	YES
Region FE	NO	NO	NO	NO	NO	NO	NO	NO
Observations	452	4,110	452	4,110	452	4,110	452	4,110
R-squared	0.487	0.014	0.446	0.014	0.425	0.014	0.489	0.013

"**CD**" is the CDP's climate change questionnaire disclosure score; "**A1CI**" is the ratio of "scope1" carbon emissions (in thousand metric tonnes) from the CDP over firms' inflation-adjusted sales revenue (in million USD); "**A2CI**" is the ratio of "(scope1+scope2" carbon emissions (in thousand metric tonnes) from the CDP over firms' inflation-adjusted sales revenue (in million USD); "**B1CI**" is the ratio of "scope1" carbon emissions (in thousand metric tonnes) from Thomson Reuters' Asset4 database over firms' inflation-adjusted sales revenue (in million USD); "**B2CI**" is the ratio of "scope1+scope2" carbon emissions (in thousand metric tonnes) from Thomson Reuters' Asset4 database over firms' inflation-adjusted sales revenue (in million USD); "**Q**" is firms' market to book ratio; "**FR**" measures firms' financial risk, calculated as firms' leverage level; "**CGRANK**" equals "2" if the highest level of direct responsibility for climate change mitigation in a firm is a subset of the board or some committee appointed by the board, it equals "1" if the highest level of direct responsibility for climate change mitigation in a firm is a manager or an officer, "0" otherwise; "**SIZE**" measures the economic scale of firms; "**IO**" is the institutional ownership of companies; "**SG**" is firms' sales growth; "**AN**" measures the newness of firms' properties, plants and equipment; "**ESG**" denotes Thomson Reuters' firm-specific environmental, social and governance (ESG) score; "**DEV**" equals "1" if a country is a member of "DAC", "0" otherwise.

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 6-3: Panel B. The results of OLS regression using A1CI, A2CI, B1CI and B2CI as the GHG performance proxy respectively, controlling for both industry and region fixed effects

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	ΔCD_{t+1}	ΔCD_{t+1}	ΔCD_{t+1}	ΔCD_{t+1}	ΔCD_{t+1}	ΔCD_{t+1}	ΔCD_{t+1}	ΔCD_{t+1}
	DEV=0	**DEV=1**	**DEV=0**	**DEV=1**	**DEV=0**	**DEV=1**	**DEV=0**	**DEV=1**
$\Delta A1CI_t(-)$	0.599*	-0.019	-	-	-	-	-	-
	(0.308)	(0.018)	-	-	-	-	-	-
$\Delta A2CI_t(-)$	-	-	0.116	-0.012	-	-	-	-
	-	-	(0.186)	(0.015)	-	-	-	-
$\Delta B1CI_t(-)$	-	-	-	-	-0.003	-0.027	-	-
	-	-	-	-	(0.105)	(0.027)	-	-
$\Delta B2CI_t(-)$	-	-	-	-	-	-	0.264**	-0.016
	-	-	-	-	-	-	(0.108)	(0.017)
ΔQ_t	-0.021	0.005	-0.025	0.005	-0.033	0.004	-0.042	0.004
	(0.029)	(0.007)	(0.036)	(0.008)	(0.029)	(0.008)	(0.027)	(0.008)
ΔFR_t	0.218	-0.028	0.135	-0.026	-0.123	-0.031	-0.134	-0.019
	(0.356)	(0.052)	(0.407)	(0.055)	(0.397)	(0.057)	(0.369)	(0.056)
CGRANK	0.032	-0.009	0.029	-0.008	-0.008	-0.008	-0.021	0.010*
	(0.076)	(0.005)	(0.074)	(0.005)	(0.046)	(0.006)	(0.042)	(0.006)
$\Delta SIZE_t$	0.059	0.008	0.071	0.008	0.053	0.011	0.071	0.009
	(0.062)	(0.009)	(0.066)	(0.010)	(0.063)	(0.010)	(0.059)	(0.010)
ΔIO_t	0.776**	-0.029	1.018	-0.028	0.895	-0.011	1.516**	-0.021
	(0.348)	(0.031)	(0.779)	(0.046)	(0.606)	(0.048)	(0.615)	(0.047)
ΔROA_t	1.386**	-0.024	1.419***	-0.017	1.435***	-0.028	1.406***	-0.001
	(0.518)	(0.065)	(0.496)	(0.066)	(0.473)	(0.068)	(0.437)	(0.067)
ΔSG_t	-0.032	0.023*	-0.023	0.023*	-0.006	0.030**	-0.076	0.025**
	(0.067)	(0.013)	(0.058)	(0.012)	(0.049)	(0.013)	(0.053)	(0.013)
ΔAN_t	-1.083**	-0.030	-1.098**	-0.032	-0.816**	-0.054	-0.778**	-0.062
	(0.426)	(0.054)	(0.423)	(0.056)	(0.337)	(0.057)	(0.311)	(0.058)
ΔESG_t	0.001	-0.000	0.001	-0.000	0.001	-0.000	0.000	-0.000
	(0.001)	(0.000)	(0.001)	(0.000)	(0.001)	(0.000)	(0.001)	(0.000)
Constant	0.062	0.078***	0.053	0.079***	0.126	0.066***	0.153	0.077***
	(0.161)	(0.017)	(0.162)	(0.017)	(0.101)	(0.018)	(0.095)	(0.018)
Industry FE	YES	YES	YES	YES	YES	YES	YES	YES
Region FE	YES	YES	YES	YES	YES	YES	YES	YES
Observations	452	4,110	452	4,110	452	4,110	452	4,110
R-squared	0.511	0.016	0.483	0.016	0.445	0.018	0.506	0.016

"**CD**" is the CDP's climate change questionnaire disclosure score; "**A1CI**" is the ratio of "scope1" carbon emissions (in thousand metric tonnes) from the CDP over firms' inflation-adjusted sales revenue (in million USD); "**A2CI**" is the ratio of "(scope1+scope2" carbon emissions (in thousand metric tonnes) from the CDP over firms' inflation-adjusted sales revenue (in million USD); "**B1CI**" is the ratio of "scope1" carbon emissions (in thousand metric tonnes) from Thomson Reuters' Asset4 database over firms' inflation-adjusted sales revenue (in million USD); "**B2CI**" is the ratio of "scope1+scope2" carbon emissions (in thousand metric tonnes) from Thomson Reuters' Asset4 database over firms' inflation-adjusted sales revenue (in million USD); "**Q**" is firms' market to book ratio; "**FR**" measures firms' financial risk, calculated as firms' leverage level; "**CGRANK**" equals "2" if the highest level of direct responsibility for climate change mitigation in a firm is a subset of the board or some committee appointed by the board, it equals "1" if the highest level of direct responsibility for climate change mitigation in a firm is a manager or an officer, "0" otherwise; "**SIZE**" measures the economic scale of firms; "**IO**" is the institutional ownership of companies; "**SG**" is firms' sales growth; "**AN**" measures the newness of firms' properties, plants and equipment; "**ESG**" denotes Thomson Reuters' firm-specific environmental, social and governance (ESG) score; "**DEV**" equals "1" if a country is a member of "DAC", "0" otherwise.

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

the process of differencing the data once could potentially wipe out or difference out most of the trend or/and seasonality in the data used, it means that first differencing does not always make the data completely stationary (Wooldridge, 2010). As Wooldridge (2010) argues that empirical models could have both an additive industry (country or region) effect and an industry (country or region) specific trend effect, differencing the data could remove the additive industry (country or region) effect, controlling for industry (country or region) fixed effects in pooled OLS regression drawing on first differenced data could remove any residual industry (country or region) specific trend effect in the data. Following which argument, I also control for industry and region fixed effects in the baseline models.

We could see from Table 6-3 that the empirical results of association between the improvement of firms' GHG performance in all four measures and the subsequent improvement of the extensiveness of firms' voluntary GHG disclosure identified in the baseline models' regression are largely insignificant. However, for firms from developing economies, when using the "scope1+scope2" GHG revenue intensity measure based on GHG emissions data from Thomson Reuters' Asset4 database, the increasing tendency of the improvement of firms' GHG performance causes a subsequent increasing tendency of the improvement of firms' voluntary GHG disclosure extensiveness. That is, if the improvement (the reduction) of firms' GHG performance (firms' GHG revenue intensity) increases by 1 metric ton per thousand USD revenue, there would be a subsequent increase of the improvement of firms' voluntary GHG disclosure extensiveness by around 0.3 points.

On the one hand, given that, as is documented in Table 6-1 Panel B, for both firms in developing economies and firms in developed economies, there is a tendency for them to beautify their GHG performance in channels like corporate reports, webpages, online media etc. at incremental (changes) level. Thus, the significant positive relationship between the improvement of firms' GHG performance and the subsequent improvement of firms' voluntary GHG disclosure extensiveness in developing economies could be spurious observation based on distorted GHG performance figures provided by firms in developing economies. Also, prior studies (Ali and Rizwan, 2013; Luo et al., 2013; Ali et al., 2017) document that society has very limited supervision power on firms in developing economies as regards CSR related issues, this situation may also contribute to greater GHG performance data manipulation by firms in developing economies, compared with their counterpart in developed economies. On the other hand, after conducting the Durbin-Wu-Hausman test of endogeneity (Wooldridge, 2010), the problem of endogeneity is identified for the results shown in Table 6-3 using OLS. The significant positive relationship between the

improvement of firms' GHG performance and the subsequent improvement of firms' voluntary GHG disclosure extensiveness in developing economies could also be resulting from endogeneity.

In addition, we could see that, for the developed economies subsample, all the results as regards the research question of interest are not significant in Table 6-3. It could be that **H9** is not true for developed economies. However, given the endogeneity problem identified in OLS regression, it could also be that the insignificant results for developed economies are not true because of the problem of endogeneity. To identify which situation discussed above is true respectively for developing economies and developed economies, the results obtained after controlling for endogeneity would be reported and discussed for both the developing economies subsample and the developed economies subsample.

6.4.3 Controlling for Endogeneity, Results from Two-Stage Least Squares (2SLS) Regression

As is discussed in chapter 5, endogeneity occurs when one or more independent variables of interest (excluding control variables) on the right-hand side are correlated with the error term in an empirical model (Wooldridge, 2010). This is because one important assumption of using OLS estimates is that the right-hand-side independent variable(s) of interest should not contain information about the mean of the error term in the empirical model, meaning that the covariance between the error term and the independent variable(s) of interest should be zero. If this assumption is not satisfied, OLS estimates would be biased, as, in this situation, OLS estimates of the coefficients of the independent variable(s) of interest cannot be regarded as Best Linear Unbiased Estimates of the population parameters.

Prior econometrical studies (Wooldridge, 2010) identified overall three sources of endogeneity namely, 1) omitted independent variable(s); 2) measurement errors in independent variable(s) of interest; 3) causal loop (simultaneity) between the dependent variable and the independent variable(s) of interest. Because the relationship that I investigate in this chapter is between the changes of firms' GHG performance at "t" and the changes of firms' voluntary GHG disclosure extensiveness at "t+1", there would be no potential endogeneity from causal loop, as future events cannot affect events that have become a matter of fact in the past. In addition, I use GHG emissions data from different channels to control for measurement errors of the independent variable of interest-"changes in GHG

emission revenue intensity", the probable source of endogeneity in the empirical model would be from "omitted variables".

Particularly, although first-differenced estimators (changes analyses) are commonly used in econometrics to control for omitted variables, first-differenced estimators could only difference out omitted time-invariant variables. The possibility of endogeneity rising from omitted time-variant variables could be not be eliminated by differencing the data. Good "instrumental variables" could separate the part of the variation of "ΔCI_t" that is not associated with the error term in the empirical model. A key advantage of using instrumental variables to control for endogeneity problems is that the coefficient estimate(s) of the endogenous independent variable(s) of interest is(are) more likely to be consistent (Wooldridge, 2010). Again, as heteroscedasticity is present in the data. GMM is implemented in the second stage regression to allow for reliable inference [see (Cheng et al., 2014)].

Specifically, the sign-inversed first-differenced form of region-industry average of "ΔCI_t" ($\Delta CIRIM_t(-)$), excluding each firm's contribution to the average, is used as the instrument for the endogenous variable "ΔCI_t". Excluding each firm's contribution to the region-industry average could ensure enough variation of the instrument. Using region-industry average of the independent variable of interest as its instrument is consistent with a few prior studies (Lev and Sougiannis, 1996; Friedberg, 2003; Hanlon et al., 2003; Cheng et al., 2014). The rationale of using the region-industry average of the changes of firms' GHG performance is that the changes of firms' GHG performance is systematically affected by those of other firms within the same industry in the same region (Ioannou and Serafeim, 2012; Cheng et al., 2014).

Table 6-4 Panel A presents a comparison of the two-stage least squares regression results (imposing GMM option to allow for heteroscedasticity in the data) of the empirical model between developing economies and developed economies, using A1CI to proxy for firms' GHG performance, $\Delta A1CIRIM_t(-)$ as the instrument for the independent variable of interest "$\Delta A1CI_t$". After controlling for the endogenous disturbances in the independent variable of interest, we could see that, for the developed economies subsample, if the improvement of firms' "scope1" GHG performance increases by one metric ton per thousand USD revenue, the subsequent improvement in firms' GHG disclosure extensiveness tends to decrease by around 5%. However, for the developing economies, improvement in firms' GHG performance does not contain any information of the subsequent changes in firms' voluntary GHG disclosure. The results stay robust after

controlling for industry-fixed effects and region-fixed effects in the second stage regression to eliminate any residual industry or/and region-specific trend effect in the first differenced dataset. Table 6-4 Panel B presents a comparison of the two-stage least squares regression results (imposing GMM option to allow for heteroscedasticity in the data) of the empirical model between developing economies and developed economies, using A2CI to proxy for firms' GHG performance, $\Delta A2CIRIM_t(-)$ as the instrument for the independent variable of interest-"$\Delta A2CI_t$". The results obtained are consistent with those reported in Table 6-4 Panel A. Specifically, for every 1 metric ton per thousand USD revenue increase in the improvement of firms' "scope1+scope2" GHG performance, there is around 4% decrease in the subsequent improvement of firms' voluntary GHG disclosure extensiveness for the developed economies subsample. Again, improvement in firms' GHG performance does not contain any information of the subsequent changes in firms' voluntary GHG disclosure for the developing economies subsample. The results stay consistent after eliminating any residual industry or/and region-specific trend effect in the data by controlling for industry-fixed effects and region-fixed effects in the second stage regression.

Table 6-4: Panel A. The results of the empirical model using A1CI as the GHG performance proxy-instrumental variables

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	First stage	ΔCD_{t+1}	First stage	ΔCD_{t+1}	First stage	ΔCD_{t+1}	First stage	ΔCD_{t+1}
	DEV=0		**DEV=1**		**DEV=0**		**DEV=1**	
$\Delta A1CI_t(-)$	-	0.553	-	-0.049***	-	0.973	-	-0.054***
	-	(0.393)	-	(0.017)	-	(1.081)	-	(0.020)
$\Delta A1CIRIM_t(-)$	-8.074***	-	-23.243***	-	-8.603***	-	-23.376***	-
	(0.808)	-	(0.462)	-	(0.917)	-	(0.468)	-
ΔQ_t	0.001	0.002	-0.005	-0.001	-0.000	-0.018	-0.006	0.002
	(0.005)	(0.029)	(0.005)	(0.007)	(0.007)	(0.044)	(0.005)	(0.007)
ΔFR_t	-0.021	0.292	-0.080**	-0.028	-0.044	0.619	-0.080**	-0.033
	(0.071)	(0.464)	(0.038)	(0.053)	(0.082)	(1.230)	(0.038)	(0.054)
CGRANK	0.008	0.354	-0.001	-0.007	0.006	-0.721	-0.001	0.009*
	(0.008)	(0.366)	(0.004)	(0.005)	(0.010)	(0.721)	(0.004)	(0.006)
$\Delta SIZE_t$	-0.001	0.062	0.002	0.012	-0.004	-0.149	0.001	0.015
	(0.012)	(0.065)	(0.007)	(0.010)	(0.012)	(0.141)	(0.007)	(0.010)
ΔIO_t	-0.010	0.453	-0.031	-0.027	-0.013	0.000	-0.031	-0.029
	(0.022)	(0.407)	(0.031)	(0.031)	(0.025)	(0.000)	(0.031)	(0.032)
ΔROA_t	0.189**	0.000	0.100**	-0.019	0.160	0.000	0.099**	-0.028
	(0.094)	(0.000)	(0.048)	(0.070)	(0.107)	(0.000)	(0.048)	(0.069)
ΔSG_t	0.009	0.037	0.031***	0.023	0.016	0.142	0.032***	0.027*
	(0.015)	(0.062)	(0.010)	(0.014)	(0.016)	(0.104)	(0.010)	(0.014)
ΔAN_t	0.118	-1.620**	0.053	-0.041	0.078	0.000	0.052	-0.034
	(0.077)	(0.639)	(0.038)	(0.055)	(0.084)	(0.000)	(0.038)	(0.056)
ΔESG_t	0.000	0.002**	0.000	-0.000	0.000	-0.001	0.000	-0.000
	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.002)	(0.000)	(0.000)
Constant	-0.016	-0.645	0.004	0.071***	0.004	1.084	0.003	0.086***
	(0.016)	(0.732)	(0.007)	(0.010)	(0.012)	(1.306)	(0.013)	(0.018)
Industry FE		NO		NO		YES		YES
Region FE		NO		NO		YES		YES
Observations	452	452	4,110	4,110	452	452	4,110	4,110
R-squared	0.659	0.356	0.522	0.004	0.700	0.401	0.524	0.019
Kleigergen-Raap rk Wald F (Weak instruments test)		67.589		11.515		25.702		11.706

"**CD**" is the CDP's climate change questionnaire disclosure score; "**A1CI**" is the ratio of scope1 carbon emissions (in thousand metric tonnes) from the CDP over firms' inflation-adjusted sales revenue (in million USD); "**$A1CIRIM_t(-)$**" is the region-industry mean of "$A1CI_t(-)$", excluding each firm's contribution to the mean; "**Q**" is firms' market to book ratio; "**FR**" measures firms' financial risk, calculated as firms' leverage level; "**CGRANK**" equals "2" if the highest level of direct responsibility for climate change mitigation in a firm is a subset of the board or some committee appointed by the board, it equals "1" if the highest level of direct responsibility for climate change mitigation in a firm is a manager or an officer, "0" otherwise; "**SIZE**" measures the economic scale of firms; "**IO**" is the institutional ownership of companies; "**SG**" is firms' sales growth; "**AN**" measures the newness of firms' properties, plants and equipment; "**ESG**" denotes Thomson Reuters' firm-specific environmental, social and governance (ESG) score; "**DEV**" equals "1" if a country is a member of "DAC", "0" otherwise.

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 6-4: Panel B. The results of the empirical model using A2CI as the GHG performance proxy-instrumental variable

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	First stage	ΔCD_{t+1}	First stage	ΔCD_{t+1}	First stage	ΔCD_{t+1}	First stage	ΔCD_{t+1}
	DEV=0		**DEV=1**		**DEV=0**		**DEV=1**	
$\Delta A2CI_t(-)$	-	0.151	-	-0.040***	-	0.053	-	-0.044***
	-	(0.216)	-	(0.015)	-	(0.093)	-	(0.017)
$\Delta A2CIRIM_t(-)$	-11.117***	-	-23.936***	-	-12.863***	-	-24.058***	-
	(0.715)	-	(0.523)	-	(0.708)	-	(0.529)	-
ΔQ_t	-0.008	0.006	-0.007	-0.000	-0.006	-0.003	-0.008	0.002
	(0.009)	(0.028)	(0.007)	(0.007)	(0.010)	(0.031)	(0.007)	(0.007)
ΔFR_t	0.070	0.321	-0.080	-0.025	0.040	0.079	-0.082	-0.031
	(0.118)	(0.464)	(0.049)	(0.053)	(0.119)	(0.577)	(0.050)	(0.054)
CGRANK	0.018	0.318	-0.001	-0.007	0.002	-0.035	0.000	0.009*
	(0.014)	(0.362)	(0.005)	(0.005)	(0.015)	(0.064)	(0.005)	(0.006)
$\Delta SIZE_t$	0.040**	0.062	0.005	0.012	0.016	-0.007	0.004	0.016
	(0.020)	(0.064)	(0.009)	(0.010)	(0.019)	(0.044)	(0.010)	(0.010)
ΔIO_t	-0.020	0.696	-0.023	-0.026	-0.030	0.000	-0.023	-0.029
	(0.037)	(0.731)	(0.040)	(0.031)	(0.036)	(0.000)	(0.041)	(0.031)
ΔROA_t	0.090	0.000	0.125**	-0.011	0.127	0.000	0.127**	-0.019
	(0.156)	(0.000)	(0.063)	(0.070)	(0.155)	(0.000)	(0.063)	(0.069)
ΔSG_t	0.076***	0.017	0.041***	0.024*	0.074***	0.059	0.041***	0.027*
	(0.023)	(0.055)	(0.012)	(0.014)	(0.022)	(0.065)	(0.013)	(0.014)
ΔAN_t	-0.030	-1.545**	0.063	-0.043	-0.058	-0.929*	0.065	-0.035
	(0.124)	(0.660)	(0.049)	(0.056)	(0.118)	(0.505)	(0.050)	(0.056)
ΔESG_t	0.000	0.002*	0.000	-0.000	0.000	0.001	0.000	-0.000
	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)
Constant	-0.033	-0.572	0.003	0.071***	0.032	0.001	0.000	0.087***
	(0.027)	(0.722)	(0.009)	(0.010)	(0.038)	(0.000)	(0.017)	(0.018)
Industry FE		NO		NO		YES		YES
Region FE		NO		NO		YES		YES
Observations	452	452	4,110	4,110	452	452	4,110	4,110
R-squared	0.840	0.397	0.476	0.004	0.894	0.382	0.478	0.018
Kleigergen-Raap rk Wald F (Weak instruments test)		13.919		10.400		10.863		10.582

"**CD**" is the CDP's climate change questionnaire disclosure score; "**A2CI**" is the ratio of "scope1+scope2" carbon emissions (in thousand metric tonnes) from the CDP over firms' inflation-adjusted sales revenue (in million USD); "**$A2CIRIM_t(-)$**" is the region-industry mean of "$A2CI_t(-)$", excluding each firm's contribution to the mean ; "**Q**" is firms' market to book ratio; "**FR**" measures firms' financial risk, calculated as firms' leverage level; "**CGRANK**" equals "2" if the highest level of direct responsibility for climate change mitigation in a firm is a subset of the board or some committee appointed by the board, it equals "1" if the highest level of direct responsibility for climate change mitigation in a firm is a manager or an officer, "0" otherwise; "**SIZE**" measures the economic scale of firms; "**IO**" is the institutional ownership of companies; "**SG**" is firms' sales growth; "**AN**" measures the newness of firms' properties, plants and equipment; "**ESG**" denotes Thomson Reuters' firm-specific environmental, social and governance (ESG) score; "**DEV**" equals "1" if a country is a member of "DAC", "0" otherwise.

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Overall, the results obtained in Table 6-4 suggest that, for the period under investigation, the changes in firms' GHG performance does not contain any information of the subsequent changes in firms' voluntary GHG disclosure for firms from developing economies. This is also consistent with the evidence obtained in chapter4 as regards the "in-levels" association pattern between firms' GHG performance and the extensiveness of firms' voluntary GHG disclosure that there is no association between GHG performance and GHG disclosure for firms from developing economies for the period under investigation. Combined with the fact that firms from developing economies have higher average CDP disclosure scores (see Table 6-1 Panel A) than firms from developed economies, the evidence indicates that firms in developing economies largely use voluntary GHG disclosure as a substitute for real GHG mitigating activities involvement, voluntary GHG disclosure from firms in developing economies tend to be heavily manipulated to make good impressions on shareholders and the wider stakeholders. Thus, **H8** is true for firms from developing economies.

The results obtained for firms from developed economies stay highly consistent with those based on the full reduced sample (see Table 5-3 in chapter 5). For firms from developed economies, the changes in voluntary GHG performance is significantly negatively associated with the subsequent changes in firms' voluntary GHG disclosure, thus, **H9** is true for firms from developed economies. So far, we could see that, after controlling for endogeneity, the contradictory empirical evidence presented in Table 6-3 has been corrected. The story behind the empirical findings in chapter 5 revealed itself to us. That is, the international evidence identified in chapter 5 as regards the relationship between the improvement of firms' GHG performance and the subsequent improvement of firms' voluntary GHG disclosure extensiveness is driven by firms from developed economies. The findings identified in Table 6-4 are also highly consistent with the findings in chapter 4 as regards the "in levels" GHG disclosure-performance association pattern. The evidence obtained in chapter 5 and chapter 6 further adds to the possibility *that the relationship between firms' environmental performance and corporate environmental disclosure is associated with the respective macro environmental disclosure circumstances in society.*

Table 6-5: Panel A. The results of the empirical model using B1CI as the GHG performance proxy-instrumental variables

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	First stage	ΔCD_{t+1}	First stage	ΔCD_{t+1}	First stage	ΔCD_{t+1}	First stage	ΔCD_{t+1}
	DEV=0		**DEV=1**		**DEV=0**		**DEV=1**	
$\Delta B1CI_t(-)$	-	0.327	-	-0.022	-	0.359	-	-0.028
	-	(0.193)	-	(0.024)	-	(0.437)	-	(0.026)
$\Delta B1CIRIM_t(-)$	-4.521***	-	-21.126***	-	-5.365***	-	-21.405***	-
	(0.419)	-	(0.426)	-	(0.504)	-	(0.431)	-
ΔQ_t	0.007	-0.006	-0.003	0.003	0.009	0.002	-0.002	0.005
	(0.005)	(0.032)	(0.005)	(0.007)	(0.007)	(0.035)	(0.005)	(0.007)
ΔFR_t	-0.023	0.372	-0.068**	-0.036	0.009	0.000	-0.067**	-0.041
	(0.071)	(0.514)	(0.034)	(0.052)	(0.076)	(0.000)	(0.034)	(0.052)
CGRANK	0.003	0.323	-0.002	-0.008	-0.003	0.343	-0.002	0.011*
	(0.009)	(0.343)	(0.003)	(0.006)	(0.010)	(0.373)	(0.004)	(0.006)
$\Delta SIZE_t$	-0.043***	0.086	0.001	0.010	-0.048***	0.086	0.000	0.012
	(0.012)	(0.069)	(0.006)	(0.010)	(0.012)	(0.099)	(0.006)	(0.010)
ΔIO_t	-0.008	0.484	0.005	-0.017	-0.023	0.793	0.005	-0.021
	(0.022)	(0.503)	(0.027)	(0.035)	(0.025)	(0.988)	(0.027)	(0.035)
ΔROA_t	0.323***	0.000	0.088**	-0.043	0.317**	0.000	0.086**	-0.042
	(0.112)	(0.000)	(0.042)	(0.071)	(0.121)	(0.000)	(0.042)	(0.071)
ΔSG_t	0.007	0.030	0.036***	0.029**	0.011	0.047	0.036***	0.034**
	(0.014)	(0.067)	(0.009)	(0.015)	(0.015)	(0.089)	(0.009)	(0.015)
ΔAN_t	0.189**	-1.760**	0.056*	-0.039	0.152*	-1.877**	0.061*	-0.033
	(0.078)	(0.744)	(0.034)	(0.065)	(0.083)	(0.922)	(0.034)	(0.065)
ΔESG_t	0.000**	0.001	0.000	-0.000	0.000**	0.002	0.000	-0.000
	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)
Constant	0.001	-0.583	0.006	0.072***	0.011	-0.657	0.013	0.077***
	(0.018)	(0.685)	(0.006)	(0.010)	(0.027)	(0.680)	(0.011)	(0.018)
Industry FE		NO		NO		YES		YES
Region FE		NO		NO		YES		YES
Observations	452	452	4,110	4,110	452	452	4,110	4,110
R-squared	0.732	0.433	0.565	0.008	0.785	0.408	0.571	0.021
Kleigergen-Raap rk Wald F (Weak instruments test)		24.847		42.167		20.428		44.032

"**CD**" is the CDP's climate change questionnaire disclosure score; "**B1CI**" is the ratio of "scope1" carbon emissions (in thousand metric tonnes) from Thomson Reuters' Asset4 over firms' inflation-adjusted sales revenue (in million USD); "**$B1CIRIM_t(-)$**" is the region-industry mean of "$B1CI_t(-)$", excluding each firm's contribution to the mean; "**Q**" is firms' market to book ratio; "**FR**" measures firms' financial risk, calculated as firms' leverage level; "**CGRANK**" equals "2" if the highest level of direct responsibility for climate change mitigation in a firm is a subset of the board or some committee appointed by the board, it equals "1" if the highest level of direct responsibility for climate change mitigation in a firm is a manager or an officer, "0" otherwise; "**SIZE**" measures the economic scale of firms; "**IO**" is the institutional ownership of companies; "**SG**" is firms' sales growth; "**AN**" measures the newness of firms' properties, plants and equipment; "**ESG**" denotes Thomson Reuters' firm-specific environmental, social and governance (ESG) score; "**DEV**" equals "1" if a country is a member of "DAC", "0" otherwise.

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 6-5: Panel B. The results of the empirical model using B2CI as the GHG performance proxy-instrumental variables

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	First stage	ΔCD_{t+1}	First stage	ΔCD_{t+1}	First stage	ΔCD_{t+1}	First stage	ΔCD_{t+1}
	DEV=0		**DEV=1**		**DEV=0**		**DEV=1**	
$\Delta B2CI_t(-)$	-	0.262	-	-0.018	-	0.031	-	-0.022
	-	(0.174)	-	(0.018)	-	(0.069)	-	(0.018)
$\Delta B2CIRIM_t(-)$	-13.647***	-	-23.066***	-	-14.588***	-	-23.269***	-
	(0.689)	-	(0.537)	-	(0.674)	-	(0.542)	-
ΔQ_t	-0.013	-0.002	-0.004	0.002	-0.002	0.000	-0.003	0.004
	(0.018)	(0.028)	(0.007)	(0.007)	(0.018)	(0.033)	(0.007)	(0.007)
ΔFR_t	-0.123	0.229	-0.061	-0.022	-0.157	-0.259	-0.062	-0.023
	(0.232)	(0.428)	(0.049)	(0.051)	(0.226)	(0.667)	(0.050)	(0.052)
CGRANK	-0.053*	0.284	-0.002	-0.008	-0.059**	0.293	-0.000	0.011*
	(0.029)	(0.296)	(0.005)	(0.005)	(0.029)	(0.321)	(0.005)	(0.006)
$\Delta SIZE_t$	0.000	0.058	0.011	0.009	-0.017	0.055	0.010	0.013
	(0.038)	(0.061)	(0.009)	(0.010)	(0.036)	(0.073)	(0.010)	(0.010)
ΔIO_t	-0.009	1.272	-0.000	-0.012	-0.063	0.000	-0.001	-0.014
	(0.071)	(0.786)	(0.040)	(0.033)	(0.072)	(0.000)	(0.040)	(0.035)
ΔROA_t	-0.036	0.000	0.032	-0.010	-0.181	0.000	0.033	-0.014
	(0.362)	(0.000)	(0.062)	(0.071)	(0.361)	(0.000)	(0.062)	(0.070)
ΔSG_t	0.110**	0.008	0.042***	0.026*	0.104**	0.024	0.042***	0.029**
	(0.046)	(0.056)	(0.012)	(0.014)	(0.045)	(0.045)	(0.012)	(0.014)
ΔAN_t	-0.523**	-1.483**	0.058	-0.053	-0.430*	-1.381**	0.064	-0.052
	(0.243)	(0.646)	(0.052)	(0.066)	(0.231)	(0.661)	(0.052)	(0.067)
ΔESG_t	0.001*	0.001	0.000	-0.000	0.001	0.002	0.000	-0.000
	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)
Constant	0.099*	-0.506	0.003	0.073***	0.078	-0.515	0.013	0.084***
	(0.056)	(0.591)	(0.009)	(0.010)	(0.077)	(0.629)	(0.017)	(0.018)
Industry FE		NO		NO		YES		YES
Region FE		NO		NO		YES		YES
Observations	452	452	4,110	4,110	452	452	4,110	4,110
R-squared	0.853	0.352	0.457	0.006	0.901	0.343	0.461	0.020
Kleigergen-Raap rk Wald F (Weak instruments test)		21.262		20.287		19.928		21.345

"**CD**" is the CDP's climate change questionnaire disclosure score; "**B2CI**" is the ratio of "scope1+scope2" carbon emissions (in thousand metric tonnes) from Thomson Reuters' Asset4 over firms' inflation-adjusted sales revenue (in million USD); "**$B2CIRIM_t(-)$**" is the region-industry mean of "$B2CI_t(-)$", excluding each firm's contribution to the mean; "**Q**" is firms' market to book ratio; "**FR**" measures firms' financial risk, calculated as firms' leverage level; "**CGRANK**" equals "2" if the highest level of direct responsibility for climate change mitigation in a firm is a subset of the board or some committee appointed by the board, it equals "1" if the highest level of direct responsibility for climate change mitigation in a firm is a manager or an officer, "0" otherwise; "**SIZE**" measures the economic scale of firms; "**IO**" is the institutional ownership of companies; "**SG**" is firms' sales growth; "**AN**" measures the newness of firms' properties, plants and equipment; "**ESG**" denotes Thomson Reuters' firm-specific environmental, social and governance (ESG) score; "**DEV**" equals "1" if a country is a member of "DAC", "0" otherwise.

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

In addition to the 2SLS regression tests of the empirical model using GHG emissions data from the CDP database, as is discussed earlier, to control for the impact of potential differences of reported GHG emissions from different channels on the results obtained, I also use GHG emission revenue intensity measures calculated based on the GHG emissions data obtained from Thomson Reuters' Asset4 database to alternatively conduct another row of 2SLS regression tests of the empirical model. Table 6-5 Panel A and Table 6-5 Panel B present the comparisons of the two-stage least squares regression results (imposing GMM option to allow for heteroscedasticity in the data) of the empirical model between developing economies and developed economies, using B1CI and B2CI respectively to proxy for firms' GHG performance, $\Delta B1CIRIM_t(-)$ and $\Delta B2CIRIM_t(-)$ as the instruments for the independent variables of interest. As B1CI and B2CI are calculated respectively based on "scope1" GHG emissions and "scope1+scope2" GHG emissions collected from a variety of other channels (corporate reports, webpages, online media, publications of research institutions etc.) by Thomson Reuters' Asset4 database, we could examine whether the results obtained above is sensitive to measurement differences of GHG emissions from different data sources. We could see that all the results shown in Table 6-5 Panel A and Table 6-5 Panel B indicate that there is no association between changes in firms' GHG performance and the subsequent changes in firms' voluntary GHG disclosure. The results are consistent after controlling for industry-fixed effects and region-fixed effects to factor out any residual industry or/and region-specific trend effect in the data.

The empirical results have changed, compared with those obtained in Table 6-4. The probable reason for these different findings could be that the data of the improvement of firms' underlying GHG performance from channels like corporate reports, webpages, online media etc. for the period under investigation have been intentionally beautified to give better impressions on shareholders and the wider stakeholders. Because the data have been beautified at incremental (changes) level, the improvement of firms' GHG performance from these channels do not contain any information about the subsequent improvement of firms' voluntary GHG disclosure extensiveness unanimously for both developing economies and developed economies. In this case, the beautified GHG data disclosure from these channels are merely used as a legitimising tool. These regression results reflect the descriptive statistics shown in Table 6-1 Panel B, where it is shown that, for both firms in developing economies and firms in developed economies, it is a prevailing practice to beautify firms' GHG performance data at incremental (changes) level in channels like corporate reports, webpages, online media etc. to create good impression on shareholders and the wider

stakeholders regarding firms' GHG management and performance. This is probably because corporate reports, website disclosure or online media disclosure are literally the most accessible and cost-effective ways for shareholders and the wider stakeholders who are climate change concerned to know how firms manage their GHG impact.

In sum, by synthesising the information that all the regression results provide, the empirical evidence indicates that **H8** is true for firms from developing economies, that is, the changes in firms' GHG performance does not contain any information of subsequent changes in firms' voluntary GHG disclosure extensiveness for firms from developing economies. This is in line with the no-association "in levels" evidence in chapter 4 regarding the association pattern between firms' GHG performance and the extensiveness of firms' voluntary GHG disclosure for firms from developing economies for the period under investigation; Also, **H9** is true for firms from developed economies, namely, the changes in the improvement of firms' GHG performance is negatively associated with the subsequent changes in the improvement of firms' voluntary GHG disclosure extensiveness for firms from developed economies. This also corresponds to the negative association "in levels" evidence in chapter 4 regarding the association pattern between firms' GHG performance and the extensiveness of firms' voluntary GHG disclosure for firms from developed economies for the period under investigation. Overall, the results obtained in this chapter indicate that, for both firms from developing economies and firms from developed economies, GHG disclosure is mainly used as a legitimising tool for their operations and a substitute for substantial continual involvement in climate change mitigation activities for the period under investigation. The international evidence obtained in chapter 5 regarding the research question of interest is driven by firms from developed economies.

6.5 Conclusions

The previous chapter has identified that, for the period under investigation, the overall global evidence suggests that firms' GHG disclosure would not change to promote climate information transparency as a result of the changes in firms' GHG mitigating performance trajectory. Globally speaking, the increasing tendency in the improvement of firms' GHG performance causes a decreasing tendency in the subsequent improvement of the extensiveness of firms' voluntary GHG disclosure for the period under investigation. Namely, for the period under investigation, firms' voluntary GHG disclosure tends to dissociate with firms' underlying GHG performance globally. The finding corresponds to legitimacy theory's prediction over the relationship between the changes of firms' GHG performance and the subsequent changes of the extensiveness of firms' voluntary GHG disclosure. Although the overall international evidence suggests that firms' voluntary GHG disclosure tends to dissociate with firms' underlying GHG performance for the period under investigation, we do not know exactly how firms from developing economies and firms from developed economies contribute to such empirical evidence. Also, even though there are prior studies that investigate CSR related disclosure-performance association problem either using data from developing economies or using data from developed economies respectively in different empirical research, these studies vary significantly speaking of methodology and general research design. This makes direct comparison and inferences of the empirical evidence presented in different studies very difficult. There is a lack of direct comparative evidence between developing economies and developed economies that is obtained through consistent methodology and general research design, as regards the issue of CSR related disclosure-performance association.

In the light of the situation in SEA literature shown above, this chapter strives to provide a comparative analysis as regards the possible difference of empirical evidence of the research question "Would changes in GHG performance cause any subsequent changes in GHG disclosure strategy?" between developing economies and developed economies. Extant evidence (Belal, 2000; Islam and Deegan, 2008; Ali and Rizwan, 2013; Luo et al., 2013; Ali et al., 2017) indicates that the local stakeholders in developing economies have limited influence on firms, the social contracts between firms and the societies in developing economies also tend to be weak. In contrast, extant evidence (Xiao et al., 2005; Branco and Rodrigues, 2008; Reverte, 2009; Luo et al., 2013) based on data from developed economies suggests that, besides firm-specific internal factors like firms' economic scale, financial

capability and corporate governance characteristics etc, stakeholders' pressure could also effectively affect firms' CSR related strategies and practices, as the social contracts between firms from developed economies and the societies of developed economies are strong. The differences of macro CSR related disclosure circumstance between developing economies and developed economies create a possibility for the empirical evidence of the research question of interest between developing economies and developed economies to be different. If the expected difference as regards the research question of interest between developing economies and developed economies could be identified, such evidence could further point to the possibility that *that the relationship between firms' environmental performance and corporate environmental disclosure is associated with the respective macro environmental disclosure circumstances in society.*

After splitting the same international dataset used in chapter 5 into 452 observations from developing economies corresponding to 237 firms and 4110 observations from developed economies corresponding to 1409 firms, the same empirical model is examined respectively using the developing economies subsample and the developed economies subsample to provide comparative analyses as regards the research question of interest. Specifically, the results indicate that, when using reported GHG emissions data from the CDP database, changes in firms' GHG performance do not contain any information of subsequent changes in the extensiveness of firms' voluntary GHG disclosure for firms from developing economies. However, the changes of firms' GHG performance is negatively associated with subsequent changes in firms' voluntary GHG disclosure extensiveness for firms from developed economies. The proposed **H8** and **H9** under the prediction of legitimacy theory are true respectively for firms from developing economies and firms from developed economies.

Also, in line with the findings in chapter 5, when using reported GHG emissions data obtained by Thomson Reuters' Asset4 database from other channels like corporate reports, webpages, online media and publications of research institutions etc., however, the results indicate that there is no association between changes in firms' GHG performance and subsequent changes in firms' voluntary GHG disclosure extensiveness consistently for firms from developing economies and firms from developed economies, after controlling for endogeneity. The probable reason for these different findings could be that the data of the improvement of firms' underlying GHG performance from channels like corporate reports, webpages, online media and publications of research institutions etc. for the period under investigation have been intentionally beautified at incremental (changes) level (as is shown

by the descriptive statistics in Table 6-1 Panel B) to give better impressions on shareholders and the wider stakeholders. Because the data have been beautified, the changes in firms' GHG performance from these channels do not contain any information about the subsequent changes in the extensiveness of firms' voluntary GHG disclosure.

In conclusion, the expected difference of empirical evidence of the research question "Would changes in GHG performance cause any subsequent changes in GHG disclosure strategy?" between developing economies and developed economies is confirmed by the empirical evidence obtained in this chapter. The global evidence obtained in chapter 5 is driven by firms from developed economies. The evidence further adds to the possibility that *that the relationship between firms' environmental performance and corporate environmental disclosure is associated with the respective macro environmental disclosure circumstances in society*. Overall, legitimacy theory has predominant explanatory power over the relationship between firms' GHG performance and firms' GHG disclosure for the period under investigation.

7. Discussions and Conclusions

This chapter starts with a review of the background of the thesis. Subsequently, the major findings of this thesis would be summarised as per empirircal chapter. Following which, the contributions of the findings of the thesis would be discussed and specified. The chapter concludes with a discussion of potential practical implications of the findings of the thesis, the limitations of the thesis and the corresponding navigation for future research.

7.1 Thesis Background

The environmental disclosure-performance association problem has been an important research topic of interest in SEA literature. However, the empirical evidence presented in the extant literature of this research topic is conflicting and predominantly from North American studies. Specifically, early North American studies principally find that environmental disclosure does not contain any information about firms' real environmental performance (Ingram and Frazier, 1980; Wiseman, 1982; Freedman and Wasley, 1990). Later North American studies predominantly find that bad environmental performers tend to have more extensive environmental disclosure (Bewley and Li, 2000; Hughes et al., 2001; Patten, 2002). Most recent North American studies primarily find that good environmental performers tend to disclose their environmental information more extensively (Al-Tuwaijri et al., 2004; Clarkson et al., 2008). This situation causes many problems for information users.

For those environmentally concerned investors, if firms' corporate environmental disclosure (free to the public) could not be used to reliably gauge firms' environmentally related risks, their investment-decision making costs would increase. This is because they have to turn to other resources to help them reliably gauge their potential investee firms' environmentally related risks. Specifically, one important interfering factor in their investment-decision making process would be the extensiveness and detailedness of their potential investee firms' environmental disclosure. This is because one may intuitively perceive that firms that have extensive environmental disclosure are those who perform well in corporate environmental areas and/or those who carefully manage their environmentally related risks. However, the empirical evidence provided in the literature suggests otherwise. For regulators, governments and other concerned entities, firms' corporate environmental disclosure is a very important channel for them to monitor related firms' environmental involvement and performance. If firms' environmental disclosure cannot be used to reliably

monitor firms' underlying environmental involvement and performance, their monitoring costs would also be expected to significantly increase.

Given the contradictory evidence documented in the literature and corporate environmental information users' practical expectations on firms' environmental disclosure, it is both pragmatic and necessary to gain understanding on why the relationship between firms' environmental performance and corporate environmental disclosure takes on the different association patterns chronologically in the extant literature. However, the extant literature on this research topic is lacking in this kind of research. Starting from this point, the investigations conducted in this thesis strive to shed some light on this under-explored research area.

Particularly, like other general CSR related issues, managing firms' GHG impact would elicit non-trivial costs that are not related to firms' core business activities. Thus, it is expected that the management of firms would only disclose corporate GHG emission related information when the expected benefits outweigh the costs associated with such disclosure. As the importance of GHG emission issues and related climate change risks deepens in a society, it is expected that the changes and increases of stakeholders that have different influencing power on firms to make them disclose desired GHG emission related information would lead to different GHG disclosure circumstances in different periods of society. The different GHG disclosure circumstances in different periods of society, in turn, would stimulate different types (low-profile firms; average firms; high-profile firms) of firms as regards corporate GHG emission issues to disclose the desired GHG emission related information.

Based on the arguments above and the fact that the extant conflicting North American evidence in this research area clusters in different periods of North American society over time, there is a possibility *that the different association patterns between firms' environmental performance and corporate environmental disclosure could be associated with the respective macro environmental disclosure circumstances in society.* Following this thinking pattern, first, the thesis intends to provide new global evidence that would either add to the proposed possibility or go against the proposed possibility through investigations on the association problem between firms' GHG performance and corporate GHG disclosure on a global basis for a recent period under investigation. These investigations are conducted based on the situation that the global macro GHG disclosure circumstance is different from the global macro disclosure circumstance regarding other general CSR or environmental issues (KPMG, 2015; KPMG, 2017) at current stage. And the macro GHG disclosure circumstance in developing economies is different from that in developed economies (Ali and Rizwan, 2013;

Luo et al., 2013; Frynas and Yamahaki, 2016; Ali et al., 2017; Ali and Frynas, 2018) at current stage. In addition, the thesis also strives to provide empirical evidence on another issue that is under-explored-"whether changes in firms' GHG performance would cause any subsequent changes in firms' GHG disclosure strategy on a global basis" in the same international setting.

Specifically, the thesis investigates the relationship between firms' GHG performance and GHG disclosure for a recent period (years 2009-2014) under investigation in terms of four research questions: **(1)** "For years 2009-2014, would the observed association pattern between firms' GHG performance and corporate GHG disclosure on a global basis be different from the most recently observed positive association (Al-Tuwaijri et al., 2004; Clarkson et al., 2008) pattern between firms' environmental performance and corporate environmental disclosure?" (chapter 4); **(2)** "For the same period under investigation, would the association pattern between firms' GHG performance and corporate GHG disclosure in developed economies be different from that in developing economies?" (chapter 4); **(3)** "Globally speaking, for years 2009-2014, would changes in firms' GHG performance cause any subsequent changes in firms' GHG disclosure strategy?" (chapter 5); **(4)** "For the same period under investigation, would there be any difference of the evidence regarding research question (3) between developing economies and developed economies?" (chapter 6).

In the next section, the findings as regards the research questions above would be summarised. Subsequently, the contribution of the thesis to the literature would be discussed. In the end of the chapter, the implications, and limitations of this piece of research would be presented and discussed. In addition to which, the possibilities of future research would also be discussed.

7.2 Summarising the Findings of the Thesis

The thesis first examines the association between firms' GHG performance and the extensiveness of firms' GHG disclosure on a global basis. Following which, the potential causal relationhsip between the changes of firms' historical GHG performance trajectory and the subsequent changes of the extensiveness of firms' GHG disclosure is investigated on a global basis. There is progression between the research questions for each empirical chapter. Thus, this section is organised per empirical chapter.

7.2.1 Summary of the Findings in Chapter 4

As is mentioned earlier, the two major tasks chapter 4 deals with are (i) Formally advancing the possibility *that the different association patterns between firms' environmental performance and corporate environmental disclosure could be associated with the respective macro environmental disclosure circumstances in society,* based on detailed review of the chronologically clustering continuous North American evidence. (ii) Given that, at current stage, global macro GHG disclsoure circumstance is different from that of other general CSR or environmental issues. And there are significant differences between developing economies and developed economies as regards their repective macro GHG disclosure circumstances at current stage. For the recent period- "years 2009-2014", using consistent research design, the investigations in this chapter intend to identify if there is any significant difference between the observed global GHG disclosure-performance association pattern for the period under investigation and the most recently identified positive disclosure-peformance associaiton pattern (Al-Tuwaijri et al., 2004; Clarkson et al., 2008) regarding other general environmental issues. In addition, this chapter also would like to see whether there is any significant difference between developing economies and developed economies as regards their respectively observed GHG disclosure-performance association pattern for the same period under investigation. If the expected differences could be empirically observed, then such evidence would add to the possibility *that the different association patterns between firms' environmental performance and corporate environmental disclosure are associated with the respective macro environmental disclosure circumstances in society.*

Specifically, the results obtained in chapter 4 suggest that, compared with the most recent empirical evidence [**Phase3** (positive association) illustrated in Table 1-1] as regards the environmental disclosure-performance association pattern of other general environmental issues, the overall global evidence suggests that, for years 2009-2014, there is a negative association between firms' GHG performance and the extensiveness of firms'

voluntary GHG disclosure, corresponding to **Phase2** (negative association) of Table 1-1. This evidence echoes the fact that, globally speaking, *the time length of the propaganda and education efforts to diffuse and sediment the importance of GHG emission issues and related climate change crisis in global society* is much shorter than that of other general CSR or environmental issues. In addition, for years 2009-2014, no significant association between firms' GHG performance and the extensiveness of firms' voluntary GHG disclosure is identified for firms from developing economies, corresponding to **Phase1** (no association) of Table 1-1. And for years 2009-2014, the observed association pattern between firms' GHG performance and the extensiveness of firms' voluntary GHG disclosure is negative for firms from developed economies, corresponding to **Phase2** (negative association) of Table 1-1. This evidence also echoes that fact that *the importance and relevance of GHG emission issues and related climate change crisis* were initiated and promoted by the world's most advanced economies (Thinkingshift, 2007), thus, *the time length of the propaganda and education efforts to diffuse and sediment the importance of GHG emission issues and related climate change crisis in the society of developed economies* is longer than that in the society of developing economies.

The evidence obtained in chapter 4 indicates that the new global evidence as regards the association pattern between firms' GHG performance and the extensiveness of firms' voluntary GHG disclosure adds to the possibility that *that the different association patterns between firms' environmental performance and corporate environmental disclosure are associated with the respective macro environmental disclosure circumstances in society.* This possibility, in turn, could be more confidently used to explain the conflicting evidence in this research area. The evidence obtained in chapter 4 suggests that both *legitimacy theory's prediction as regards the relationship of interest* and *discretionary disclosure theory's prediction as regards the relationship of interest* could be right but under the corresponding different macro disclosure circumstances.

7.2.2 Summary of the Findings in Chapter 5

Because the vast majority of prior studies stop only at identifying potential association between firms' environmental performance and corporate environmental disclosure, we do not know whether firms would make any disclosure strategy change based on the changes of firms' realised environmental mitigating achievement. Understanding this problem would help shed light on potential patterns of firms' environmental disclosure strategy change. Further to the investigations conducted in chapter 4, chapter 5 investigates the so-far under-explored issue of whether changes in corporate environmental performance would cause any

subsequent changes in firms' environmental disclosure strategy, in the case of corporate GHG emission issues on a global basis.

The overall international evidence obtained in chapter 5 indicates that, for the period under investigation, firms' GHG disclosure would not change to promote climate information transparency as a result of the changes in firms' GHG mitigating performance trajectory. On the contrary, firms tend to see a subsequent decreasing tendency of the improvement of voluntary GHG disclosure extensiveness following an improving tendency of the improvement of firms' historical GHG performance. The evidence is consistent with legitimacy theory's prediction over the research question in chapter 5. This also echoes the overall international evidence obtained in chapter 4 that, for the period under investigation, there is a negative association between firms' GHG performance and the extensiveness of voluntary GHG disclosure on a global basis. For the period under investigation, globally speaking, legitimacy theory has strong explanatory power over the relationship between firms' GHG performance and the extensiveness of corporate GHG disclosure. The results in chapter 5 is obtained after factoring out the impact of potential endogeneity problems and data-trending problems. Such evidence further adds to the possibility *that the relationship between firms' environmental performance and corporate environmental disclosure is associated with the respective macro environmental disclosure circumstances in society.*

7.2.3 Summary of the Findings in Chapter 6

Following the investigation in chapter 5, given that *the time length of the propaganda and education efforts to diffuse and sediment the importance of GHG emission issues and related climate change crisis in the society of developing economies* is shorter than that in the society of developed economies*, the degree to which the importance of GHG emission issues and related climate change crisis is accepted by the society of developing economies* is expected lower than that by the society of developed economies. Again, given that the macro GHG disclosure circumstances are different between developing economies and developed economies (Ali and Rizwan, 2013; Luo et al., 2013; Frynas and Yamahaki, 2016; Ali et al., 2017; Ali and Frynas, 2018). For the same recent period under investigation, it is expected that there should be a difference of the empirical evidence as regards research question **(3)** between developing economies and developed economies. Chapter 6 investigates whether it is developing economies or developed economies that drive the overall international evidence obtained in chapter 5 regarding research question **(3)**.

Specifically, the results in chapter 6 find that changes in firms' GHG performance do not contain any information of subsequent changes in firms' GHG disclosure extensiveness (strategy) for firms from developing economies. This is consistent with the evidence identified in chapter 4 that there is no statistically significant association between firms' GHG performance and the extensiveness of firms' voluntary GHG disclosure for the period under investigation for firms from developing economies. For firms from developed economies, however, the results in chapter 6 reveal that the increasing tendency of the improvement of firms' GHG performance causes a subsequent decreasing tendency of the improvement of the extensiveness of firms' voluntary GHG disclosure. This, again, is congruent with the evidence identified in chapter 4 that firms' GHG performance and the extensiveness of firms' voluntary GHG disclosure are negatively associated with each other for firms from developed economies for the period under investigation.

Overall, the evidence obtained in chapter 4 and chapter 6 both indicates that, for the period under investigation, the general GHG disclosure strategy adopted by firms from developing economies is to use voluntary GHG disclosure as a pure legitimising tool that does not reflect firms' underlying GHG performance. In contrast, for the same period under investigation, although firms from developed economies also mainly use voluntary GHG disclosure as a legitimising tool, they tend to adopt a neutral strategy that balances the costs of GHG disclosure and the legitimising benefits they want to get through GHG disclosure. The identified differences regarding the relationship between firms' GHG performance and the extensiveness of firms' voluntary GHG disclosure between developing economies and developed economies in chapter 4 and chapter 6 all add to the possibility *that the relationship between firms' environmental performance and corporate environmental disclosure is associated with the respective macro environmental disclosure circumstances in society.*

7.3 Contributions of the Thesis

The evidence provided for the relationship between firms' environmental performance and corporate environmental disclosure in the extant SEA literature suffers from several problems: (i) The findings of this research topic are predominantly based on cross-sectional research from developed economies. Among which, most of these findings are from North American countries. (ii) The evidence provided as regards the relationship of interest are conflicting, making the literature split and creating lots of confusion for non-academic environmental information users. (iii) Given the problem of (ii), prior studies focus on arguing how their own respective findings are reliable, little evidence so far has been provided to connect and unify these contradictory findings, irrespective of the different research design and data employed in different studies. (iv) The vast majority of prior studies only stop at claiming possible association as regards the relationship of interest. And given the contradictory association patterns documented in the literature, we do not know whether the management of firms would adjust their environmental disclosure strategies according to their underlying environmental performance changes. (v) Because prior studies in this research area all take a single country/region perspective, the generalisability of the evidence from such research is low. Comparative analyses employing consistent research design across countries/regions are lacking in this research area.

Instead of simply attributing the contradiction of evidence presented in prior studies as regards the research topic of interest to gradual improvement in research design and improved data quality, this thesis argues that the contradictory evidence in extant literature could be all true under different macro disclosure circumstances. This is because prior studies have all neglected an important possible situation here, that is, the association pattern between firms' environmental performance and corporate environmental disclosure is really changing in different periods of society. And those studies with contradictory evidence are documenting the real situation as regards the relationship of interest in different periods of society. After a detailed chronological review of the continuous North American[33] evidence on the relationship of interest, the possibility *that the different association patterns between firms' environmental performance and corporate environmental disclosure could be associated with the respective macro environmental disclosure circumstances in society* is formally advanced in chapter 4.

[33] As for why only North American evidence was reviewed when deducing the possibility, please refer back to footnote 4.

The macro environmental disclosure circumstance in society is expected to change gradually over time, because corproate environmental issues (together with other CSR related issues) are not originally considered an integrated part of firms' business activities that firms must attend to. It then follows that making society as a whole accept and believe that firms should sufficiently manage their environmental impact in their daily operations is a process that takes time. And this process is conjoint with the corresponding propaganda and education efforts in society. During this process, the changes and increases of various stakeholders that have different corporate behaviour-changing abilities would lead to different macro environmental disclosure circumstances (for a possible situation of the different macro environmental disclosure circumstances in society over time, please refer back to section1.1.2 and section2.2.1.5) in society over time. Accordingly, under different macro environmental disclosure circumstances, different types [low-profile firms, average firms, high-profile firms regarding a specific environemental (CSR) related issue] of firms and different amount of firms would respond to the concerned corporate environmental (CSR related) issue(s).

Consequently, based on the different environmental disclosure and performance data obtained under different macro environmental disclosure circumstances in society over time, cross-sectional studies in different macro environmental disclosure circumstances would identify conflicting association patterns between firms' environmental performance and corporate environmental disclosure. Further, in chapter 4, it is documented that the overall international evidence regarding the association between firms' GHG performance and the extensiveness of firms' voluntary GHG disclosure for the period under inevstigation is negative (corresponding to **Phase2** of Table 1-1). This is different from the most recently observed positive association (Al-Tuwaijri et al., 2004; Clarkson et al., 2008) pattern between firms' environmental performance regarding other general environmental issues and corporate environmental disclosure regarding other general environmental issues (corresponding to **Phase3** of Table 1-1). And this finding coincides with the fact that the global GHG disclosure circumstance is different from the global disclosure circumstance as regards other general environmental issues at current stage (KPMG, 2015; KPMG, 2017).

In addition, it is also identified in chapter 4 that there is no significant association between firms' GHG performance and the extensiveness of firms' voluntary GHG disclosure in developing economies for the period under investigation (corresponding to **Phase1** of Table 1-1). However, consistent with the overall international evidence obtained in chapter 4, a negative association between firms' GHG performance and the extensiveness of firms' voluntary GHG disclosure in developed economies is identified for the period under investigation (corresponding to **Phase2** of Table 1-1). This again is in line with the

fact that the respective macro GHG disclosure circumstances of developing economies and developed economies are significantly different at current stage (Ali and Rizwan, 2013; Luo et al., 2013; Frynas and Yamahaki, 2016; Ali et al., 2017; Ali and Frynas, 2018). The evidence identified in chapter 4 together adds to the possibility *that the different association patterns between firms' environmental performance and corporate environmental disclosure are associated with the respective macro environmental disclosure circumstances in society*. Particularly, returning to the problems that the extant literature as regards the research topic of interest suffers from at the beginning of this section, the comparative analyses between developing economies and developed economies as regards the relationship of interest in chapter 4 help alleviate the lack of such research in the literature regarding the research topic of interest. In addition, the international evidence provided in chapter 4, to some degree, addresses problem (v) in terms of the generalisability problem of the evidence provided by prior studies.

Subsequent to the investigations and supporting evidence identified in chapter 4, chapter 5 further investigates whether changes in firms' GHG performance would cause any subsequent changes in firms' GHG disclosure strategy to improve climate information transparency. The evidence indicates that, at current stage, firms' GHG disclosure would not change to promote corporate climate information transparency according to the historical changes in firms' underlying GHG performance on a global basis. Instead, an increasing tendency of the improvement of firms' historical GHG performance is often followed by a subsequent decreasing tendency of the improvement of firms' GHG disclosure extensiveness internationally. Further revealed in chapter 6 is that, the overall international evidence identified in chapter 5 is driven by firms from developed economies. In contrast, the changes in firms' GHG disclosure extensiveness do not contain any information of the historical changes in firms' underlying GHG performance in developing economies. The evidence obtained in chapter 5 and chapter 6 is consistent with the evidence obtained in chapter 4. Specifically, going back to the problems that the extant literature as regards the research topic of interest suffers from, the findings presented in chapter 5 and chapter 6 serve to mitigate the identified problems (i), (iv) and (v) in the extant literature.

Overall, the investigations included in the thesis provide new global evidence that further adds to "the possibility" *that the relationship between firms' environmental performance and corporate environmental disclosure is associated with the respective macro environmental disclosure circumstances in society*. This new international evidence further indicates that the above possibility could be more confidently used to connect and unify the seemingly conflicting evidence in the extant literature on this research topic. The possibility, together with the evidence obtained in this thesis that supports it, introduces a new thinking pattern in this

research topic, simultaneously addressing the identified problems (i), (ii), and (iii) of the extant literature.

In addition, the investigations conducted in this thesis also methodologically contribute to the literature. Firstly, the proxies employed for GHG performance and GHG disclosure are more accurate, speaking of measurement, compared with those proxies used in prior studies for general environmental performance and general environmental disclosure (where they only use the performance and disclosure data of one or two environmental issue/issues to proxy for the overall environmental performance and disclosure, given there are so many different issues under the umbrella of the concept of corporate environmental issues. Please refer to the arguments on page 73 in section3.2.1). Secondly, the explicit control for the impact of endogeneity resulting from potentially omitted time-variant variables on the reliability of the empirical evidence obtained is, for the first time, introduced to the literature by means of instrumental variables. In addition, the potential impact of data trending problem on the reliability of the empirical evidence obtained is also controlled through differencing the original data and simultaneously controlling for industry-fixed effects and region-fixed effects. These methodological improvements significantly increase the trustworthiness of the empirical evidence obtained in this thesis.

7.4 Implications, Limitations of the Thesis; Suggestions on Future Research

The findings in this thesis also have pragmatic and instructional significance to environmentally concerned (especially, climate change risks concerned) investors, environmental regulators, and firms' management. Firstly, it should be noted that, the major argument in this thesis about the relationship between firms' environmental performance and corporate environmental disclosure is that the association pattern regarding this relationship of interest changes under different macro environmental disclosure circumstances. Speaking of the exact situations under different macro environmental disclosure circumstances, section1.1.2 and section2.2.1.5 provide a plausible storyline of the shifts of the different macro environmental disclosure circumstances in society over time. Although the evidence obtained in this thesis does not provide any direct testification of such a plausible storyline, it does tell corporate environmental information users that extensive environmental disclosure does not necessarily mean good environmental performance, good environmental impact management and low corporate environmental risks.

When environmentally concerned (especially, climate change risks concerned) investors intend to gauge their interested firms' environmental risks (or GHG related risks) through these firms' environmental disclosure (GHG disclosure) in a certain period, they could now have relatively more reliable estimation about their interested firms' underlying environmental risks (or GHG related risks) even with the interfering factor of the extensiveness of firms' environmental (GHG) disclosure. Take climate change risks concerned investors for instance, if they find that, in a certain period, their interested firms with business activities exposed to potential climate change risks (for example, a multinational corporation with departments in oil mining industry or/and in energy industry) have been continually active in extensive GHG disclosure through a variety of channels. In contrast, the majority of other firms (especially, those operating in heterogeneous business areas) have limited or little GHG disclosure in various channels. This may probably[34] indicate that society is in a period where heavy GHG emitters are using extensive GHG disclosure as a deflector that may prevent them from reliably gauging these firms' climate change related risks. Thus, the investors should exercise enough caution when evaluating the related assets

[34] Indeed, the inference is based on the reasonable assumption that these investors have a good knowledge of their interested firms' business operation areas, and the assumption that they have access to the GHG related disclosure information of firms that operate in heterogeneous business areas, so that they could make valid comparisons.

of their interested firms using climate change related information from firms' GHG disclosure.

The argument that the association pattern between firms' environmental performance and corporate environmental disclosure changes under different macro environmental disclosure circumstances in society over time also provides heuristic references for regulators. For example, along with the gradually changing disclosure circumstance as regards a specific corporate environmental issue, regulators could interfere with flexible combinations of various regulations (e.g. "imposing compulsory and/or consistently formatted disclosure from firms"; "requiring compulsory assurances from reliable third parties" etc.) to promote as reliable as possible disclosure regarding this corporate environmental issue and inhibit firms from misleading investors in their environmentally responsible investment decision-making process.

For the management of firms, the evidence provided in this thesis would create motivations for them to reflect on their own existing GHG (environmental) disclosure strategies. Given the documented evidence regarding the directional changes of association between firms' GHG (environmental) performance and the extensiveness of firms' GHG (environmental) disclosure , it is expected that an increasing number of stakeholders would become more vigilant and prudent when including the GHG (environmental) information provided in firms' GHG (environmental) disclosure to their decision-making models. Consequently, firms' extant GHG (environmental) disclosure strategies are bound to change to accommodate such behavioural change of their respective stakeholders.

Besides the contributions and the practical implications of the thesis discussed above, the evidence provided in this thesis also suffers from some limitations. To start with, the period under investigation is relatively short. Thus, the evidence provided in the thesis does not provide direct vertical evidence documenting that there is a series of association directional changes regarding the association pattern between firms' GHG performance and the extensiveness of firms' GHG disclosure on a global basis. Most importantly, the thesis only provides some rudimentary international evidence that further points to the possibility *that the relationship between firms' environmental performance and corporate environmental disclosure is associated with the respective macro environmental disclosure circumstances in society,* the mechanism of how different macro environmental (GHG) disclosure circumstances affect the association pattern between firms' environmental (GHG) performance and corporate environmental (GHG) disclosure is not explored.

Starting from the limitation of the evidence provided in this thesis that no direct vertical evidence documenting the shifts of association patterns between firms' GHG performance and the extensiveness of firms' GHG disclosure is provided, one possible direction of future research on this topic could be employing a longer time series of GHG disclosure and performance data to see if the longitudinal evidence would document direct shifts of the direction of association between firms' GHG performance and the extensiveness of firms' GHG disclosure in the same society. Further, future studies could potentially investigate the possible mechanism of how the corresponding macro disclosure circumstances affect the association pattern between firms' GHG performance and the extensiveness of firms' GHG disclosure. Additionally, recent evidence suggests that voluntary GHG disclosure and corporate financial performance are positively associated with each other (Alsaifi et al., 2020a). Firms' voluntary GHG disclosure in social media platform and annual reports is associated with changes of firms' cost of equity (Jizi et al., 2016; Albarrak et al., 2019; Alsaifi et al., 2020b). Given that the evidence obtained in all the three empirical chapters supports legitimacy theory's prediction over the GHG disclosure-performance relationship for the period under investigation, it indicates that, at current stage, heavy GHG emitters are potentially using extensive GHG disclosure to greenwash themselves. Thus, it would be of great interest for future studies to investigate if there is any further evidence for the greenwashing (e.g. the evidence of financial benefits associated with extensive voluntary GHG disclosure) effects of GHG disclosure in international society as a whole, in developing economies and in developed economies for a similar period under investigation.

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