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Stock Market Reactions to Firms' First Publication of Sustainability Reports

Evidence from multiple industries in Nordic countries, the United States, and China

by

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Abstract

This study investigates the market reactions to firms' first publication of sustainability reports. The data of listed companies in the Nordic, the United States, and Chinese stock markets are utilized to examine whether the event leads to abnormal returns in the short term and whether the results are identical across regions. The companies are divided into two groups based on their impact on the environment and society to investigate industry-specific characteristics.

Evidence from model estimations demonstrates that companies that release their sustainability reports for the first time generate negative abnormal returns in the short term and that both groups show similar results. One potential reason is that investors assume the cost of the investment in the sustainability exceeds the potential future returns. The results also show that Nordic countries have a higher level of market efficiency when it comes to sustainability-related events. The cross-sectional regression shows that three regions have distinct characteristics. Investors in Nordic countries care more about the environment and ESG, while the tone of the context in the sustainability reports is more significant in the US and Chinese markets.

Keywords: sustainability reports, ESG, sentiment analysis, LASSO, event study, machine learning

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1 Introduction

Many researchers have studied the impact of sustainability-related disclosure published by companies in developed countries over the past decades (Hamilton, 1995; Khana et al., 1998; Konar et al., 2001; Garcés-Ayerbe et al., 2009). However, the research on the effectiveness of companies' sustainability reporting in emerging markets has just recently commenced (Yin et al., 2017), let alone the cross-country studies. This study aims to fill the gap of cross-country comparison on market reactions to the first publication of sustainability report. At stage I, the study explores the stock reactions to the first-time publication of sustainability report by using event study to analyze cumulative abnormal returns as well as level of market efficiency in US, Nordic, and Chinese markets. At stage II, new text-as-data approaches such as word count and sentiment analysis, machine learning tools such as LASSO are incorporated to design a cross-sectional regression so as to investigate the firm-level heteroskedasticity of the abnormal returns. Furthermore, the study provides evidence for policymakers and investors to discuss and refer to when taking sustainability factors into decision making process.

This section introduces the background as well as the aim and objectives of the study.

1.1 Background

Environment, social responsibility, and corporate governance (ESG) is a new enterprise assessment framework that includes assessing environmental effects, social responsibility, and corporate internal control and compliance. The concept of ESG dates back to 1970 in the United States when a mutual fund was created to avoid investing in the enterprises involved in the Vietnam War. Later, a new stock index was created based on social and environmental performance in order to stand out from the indices that primarily focus on market and financial performances. Traditional enterprise assessment system mainly relies on a company's fundamental valuation, encompassing corporate operating environment, production situation, revenue and profitability, cash flow situation, financial leverage, and debt financing ability (Ba, 2020). Compared to the conventional enterprise assessment system, which focuses solely on financial results, ESG promotes a business model that generates continuous and sustainable profits in the long term (Ba, 2020).

Because of the increased emphasis on the effects of climate change, financial markets now pay extra attention to a company's sustainability-related performance and tend to incorporate this assessment scheme into enterprise valuation. In addition, it is widely accepted that the byproduct generated during companies' production process has a significant impact on the society and the environment. In this context, many companies worldwide have taken actions to present their efforts in transitioning to a low-carbon economy. In the United States, all the S&P

500 companies have taken the initiatives to publish their sustainability or corporate social responsibility reports, although it is not mandatory. Many countries have also incorporated sustainable economic development into regulations. For example, Hong Kong Stock Exchange has required all the publicly listed companies to publish sustainability reports since 2019. In Nordic markets, the actions were taken even earlier, and the regulations are stricter compared to other markets. For example, the Danish government passed legislation on corporate social responsibility in December 2009. Sweden introduced a new law requiring companies to disclose information about environment, social responsibility, and anti-corruption and bribery issues from January 1st, 2017 (Tillväxtanalys, 2017). Meanwhile, since 2000, research on the ESG-related topics have increased dramatically, as more and more scholars attempt to investigate how ESG or environmental disclosure affects equity markets and how significant the reaction is (Hamilton, 1995; Khana et al., 1998; Konar et al., 2001; Garcés-Ayerbe et al., 2009).

However, there is no universal or standardized ESG evaluation framework. Despite the fact that the 4th generation of guidelines of the Global Reporting Initiative (GRI), which covers 34 environmental targets and 48 social responsibility targets, is regarded as a practical guide for sustainability reporting (GRI and SASB joint publication, 2021), different institutes have different ESG evaluation models that cover distinct aspects of ESG or give distinct scale to the very same ESG content.

As a result, the non-standardized ESG framework has become one of the main challenges for investors and financial markets to evaluate a company's sustainability-related performance and investigate whether the company's business model is in line with a sustainable future, particularly when a company discloses its ESG report for the first time. Furthermore, uneven development and a growing number of diversified ESG reporting methodologies in different markets have become another obstacle for investors when they perform enterprise valuation, construct portfolios and make investment decisions in a global context (MacMahon, 2020).

Nevertheless, many large institutional investors use ESG scores and ESG disclosure as an index to complement a company's financial disclosure. This also suggests that the investors should be less inclined to invest in companies with ESG controversies due to the nature of the industry or companies that take no effort in publishing a solid quantitative and qualitative sustainability report. Therefore, investigating market reactions to a company's ESG information disclosure is relevant to the evaluation of the effectiveness of ESG reporting. In addition, employing a country-specific and industrial-specific analysis is expected to provide valuable insights in understanding the market reactions to the publication of environmental risks, social responsibilities, and corporate governance in different contexts.

1.2 Aim and Objectives

The effect of sustainability or environmental information disclosure on stock markets in developed countries has been examined by a number of researchers. Similar studies on developing countries, on the other hand, have only recently piqued the interest of scholars (Yin et al., 2017; Sultana et al., 2018), let alone comparing industrial and regional specific

characteristics. Some developed countries, such as the Nordic countries and the United States, which play vital roles in the global financial system, are pioneers in environmental protection awareness and green finance. However, in emerging markets, the power of this corporate sustainability scheme is not well established; for example, a previous study on the stock market reactions to a company's ESG information disclosure found a negative effect. (Xu, Zeng, and Tam, 2012). Therefore, cross-country analysis not only exhibits the development of the policy and credit rating system in the emerging markets in response to the transition to a greener state of business, but also provides empirical evidence of how the companies in the developed markets adapt to new corporate evaluation systems.

The objective of this study is, firstly, to investigate how the stock prices of the companies in different industrial groups in the Nordic countries, the United States, and China, react when the companies publish their first sustainability reports. Secondly, what are the country-wise or industry-specific characteristics in terms of abnormal returns arising from this event? Are the characteristics identical across the regions and industries? Thirdly, what are the potential main drivers of abnormal returns arising from the publication of the sustainability reports?

As different industries in different countries are exposed to various environmental risks, changes in customer behavior, and changes in the regulatory landscape, it is challenging to use one standard to measure the impact of ESG information disclosure on the financial markets. Therefore, the industry sectors are divided into 2 groups to reflect the nature of the industry and make results comparable across industry sectors as well as regions. Furthermore, since the companies in the same industry present similar traits and are exposed to similar sustainability-related risks, the grouping of the industries also helps to test whether the industry of interest displays strong reactions to the event. The first group consists of the companies that are assumed to have a relatively low impact on the environment and the society. In contrast, the second group includes the companies that are assumed to have a significant effect on the environmental deterioration and society.

2 Literature/Theoretical Review

This section covers literature review on the market's understanding of sustainability reporting, the development of sustainability reporting frameworks, and provides background for the implementation of sustainability reporting in different countries in the world. The literature also lays the foundation for the investigation of the relationship between market reactions and the publication of the sustainability reports using event study, cross-sectional regression and LASSO.

2.1 Sustainability Reporting

While sustainability reporting has a long history, there is no universal definition and standardized methodology for it (Ortiz and Crowther, 2005; Daizy and Das, 2013). Sustainability reporting, which is defined by researchers in different ways, is synonymous with environmental, social and governance (ESG) reporting and corporate social responsibility (CSR) reporting (Asungo, 2007; Aras et al, 2010; Daizy and Das, 2013). Dyllick and Hockerts (2002) define sustainability reporting as meeting the economic needs of a firm's direct and indirect stakeholders while maintaining the firm's social and environmental goals. Hart and Milstein (2003) describe sustainability reporting as a means of promoting firms' intent to present their actions being and to be undertaken for a sustainable future. According to Slater and Gilbert (2004), sustainability reporting is defined as a structured way to complement financial reporting and reflect how non-financial factors affect business operations and enterprise values.

Since the publication of the first environmental reports in the late 1980s by chemical companies, there has been an increasing trend for sustainable economic development and sustainability reporting (Kolk, 2003). Over the last three decades, sustainability reporting has been adopted by organizations and firms worldwide, and has become to be critical for enterprise valuation and performance analysis (Porter and Claas van der Linde, 1995; Klassen and McLaughlin, 1996; Yamaguchi, 2008; Blanco et al., 2009; Aras et al, 2010). More firms have acknowledged the financial impact arising from the sustainability-related risks. In addition, from an investor's perspective, sustainability topics, such as pollution prevention and energy management, affect monetary amounts in the firms' financial statements, which creates or erodes the enterprise value (Aupperle et al, 1985). Due to the increasing financial importance of sustainability matters, enterprises have implemented initiatives to issue sustainability reports, which present environmental and social impacts arising from corporate activities, in order to manage corporate reputation, benchmark against competitors and increase enterprise value (Belu, 2009). Meanwhile, public authorities and organizations have become increasingly active in

constructing and building on sustainability reporting frameworks at an international level (Inderst and Stewart, 2018).

2.1.1 Dow Jones Sustainability Index (DJSI)

In 1999, the Dow Jones Sustainability Index (DJSI), which is a division of S&P Global, was launched to evaluate the sustainability performance of publicly listed companies (Searcy and Elkhawas, 2012). Companies that are among the top 10% of CSR leaders in their respective industries are eligible to participate in this index and ranking. They fill out the DJSI survey every year and are assessed based on long-term climate change mitigation, corporate governance and social performance parameters. Once the firm no longer meets the membership criteria, it will be removed from the index. In 2020, 1386 companies from all over the world participated in the DJSI, almost doubling the number from 2010¹. Nevertheless, one of the drawbacks of the DJSI is the subjectivity of the rankings, raising doubts on the reliability and validity of the methodology (Hawn et al, 2011).

2.1.2 UN Global Compact

The United Nations (UN) Global Compact principles were framed by the UN in 2000, which are a new initiative on voluntary corporate policies and actions. The UN defines ten principles, used as a starting point for firms to advance in human rights, the environment and anti-corruption (Williams, 2004). The principles encourage participating companies to communicate with the public annually in terms of their social and environmental responsibilities, reflecting whether they set strategies to align with the goals for a sustainable future. However, the UN Global Compact is questioned for not being designed as an independent and quantitative mechanism (Thérien and Pouliot, 2006), resulting in the lack of transparency and non-auditable compliance (Adams, 2013).

2.1.3 Carbon Disclosure Project (CDP)

Carbon Disclosure Project (CDP) is a not-for-profit organization and was launched in 2002 (Luo et al, 2012). Its aim is to offer the firms a channel to measure and report their greenhouse gas (GHG) emissions, energy use and climate change strategies through energy-efficient methods (Hrasky, 2011; Li et al, 2018). Once a company agrees to participate in the CDP, it is unable to change the presentation's style or questions in the survey provided by the CDP (Cormier et al, 2008). The company can choose to skip a question in the survey, but it cannot delete the question. The absence of a response delivers the message that the underlying item may be sensitive to the company that is reluctant to disclose (Luo et al, 2012). According to the

¹ DJSI Annual Review 2020, S&P Global: <https://www.spglobal.com/esg/csa/djsi-csa-annual-review-2020>

CDP 2019 GHG emissions summary², more than 5000 companies are involved in this project and 35% of the total GHG emissions are reported by the companies through CDP.

2.1.4 Global Reporting Initiatives (GRI)

In 2003, the Global Reporting Initiatives (GRI) guidelines were established by the Global Sustainability Standards Board (GSSB) to help businesses identify and quantify the costs and benefits associated with sustainable matters, such as climate change, human rights and corporate governance. The guidelines contain a set of performance indicators (PI) measuring the company' environmental impact, including energy use, biodiversity and emissions, as well as a template for the design of the sustainability reporting. Although the guidelines enable governments and other stakeholder groups to understand the reporting in a transparent, comparable and auditable manner (Bustami et al, 2013), Hedberg and Malmborg (2003) suggest that internal organizational communication benefit more from the GRI guidelines than external communication.

2.1.5 Sustainability Accounting Standards Board (SASB)

Sustainability issues can impact the financial performance of the companies, but not all the sustainability issues affect every industry. In other words, financially-material sustainability issues can vary across industries (Grewal et al, 2019). Because of this, Sustainability Accounting Standards Board (SASB) identified a set of industry-specific standards, relevant disclosure topics, qualitative and quantitative accounting metrics for each industry, based on five dimensions of sustainability, covering environment, social capital, human capital, business model and governance (Hales, 2021). SASB establishes a materiality map to explain which issues are impacting the financial condition or operating performance of a firm in respective industry. This leads to the financial-material topics and information disclosed by the firms, which implement SASB standards, comparable and consistent across different industries (Schooley et al, 2015).

2.1.6 UN Sustainable Development Goals (UN SDGs)

The United Nations Sustainable Development Goals (UN SDGs) were introduced in 2015 at the United Nations Sustainable Development Summit, with the aim of providing 17 goals which interact with each other and encouraging governments, businesses and all the stakeholders to work together to address the issues relating to global sustainable development. Although the UN SDGs offer a roadmap for a sustainable development strategy, researchers have raised concerns about the implementation of the UN SDGs and the commitment of the businesses. Kim (2018) suggests that the UN SDGs depend on intergovernmental collaboration and require

² CDP Full GHG Emissions – 2019 Summary: <https://www.cdp.net/en/investor/ghg-emissions-dataset>

the participation from all sectors of the global society, making it dangerous to be overly optimistic. Tedd (2017) suggests that goals may collide due to conflict interests of various stakeholders, and that businesses may be under heavy pressure to strike a balance between maximization of the profit and long-term sustainability.

2.1.7 Task Force on Climate-related Financial Disclosures (TCFD)

Over the past 5 years, the global financial system is affected by climate change, natural hazards, new technologies and other physical threats (TCFD, 2017), resulting in massive losses on a global scale (Tyagi, 2018). In order to help businesses to identify the climate-related risks as well as opportunities arising from the transition to a low-carbon economy, Task Force on Climate-related Financial Disclosures (TCFD) published a framework in 2017. The TCFD framework provides guidance to the firms on how to report critical financial activities in the context of climate change and how to align their business models with their commitment to reducing carbon footprint in various scenarios. According to the TCFD 2020 status report³, more than 1500 organizations from all over the world have adopted the TCFD framework in disclosing the climate-related financial activities, and over 110 regulators, governments and central banks around the world support the TCFD through legislation and regulation. However, there are still some obstacles to overcome. Only one out of every fifteen companies disclose information on the resilience of their strategies, and the climate-related financial activities disclosed by asset managers and asset owners to their clients and beneficiaries are insufficient⁴.

2.1.8 EU Taxonomy

The European Commission published a new corporate Sustainability Reporting Directive on April 21, 2021, as well as a taxonomy, a classification scheme for economic activities that can be regarded as environmentally friendly, with the aim of making Europe climate neutral by 2050. This reporting framework provides signals to firms about the potential economic development and risks, and encourages businesses and investors to understand the essence of the investments and whether the investments reduce or avoid GHG emissions, water waste, contamination, and ecosystem harm. According to Lucia et al. (2020), the EU taxonomy-related topics have been incorporated into legislation, and the EU taxonomy has laid a foundation for further policy action in sustainability. Lucarelli et al. (2020) suggest that a lower level of CO₂ emissions is correlated with a higher level of EU taxonomy-related publications. Franziska et al. (2020) argue that while the EU taxonomy paves the way to climate neutrality in some

³ TCFD Status Report (2020). Full report available at: https://assets.bbhub.io/company/sites/60/2020/09/2020-TCFD_Status-Report.pdf

⁴ TCFD Status Report (2019). Full report available at: <https://assets.bbhub.io/company/sites/60/2020/10/2019-TCFD-Status-Report-FINAL-0531191.pdf>

economic sectors, such as the automotive industry, the guidance on some emission-intensive sectors, such as materials, is insufficient.

According to the KPMG Survey of Sustainability Reporting 2020⁵, the sustainability reporting has been trending upward on a global scale since 1993, and the percentage of the companies which disclose sustainability is expected to continue to rise. However, one of the reporting risks is that few firms disclose biodiversity loss and the firm’ impact on biodiversity arising from the economic activities.

Figure 1 shows the development of sustainability reporting frameworks over the last 2 decades.

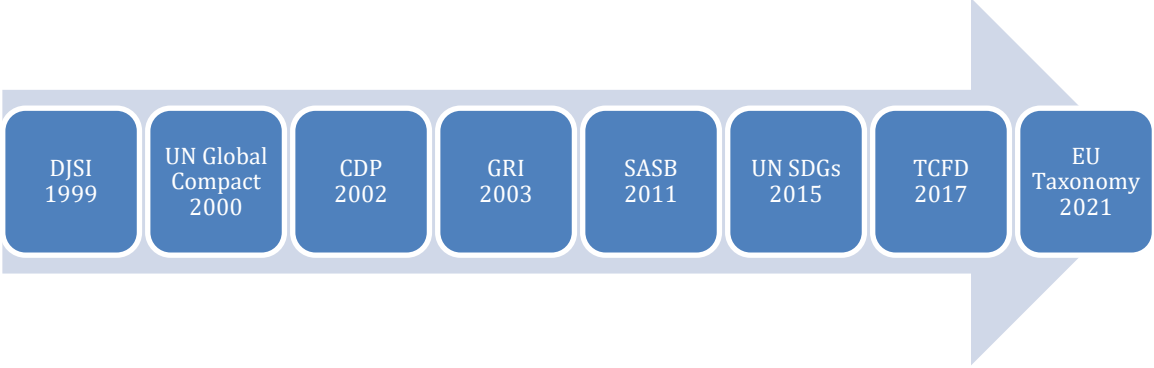


Figure 1 Development of sustainability reporting frameworks from 1999 to 2021

2.2 Event Studies on Sustainability Reporting

2.2.1 Environmental disclosure

Many researchers have used event study and abnormal returns to measure and test the effectiveness of environmental information disclosure (Aupperle et al, 1985; Hamilton, 1995; Khanna et al, 1998; Konar and Cohen, 2001; Cormier and Magnan, 2008; Portney, 2008; Aras et al, 2010). Laplante and Lanoie (1994) analyze how stock prices of 47 Canadian companies respond to environment-related news using event study methodology. According to their study, there is no strong evidence showing there are abnormal returns the day after the announcement of negative environmental events. However, Hamilton (1995)’s findings are not in accordance with Laplante and Lanoie (1994)’s study. Hamilton (1995) examines the American stock market reactions to the pollution data released by 450 companies. The results indicate that as the pollution figures increase, the news organizations are more likely to report the firm’s toxic release, and that the stock returns are negatively affected by the pollution figures.

⁵ KPMG Survey of Sustainability Reporting (2020). Full report available at: <https://assets.kpmg/content/dam/kpmg/xx/pdf/2020/11/the-time-has-come.pdf>

Vance (1975) suggests that investors tend to believe costs invested in environmental improvements exceed the expected future benefits. Fisher-Vanden and Thorburn (2011)'s study supports Vance (1975)'s findings. Fisher-Vanden and Thorburn test the relation between environmental investments and financial performance. They provide some evidence showing that firms' stock returns decline after they announce participation in a program aimed at reducing GHG emissions. They also suggest that firms with weak corporate governance experience a larger decline. Furthermore, they argue that corporate commitments to a greener state of business and lower GHG emissions are incompatible with the goal of maximizing the firm value, limiting the discretion of managers to make lower-carbon investment decisions.

Krueger (2015) uses the event study methodology to examine how the stock prices of 745 American companies react to positive and negative environmental news. Following the news announcements, he finds that the stock prices fall in the short term. Furthermore, Krueger (2015) suggests that following the announcement of improvements on CSR, there exists abnormal negative stock returns. His study is consistent with the findings of Vance (1975) and Laplante and Lanoie (1994).

Klassen and McLaughlin (1996) use the event study methodology and cross-sectional analysis to test the relationship between a firm's environmental management and stock market performance. The authors find that the firm's stock returns are positively correlated with strong environmental management and are negatively affected by environmental crises. The authors also suggest that the market value of the firm is positively correlated with first-time award announcements. The market is skeptical when it sees that heavy-industrial companies, which are regarded as contributors to environmental deterioration, are given awards.

Flammer (2013) extended the methodology developed by Klassen and McLaughlin (1996) to examine how the stock market is affected by firms' environmental footprint. The dataset includes all the US publicly listed companies over a 30-year period. Flammer finds that the firms that actively respond to the environment have a significant increase in stock price, while the firms that react irresponsibly experience a decrease in the stock price, which is consistent with the findings of Klassen and McLaughlin (1996). Flammer (2013) also suggests that the pressure coming from the public pushes the companies to react responsibly and the external pressure has grown rapidly in recent decades. Interestingly, Flammer (2013) finds that the stock prices' reactions to negative environmental behavior increase over time, while the reactions to positive environmental measures decrease over time.

2.2.2 Corporate governance

Some academic papers have also investigated the market reactions to corporate governance and fraud. Karpoff et al. (2005) investigate how the market value of a company is affected by its breach of regulations. According to the authors, a firm's market value erodes after it receives a legal penalty for environmental damage. They also find that the loss of the market value is correlated with the legal penalty and corporate fraud. Capelle-Blancard and Laguna (2010) examine how the stock market reacts to chemical disasters which cause ecological damages. The dataset includes 64 explosions in chemical plants and refineries over a 15-year period. The

petrochemical companies see a decrease in market value of nearly 1% on the day when the accident happens and experience a 1.4% drop over the first week.

Cellier and Chollet (2011) review how events related to corporate governance and strategic implementation affect the short-term stock returns in European stock markets from 2004 to 2009. Interestingly, they find that human rights announcements have a positive impact on abnormal returns, while announcements about human resources and community involvement have a negative or mixed impact. Their research shows that corporate governance has a significant effect on the financial markets, with the reactions being dominated by disaggregated corporate governance initiatives.

2.2.3 Sustainability disclosure and firm value

Yu et al. (2013) investigate how the US stock market reacts to CSR communication and initiatives. They suggest that investors tend to rely heavily on CSR reports when it comes to enterprise valuation. In an inefficient or semi-inefficient market, firms that are more environmentally conscious and have higher investment in R&D experience higher abnormal stock returns, implying that the investment in R&D is a driver of the business value of CSR. However, Yu et al. (2013)'s study is inconsistent with Becchetti et al. (2012) and Harjoto and Jo (2015)'s findings that show a negative correlation between CSR initiatives and enterprise value.

More recently, Brogi and Lagasio (2019) test the relationship between long-term corporate performance and firm value and ESG disclosure. The dataset includes 3476 publicly listed firms in the United States from 2000 to 2016. The authors use three dimensions of ESG score, which are environmental, social and governance, to run the statistical model and find that firm value has a positive relationship with ESG initiatives. Furthermore, they suggest that the association between firm value and ESG disclosure varies across industries. The corporate profitability of financial intermediaries, such as banks, has a strong relationship with ESG, compared to other industries. This can be attributed to US's banks long-standing commitment to reducing their carbon footprint.

2.3 Sustainability Information Disclosure in Different Countries

There has been a growing trend in the last decades focusing on the sustainability reporting. The total value of green bond and ESG related loans has exceeded 80 billion USD in the fourth quarter of 2020 (Gassmann, P., and Kelly, C., 2021 PwC How ESG will drive the next wave of transformation).

Manita, Bruna, Dang and Houanti (2017) analyzed the relationship between the transparency and the feminization of boards by studying the companies in US S&P 500 index from 2010 to

2015. In the research, they also studied the potential relationship between ESG and other control variables such as firm size, return on equity (ROE), firm's leverage ratio, and research & development (R&D) expenditures. Their empirical results show that there is a statistically positive relationship between the board's feminization and the ESG transparency in US. Meanwhile, they also find that ESG rating is highly sensitive to company-specific characteristics. For example, the ESG rating is significantly and positively impacted by the firm size but negatively affected by the firm's leverage ratio. According to the study, companies expect positive reactions from the markets to the board gender diversity and ESG disclosure.

The event study conducted by Gálvez and Kuiper (2020) investigates the impact of ESG rating on stock prices. The authors use publicly listed companies in the S&P 500 from 2015 to 2017. The study shows that there exists no significant relationship between ESG rating and stock price volatility. The authors explain that stock prices mainly focus on a company's ability to generate profit to meet stakeholders' requirements rather than social indicators such as ESG rating. They also argue that environmental sector is more visible on an industrial level than the whole ESG pillar. Another reason is that there is a country-specific factor that influences the significance of the results. Both reasons lead to the conclusion that their results are not significant.

Semenova, Hassel, and Nilsson (2010) studied the influence of environmental and social performance on stock market value using SIX 300 company in OMX Stockhol. In the study, they tested the theory that an environmentally proactive and socially responsible company is rewarded by the market due to reputational benefits arising from the participation in the sustainability reporting. Their theory is also based on previous studies indicating there is a solid proven relationship between the corporate social responsibility performance and the market value (Orlitzky et al., 2003). According to Semenova and Hassel (2016), they used a panel regression of the market value deflated by book value of assets as dependent variable, book value deflated by book value of assets, net income deflated by book value of assets, vector of proxies for environmental and social performance indicators, and a vector of other control variables as independent variables. Their results show that the stakeholders and investors react positively when a listed SIX 300 company in OMX Stockholm has a higher environmental index. Controlling the firm-specific characteristics, the result also indicates that the environmental performance is statistically relevant to stock market value both on an aggregate level and on sub-aggregate level. In addition, they concluded that companies with better environmental and social responsibility performance are traded at a higher price compared to the lagging companies with lower environmental scores. They also suggested that understanding the environmental and social norms across industries is a valuable area, which is not covered in their study.

Schadewitz and Niskala (2010) studied the sustainability reporting and its impact on market value in Finland. Both Schadewitz and Niskala (2010) and Semenova and Hassel (2016) focus on one country in Scandinavian area, but Schadewitz and Niskala (2010) used Ohlson model in their research to probe whether publishing a GRI social responsibility report influences the firms' market value. Their study shows that firms publishing GRI social responsibility reports have a statistically and relatively better performance on three Finnish financial reporting competition websites which are H&H Webranking, Talouselämä, and OMX Finland. This indicates there is a positive relationship between the sustainability reporting and the firm's

market value. However, the authors also suggest that the sample size in their research is relatively small since there are only 7 companies in 2002 and 15 in 2005.

Gálvez and Kuiper (2020), Alareeni and Hamdan (2020) also studied the ESG-related impact on the performance of US S&P 500 listed firms. They aim to find the impact of corporate ESG disclosure on return on asset (ROA), return on equity (ROE), and Tobin's Q which is a market performance indicator. In the study, Alareeni and Hamdan (2020) also include firm size, leverage ratio, assets turnover rate as control variables to explain the firm-specific heteroskedastic features. In each regression, they used one of the 4 dependent variables that are ESG rating, CSR rating, pure environmental score, and pure corporate governance score, which can present the degree of ESG disclosure. They also include one of the 3 independent variables, which are ROA, ROE, and Tobin's Q in each regression. All the data is downloaded from Bloomberg. The results imply that all the 3 ESG-related measures significantly affect ROA and Tobin's Q in a positive direction yet influence ROE in a negative direction. The most interesting finding of this study is that there is a mixed relevance between sustainability reporting and financial performance in US. The authors also suggest that in general firm size has a positive effect on the firm's financial performance since smaller firms have less assets, less high-qualified employees and a lower level of efficiency, leading to lower performance scores. Regarding another control variable, financial leverage, it is only statistically and significantly related to ROA but not ROE or Tobin's Q, because financial leverage is a ratio that is not highly relevant to sustainability reporting. These findings have significant implications on how sustainability reporting meets stakeholders' interests in the United States in the long term. The authors claim that central bankers, auditors and stock market organizers in the United States have regarded the sustainability reporting as a key social responsibility indicator. The organizers, however, may also find it hard to find a universal standard of sustainability disclosure.

The results of Alareeni and Hamdan (2020)'s research is consistent with another study done by Core et al. (2006) when it comes to the relationship between corporate governance rating and ROE. Core et al. (2006) investigated whether implementing more corporate governance regulations weakens a firm's operating performance and disobeys investor's expectations. By using a panel regression and applied microeconometrics methods, the authors test the impact of corporate governance reporting on ROE. In addition, the authors used different control variables to investigate how the companies with different characteristics perform in the equity markets. Overall, their results do not provide strong evidence to show that weak corporate governance leads to underperformance in the stock market.

In addition to aforementioned studies focusing on the sustainability information disclosure in the US market and the Nordic markets, Ender and Brickmann (2019) investigated the efficiency and influence of CSR related news on stock price for Austrian Traded Index (ATX). Their study examines the influence both in the short term and in the long term. In the study, they tested several hypotheses: firstly, does positive CSR-related news contribute to economically positive and significant abnormal return? On the other side, does negative CSR-related news contribute to negatively significant abnormal return in the stock market? What's more, the paper assessed the impact of 3 measurement indicators, environmental rating, social responsibility rating, and corporate governance rating. In the study, Ender and Brickmann (2019) used event study

instead of panel regression with control variables that is used in other studies. The authors designed five steps for the experiment. To begin with, they defined the event and the hypothesis for the first two steps. Then, they calculated the abnormal returns and the cumulated abnormal returns. Finally, they analyzed the results based on the calculated cumulative average abnormal returns. The conclusion is that there is a statistically positive response from the stock market to the positive news for ATX in environmental category and socially responsible category, yet the response is negative for corporate governance related news which is consistent with the research of Alareeni and Hamdan (2020). There are 2 more main contributions in this article. The authors point out that the empirical studies depend on geographic locations as different markets react differently to the sustainability reporting information; the authors also suggest that positive CSR related news has a statistically significant impact that lasts for 11 days whereas negative CSR related news has a statistically impact lasting for only 1 day. In addition, the authors present that only half of the results are significant and the rest is refuted. One plausible explanation is that positive cumulative average abnormal return is relevant to the short-term media presence rather than the content of the news.

Researches in the developed countries conclude there is a potential positive relationship between the ESG rating or social responsibility reporting and firm valuation. However, there are potential endogeneity problems resulting from firms' sizes, public branding, historically strong and healthy financial performance that can also affect the stock performance or financial performance.

In addition to the high-level integration in the financial markets in developed countries, emerging markets also publish regulations to improve sustainability information disclosure. For example, Hong Kong Stock Exchange passed legislation requiring all listed firms to publish sustainability reports from December 2019 (HKEX ESG reporting guide, 2019). In February 2020, Banco de Mexico recommended the firms to provide a clear strategy on physical and transaction risk analysis, following the TCFD recommendations. In May 2020, National Treasury of South Africa's draft technical paper recommended regulators and the financial sector to establish standards on identifying, monitoring, and reporting climate-related risks. In June 2020, Monetary Authority of Singapore indicated that banks should use international reporting framework to guide disclosure. In September 2020, Banco Central Do Brasil announced a plan recommending the firms and banks to disclose sustainability-related information. In September 2020, New Zealand government announced it would introduce a mandatory climate-related financial disclosure regime.

Following the financial policies published by the central banks or security institutes in the emerging markets, the sustainability information disclosure related studies are carried out in a great quantity recently. Yin and Zhou (2017) investigated how the Chinese stock market responds to multiple environmental disclosure which was released and assessed on a weekly basis by a news media outlet, Securities Times (STCN). Since STCN only publishes the environmental information of the companies which have frequent and severe pollution discharges as a result of failing to meet the state regulatory requirements, the listed companies are likely to have a negative news shock from the public. According to Yin and Zhou (2017), the stock response to the environmental disclosure in China has been either not significant (Xu, Zeng and Tam, 2012) or pessimistic which means the stock prices drop (Lyon et al., 2013). Yin

and Zhou (2017) also claim that the quality of the environmental information disclosure needs to be improved. Investors and public have a more positive view on the business when the companies take active initiatives to disclose environmental information rather than waiting for it to be passively published by the news media, which disproportionately focuses on negative news. The study provides in-depth analysis and concludes that the stock market responses in an unfavorable way once a company appears on STCN due to pollution discharge. The event window is statistically significant at 1% level 5 days after the event day and the significant level drops to insignificant 10 days after the event day. Additionally, the authors tested the impact arising from the event that a company's name appears on the List of Public Companies Causing Significant Environmental Risks multiple times in a month. They found that the event is statistically significant at 5% level but the impact fades away quickly. The main reason is that there is no additional information released once a company appears on the list several times in a month for the same reason.

Similarly, Al-Musawi (2015) discusses the connection between environmental information disclosure and financial performance of companies listed on Amman Stock Exchange. In the article, Al-Musawi (2015) uses data between 2009 and 2013 for 28 industrial entities to investigate whether there is a significant change of the stock prices when an entity discloses environmental information or corporate responsibility information in its annual report. Al-Musawi (2015) identifies no significant relationship between environmental information disclosure and the stock price fluctuation, implying that the investors in Amman market pay little attention to a company's initiative of unveiling its environmental related news.

Another article written by Ofoegbu et al (2018) study and compare how the corporate board characteristics affect environmental disclosure. The companies of interest include those with robust sustainability reporting programs and those that pay little attention to the sustainability reporting. Ofoegbu et al (2018) study 213 South African listed companies on Johannesburg Stock Exchange (JSE) and 90 Nigerian listed companies on Nigerian Stock Exchange (NSE) in 2015. The authors investigate whether the companies embed environmental information into annual reports and how much environmental information is disclosed. Their hypothesis is that there is a connection between corporate board characteristics and the level of corporate environmental disclosure in Nigeria and South Africa. As for control variables, they include the number of the board members, board independence score, the total number of board meetings in 2015, audit committee independence scores, whether the firm has an environmental committee or not, firm size, a dummy that notes whether a company operates in a heavily environmental impact industry or not, and whether a company is audited by one of the big four audit firms. Including these 8 control variables helps to compare the firms having different levels of the environmental disclosure. They suggest that there is a significant connection between the corporate board characteristics and the willingness to publish an integrated annual report in South Africa. However, such relationship does not exist in Nigeria. What's more, they find that companies in heavy industries are more willing to disclose their environmental impact compared to those that are in less environmentally sensitive industries. In contrast to companies without an environmental committee, those with an environmental committee are more likely to adopt integrated financial reporting. The authors also mention that there is still a long way to go to establish a comprehensive and standardized environmental information disclosure system in South Africa and Nigeria.

Sobhani, Amran, & Zainuddin (2009) argue that even though environmental disclosure in emerging markets still falls short and has a long way to go, the quantity and quality have been greatly improved from 2000 to 2010. Sobhani, Amran, & Zainuddin (2009) study the environmental information disclosure situation in Bangladesh through context analysis based on a sample of 100 listed companies both on the Dhaka Stock Exchange (DSE) and the Chittagong Stock Exchange (CSE). Sobhani, Amran, & Zainuddin (2009) concluded that all the companies have disclosed at least one item on the human resources issue, 47% of the companies disclose community issues, 23% disclose consumer issues, and 19% of the companies disclose environmental issues, which is a big progress compared to their study on the same issue in 1999. However, they emphasized that no matter the level of corporate social and environmental disclosure, the quality of the sustainable information disclosure is still relatively meagre in Bangladesh.

Mohammed and Wasiuzzaman (2021) are also optimistic about ESG information disclosure in emerging markets. They support the viewpoint that ESG information disclosure helps companies in the emerging markets have a better financial performance than those that only publish a few environmental related items in their ESG reports or do not publish ESG report. Mohammed and Wasiuzzaman (2021) use observations from year 2012 to 2017, consisting of 661 firms listed in the Bursa Malaysia. They implement clustering techniques in their research to test the hypothesis that companies with high ESG scores have better financial performance. The results present that investors in Malaysia give the same rewarding signal to the companies that improve their ESG rating as the investors in developed markets such as US, Sweden and Austria. In the article, they suggest that companies that do not publish ESG reports or have low ESG ratings may be in need of help from government to motivate them to participate in more environmental disclosure activities. Finally, the authors recommend other researchers to investigate the relationship between ESG information disclosure and financial or stock price performance in Asian and other developing countries in order to accelerate the development of ESG information disclosure.

In developed countries, the general trend for sustainability information disclosure is increasing. Numerous studies have shown a positive and significant relationship between sustainability information disclosure and financial results. In contrast, even if the quality and quantity of sustainable information disclosure has been gradually improved in emerging markets, the relationship between sustainable information disclosure and financial performance or stock response remains mixed or tilt to be unfavorable. What needs to be emphasized here is that there is so far no cross developed and emerging markets study focusing on stock market reactions to the shock when companies release their first sustainable reports. This study expects to fill the gap and provide a holistic analysis, acting as a stepping-stone for policy makers and researchers to formulate and establish a better sustainable information disclosure system globally.

3 Methodology

This section mainly discusses the methodology employed in the study. Compared to panel regression, event study can capture a news shock or information disclosure shock and estimate the impact of the shock on stock prices through days. Since not all companies release their sustainability reports on the same day, the event study also explores when the shock fades away in a more precise and dynamic method. Yin and Zhou (2017) tested the effectiveness of the publication of environmental information disclosure in the biggest emerging market, China. This study will apply the same method as Yin and Zhou (2017) but expand the methodology to cover 2 more developed markets, Nordic region and US, in addition to 1 emerging market, China. Moreover, this study compares the industry-wise heteroskedasticity of 3 markets at stage I and investigate the firm-level heteroskedasticity of the abnormal return across markets at stage II by applying cross-sectional regression. What's more, the study will apply Lundqvist and Vilhelmsson (2017) text-based method to measure the degree of sustainability information disclosure so that the industry-specific and country-specific characteristics of stock returns can be incorporated and compared at stage II.

3.1 Research Approach

There are many researches using event study to investigate the stock reactions to sustainability information disclosure. Yin and Zhou (2017) examine the stock volatility during the period when a company's name appears on the state's List of Public Companies Causing Significant Environmental Risks and is meanwhile published by STCN, a news media organization. The authors denote the date when a company's name appears on the STCN's list for the first time as day 0, and denote 5 different event windows, [-10, -1], [-1, 0], [0, 5], [0, 10] to assess the effect. Furthermore, as some companies' names may appear on the STCN's list more than once, Yin and Zhou (2017) also calculate the AR and CAR using event window [-1, 0], [0, 5]. Afterwards, the authors calculate the CAAR across companies to investigate the real shock impact of such environmental disclosure on the stock prices.

Wang (2019) employs the same method to study how the stock market reacts to the macroeconomic events. Instead of using the date when a company appears on an unfavorable list, he uses the date from the Down Jones Adverse Media Entity covering a period from 2012 to 2019 and estimates the short-term effect. One of the challenges that he encounters is that the CAR has already significantly dropped below 0 ahead of the negative news, indicating that the event might not be isolated. He addresses several reasonable explanations, such as (i) trading from insiders; (ii) the stock price is partially adjusted prior to the event at day 0; (iii) investors react based on speculations and predictions; (iv) disturbance or confounding from other event(s). The event window in his study is 21 days rather than 5 or 10 days as Edmans (2011).

Nevertheless, Edmans (2011) has a different focus. He tests the stock reactions to employee's satisfaction in the long run, which is not relevant to the publication of sustainability reports.

A participatory text-based qualitative research approach is used in this study to provide a holistic picture of the degree of sustainability reporting. Enlightened by Lundqvist and Vilhelmsson (2017) and Baier et al. (2020), 59 dimensions are applied to capture the comprehensiveness and systematicity of a company's sustainability information disclosure. The authors search different words combinations within the dimensions to identify the key words "hits". For each key words "hits", there is no more than ± 200 characters gap between two words. For example, when searching "sustainability+report", it signals and exports 1 hit if and only if there is no more than 200 characters between the word, sustainability, and the word, report. In the end, all companies in the sample have a total score of the degree of sustainability reporting for their very first sustainability reports.

Sentiment analysis is incorporated in this study to support the investigation of the sensitivity of stock market response to the sustainability disclosure and the underlying tone of the context in the sustainability reports. To begin with, sustainability reporting and ESG related key words are stipulated from the Loughran and McDonald (2013) positive and negative words dictionary which is broadly used in the financial and business-related text analysis. Based on the traits of key words, each word in the news is categorized into positive, negative, or neutral. All companies' first sustainability reports have a general rating indicating whether positive or negative words predominate in the context of the reports.

3.2 Research Design

3.2.1 Identification of Event and Sustainability Report Publication Date

This study uses event study methodology to test whether the first publication of sustainability reports results in abnormal returns in the financial markets. The event, in this study, is defined as the day on which firms that publish sustainability reports or likewise CSR reports for the first time. Therefore, it is considered as a breakthrough for those firms to present their environmental, social and governance performance to the public, and one of our hypotheses is that it would have an effect on the stock returns.

This study does not differentiate between reports that follow different international sustainability reporting frameworks, such as GRI, UN SDGs or TCFD. What this study does consider is the release date by the company. In practice, however, some firms publish their first sustainability reports together with annual reports, which makes it difficult to quantify the abnormal returns that arise from the publication of the sustainability reports alone. In such case, in order to get rid of the confounding event from the annual reports, these firms are dropped from the dataset.

3.2.2 Abnormal Return (AR), Cumulative Abnormal Return (CAR) and Cumulative Average Abnormal Return (CAAR)

The basic idea of event study is to measure the effect of the event on the stock returns changes around the event. The first step in performing the event study is to define the event and time period over which the stock returns should be analyzed. Figure 2 shows the time period for the study.

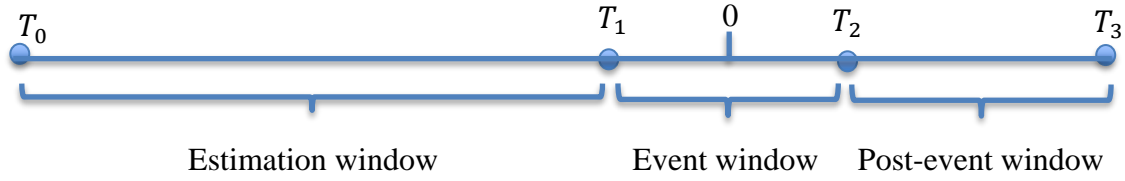


Figure 2 Time period for the event study

T_0 indicates the start date of the estimation window. T_1 indicates the start date of the event window and T_2 indicates the end date of the event window. 0 represents the time of the event. From T_0 to T_1 , we have L_1+1 observations, where L_1 is the length of the estimation window. From T_1 to T_2 , we have L_2+1 observations, where L_2 is the length of the event window.

Incorporating the period from T_1 to 0 in the event window takes into account the effect if information leaks before the event. Similarly, the time period T_1 to T_2 is included in the event window to account for the effect if the market is inefficient.

$E[R_{it}^*|\Omega_{it}]$, known as the expected normal return, is the return that would be expected if the event did not happen. R_{it}^* indicates the return on asset i at time t in the event window and Ω_{it} is the conditioning information. Equation 3.1 shows the market model which assumes a stable relation between the market return and the stock return. By using this model, the expected normal return is estimated.

$$R_{it} = \alpha_i + \beta_i R_{mt} + \varepsilon_{it}, t \in \text{estimation window} \quad (3.1)$$

$$E[\varepsilon_{it}] = 0 \quad (3.2)$$

$$\text{Var}(\varepsilon_{it}) = \sigma_{\varepsilon_i}^2 \quad (3.3)$$

$$E[R_{it}^*|\Omega_{it}] = \hat{\alpha}_i + \hat{\beta}_i R_{mt}^* \quad (3.4)$$

where $\hat{\alpha}_i$ and $\hat{\beta}_i$ are the estimates of the intercept and slope in the OLS regression on the observations in the estimation window.

The abnormal return, which is shown in equation 3.5, is the difference between the observed return in the event window and the expected normal return. Therefore, the abnormal return is a measure of the deviation associated with the event.

$$\varepsilon_{it}^* = R_{it}^* - E[R_{it}^*|\Omega_{it}] \quad (3.5)$$

where returns marked with * belong to the event window.

Cumulative abnormal return (CAR) of the asset i during the event window (T_1, T_2) is measured as:

$$CAR_{it}(T_1, T_2) = \sum \varepsilon_{it}^* \quad (3.6)$$

Since this study seeks to test whether the cross-sectional stock returns at the time of the event are abnormal, cumulative average abnormal return (CAAR) is used and measured, as shown in equation 3.7.

$$\overline{CAR}_{it}(T_1, T_2) = \frac{1}{N} \sum_{i=1}^N CAR_{it}(T_1, T_2) \quad (3.7)$$

The variance of the CAAR is measured as:

$$Var(\overline{CAR}_{it}(T_1, T_2)) = \frac{1}{N} var(CAR_{it}(T_1, T_2)) \quad (3.8)$$

The null hypothesis to be tested is whether the CAAR in the event window is equal to zero.

$$\begin{aligned} H_0: \overline{CAR}_{it}(T_1, T_2) &= 0 \\ H_1: \overline{CAR}_{it}(T_1, T_2) &\neq 0 \\ t_{CAR_{it}} &= \frac{\overline{CAR}_{it}(T_1, T_2)}{\overline{\sigma}(T_1, T_2)} \sim N(0,1) \end{aligned} \quad (3.9)$$

The null hypothesis is rejected if the test statistic exceeds the critical value. The significance level of 1%, 5% and 10% will be used in this study.

3.2.3 Event window

The length of the estimation window and event window is possibly one of the most important research design factors of event methodology. The estimation window is 252 days, following standard practice, and provides sufficient observations to estimate the OLS parameters. In terms of the length of the event window, different researchers use different event windows. Hannon and Milkovich (1996) and Griffin and Sun (2013) select $[-2,2]$ as the event window, testing the US market reactions to environmental and human resources events, while Krueger (2015) uses $[-5,5]$ and $[-10,10]$ as the event window to test the same financial market. Arya and Zhang (2009) and Cellier and Chollet (2011) choose $[-5,5]$ to test the South Africa and European stock markets reactions to corporate governance events. Hamilton (1995) uses $[-1, 1]$, $[0,0]$ and $[0,5]$ and Godfrey et al. (2009) select $[-1,0]$ to test how US stock market responds to sustainability-related events and news.

Although the availability of public information has increased over the past decades, some less developed financial markets, such as south Asian and Chinese stock markets, have yet achieved weak-form market efficiency (Mobarek and Keasey, 2000; Chung, 2006; Mahmood, 2010;

Nisar et al, 2012). In order to make the results comparable across regions and take into account the consistency of the length of the event window based on existing empirical studies, [0,0], [-1,1], [-2,2], [-5,5] and [-10,10] are used as event window in this study.

3.2.4 Industries Grouping

As discussed previously, sustainability issues affect each industry differently. In addition, different industries in different countries are exposed to various environment-related risks, changes in customer behavior, and changes in the regulatory landscape. For example, a heavy industry is exposed to higher risks of regulatory changes in terms of carbon pricing and energy consumption, compared to a light industry, and its stock returns can be more sensitive to such a change which is reflected in its sustainability report. As a result, the stock returns of the companies belonging to different industries can react differently to the publication of the sustainability reports, due to investors' perceptions regarding the nature of the industry.

Therefore, in order to reflect the nature of the industry and make results comparable across industry sectors as well as regions, the industry sectors are divided into 2 groups: heavy industries, which are assumed to have a significant effect on the environmental deterioration and the society, and light industries that are assumed to have a relatively low impact. The grouping of the industries also aims to test whether the industry of interest displays robust reactions to the event. The industries⁶ available in the database include:

- Communication Services
- Consumer Discretionary
- Consumer Staples
- Energy
- Financials
- Health Care
- Industrials
- Information Technology
- Materials
- Real Estate
- Utilities

To measure the impact of each industry on the society and environment, environmental performance indicator, which is defined as the environmental risk metrics divided by revenues, is used to compute an aggregate score and measure the relative position of each industry. The environmental performance indicators include:

- Total CO₂ equivalent emissions to revenues
- Electricity purchased to revenues
- Total energy use to revenues

⁶ The classification of the industry follows the Global Industry Classification Standard (GICS), which is an industry taxonomy developed by MSCI and S&P. Available at: <https://www.msci.com/gics>

- Total hazardous waste to revenues
- Total waste to revenues
- Water use to revenues
- Renewable energy use ratio
- Waste recycling ratio

To estimate the relative position of each industry, firstly, the average of each environmental performance indicator is calculated. Equation 3.10 is an example showing the formula which calculates the average of total CO₂ equivalent emissions to revenues for financials sector.

$$\text{Industry average}(\text{Financials}) = \frac{CO_{2\text{company}_1} + \dots + CO_{2\text{company}_n}}{N} \quad (3.10)$$

Secondly, percentile rank is used to convert each indicator to a score with a range between 0 and 1. Equation 3.11 shows the formula of the percentile rank.

$$\text{Percentile rank} = \frac{M + 0.5 * R}{Y} * 100 \quad (3.11)$$

where M is number of ranks before observation i , R is the number of ranks equals observation i , and Y is the total number of the ranks.

Finally, an average score is calculated for each industry.

$$\text{Industry average score} = \frac{CO_{2\text{industry}_1} + \dots + \text{Waste recycling}_{\text{industry}_1}}{N} \quad (3.12)$$

3.2.5 Degree of Sustainability Reporting

In terms of sustainability information disclosure, none of the protocols provides a globally recognized evaluation criteria, and most of the countries require companies to public sustainability report voluntarily. Even for those countries which legislate the sustainable report publication, there is no hard standard requesting the quantitative measurement of the environmental impact or the social responsibility. As a result of unstrict implementation of sustainability reporting and heterogenous reporting standards, companies may publish a comparably vague report. For that reason, it is difficult to measure the degree of sustainability reporting. However, Lundqvist and Vilhelmsson (2018) sheds new light on using a text-based approach to estimate the degree of enterprise risk management. Firstly, they collect and organize several dimensions that are able to fully cover and measure that reporting standard. Secondly, for each dimension, key words are extracted to target the key words “hits” in the reports. After searching the key words “hits” as well as dimension in the reporting, they calculate the frequency of appearance of key words “hits” from the reports as well as the number of dimensions that are covered in the reports to determine the degree of reporting. Yan and Wang (2020) utilized the same method on probing the relationship between enterprise risk management (ERM) and default risk and proved that this text-based method is efficient when assessing the degree of reporting.

Based on the studies from Baier et al. (2020), Roberts et al. (2019), and the tag cloud results from several the most commonly used sustainability reporting standards, which are UN Global Impact, GRI, SASB, TCFD, and EU Taxonomy, a list of words covering the maximum dimensions of sustainable information disclosure is created. Furthermore, all the key words are categorized into 59 dimensions based on the Baier et al. (2020) and Roberts et al. (2019). Subsequently, in this study, Python is utilized to search all the keywords and dimension from sample companies' first published sustainability reports. The number of dimensions that is covered in the sustainability reports is counted as the degree of sustainability report and the range of the degree of sustainability reporting is from 0 to 59. Moreover, all sustainability reporting dimensions share an equal explanation power since there is no additional emphasis given on any specific dimension, which is in line with previous studies.

Myšková and Hájek (2018) suggest that sustainability-related disclosure in annual reports, which is a source of qualitative information, is an important determinant of future profitability. To evaluate the degree of the qualitative information, the authors suggest using sentiment analysis with collocation analysis and sentiment word lists. Following the same methodology, in this study, the word lists created by Loughran and McDonald⁷, and Pencle and Malaescu⁸ are downloaded and used to assess sentiment in the context of sustainability. To perform the collocation analysis, WordStat software is used to calculate the frequencies of positive collocations and negative collocations, and a sentiment score is defined as:

$$Sentiment\ score = \frac{Collocations_{positive} - Collocations_{negative}}{Collocations_{positive} + Collocations_{negative}} \quad (3.13)$$

A positive score suggests that positive collocations or words predominate in the sustainability reports, while a negative score indicates that the sustainability-related activities are presented with a negative overtone.

3.2.6 Least Absolute Shrinkage and Selection Operator (LASSO)

The Least Absolute Shrinkage and Selection Operator (LASSO) is a traditional statistical machine learning approach that uses variable selection and regularization to improve accuracy and interpretability. In order to achieve a refined model, this compact method creates a penalty function and penalizes the coefficient. Geometrically, the LASSO conducts shrinkage where there are two "corners" in the constraint, which corresponds to a diamond in two dimensions. If the sum of squares hits one of these two corners, the coefficient corresponding to the axis is penalized to zero.

Compared to another machine learning method, ridge regression, which does not penalize the sum of squared coefficients (the so-called L2 penalty or L2 constrained fitting), LASSO shrinks the coefficient to 0 through penalizing the sum of absolute coefficients (L1 penalty or L1

⁷ https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1331573

⁸ <https://provalisresearch.com/Download/CSR.zip>

constrained fitting). The regularization penalty is denoted as λ , where λ converges to 0 means the LASSO regression estimates is getting closer to the OLS estimates. As a result, when λ is high, the respective coefficient is accurately zeroed under the LASSO, which will never be the case in ridge regression.

The mechanism of LASSO can be described by the following formula:

$$\min_{\beta, \beta_0} \left(\frac{1}{2N} \sum_{i=1}^N (y_i - \beta_0 - x_i^T \beta)^2 + \lambda \sum_{j=1}^p |\beta_j| \right)$$

where β, β_0 are parameter vectors.

The linear regression part $\sum_{i=1}^N (y_i - \beta_0 - x_i^T \beta)^2$ is the deviation between the estimated equation and the measured value. Penalty function part $\lambda \sum_{j=1}^p |\beta_j|$ helps drop the variables that have relatively lower interpretation power. λ is the controller of the whole penalty function part and the smaller the λ is, the lighter the penalty is, and the more variables for the linear model are selected, vice versa. Eventually, a model with variables that have the most interpretation power and accuracy is generated.

In short, the logic for the function is that firstly, assume all coefficients β_j are zero, then using different combinations and simulations to explore and find the independent variables X_j which have the most interpretation power to the dependent variables y . Afterwards, in the linear regression part, LASSO will raise up the coefficient β_j within the course of the sign of its relationship with y and calculate the residuals $\varepsilon_j = y - \hat{y}$ at the same time. Subsequently, LASSO keeps trying new (β_j, β_k) combinations and adding new β_j until a few other indicators X_k have as much relationship with the residuals ε_j . The whole process will not stop until all indicators have been explored within the model.

K-fold cross validation is applied to choose up the best λ . Cross validation is a tool to separate the original sample into two sub-samples: training sample and validation sample. Using K-fold cross validation can avoid over-fitting problem during the model selection process when the data size is relatively small. To begin with, the training samples are used to generate various possible values of λ and calculate the forecast error for each λ by comparing the forecasted value to the true value in the validation sample along the way. The λ with the minimum forecast error is selected for the final stage of estimation and later on is applied to the entire sample. During the process, K-fold cross validation randomly divides the data sample into K subsets which are different from each other, taking 1 of the subsets as the validation set then assess the rest $K - 1$ subsets as an extension of values of the parameter λ . The whole process repeats K times so each subset gets an opportunity to be a validation sample. At last, the simulation generates the average of λ which has the minimum forecast errors.

Ranstam and Cook (2018) suggest that LASSO regression outperforms some other regression models in terms of the variable selection settings, and that LASSO trades off the potential bias and the accuracy. Furthermore, it is extraordinarily useful when a model has multidimensional datasets. All of these good characteristics make LASSO to play an important role in the economic and finance research field.

In this study, LASSO is used to find the key words that are the most relevant to sustainability information disclosure and factor out words combinations that relatively have less interpretation power to the degree of sustainable reporting. As there are 84 key words covering 59 dimensions involved as explanatory variables, this high dimensional case matches LASSO's expertise. After running a LASSO regression, less than 10 of the keyword combinations are picked for their high correlation to the sustainable information disclosure. As for K-fold cross validation, the rule of thumb is to use K=10 that is the most efficient way to select the best λ .

3.2.7 Dependent and control Variables

3.2.7.a Dependent variables

Cumulative Abnormal Return (CAR) over the horizons [-5,5] and [-10,10]

CAR is widely used to examine whether an event leads to abnormal returns of a stock. In this study, CAR is used to test how the stock markets in different regions react to the event, which is firms' first publication of sustainability report. As discussed previously, CAR is measured by summing the difference between the observed return in the event window and the expected normal return, and a statistic test is used to investigate whether the abnormal returns are significant.

CAR over the horizon [-5,5] and [-10,10] are selected in this study due to the fact that the stock reactions are at the highest significance level in the event window [-5,5] and [-10,10]. Using two horizons also helps to investigate if the effect arising from the event fades away over time.

3.2.7.b Control variables

- (1) Degree of sustainability reporting: this variable measures the comprehensiveness and systematicity of a company's sustainable information disclosure. It is the sum of the number of keyword hits and ranges from 0 to 59.
- (2) Word count: word count is collected based on a text-based method by constructing a proxy which calculates the frequency of each key word "hit". All the key words "hits" together represents the depth of a sustainability reporting.
- (3) ESG disclosure score: a rating which reflects the level of ESG disclosure of a company. The higher the score, the higher the level of ESG disclosure.
- (4) Environmental, social and governance disclosure scores: firms are given three separated environmental, social and governance scores in terms of the disclosure of respective topic.
- (5) Percentage of independent directors: this variable measures the proportion of board of directors who do not have a material relationship with the company. It is a potential driver of the enhancement of internal control.
- (6) CAPEX / Sales: according to TCFD (2017), capital expenditures can be used as a measurement of how much the firms are willing to invest in low-carbon operations or green

technology. A higher investment in sustainability may lead to better ESG performance. However, the causality may not hold vice versa.

(7) Fines: it is the sum of environmental fines, bribery and corruption fines, and health and safety fines.

(8) $Collocations_{positive}$: the frequencies of positive collocations that match pre-defined keywords or key topics.

(9) $Collocations_{negative}$: the frequencies of negative collocations that match pre-defined keywords or key topics.

(10) Sentiment score: a score measuring whether the context of the sustainability report is predominated by positive collocations or negative collocations.

(11) Firm size: the variable measures the size of the firm based on the market capitalization, which is a measurement of available sources that can be invested in sustainability-related activities.

(12) HML: high minus low. It measures the outperformance of value stocks versus growth stocks. Value stocks refer to the listed companies that have high book-to-market ratios.

3.2.8 Modeling CAR

Using the event study methodology, the country-specific and industry-specific characteristics of the CAAR will be presented. In order to explain firm-level heterogeneity, sustainability information disclosure related variables and accounting variables for the firms are included to probe what affects a firm's CAR and how a firm's CAR responds to the publication of its very first sustainability report. As mentioned in Section 3.2.5, sentimental analysis is an interesting aspect of environmental information disclosure and is thus incorporated in the model. Therefore, an OLS cross-sectional regression is used of the form:

$$CAR_i = \alpha_i + \beta_{1i} \circ Sustainability_i + \beta_{2i} word\ count_i + \gamma_i X_i + \delta_i Z_i + u_i$$

where X_i is a vector of sustainability information disclosure related variables, Z_i is a vector of accounting variables, γ_i and δ_i are vectors of coefficients. As for the sustainability information disclosure related variables, X_i contains 4 ESG variables, which are ESG_i , Env_i , $Social_i$, Gov_i , 1 innovation and sustainable investment variable $CAPEX/Sales_i$, 1 sustainability-related penalty payment variable $Fine_i$, and 3 sustainability disclosure context related variables which are $Negative_i$, $Positive_i$, and $Sentiment\ Score_i$. As for accounting related variables, $Firm\ size_i$ and HML_i are included. One of the advantages of using cross-sectional data is that the longitudinal effect of all explanatory variables on the CAR at the time companies release their sustainability reports can be presented.

In this study, 5 specifications are utilized to i) check if the degree of sustainability reporting has an impact on the CAR generated by the first publication of sustainability report; ii) demonstrate whether the frequency of key words “hits” appearing in the sustainability report can explain certain degree of the variations in CAR; iii) present influence of the environmental, social and governance related variables on the CAR; iv) analyze the explanation power of financial and accounting variables on the CAR; v) estimate the individual explanation power of each control variables on the heteroskedasticity of CAR on the full specification. In addition, comparison of results between countries are conducted in Section 4 to document the country-level differences and similarities as well as to find economic interpretation behind the firm-level heteroskedasticities of the CAR.

4 Data and Descriptive Statistics

4.1 Data

The dataset includes the date of companies' first publication of sustainability reports, environmental risk metrics, stock returns, market returns and country risk-free rate for OMXS30, OMXH25, OMXO20, OMXC25, OMXI10, HSI55, SSE50 and OEX100. ESG disclosure scores, percentage of independent directors, CAPEX/Sales, fines, market capitalization and HML are also included in the dataset. The countries cover Sweden, Denmark, Iceland, Finland, Norway, China and the United States. The date of publication of sustainability reports is collected from company news release, GRI sustainability disclosure database and Shanghai Stock Exchange (SSE) news release database. According to the date of the company's publication of sustainability reports, stock returns, market returns and country risk-free rate for respective estimation window as well as event window of each stock are downloaded from Bloomberg database. Environmental risk metrics of each stock are extracted from Refinitiv Eikon database. As discussed previously, some firms are dropped from the dataset if confounding event is identified. The data of other variables is downloaded from Bloomberg. Table 1 shows the number of valid observations for each index and Table 2 shows the number of firms that started to publish sustainability reports in different time period.

Table 1 Number of the observations for each index

Index	Country	Valid observations	Total observations
OMXS30	Sweden	14	30
OMXH25	Finland	13	25
OMXO20	Norway	7	20
OMXC25	Denmark	14	25
OMXI10	Iceland	1	10
HSI55 & SSE50	China	50	105
OEX100	USA	96	101
Total		195	316

Table 2 Number of firms starting to publish sustainability reports in different time period

Year	Nordic	China	United States
1990-1999	2	-	-
2000-2009	16	7	22
2010-2019	25	34	61
2020-2021	6	9	13
Total	49	50	96

What can be seen in Table 2 is the general pattern of the first sustainability report publish time in each country. Most companies in these three regions chose to disclose their sustainability reports starting from the year 2000, showing their motivation and commitment to the transition to a sustainable future. 33% of the Nordic companies, 14% of the Chinese companies, and 23% of the US companies published their first sustainability reports between the year 2000 to 2009; while in the next decade 51% of the Nordic companies, 68% of the Chinese companies, and 64% of the US companies published their first reports. One of the main reasons for this phenomenon is that investors laid more emphasis on a company’s environmental, social and corporate governance performance since the subprime crisis in 2008. Another plausible reason is that the sustainable reporting standard has become more transparent, quantifying, and auditable within the most recent decade.

4.2 Descriptive Statistics

4.2.1 Industry grouping

Table 3 shows the percentile rank and average scores of aforementioned industries. As it is seen, the average scores are within the range between 0.10 and 0.80. As expected, Financials and communication services are the two industries with the highest scores while energy and materials are the two lowest performing industries. Financials industry outperforms other industries in terms of the majority of the performance indicators, showing a relatively low impact on the environment and society. Overall, the scores and rankings are in line with general perceptions of the nature of the industry.

Table 3 Average scores of the industries (the lower the score, the higher the environmental and societal risk for the company)

	Total CO2 Equivalent Emissions to Revenues	Electricity Purchased to Revenues	Total Energy Use to Revenues	Total Hazardous Waste to Revenues	Total Waste to Revenues	Water Use to Revenues	Renewable Energy Use Ratio	Waste Recycling Ratio	Average
Communication Services	0.30	0.90	0.70	0.80	1.00	1.00	0.80	0.60	0.76
Consumer Discretionary	0.80	0.50	0.60	0.40	0.60	0.70	0.50	0.80	0.61
Consumer Staples	0.60	0.80	0.50	0.30	0.40	0.30	0.40	1.00	0.54
Energy	0.10	0.10	0.00	0.10	0.20	0.20	0.10	0.00	0.10
Financials	1.00	0.70	0.80	1.00	0.90	0.60	1.00	0.40	0.80
Health Care	0.90	1.00	1.00	0.70	0.80	0.90	0.20	0.50	0.75
Industrials	0.40	0.40	0.40	0.60	0.50	0.50	0.00	0.70	0.44
Information Technology	0.70	0.60	0.90	0.50	0.70	0.80	0.70	0.90	0.73
Materials	0.20	0.00	0.20	0.00	0.00	0.10	0.30	0.20	0.13
Real Estate	0.50	0.20	0.10	0.90	0.10	0.40	0.90	0.10	0.40
Utilities	0.00	0.30	0.30	0.20	0.30	0.00	0.60	0.30	0.25

According to the rankings and average scores, the industries are divided into two groups, and the classification threshold is set at 0.5. One of the main reasons to choose 0.5 as the threshold is that for companies whose average scores are above 0.5, the gap between their scores is smaller than 0.1, meaning they demonstrate similar performance characteristics; while the gap for companies with average scores below 0.5 is less than 0.1 as well, showing that they are exposed to similar environmental and social risks as well as challenges. But there is an obvious and relatively large gap between companies in Consumer Staples and Industrials. Hence, 0.5 can be used as a rational bar to categorize companies. As it is shown in Table 4, Financials, Communication Services, Health Care, Information Technology, Consumer Discretionary and Consumer Staples are classified into Group 1, while Industrials, Real Estate, Utilities, Materials and Energy are mapped to Group 2.

Table 4 Industry grouping

Group	Industry	Average score
Group 1	Financials	0.80
	Communication Services	0.76
	Health Care	0.75
	Information Technology	0.73
	Consumer Discretionary	0.61
	Consumer Staples	0.54
Group	Industry	Average score
Group 2	Industrials	0.44
	Real Estate	0.40
	Utilities	0.25
	Materials	0.13
	Energy	0.10

4.2.2 Sentimental Analysis

Table 5 shows the sentiment scores of each industry in Nordic countries, the United States and China. As it is shown, the sentiment scores range from 0.001 to 1. All the industries, except Energy, Health Care, and Information Technology, in the Nordic countries have a lower sentiment score compared to other two countries. One potential reason is that a large number of companies in the Nordic countries have high knowledge about the sustainability-related risks that the companies are exposed to and improvement areas. In addition, customers and the market place a higher value on the disclosure of a company’s risks and challenges, which drives the companies to report not only achievements but also potential risks and threats. Therefore, the companies’ tones are more neutral compared to other regions.

As expected, some heavy industries, such as Energy and Materials, have a lower sentiment score compared to other industries. This might be due to the nature of the industry, and some controversial topics might affect the sentiment scores. Surprisingly, the sentiment score of the Energy sector in the Nordic countries is higher than its peers as well as other industries in this region. One possible reason is that the Nordic countries place a higher value on sustainability

and environmental protection. Hence, the companies in this sector are vigilant and tend to have a positive overtone in their sustainability reports.

Overall, Nordic countries have the lowest average sentiment score (0.159), while the United States have the highest average sentiment score (0.267).

Table 5 Sentiment scores by country by industry

	China			Nordic countries			US		
	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max
Communication Services	0.312	0.226	0.423	0.062	0.014	0.160	0.309	0.059	0.466
Consumer Discretionary	0.195	0.033	0.346	0.117	0.018	0.301	0.272	0.093	0.438
Consumer Staples	0.176	0.018	0.263	0.080	0.014	0.123	0.286	0.041	0.536
Energy	0.133	0.126	0.140	0.530	0.059	1.000	0.140	0.089	0.181
Financials	0.175	0.016	0.393	0.081	0.041	0.135	0.346	0.098	0.789
Health Care	0.065	0.026	0.104	0.129	0.007	0.285	0.229	0.106	0.450
Industrials	0.158	0.036	0.302	0.157	0.009	0.307	0.239	0.119	0.436
Information Technology	0.072	0.072	0.072	0.193	0.129	0.256	0.298	0.042	0.479
Materials	0.185	0.185	0.185	0.115	0.081	0.164	0.200	0.150	0.259
Real Estate	0.232	0.004	0.558	-	-	-	0.327	0.247	0.407
Utilities	0.209	0.054	0.321	0.127	0.001	0.253	0.288	0.184	0.381

4.2.3 LASSO Regression Results

Table 6 shows the explanatory variables selected by LASSO for the 3 regions. As we can see, the variables selected by LASSO are different among the regions. Among 59 explanatory variables, LASSO has selected 4 variables in the event window [-5,5] and 6 variables in the event window [-10,10] for the United States stock market. The variables chosen by LASSO are assumed to play a significant role in the sustainability disclosure in this market.

(1) Consideration of the anti-corruption: ethical business practices are an important component of sustainability. Corruption, which is illegal, distorts market competition and hinder economic development. If a company tolerates corruption, it risks facing fines and lawsuits, which may negatively affect the daily operations and damage the company's reputation. The fight against corruption has a long history in the United States, which has now been a global leader in anti-corruption. Due to harsh punishment and well-established legislative framework, companies in the United States engage in efforts to prevent corruption and prevent themselves from reputational and regulatory risks.

(2) Consideration of the customer privacy: as consumers have increasingly adopted new technology in the business world, customer information protection is regarded as a critical factor for companies' sustainable development. Companies may use consumer data to analyze consumer behavior, develop business models, and increase profitability. Information leakage may lead to trust issues, forensic investigations and diminished reputation. Therefore, it is not surprising that companies proactive about customer data protection and value security practices.

(3) Application and development of new materials: since the United States is one of the world's most material-intensive economies, how to manage natural resources efficiently and develop new materials has become of importance for the companies in the United States. Companies proactively take minimizing environmental impact into consideration when they design, upgrade and produce their products to meet the growing demand for sustainable products. It is therefore, understandable that LASSO selected this variable which reflects companies' efforts to transit to a more sustainable future.

(4) Application of sustainability standards: embedding the sustainability standards at the company level is beneficial. Companies can refer to ready-to-use mechanism which has been tested by international institutions. By adopting credible sustainability standards, companies have a better understanding of sustainability-related issues and risks, which motivates the management teams to take actions to mitigate the risks and identify the opportunities to achieve sustainable goals. Meanwhile, the companies can improve the quality of the reporting and increase efficiency and productivity.

(5) No child labor: in 1938, the federal child labor laws were launched to restrict the abuse of child workers and prevent children from being undermined their health, safety or educational opportunities. The listed companies in the United States have to be vigilant regarding the child labor and other relevant human rights violations in the management of supply chains. Companies that violate the child labor laws face severe penalties.

(6) Human rights assessment: companies are expected to respect human rights which are associated with legal, financial and reputational risks. Companies implement human rights policies to minimize harm to employees and communities because human rights matter to operations throughout the value chain. This is particularly important for the companies that belong to dangerous industries, such as chemical and construction, where employees are exposed to risks leading to injuries, illness and deaths. In addition, employees working in an organization where human rights are well integrated into sustainable business are more likely to be productive as they are treated fairly and with dignity.

In comparison, the variables selected by LASSO for Nordic countries show distinct characteristics. More than half of the variables are related to environment, suggesting that the Nordic countries and businesses place a higher value on the environment.

(1) Tax: tax reporting is an important component when firms communicate and build trust with stakeholders and the public. Tax reporting that is transparent and compliant drives sustainable value for both stakeholders and firms. In the light of low-carbon economy, many countries have imposed carbon taxes, and Nordic countries are among the top 10 in terms of carbon pricing, according to the World Bank⁹. This motivates the companies in the Nordic countries to put additional efforts to enhance operating efficiency while aligning with their sustainable goals.

⁹<https://openknowledge.worldbank.org/bitstream/handle/10986/33809/9781464815867.pdf?sequence=4&isAllowed=y>

In other words, taxes are influencing companies' efforts in decarbonization and sustainability in the Nordic countries.

(2) Environmental management: in the context of sustainable business, environmental management has gained growing popularity, and many firms have incorporated environmental management into their corporate agenda. The firms take initiatives and implement environmental policies, such as pollution prevention, waste management, application of green materials and energy reduction, to improve operational performance and accelerate the sustainability movement. It is not surprising that this variable is selected for Nordic region which has a high maturity-level of sustainable business.

(3) Consideration of the customer health and safety: customer health and safety is an essential factor that determines the sustainability of a business and is across the entire supply chain. A company that prioritizes product safety and customer care is more likely to gain customer trust and strengthen its brand. Proactive efforts to enhance product quality and customer safety also helps companies to drive innovation and implement differentiation strategy in marketing.

(4) Environmental standards: adoption of environmental standards helps the companies to improve the quality of products to meet customers' sustainable demands and reduce operational risks leading to environmental impact. This is particularly beneficial to the companies in energy-intensive industries like metals and mining, as well as iron and steel, that face many challenges in achieving their sustainable goals.

(5) Greenhouse gas emissions: firms' increasing efforts in greenhouse gas (GHG) reduction are valued in the light of global warming, and this contributes to cost reductions where carbon taxes are imposed. In the context of sustainable investment, GHG emissions have become an important risk factor when evaluating a company's holistic performance as well as a key component when rating a company's environmental performance, which is a pillar of ESG score. Enhancing the GHG emissions disclosure in the sustainability report allows investors and stakeholders to understand how companies are tackling with climate change and recognize future costs related to carbon pricing.

The situation also varies when it comes to the Chinese market. LASSO selects more variables in Chinese markets than the US markets and the Nordic markets. Table 6 reveals that 6 predictors out of 59 are selected when the CAR event window is [-5,5] and the 9 are picked when the event window is [-10,10]. Generally, all coefficients are relatively small, meaning the scale of their impacts on the CAR is relatively small. In addition, the predictors picked by LASSO for the Chinese market differ from those selected for US and Nordic markets. There are more corporate governance and social responsibility related predictors as well as the predictors that reflect a company's ability to follow public policies and call for development of ecological materials.

(1) One main predictor that is picked and with relatively high coefficient is the dimension of application and development of new materials. Wang (2019) mentioned that companies in China pay much more attention and take more efforts to develop and apply new materials after the government launched its Made in China 2025 Strategy Plan in 2015, aiming to transforming from world's factory for low-value and low-quality products to high-value-added goods and

services. Under the guidance of this state announced 10-year strategic plan, companies in China have great motivation to highlight their achievements and progress on the application of new materials in their first publishment of sustainability report. Besides, it is noticed that 68% of the Chinese companies publish their first sustainability report around the time period that strategic plan was launched.

(2) Consideration of human rights was another social responsibility predictor that was picked at event window [-5, 5] for the Chinese market. A conventional idea is that there is a gap between the public expectations and corporate disclosure regarding the human rights in China. However, Ma (2017) argues that Chinese companies are trying to fill the gap between stakeholders' expectations and corporate social responsibility (CSR) report regarding labor practice and human rights from 2011 to 2016. This is because more and more companies are expanding their business globally, and the international stakeholders and foreign stock exchange markets regulations are putting pressure on the Chinese companies that are listed in domestic or foreign market to disclosure human rights related information.

(3) A plausible explanation that supplier social responsibility is selected for the Chinese market is that Chinese suppliers are integrated into the global supply chains (Schwerk & Schneider, 2010), and that the global supplier network shares Code of Conduct to endeavor their commitment to improve the working conditions. In this context, and in light of the fact that China has become the world's second largest exporter and the biggest producer, western customers require their Chinese suppliers to adhere to the Code of Conduct and disclose supplier social responsibility related information (Schwerk & Schneider, 2010).

(4) Support alleviating poverty is not a mandatory disclosure item in all the sustainable reporting standards. Nevertheless, it is popular to a large extent for Chinese companies to publish corresponding information. According to Xinhua News (2020), one of the biggest official state-owned media, more than 100,000 Chinese companies help alleviate poverty. The study of Boullenois (2021) indicates that the reason why Chinese companies have strong motivation to reveal their passion for reducing poverty is that the state granted massive amount of funding to encourage companies to take actions to support alleviate the campaigns. As a result, disclosing corresponding information may provide evidence to the governance and help companies to obtain funding or tax deduction benefits.

(5) Talent acquisition disclosure is another example showing that Chinese companies follow the state policies. Carman et al. (2021) suggest that companies use talent acquisition information on the reports to obtain financial support and compensation from the government since China accelerated its pace to attract talents from overseas after employing Thousand Talents Program in 2008. According to the program, companies with advanced talents are promised for research funding and, occasionally, compensations from the government.

(6) Indirect economic impact picked by LASSO has the relatively highest coefficient among all the picked predictors in the event window [-10,10]. The reason of publishing indirect economic impact information can be hybrid. It is highly possible that Chinese companies encounter challenges when quantifying the indirect economic impact but it is significantly important for the companies to take this factor into consideration when conducting production activities and reporting their corporate social responsibilities.

(7) According to Lan et al. (2013), following public policy may not be the determinants of voluntary disclosure in the Chinese stock market, but Chinese companies are active when presenting their commitment to adhere to public policies in voluntary reporting.

(8) According to both CISION PR Newswire (2020) and CDP Disclosure Insight Action (2020), Chinese financial institutes and Chinese companies are still at an early stage in terms of disclosing environmental, social and corporate governance related information. Hence, compared to other markets, publishing climate related risks helps a Chinese company to stand out from its competitors and cheer the investors. That may be the reason why reporting climate related risks is selected as a main predictor by LASSO and the sign is negative in this case.

(9) The study of Jonsson (2014) provides evidence indirectly explaining why stakeholders expect companies in China to disclose employee health related information. In the study of Jonsson (2014), results from quantitative survey-based method imply that disclosing CSR related information, especially employee health related corporate policy and other information, increases the loyalty of employees, which is a positive sign for corporate governance.

(10) Liu et al. (2019) suggest that there are political factors encouraging firms to process and treat effluents. Examples include policies launched by the Chinese government, such as Law of the People's Republic of China on Prevention and Control of Water Pollution in 2017, Marine Environment Protection Law of the People's Republic of China in 2017, and Action Plan for Prevention and Control of Water Pollution. At the same time, more than half of the sample Chinese companies published their first sustainability report. This may be one of the reasons why water and effluents are chosen as one of the main predictors influencing the CAR of Chinese companies.

(11) The stakeholder engagement is not chosen by random. Hofman et al. (2019) study the relationship between institutional drivers of stakeholders and legitimacy of Chinese multinational companies. In the study, they mentioned that institutional stakeholders can help Chinese firms deal with the legitimization challenges when entering western markets. In addition, stakeholders play an important role in driving Chinese MNEs to improve the quality of information disclosure and dispel westerners' mistrust of Chinese MNEs.

Table 6 LASSO Regression Results

Country	US				Nordic Countries				China			
	[-5, 5]		[-10, 10]		[-5, 5]		[-10, 10]		[-5, 5]		[-10, 10]	
	°Sustainability dimensions	coefficient	°Sustainability dimensions	coefficient	°Sustainability dimensions	coefficient	°Sustainability dimensions	coefficient	°Sustainability dimensions	coefficient	°Sustainability dimensions	coefficient
1	Consideration of the anti-corruption	-0.0014	Consideration of the customer privacy	-0.0029	Tax	-0.0041	Tax	-0.0076	Application and Development of new materials	-0.0017	Consideration of the indirect economic impacts	-0.0023
2	Consideration of the customer privacy	-0.0013	Application and development of new materials	-0.0019	Environmental management	-0.0040	Environmental standards	-0.0046	Consideration of the human rights	-0.0011	Public policy	-0.0015
3	Application and development of new materials	-0.0008	Consideration of the anti-corruption	-0.0015	Greenhouse gas emissions	-0.0016	Environmental management	-0.0007	Supplier social responsibility assessment	-0.0005	Supplier social responsibility assessment	-0.0007
4	Application of sustainability standards	-0.0001	No child labor	-0.0014	Consideration of the customer health and safety	-0.0011	Greenhouse gas emissions	-0.0003	Support alleviating poverty	-0.0002	Reporting climate related risks	-0.0007
5			Human rights assessment	-0.0004	Environmental standards	-0.0002			Talent acquisition	-3.19E-05	Employee health	-0.0006
6			Application of sustainability standards	-0.0001					Privacy and free express	-5.23E-06	Water and effluents reporting regulations	-0.0004
7											Application and development of new material	-0.0001
8											Stakeholder engagement	-0.0001
9											Local communities	-1.01E-05

Note: LASSO regression results are ranked on the absolute value of its coefficient. Negative sign of coefficients means that increasing the degree of sustainability at that dimension leads to a decrease in the CAR.

4.2.4 Control Variables

4.2.4.a Control variables

Table 7 shows the descriptive statistics of dependent variables and control variables. As we can see, the number of observations of some variables are less than 195, which is due to the missing data. The reason why the CAR of 5 companies are missing is that these companies published their first sustainability reports before they became publicly listed, resulting in the unavailability of stock returns. In addition, some companies released their first reports before ESG disclosure rating system as well as the quality of sustainability-related disclosure reached a mature level.

Notably, 4 disclosure scores, including ESG, Environment, Social and Governance, have a wide range, implying that companies in the dataset have different maturity-levels in terms of ESG reporting. Regarding the sentiment analysis, the range of positive collocations as well as negative collocations is also broad, reflecting companies' differing perspectives on sustainability reporting. The mean of the sentiment score is low and near zero, which is regarded as a close-to-neutral tone and seems to be realistic.

Table 7 Descriptive statistics of dependent variables and control variables

Variables	(1) N	(2) Mean	(3) Std. Dev	(4) Min	(5) Max	(6) Median
CAR_5	190	-0.154	0.137	-0.710	0.194	-0.143
CAR_10	190	-0.293	0.262	-1.367	0.324	-0.271
Degree of Sustainability Report	194	25.38	8.828	0	49	26
Wordcount_5	190	415.0	571.4	0	4,543	236
Wordcount_10	190	324.3	406.8	0	3,039	197
ESG	172	39.64	12.77	0	71.49	40.2
Env	169	32.90	15.81	0	75.19	34.88
Social	172	36.49	14.65	0	73.68	38.60
Gov	172	58.52	11.72	0	90.55	57.14
Ind of board	170	67.65	25.87	0	100	75.96
CAPEX/Sales	176	0.0830	0.109	0	0.692	0.043
Fines	194	0.0994	0.953	0	12.42	0
Positive	195	1,267	942.2	9	6,308	986
Negative	195	852.2	661.1	14	3,368	641
Sentiment score	195	0.181	0.147	0.000606	1	0.193
Firm size	183	2.027	0.801	1	3	2
HML	195	-0.0183	0.659	-2.590	4.540	-0.05

4.2.4.b Correlation

Table 8 demonstrates the correlation between control variables. As it can be seen, the degree of sustainability reporting has a positive correlation with the word count of companies' sustainability reports. It suggests that the higher the number of word count, the higher the degree of sustainability reporting. In addition, positive correlations between the degree of sustainability

reporting and ESG, environmental, social and governance disclosure scores are in line with the reality. However, the correlation coefficient which measures the relationship between the degree of sustainability reporting and percentage of independent directors is near zero, which is not consistent with our assumption. One possible reason is that even though the proportion of independent directors is part of corporate governance mechanism and is relevant to firm performance, the independent directors do not have a dominant role in the committee in terms of monitoring the sustainability-related disclosure. Similarly, it is noticed that the degree of sustainability reporting is not correlated with the CAPEX, suggesting that not all the funds used by the firms are related to green technology or likewise sustainable projects.

Furthermore, a negative correlation between the degree of sustainability reporting and the fines is noticed, implying that companies with a higher degree of sustainability reporting are more likely to have better corporate governance and less likely to be fined. Unexpectedly, the degree of sustainability reporting is positively correlated with sentiment score. One potential explanation is that firms tend to present more dimensions of their activities and achievements in sustainability with a positive overtone in order to achieve a favorable image of the business among stakeholders. Surprisingly, the degree of sustainability reporting has little to do with the firm size, and it does not rely on the value premium. It reflects the growing trend in sustainability reporting, and firms across regions and across industries increasingly understand the importance of sustainability disclosure, which leads to more resilient business.

The ESG disclosure score is highly correlated with environmental disclosure score and positively correlated with other 2 disclosure scores, which is consistent with the reality. In addition, there exists a positive correlation between sentiment score and ESG disclosure scores, but the coefficients are relatively small. Unlike the degree of sustainability reporting, the ESG disclosure scores are positively correlated with the proportion of independent directors, which is a factor measuring the corporate governance. It is in line with the assumption that better corporate governance ultimately fosters sustainability and helps companies to achieve long-term goals.

Overall, there is no strong correlations found between CAPEX/Sales, fines, firm size and HML. One plausible reason is that our sample size is relatively small, which reduces the power of correlation and leads to less conclusive results.

Table 8 Correlation matrix of control variables

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Sustainability	1.000														
2. Word count_5	0.473	1.000													
3. Word count_10	0.463	0.875	1.000												
4. ESG	0.398	0.271	0.368	1.000											
5. Env	0.393	0.267	0.401	0.946	1.000										
6. Social	0.329	0.189	0.254	0.781	0.606	1.000									
7. Gov	0.186	0.131	0.155	0.719	0.555	0.427	1.000								
8. Ind of board	-0.002	0.048	0.095	0.419	0.377	0.220	0.482	1.000							
9. CAPEX/Sales	0.038	0.037	0.026	0.027	0.083	-0.134	0.054	-0.142	1.000						
10. Fines	-0.176	-0.067	-0.073	-0.077	-0.039	-0.135	-0.048	-0.046	-0.038	1.000					
11. Positive	0.647	0.458	0.390	0.353	0.318	0.290	0.239	-0.020	0.045	-0.069	1.000				
12. Negative	-0.701	-0.477	-0.418	-0.373	-0.347	-0.303	-0.224	0.063	0.000	0.070	-0.937	1.000			
13. Sentiment score	0.320	0.141	0.169	0.104	0.115	0.152	0.094	-0.270	0.095	-0.116	0.110	-0.315	1.000		
14. Firm size	0.021	-0.057	-0.092	0.011	0.024	0.007	0.036	-0.055	0.001	0.124	0.131	0.099	0.014	1.000	
15. HML	-0.139	-0.216	-0.233	0.051	0.061	0.075	0.020	-0.076	0.038	0.077	0.032	-0.052	0.103	0.114	1.000

5 Empirical Results

In this section, event study results of country-level and industry-level heteroskedasticity as well as regression results of the firm-level heteroskedasticity on the CAR are outlined and discussed. It starts with stock reaction to the first publication of sustainability reports in different industrial sectors, groups, and different markets. After that, it presents the regression results of firms in Nordic, the US, and Chinese market under event window $[-5, 5]$ and event window $[-10, 10]$. Moreover, the result analysis and economic interpretation of companies in the three markets are discussed. Highly homogenous stock reaction in both groups and three markets to the firms' first publication of sustainability reports are found, significant differences of firm-level heteroscedasticities are noticed among three regions.

5.1 Event study results

Table 9, 10, and 11 show the CAAR and the standard deviation of CAAR by region. It is noted that overall, the CAAR has a downward trend following the publication of sustainability reports regardless of industry or country. Most of the CAAR are negative, implying that investors and public might have an impression that the firms' environmental performance is not up to the mark or lower than the global standard. Interestingly, as the event window increases from $[-2, 2]$ to $[-5, 5]$, the CAAR nearly double in each industry, regardless of region. It is also noticed that as the length of the event window expands, the standard deviation of CAAR increases as well. Figure 3, 4, and 5 visualize the CAAR of each region taking the event window $[-5, 5]$ as an example.

As it can be seen in Table 11, in the Chinese stock market, Health Care and Information Technology sectors have a lower magnitude of CAAR, compared to other industries. When the event window reaches $[-10, 10]$, Financials, Energy and Utilities are the three industries that have the lowest CAAR. In addition, the CAAR of Consumer Discretionary, Financials and Real Estate are statistically significant at 1% level. One potential reason is that these sectors are regarded as main pillars in the Chinese economy and that investors are sensitive to the news or event in these sectors. When the firms belonging to these sectors release the sustainability reports, the market tends to believe that the future expected returns will not be able to cover the cost due to the immaturity level of ESG implementation in the Chinese market.

The average difference between the observed returns and expected returns in the Nordic financial markets is smaller comparing to the Chinese stock market, showing a smaller average loss in stock value resulting from the publication of sustainability reports. It also suggests that as expected, Nordic stock markets show a higher level of market efficiency compared to the Chinese stock market. Same as the Chinese stock market, Utilities sector in the Nordic markets

has a low CAAR. Surprisingly, Energy is the only sector that has positive CAAR for the trading days period [-10,10] in Nordic countries. One possible reason is that the companies belonging to this sector in this region value more on the sustainability, and that the market is surprised by the sustainability-related performance of these firms that are thought to be the primary contributors to the environmental damage.

All the CAAR in the US market are negative, regardless of industry and the length of the event window. Consumer staples, Energy and Information Technology are the three industries having the lowest CAAR. Furthermore, the CAAR of all the industries except Real Estate show significant results. One explanation is that investors consider the sustainability performance disclosed by the firms as an important factor for enterprise evaluation and their investment assessment. However, firms' performance falls short of expectations.

Table 9 Cumulative average abnormal returns of industries in the United States

US	[0,0]	[-1,1]	[-2,2]	[-5,5]	[-10,10]
Communication Services	-0.0315*** (0.0194)	-0.0163** (0.0135)	-0.0247** (0.0200)	-0.0504*** (0.0403)	-0.0936*** (0.0740)
Consumer Discretionary	-0.0239*** (0.0183)	-0.0269*** (0.0224)	-0.0405*** (0.0336)	-0.0808*** (0.0676)	-0.1486*** (0.1255)
Consumer Staples	-0.0322*** (0.0110)	-0.0392*** (0.0139)	-0.0588*** (0.0209)	-0.1175*** (0.0417)	-0.2153*** (0.0759)
Energy	-0.0426* (0.0188)	-0.0415* (0.0192)	-0.0621* (0.0290)	-0.1234* (0.0584)	-0.2234* (0.1097)
Financials	-0.0202*** (0.0191)	-0.0206*** (0.0205)	-0.0305*** (0.0318)	-0.0607*** (0.0671)	-0.1119*** (0.1247)
Health Care	-0.0246*** (0.0128)	-0.0300*** (0.0140)	-0.0450*** (0.0210)	-0.0893*** (0.0424)	-0.1622*** (0.0793)
Industrials	-0.0149** (0.0195)	-0.0191** (0.0188)	-0.0284** (0.0283)	-0.0560** (0.0569)	-0.1043** (0.1033)
Information Technology	-0.0229** (0.0300)	-0.0391*** (0.0396)	-0.0585*** (0.0595)	-0.1172*** (0.1191)	-0.2160*** (0.2181)
Materials	-0.0155 (0.0123)	-0.0064* (0.0034)	-0.0095* (0.0047)	-0.0193* (0.0094)	-0.0382* (0.0171)
Real Estate	-0.0180 (0.0089)	-0.0286 (0.0190)	-0.0430 (0.0286)	-0.0856 (0.0586)	-0.1577 (0.1069)
Utilities	-0.0358*** (0.0089)	-0.0315** (0.0121)	-0.0473** (0.0178)	-0.0948** (0.0347)	-0.1740** (0.0653)

Note: *Denotes significance at the 10% level, **5% level and ***1% level based on standard errors.

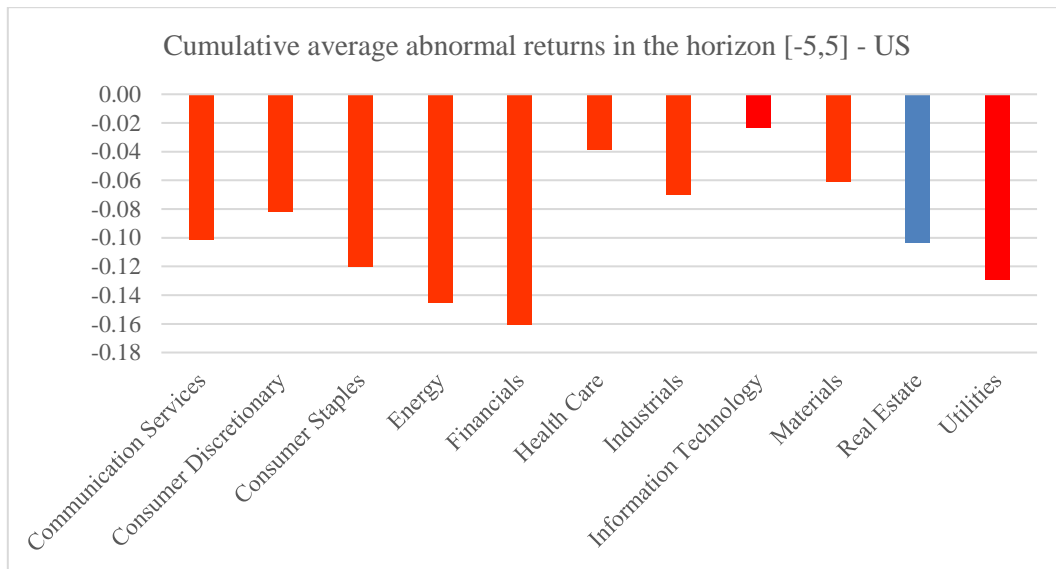


Figure 3 Cumulative average abnormal returns of industries in the United States (the columns highlighted in red mean that the CAAR of respective industries are significant)

Table 10 Cumulative average abnormal returns of industries in Nordic Countries

Nordics	[0,0]	[-1,1]	[-2,2]	[-5,5]	[-10,10]
Communication Services	-0.0034 (0.0040)	-0.0205 (0.0301)	-0.0313 (0.0455)	-0.0570 (0.0840)	-0.0983 (0.1449)
Consumer Discretionary	-0.0047 (0.0146)	-0.0079 (0.0166)	-0.0121 (0.0247)	-0.0247 (0.0494)	-0.0429 (0.0909)
Consumer Staples	-0.0170 (0.0105)	-0.0186 (0.0373)	-0.0296 (0.0532)	-0.0583 (0.1082)	-0.1124 (0.1903)
Energy	-0.0159 (0.0225)	-0.0058 (0.0069)	-0.0084 (0.0100)	-0.0168 (0.0199)	0.0057 (0.0149)
Financials	-0.0069 (0.0161)	-0.0072* (0.0066)	-0.0109* (0.0099)	-0.0225* (0.0189)	-0.0421** (0.0333)
Health Care	-0.0004 (0.0340)	-0.0132 (0.0206)	-0.0200 (0.0311)	-0.0404 (0.0626)	-0.0755 (0.1151)
Industrials	-0.0039 (0.0227)	-0.0184** (0.0262)	-0.0271** (0.0382)	-0.0545*** (0.0702)	-0.1039*** (0.1204)
Information Technology	-0.0272 (0.0326)	-0.0454 (0.0489)	-0.0681 (0.0732)	-0.1379 (0.1434)	-0.2568 (0.2554)
Materials	-0.0251 (0.0342)	-0.0211** (0.0087)	-0.0274** (0.0155)	-0.0488* (0.0369)	-0.0718 (0.0848)
Utilities	-0.0123 (-)	-0.0352 (-)	-0.0527 (-)	-0.1051 (-)	-0.1919 (-)

Note: *Denotes significance at the 10% level, **5% level and ***1% level based on standard errors.

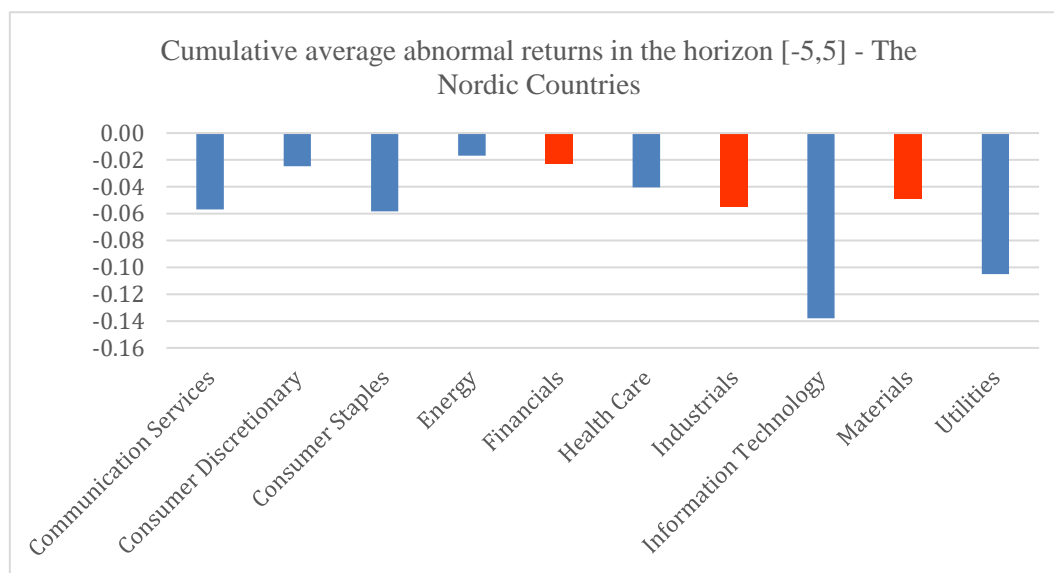


Figure 4 Cumulative average abnormal returns of industries in Nordic countries (the columns highlighted in red mean that the CAAR of respective industries are significant)

Table 11 Cumulative average abnormal returns of industries in China

China	[0,0]	[-1,1]	[-2,2]	[-5,5]	[-10,10]
Communication Services	-0.0215 (0.0146)	-0.0342 (0.0227)	-0.0512 (0.0341)	-0.1017 (0.0677)	-0.1845 (0.1264)
Consumer Discretionary	-0.0080 (0.0228)	-0.0271*** (0.0128)	-0.0406*** (0.0190)	-0.0817*** (0.0389)	-0.1513*** (0.0737)
Consumer Staples	-0.0125 (0.0304)	-0.0398 (0.0435)	-0.0599 (0.0652)	-0.1200 (0.1302)	-0.2198 (0.2390)
Energy	-0.0019 (0.0146)	-0.0486 (0.0399)	-0.0728 (0.0599)	-0.1457 (0.1199)	-0.2672 (0.2192)
Financials	-0.0243*** (0.0191)	-0.0536*** (0.0219)	-0.0804*** (0.0329)	-0.1607*** (0.0656)	-0.2928*** (0.1174)
Health Care	-0.0111 (0.0058)	-0.0128 (0.0119)	-0.0193 (0.0178)	-0.0388 (0.0353)	-0.0712 (0.0641)
Industrials	-0.0437 (0.0440)	-0.0231* (0.0099)	-0.0347* (0.0150)	-0.0703* (0.0313)	-0.1315* (0.0609)
Information Technology	0.0111 (-)	-0.0078 (-)	-0.0117 (-)	-0.0235 (-)	-0.0429 (-)
Materials	-0.0449 (-)	-0.0170 (-)	-0.0282 (-)	-0.0613 (-)	-0.1179 (-)
Real Estate	-0.0210*** (0.0186)	-0.0340*** (0.0237)	-0.0512*** (0.0353)	-0.1033*** (0.0697)	-0.1923*** (0.1263)
Utilities	-0.0227 (0.0161)	-0.0430 (0.0283)	-0.0645 (0.0425)	-0.1290 (0.0848)	-0.2361 (0.1550)

Note: *Denotes significance at the 10% level, **5% level and ***1% level based on standard errors.

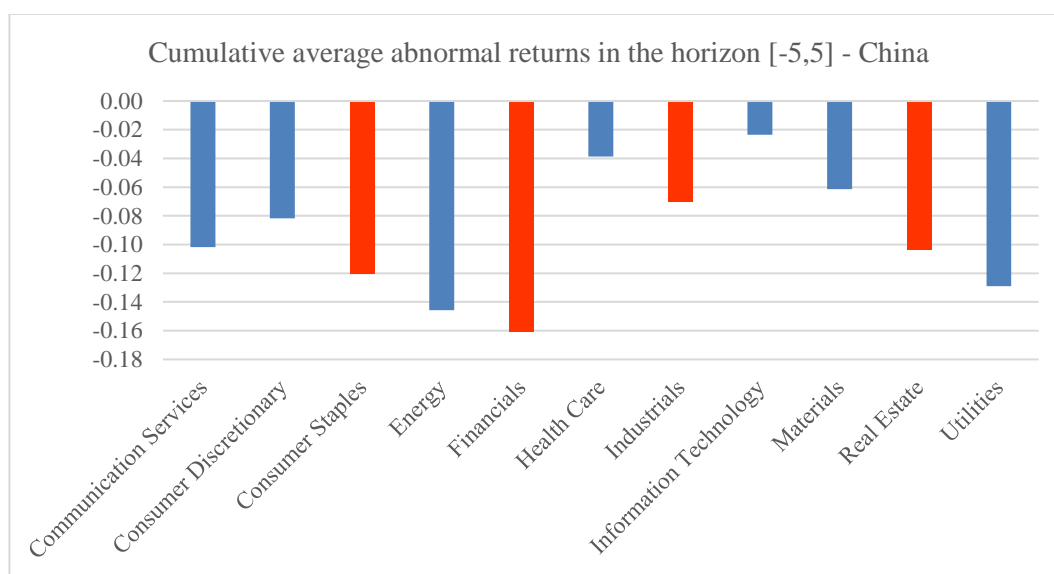


Figure 5 Cumulative average abnormal returns of industries in China (the columns highlighted in red mean that the CAAR of respective industries are significant)

As it is shown in Table 12 and Table 13, the CAAR of Group 1 and Group 2 in different regions show somewhat similar characteristics. The CAAR in Group 1, except for the Nordic markets in the event window [0,0], is statistically significant at the 1% level. In addition, the CAAR shows a same pattern in each region as the length of the event window increases, rising when the trading day period increases from [0,0] to [-1,1] and then dropping continuously. Overall, the average different between the observed returns and expected returns in Chinese stock market is the biggest among the three regions, reflecting the lowest level of market efficiency, while the average difference between the observed returns and expected returns in Nordic stock market is the smallest.

In comparison, the CAAR in Group 2 is statistically significant at the 10% level, and it shows a same trend as Group 1 as the trading days period increases. Similarly, the magnitude of the CAAR in each region gives somewhat similar result in terms of the level of market efficiency as discussed in Group 1.

In the Chinese and Nordic stock markets, the CAAR of Group 1 is smaller than Group 2, reflecting a greater average loss in stock value in the heavy industries. The US stock market, however, gives different results. The CAAR of Group 1 is lower than Group 2, except for the event window [-1,1]. This might be due to legislation or regulatory changes in heavy industries in terms of a transition to a greener state of business or improvement on the sustainability reporting, leading to better-than-expected performance. In order words, the market is surprised by the performance of the companies that are assumed to be the main contributors to the environmental deterioration.

Table 12 CAAR of Group 1

		[0,0]	[-1,1]	[-2,2]	[-5,5]	[-10,10]
China	Mean	-0.018***	0.079***	-0.103***	-0.226***	-0.430***
	Std. Dev	0.021	0.101	0.066	0.145	0.275
	T-stat	-4.744	4.390	-8.828	-8.823	-8.844
	P value	0.000	0.000	0.000	0.000	0.000
USA	Mean	-0.025***	0.043***	-0.074***	-0.162***	-0.309***
	Std. Dev	0.020	0.050	0.062	0.137	0.261
	T-stat	-10.728	7.235	-10.090	-10.026	-10.049
	P value	0.000	0.000	0.000	0.000	0.000
Nordics	Mean	-0.007	0.033***	-0.039***	-0.084***	-0.160***
	Std. Dev	0.022	0.043	0.059	0.131	0.250
	T-stat	-1.574	3.693	-3.223	-3.143	-3.144
	P value	0.129	0.001	0.004	0.005	0.005

Note: *Denotes significance at the 10% level, **5% level and ***1% level based on standard errors.

Table 13 CAAR of Group 2

		[0,0]	[-1,1]	[-2,2]	[-5,5]	[-10,10]
China	Mean	-0.024***	0.097*	-0.086***	-0.190***	-0.367***
	Std. Dev	0.024	0.200	0.058	0.127	0.240
	T-stat	-4.247	2.057	-6.286	-6.336	-6.472
	P value	0.001	0.055	0.000	0.000	0.000
USA	Mean	-0.022**	0.037***	-0.058***	-0.127***	-0.242***
	Std. Dev	0.019	0.041	0.046	0.102	0.194
	T-stat	-5.379	4.151	-5.690	-5.667	-5.716
	P value	0.000	0.000	0.000	0.000	0.000
Nordics	Mean	-0.009*	0.037**	-0.045***	-0.097***	-0.179***
	Std. Dev	0.025	0.080	0.055	0.118	0.225
	T-stat	-1.747	2.201	-3.850	-3.961	-3.821
	P value	0.095	0.039	0.001	0.001	0.001

Note: *Denotes significance at the 10% level, **5% level and ***1% level based on standard errors.

As shown in Figure 6, the CAAR shows a downward trend in each region following the announcement of the firms' sustainability-related performance. One possible reason is that investors and public tend to believe that cost of the investment in sustainability exceeds the potential future returns. In addition, it is noted that the slope of the Chinese market is the steepest while the Nordic markets have a more gentle slope. Surprisingly, the US market has a steeper slope than the Nordic markets, suggesting a lower level of market efficiency, which is not consistent with the universal perception that the US market has the highest level of market efficiency (Lim, 2006). This might be due to the fact that Nordic countries and investors are more sensitive to sustainability and value more on companies' ESG performance, which drives the companies, especially those heavy-industrial companies, in this region to outperform other regions in terms of sustainable development and improve the quality of the disclosure of sustainability-related strategies and activities.

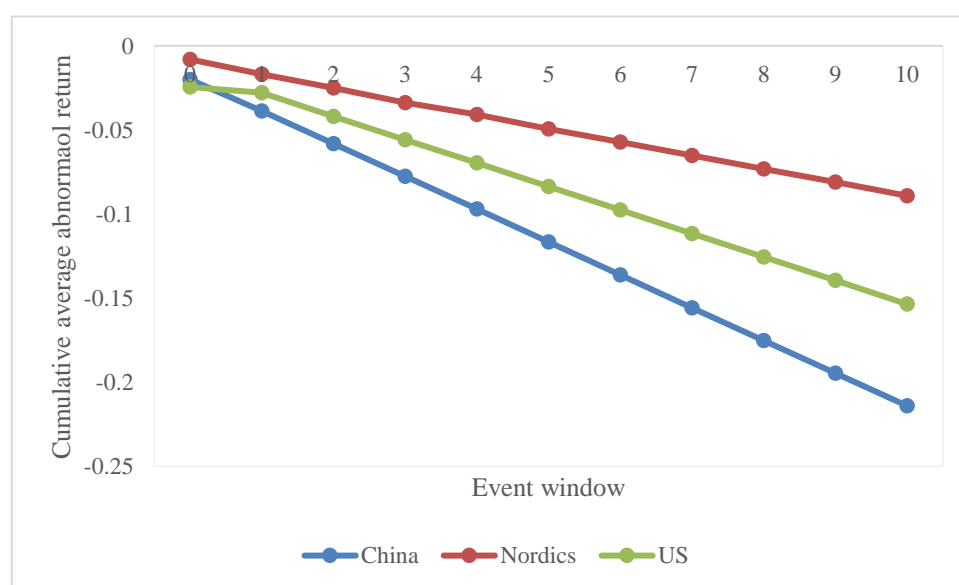


Figure 6 CAAR within the 10-day event window by region

5.2 Cross-sectional regression results

5.2.1 US

Since different event studies have their own mostly commonly adopted event windows and the results at the stage I show that the stock reactions are the most significant at day 5 and day 10 after firms' publishing the first sustainability reports, therefore, event window [-5, 5] and [-10, 10] are employed as dependent variables at stage II to further investigate the firm-level heteroskedasticity.

Table 14 shows the results from running a cross-sectional regression on US sample under event window [-5, 5] and [-10, 10]. There are 5 specifications in the regression: firstly, the relationship of degree of sustainability reporting are tested; secondly, word count is incorporated in order to examine the impact of the depth of sustainability reporting on CAR along with the completeness of sustainability reporting which is assessed in the first specification; next, all the 10 environmental, social and corporate governance related variables are added in the model to evaluate the effect of ESG variables on the CAR. Sentiment analysis based on the context of firms' first sustainability reports is included as well; fourthly, accounting related variables along with the broadness and depth of the degree of sustainability reporting are involved to estimate the influence of accounting related variables on US sample firms' CAR; lastly, all the variables are added in the specification to investigate the general explanation power of all the variables.

Under both event window [-5,5] and [-10,10], °sustainability is statistically significant at 10% level in all the specifications, meaning the completeness of sustainability reporting has a significant impact on the CAR. The negative sign implies that the more dimensions covered in the first published sustainability report, the more abnormal returns are generated. For example, in the specification (1) under event window [-5,5], the coefficient -0.0239 with significance level at 10% shows that with of °sustainability increases one more unit, the CAR decreases 2.39%. This result is consistent with the results of Breitz & Partapuoli (2020)'s study that stocks with lower level of ESG related information disclosure performs better than those stocks with higher level of ESG related information disclosure regarding the abnormal returns in US market. In the study of Classon & Dahlström (2006), they mentioned that according to the Noble Prize Winner Milton Friedman, sustainability reporting increases companies' cost and fails to boost financial performance in the short run. Considering 23% of US firms published their first sustainability reports between 2000 to 2009, it is reasonable that the stakeholders hold the same opinion as Milton Friedman and stakeholders concerned about the profitability of the company. This pessimistic awareness of the degree of sustainability reporting explains the negative sign of the coefficient of the sustainability report on CAR. It is also noticed that this viewpoint among stakeholders run through all specifications under both event windows.

Another finding is that word count has a relatively small but positive impact, indicating that for one unit increase word, there is 0.04% (for event window [-5,5]) and 0.01% (for event window [-10,10]) increase of abnormal returns for the companies in the US market. However, when incorporating other ESG, ESG related sub-category variables, and accounting variables, the significant impact of word count on the CAR disappears. Based on the fact that word count is

insignificant in most specifications and that the impact on the CAR is at a low scale when it is significant, to some extent, word count is regarded to have a mild impact on the CAR.

Sentiment score is another explanatory variable that affects CAR at 10% level for specification (3) and specification (5) under both event windows. The positive coefficient implies that the abnormal returns increase with the sentiment score. Wang (2016) studied the impact of sentiment scores, positive news, and negative news on stock volatility. In his study, he shows that people tend to overreact to negative news than to positive news. His study also demonstrates that higher sentiment score generates high abnormal returns. The result from this study is in line with the result from Wang (2016)'s study.

Firm size also matters when it comes to the impact on the CAR. The significance at 10% level for specification (4) and (5) displays that for US firms, the firm size influences the stock abnormal returns negatively when the firms publish their first sustainability reports. A plausible reason is that investors reckon that for big firms, publishing first sustainability report may lead to an increase in absolute amount of cost compared to small firms, resulting in negative abnormal returns.

Above all, it is noted that the degree of sustainability, sentiment score and firm size have a significant impact on the CAR. Despite a relatively large sample, the R-squared is relatively low for all specifications in the US market, indicating that there are other factors affecting the variation.

5.2.2 Nordic Countries

Table 15 shows the OLS cross-sectional regression results for Nordic countries.

In the first specification, the degree of sustainability reporting is used as the sole explanatory variable to investigate the relationship between °Sustainability and CAR. As we can see in the column (1) in Table 15, the coefficients for both event windows are negative and statistically significant at 10% level. It suggests that one unit increase in the degree of sustainability disclosure leads to 2.8% decrease in CAR in a 5-day trading horizon, and that the decrease slows down when the trading horizon goes to 10 days. It is not consistent with the expectation that companies with better sustainability disclosure are rewarded by the market. One possible reason is that the more dimensions the companies report, the more investors see the improvement areas as well as risks the companies are exposed to and that they tend to believe the investment in the sustainability-related activities may not bring expected returns. This is consistent with Vance (1975) and Fisher-Vanden and Thorburn (2011)'s findings. Another potential reason is that, while companies in the Nordic countries present sustainability performance in their first-time reports, investors doubt the reports' quality, and the completeness and reliability of the sustainability reports does not live up to investors' expectations.

When controlling for the word count in the specification (2), it is noticed that the coefficients for the degree of sustainability reporting are almost unchanged and remain significant at 10% level. It suggests that controlling for the word count does not have a great impact on the results.

In the specification (3), more control variables are included in the model and the coefficients for Δ Sustainability drop but remain significant. In addition, in both event windows, the coefficients for ESG disclosure scores as well as environmental disclosure score are negative and statistically significant at 10% level. It reflects that investors in the Nordic countries have higher demands for companies' environmental performance, compared to other two markets. It supports the common belief that Nordic countries are more environmentally conscious. Furthermore, as the number of control variables in the model grows, the R-square increases from around 6% to 40%, indicating a high power of explanation.

In the specification (4), after controlling for the word count and two accounting variables, the coefficients for the Δ Sustainability in both event windows increase slightly. Meanwhile, it is noticed that the firm size is significantly and positively associated with CAR, suggesting that firm size positively affects stock returns and that investors will be better off by investing in large companies compared to small companies.

In the specification (5), all the control variables are included in the model, and as we can see, this has an impact on the coefficients for the Δ Sustainability which increase in both event windows. Interestingly, the coefficients for ESG disclosure score as well as environmental disclosure score are significant at 10% level in the event window [-5,5] while insignificant in the event window [-10,10]. One possible reason is that the effect fades over time and that investors tend to focus on other factors in a longer event window. Furthermore, it is noticed that compared to the specification (4), the coefficients for firm size in the specification (5) remain significant, but at 1% level.

5.2.3 China

The firm-level heteroscedasticity is distinct in the Chinese market compared to US and Nordic markets. The degree of sustainability reporting is no longer statistically significant in most specifications. So does the firm size in this market. Notwithstanding, word count still has a mild and significant impact on the CAR at specification (2) under both event windows. What's more, sentiment score plays a statistically significant role in predicting CAR and it is significant at 10% level for all specifications. The explanation power of the model also increases from below 10% to around 25% every time it is involved in the regression.

Chi et al. (2011) investigate the influence of sentiment factors on the Chinese stock market. They used samples from January 2004 to June 2008 and they concluded that there is a significant impact of sentiment on the stock returns to a large extent. The cross-sectional regression results of this study are in line with previous studies that sentiment scores have a significant influence on the CAR of the Chinese companies. In addition, the coefficients are all negative, meaning with one unit increase of the sentiment score, there is around 0.51, 0.59, 0.92 and 1.0 unit decrease of CAR at the specification (3) and (5) under the event window [-5,5] and [-10,10], respectively. The changes of coefficient also shows that the influence of sentiment score on CAR does not fade away but instead grows over time. One plausible explanation is that Chinese investors are skeptical about the sustainability performance released by the firms, leading to negative CAR.

For the same reason as in the US market, word count only appears to be significant when it is added to the model along with the degree of sustainability at specification (2) and the coefficient is at a small scale. Another thing needs to be mentioned is that the explanation power of the model is not very high except the specifications with sentiment score variable. Therefore, there are other potential components affecting the variation. The negative coefficient means that unlike US, the higher the quality of sustainability report is, the more concerned investors are about sustainability-related costs and challenges to the management.

One plausible explanation for why ρ sustainability has only a minor impact on the CAR of the companies in the Chinese market is that the information in the first sustainability reports is generally not very precise. In addition, because the publication of sustainability reports is not mandatory in this region, the investors tend to hold a skeptical attitude towards the reports when they firstly come to the public eyes. As a result, when other factors, such as the tone of sustainable information disclosure, may doing a better job at suggesting a firm's motivation and commitment to a sustainable future, investors prefer to shift their focus away from ρ sustainability.

5.2.4 Cross-country comparison

The regression results demonstrated some interesting characteristics of three regions. Compared to the United States and China, investors in Nordic countries care more about environment and ESG, which motivates companies to transit to a carbon-neutral business model and enhance sustainability disclosure to meet the investors' demands. In terms of the sentiment score, three regions show distinct results. The overall tone of the sustainability reports has a positive and significant impact on the CAR in the US market, but a negative and significant effect on the CAR in China. This may be because investors in these two regions have different perspectives on the information released by the companies. The US investors tend to trust and rely on the published information. A positive overtone of the sustainability report leads to a higher CAR. Chinese companies, on the other hand, struggle to gain investors' trust and investors are skeptical about the sustainability reports, even if they have a positive tone. In contrast, the tone of the reports does not have any effect on the CAR in the Nordic markets. One possible reason is that companies in the Nordic countries tend to be neutral when they report their sustainability-related activities and achievements, which is consistent with the result that this region has the lowest average sentiment score among three regions. Last but not least, in the US and Nordic markets, firm size has a significant effect on the CAR, while in China it is insignificant. One potential reason is that compared to the firm size, Chinese investors care more about other factors during the investment process, such as government policy or industry news.

Table 14 US Sample – OLS Cross-sectional Regression Results

Event Window Explanatory Variable	Event Window [-5, 5]					Event Window [-10, 10]				
	(1) Coefficient	(2) Coefficient	(3) Coefficient	(4) Coefficient	(5) Coefficient	(1) Coefficient	(2) Coefficient	(3) Coefficient	(4) Coefficient	(5) Coefficient
°Sustainability	-0.0239*	-0.0245*	-0.0287*	-0.0258*	-0.0294*	-0.0261*	-0.0249*	-0.0326*	-0.0247*	-0.0256*
	[0.0014]	[0.0014]	[0.0020]	[0.0015]	[0.0020]	[0.0016]	[0.0016]	[0.0021]	[0.0015]	[0.0018]
Word count		-0.0004*	-0.0000	-0.0000	-0.0000		-0.0001*	-0.0001	-0.0001	-0.0001
		[0.0000]	[0.0000]	[0.0000]	[0.0000]		[0.0001]	[0.0001]	[0.0001]	[0.0001]
ESG			-0.0011		0.0001			-0.0025		-0.0001
			[0.0159]		[0.0157]			[0.0305]		[0.0301]
Env			0.0010		0.0004			0.0021		0.0001
			[0.0081]		[0.0080]			[0.0155]		[0.0153]
Social			-0.0007		-0.0015			-0.0012		-0.0028
			[0.0038]		[0.0038]			[0.0073]		[-0.0072]
Gov			0.0030		0.0031			0.0058		0.0060
			[0.0052]		[0.0051]			[0.0099]		[0.0097]
Ind of Board			0.0003		-0.0000			0.0005		0.0000
			[0.0015]		[0.0016]			[0.0029]		[0.0030]
CAPEX/Sales			0.1650		0.1100			0.3170		0.2130
			[0.1790]		[0.1790]			[0.3410]		[0.3410]
Fines			0.0050		0.0159			0.0124		0.0332
			[0.0276]		[0.0278]			[0.0526]		[0.0530]
Positive			-0.0001		-0.0001			-0.0001		-0.0001
			[0.0001]		[0.0001]			[0.0001]		[0.0001]
Negative			0.0001		0.0001			0.0002		0.0002
			[0.0001]		[0.0001]			[0.0002]		[0.0002]
Sentiment score			0.2460*		0.2430*			0.4570*		0.4860*
			[0.0165]		[0.0165]			[0.0315]		[0.0316]
Firm size				-0.0307*	-0.0495*				-0.0581*	-0.0561
				[0.0158]	[0.0168]				[0.0302]	[0.0358]
HML				-0.0144	-0.0223				-0.0276	-0.0429
				[0.0162]	[0.0200]				[-0.0310]	[0.0381]
R-squared	3.1%	3.7%	11.2%	9.7%	16.5%	3.0%	3.4%	11.5%	9.9%	16.7%
#Observations	93	93	76	90	76	93	93	76	90	76

Note: Coefficients from OLS cross-sectional regressions with heteroskedasticity (White) adjusted standard errors in square brackets. *Denotes significance at the 10% level, **5% level, and ***1% level based on heteroskedasticity (White) adjusted standard errors.

Table 15 Nordic Countries Sample – OLS Cross-sectional Regression Results

Event Window	Event Window [-5, 5]					Event Window [-10, 10]				
	(1)	(2)	(3)	(4)	(5)	(1)	(2)	(3)	(4)	(5)
Explanatory Variable	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient
°Sustainability	-0.0277*	-0.0243*	-0.0466*	-0.0239*	-0.0191*	-0.0209*	-0.0192*	-0.0221*	-0.0183*	-0.0101*
	[0.0020]	[0.0021]	[0.0042]	[0.0021]	[0.0019]	[0.0018]	[0.0016]	[0.0022]	[0.0016]	[0.0010]
Word count		-0.0001	-0.0001	-0.0001	-0.0001		-0.0001	-0.0002	-0.0001	-0.0001
		[0.0001]	[0.0001]	[0.0001]	[0.0001]		[0.0001]	[0.0002]	[0.0001]	[0.0002]
ESG			-0.0751*		-0.0701*			-0.117*		0.1550
			[0.0076]		[0.0068]			[0.0117]		[0.0950]
Env			-0.0405*		-0.0438*			-0.079*		-0.0843
			[0.0030]		[0.0036]			[0.0078]		[0.0508]
Social			-0.0148		-0.0171			-0.0290		-0.0331
			[0.0117]		[0.0010]			[0.0228]		[0.0198]
Gov			-0.0186		-0.0203			-0.0366		-0.0394
			[0.0154]		[0.0131]			[0.0299]		[0.0260]
Ind of Board			-0.0001		0.0012			-0.0000		0.0024
			[0.0010]		[0.0009]			[0.0019]		[0.0019]
CAPEX/Sales			0.3020		0.1540			0.7260		0.4480
			[0.4200]		[0.3890]			0.8190		[0.7750]
Fines			0.0022		0.0072			0.0045		0.0126
			[0.0123]		[0.0110]			[0.0240]		[0.0219]
Positive			-0.0001		-0.0000			-0.0002		-0.0000
			[0.0001]		[0.0001]			[0.0003]		[0.0002]
Negative			0.0002		0.0000			0.0004		0.0000
			[0.0002]		[0.0001]			[0.0003]		[0.0003]
Sentiment score			-0.0863		-0.0772			-0.1770		-0.1750
			[0.2530]		[0.2160]			[0.4930]		[0.4300]
Firm size				0.0478**	0.0841***				0.0926**	0.1550***
				[0.0205]	[0.0261]				[0.0394]	[0.0518]
HML				-0.0352	0.0180				-0.0682	0.0321
				[0.0341]	[0.0415]				[0.0655]	[0.0827]
R-squared	4.1%	6.5%	40.1%	20.8%	61.0%	3.5%	5.7%	40.8%	20.0%	59.5%
#Observations	47	47	35	45	35	47	47	35	45	35

Note: Coefficients from OLS cross-sectional regressions with heteroskedasticity (White) adjusted standard errors in square brackets. *Denotes significance at the 10% level, **5% level, and ***1% level based on heteroskedasticity (White) adjusted standard errors.

Table 16 China Sample - OLS Cross-sectional Regression Results

Event Window	Event Window [-5, 5]					Event Window [-10, 10]				
	(1)	(2)	(3)	(4)	(5)	(1)	(2)	(3)	(4)	(5)
Explanatory Variable	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient
°Sustainability	-0.0218 [0.0019]	-0.0298 [0.0024]	-0.0315* [0.0028]	-0.0041 [0.0036]	-0.0027 [0.0052]	-0.0393 [0.0030]	-0.0373 [0.0031]	-0.0086 [0.0093]	-0.0032 [0.0075]	-0.0099 [0.0097]
Word count		-0.0001* [0.0001]	-0.0000 [0.0001]	-0.0001 [0.0001]	-0.0001 [0.0001]		-0.0004* [0.0003]	-0.0002 [0.0003]	-0.0005 [0.0003]	-0.0002 [0.0004]
ESG			-0.0080 [0.0279]		-0.0024 [0.0293]			-0.0164 [0.0506]		-0.0112 [0.0529]
Env			0.0071 [0.0142]		0.0041 [0.0149]			0.0150 [0.0251]		0.0124 [0.0260]
Social			0.0031 [0.0073]		0.0017 [0.0077]			0.0066 [0.0130]		0.0051 [0.0139]
Gov			-0.0019 [0.0085]		-0.0026 [0.0088]			-0.0035 [0.0156]		-0.0037 [0.0165]
Ind of Board			-0.0001 [0.0013]		0.0003 [0.0014]			-0.0001 [0.0025]		0.0005 [0.0026]
CAPEX/Sales			-0.0446 [0.1500]		-0.0539 [0.1540]			-0.0493 [0.2830]		-0.0616 [0.2920]
Fines			0.0030 [0.0172]		0.0019 [0.0179]			0.0026 [0.0192]		0.0012 [0.0137]
Positive			0.0001 [0.0001]		0.0001 [0.0001]			0.0002 [0.0002]		0.0002 [0.0003]
Negative			-0.0002 [0.0002]		-0.0002 [0.0002]			-0.0003 [0.0003]		-0.0003 [0.0003]
Sentiment score			-0.5130* [0.0340]		-0.5860* [0.0355]			-0.9160* [0.0647]		-1.0390* [0.0682]
Firm size				-0.0081 [0.0275]	-0.0273 [0.0330]				-0.0065 [0.0523]	-0.0400 [0.0642]
HML				0.0198 [0.0425]	0.0296 [0.0523]				0.0490 [0.0804]	0.0538 [0.0982]
R-squared	1.1%	3.3%	24.2%	4.1%	26.5%	1.1%	5.3%	25.0%	5.9%	26.7%
#Observations	50	50	42	48	42	50	50	42	48	42

Note: Coefficients from OLS cross-sectional regressions with heteroskedasticity (White) adjusted standard errors in square brackets. *Denotes significance at the 10% level, **5% level, and ***1% level based on heteroskedasticity (White) adjusted standard errors.

6 Conclusion

With the increased focus on corporate governance and social responsibility, an increasing number of firms are seeking to consciously present their commitment to a greener state of business and achievement in sustainability. According to the KPMG Survey of Sustainability Reporting (2020), 80% of the companies worldwide publish sustainability reports. In addition, studies on firms' sustainability reporting also rise quickly since year 2000. For example, when searching sustainability reporting, there are more than two million results displayed on Google Scholar. However, the majority of the studies focus on a single market, and there are very few studies based on a country-level comparison regarding sustainability reporting.

This study aims to capture the stock reactions to the very first sustainability report publication of companies in two developed markets, US and Nordic region, and companies in an emerging market, China. In this study, the companies are divided into two groups depending on their environmental and social impact so as to identify the industry-level features. In addition, this study goes one step further by employing cross-sectional regression on ESG and related sub-category variables as well as accounting variables to explore the firm-level heteroskedasticity of the cumulative abnormal return. Moreover, cross-country comparison is incorporated in both stages so that policymakers and investors can make informed decisions based on the findings.

At the first stage when investigating the stock reactions to the first-time publication of sustainability reports, all three regions demonstrate identical trend that there is an economically significant downward CAAR following the publication. Besides, most of the CAAR have negative sign showing that stock markets respond to this event by giving a penalty because investors tend to believe that companies' sustainability performance does not meet up to the global standard or that the sustainable information disclosure is associated with more non-operational cost and may lead to less management flexibility. Furthermore, with the event window expanding, CAAR nearly doubles in each industry and the standard deviation goes up as well. Scale-wise, Nordic countries outperform US and China since the Nordic stock markets exhibit less abnormal returns and less standard deviation compared to the other two markets. Chinese stock market is the least efficient among the three markets as it generates the largest abnormal returns and the standard deviation. It is also worth noting that the CAAR is significant in Financials, Industrials, and Materials sectors in China and Nordic Countries, while it is significant in all the sectors except Real Estate in US.

At stage II, this study goes one step further to evaluate the firm-level heteroskedasticity of the CAR. 10 environmental, social and corporate governance related control variables, 2 financial performance variables, and 2 variables measuring the degree of sustainability reporting are incorporated to explore the firm-level heteroskedasticity. It is noteworthy that this study employs 2 text-as-data approaches to collect information from the sustainability reports. 59 dimensions are extracted from international sustainability reporting standards and previous

relevant studies to assess the completeness and broadness of the degree of sustainability reporting. The frequency of the sustainability reporting key words is also picked to measure the depth of the reports. Moreover, sentiment analysis is applied to capture the overall tone of the context in the sustainability reports. A machine learning tool, LASSO regression, is utilized at this stage to select the key predictors for each region from 59 dimensions that have the most explanation power. The results show that there is a big difference of firm-level heteroskedasticity across three regions. In the United States, the degree of sustainability, sentiment score, and the firm size have a significant impact on the CAR; in the Nordic region, the degree of sustainability reporting, ESG disclosure, environmental score, and the firm size have a significant influence on the CAR. In China, however, the degree of sustainability has lost its significance, and it is the sentiment score that has a significant impact on the CAR at 10% level. Interestingly, in China and the United States, the effect of sentiment scores on CAR is different. In the United States, it has a positive impact, whereas in China, it has the opposite effect.

One intriguing observation is that the negative CAR affects enterprises' behavior in publishing sustainability reports later on. For example, (a) some firms, such as CITIC, have started to publish the sustainability reports and their annual reports on the same day in order to eliminate or reduce the negative CAR arising from the event. The confounding event is, therefore, expected to lead to lower difference between the observed returns and expected returns as a result of the disclosure of strong financial performance; (b) some firms, such as China Northern Rare Earth Group High-Tech, include the sustainability reports in their annual reports after the first publication; (c) some firms, such as Wartsila and Telia, have put their sustainability reports on hold until they are fully prepared for a potential shock on the stock prices.

Since the results show a similar pattern at stage I and a large degree of variance at stage II, further research into cross-country comparisons of stock reactions to sustainability reporting is needed. As sustainability reporting is relatively new and voluntary, the scarcity of data and resources is one of the main challenges when conducting relevant researches. Since the sample size in this study is relatively small after filtering out the companies which publish their first sustainability report along with their annual report, larger sample sizes in future studies may bring more plausible results. Furthermore, some variables, such as ESG, Env, Social and Gov, lack daily data, which poses a challenge to conclusive results. Moving forward, it is expected that with joint efforts from public authorities, governments and firms, ESG data will be in high demand and move from scarcity to abundance.

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Appendix A: Definition of Variables

Variables	Defination
°Sustainability	Degree of Sustainability Reporting, measured by keyword hits, ranging from 0 to 59
ESG	ESG Disclosure Score
Env	Environmental Disclosure Score
Social	Social Disclosure Score
Gov	Governance Disclosure Score
Ind of Board	Percentage of Independent Directors
Firm size	The size of firm, dummy variables, measured by percentile. 1 denotes small size, 2 denotes medium size, and 3 denotes big.
HML	High Minus Low
CAPEX/Sales	CAPEX Divided by Revenues
Fines	Amount of Fines (Sustainability-related)
Positive	Frequencies of Positive Collocations or Words
Negative	Frequencies of Negative Collocations or Words
Sentiment score	Predominance of Positive or Negative Collocations in the Context of the Sustainability Report
Word count_5	Number of words in each sustainability report for event window [-5,5]
Word count_10	Number of words in each sustainability report for event window [-10,10]

