The impact of Green House Gas emission on firm's performance in Japan

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ผลกระทบจากการปล่อยก๊าซเรือนกระจกต่อผลประกอบการของบริษัทในประเทศญี่ปุ่น

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การศึกษานี้สำรวจผลกระทบของการปล่อยก๊าซเรือนกระจก (GHG) ต่อผลการดำเนินงานทางการเงินของบริษัทในญี่ปุ่น โดยเน้นที่บทบาทของกฎระเบียบด้านสิ่งแวดล้อมเป็นพิเศษ โดยตั้งสมมติฐานว่าการปล่อยก๊าซ GHG ที่ลดลงโดยทั่วไปจะช่วยเพิ่มผลการดำเนินงานทางการเงิน แต่ประโยชน์จะลดลงหลังจากจุดหนึ่ง นอกจากนี้ การศึกษานี้ยังได้ตรวจสอบว่ากฎระเบียบด้านสิ่งแวดล้อมที่เข้มงวดส่งผลต่อความสัมพันธ์นี้อย่างไร โดยใช้การปล่อยก๊าซเรือนกระจกทั้งหมดและการปล่อยก๊าซเรือนกระจกทั้งหมดต่อมูลค่าบริษัทรวมเงินสด (EVIC) เป็นตัวแทนค่าก๊าซเรือนกระจก ผลการศึกษาชี้ให้เห็นว่าการปล่อยก๊าซเรือนกระจกส่งผลเสียต่อผลการดำเนินงานทางการเงินของบริษัท ตามที่วัดโดย ROA และ Tobin's Q อย่างไรก็ตาม สภาพแวดล้อมด้านกฎระเบียบ ไม่ว่าจะเข้มงวดหรือไม่ก็ตาม ไม่ได้เปลี่ยนแปลงความสัมพันธ์นี้อย่างมีนัยสำคัญ การค้นพบเหล่านี้ชี้ให้เห็นว่าแม้ว่ามาตรการด้านกฎระเบียบอาจมีผลกระทบต่อความสามารถในการทำกำไรในระยะสั้น แต่ก็ไม่ได้ส่งผลเสียต่อมูลค่าบริษัทในระยะยาวเสมอไป นอกจากนี้ การศึกษายังเผยให้เห็นว่าบริษัทที่มีการปล่อยก๊าซเรือนกระจกต่ำกว่าอาจมีต้นทุน ค่าใช้จ่ายระยะยาวน้อยลง ซึ่งเน้นย้ำถึงผลประโยชน์ทางการเงินของการจัดการมลพิษที่มีประสิทธิภาพ โดยเฉพาะอย่างยิ่งในบริบทของกฎระเบียบด้านสิ่งแวดล้อมที่เข้มงวด นอกจากนี้ การศึกษายังให้ข้อสรุปที่มีคุณค่าสำหรับผู้กำหนดนโยบายและภาคธุรกิจ โดยเน้นย้ำถึงความสัมพันธ์ที่ซับซ้อนระหว่างความรับผิดชอบต่อสิ่งแวดล้อม กรอบการทำงานด้านกฎระเบียบ และผลการดำเนินงานทางการเงิน

สาขาวิชา การเงิน ลายมือชื่อ
นิสิต .....

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This study investigates the impact of greenhouse gas (GHG) emissions on corporate financial performance in Japan, with a particular focus on the role of environmental regulations. We hypothesize that while lower GHG emissions generally enhance financial performance, the benefits diminish beyond a certain point. Additionally, we examine how stringent environmental regulations influence this relationship. We use total GHG emissions and total GHG emissions per company's enterprise value including cash (EVIC) as the proxies. The results indicate that GHG emissions negatively impact corporate financial performance, as measured by ROA and Tobin's Q. However, the regulatory environment, whether stringent or not, does not significantly alter this relationship. These findings suggest that while regulatory measures might have short-term profitability implications, they do not necessarily negatively impact long-term firm valuations. Furthermore, the study reveals that companies with lower emissions may incur fewer long-term costs highlighting the financial benefits of effective pollution management, particularly in the context of strict environmental regulations. Also, the study provides valuable implications for policymakers and businesses, highlighting the complex interplay between environmental responsibility, regulatory frameworks, and financial performance.

Field of Study:	Finance	Student's Signature .....
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Chanikan Veerachadsakulchai

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CHAPTER 1: INTRODUCTION

1. Introduction

The rise in energy use, mainly due to fossil fuel combustion, has led to an increase in greenhouse gas emissions, especially CO2. This presents a major challenge for sustainable economic development. To address this issue, the energy sector must shift towards renewable and cleaner energy sources. This shift includes adopting carbon-neutral methods in transportation, heating, cooling, power generation, and electricity. Since the Kyoto Protocol's implementation in 2005, there has been a heightened focus on carbon emissions and global warming in terms of corporate environmental responsibility. Programs like the Carbon Disclosure Project (CDP) and the European Union Emissions Trading Scheme (EU ETS) have been established to oversee and reduce corporate carbon emissions.

With the possibility of stricter regulations on greenhouse gas (GHG) emissions looming, companies are facing uncertainty related to global warming. In response, there has been a significant increase in the number of municipalities, national governments, and companies committing to achieving net zero emissions. Initiatives like the Net Zero Asset Owner Alliance and Net Zero Asset Managers have been launched, with trillions of dollars dedicated to decarbonizing portfolios. Companies recognize the need to reduce carbon emissions and mitigate the impact on their business operations to address climate change. Green finance has emerged as a crucial tool, providing financial support and credits to industries that implement environmental protection and energy conservation measures. Studies have shown that firms' financing efficiency and financial performance can be improved through green investment, highlighting its importance in the transition to a sustainable economy.

(Boiral, Henri et al. 2012) outlined two theoretical approaches regarding the impact of GHG emissions reduction on corporate performance: the win-lose and the win-win paths. The win-lose path posits that companies might suffer a competitive disadvantage as they attempt to lower carbon emissions. This viewpoint considers environmental initiatives as a diversion of resources, resulting in higher expenses and decreased company value. Conversely, the win-win path, grounded in resource-based and institutional theories, contends that reducing a firm's carbon emissions can actually bolster its sustainable competitive edge and enhance its value by prioritizing environmental issues.

Research exploring the relationship between carbon emissions and corporate performance has yielded varied results. Studies by (Walley and Whitehead 1994) and (Telle 2006), suggest that firms deviate from their core business and experience a decrease in value when investing in environmental actions. suggest that companies often see a reduction in value when they divert resources from their main business towards environmental initiatives. On the other hand, research by (Hughes 2000), on publicly traded electric utilities indicated that high carbon emissions correlate with a

decrease in firm value.(Clarkson, Li et al. 2004) found that the market generally favors environmental investments, especially for firms that are already low polluters. (Chapple, Clarkson et al. 2013) showed that in Australia, companies with higher carbon emissions tend to suffer a drop in market capitalization.

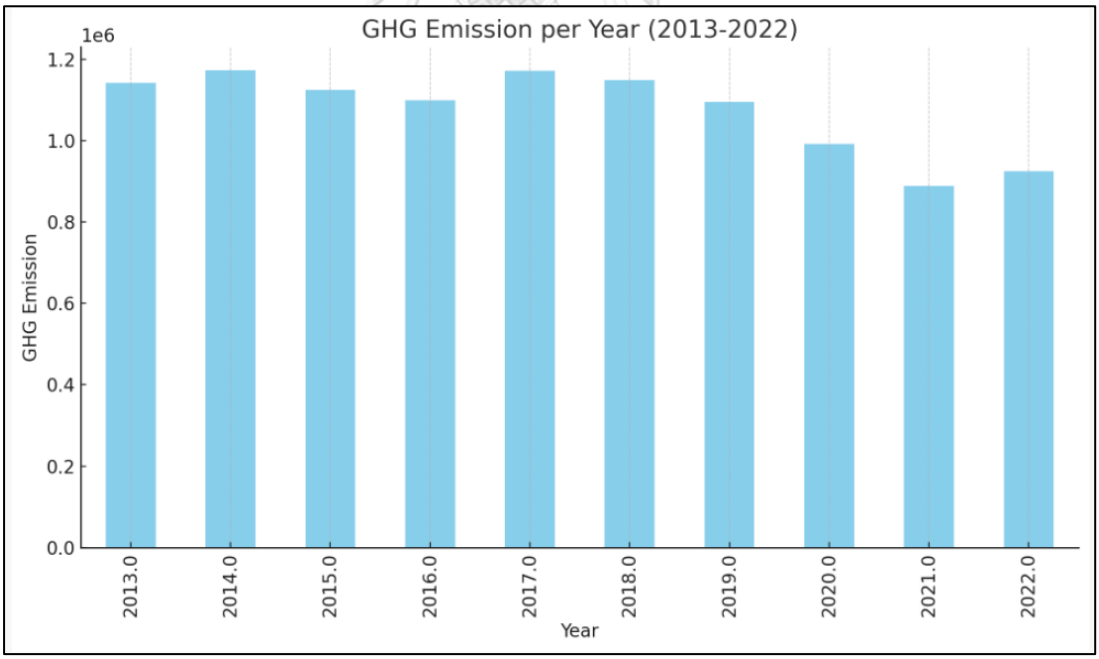
Considering the global relevance of climate change in the business world, it's essential to examine how GHG emissions directly affect firm value across international landscapes. For instance, (Choi, Luo et al. 2021) investigated the effect of disclosing carbon emissions on a company's market value. They discovered a generally positive impact, especially for businesses located in countries with strict environmental regulations.

Our research examines how carbon emissions influence different financial performance indicators and assesses the role of environmental regulation in explaining these effects.

Also, we will conduct Robustness test by considering several proxies for GHG emissions. For example, total GHG emissions per EVIC.

1.1 Motivation and Contribution

This study adds to existing research by presenting findings on the relationship between GHG emissions and corporate financial performance, specifically within the Japanese context, which is characterized by strict environmental regulations.



Despite being an early adopter of initiatives to reduce emissions, Japan is among the largest carbon emitters globally. Facing pressure from environmental groups and European nations to exceed its initial target of a 26% reduction, Japan has committed to a 46% reduction in emissions from 2013 levels by 2030, with the aim of achieving carbon neutrality by 2050. This aligns Japan's goals with the European Union, which has set a similar carbon neutrality target for 2050. Additionally, China

has pledged carbon neutrality by 2060. These ambitious targets will likely impact the financial performance of Japanese firms, as they will need to increase their investment in environmentally friendly initiatives. Furthermore, Japanese companies with branches abroad will also need to adhere to the green policies set by their headquarters (Mckinsey, 2021). Hence, this led to the research question: Does GHG emissions negatively affect firm's financial performance?

We are also interested in analyzing the effects of environmental policy measures by the Japanese government in promoting the reduction of carbon emissions on firm financial performance.

According to the BOI (Thailand Board of Investment) investment statistics report, the countries that invest in Thailand using BOI privileges the most is Japan. Therefore, the policymakers can use this study as a reference to issue policies for overall economy such as new promotion measure on carbon reduction issued by BOI to promote green activities in response to government policy on climate changes. This will encourage the investment and attract more foreign investors to invest in Thailand.

CHAPTER 2: BACKGROUND AND HYPOTHESIS DEVELOPMENT

2.1. GHG emissions and corporate financial performance

Corporate sustainability practices have sparked concerns about potential negative implications for financial performance when investing in environmental technologies to reduce emissions. These concerns include the possibility of increased short-term costs and diverting resources away from more productive investments (Palmer, Oates et al. 1995), (Fisher-Vanden and Thorburn 2011).

Some studies, such as those conducted by (Sarkis and Cordeiro 2001) and (Wagner, Schaltegger et al. 2001), have found a negative relationship between a company's environmental performance and its financial performance. However, other research, such as that by (Konar and Cohen 2001) and (King and Lenox 2002), suggests that improved environmental performance can actually lead to better financial outcomes. (Cohen, Fenn et al. 1995) discovered that companies considered environmental leaders had stock returns equal to or surpassing those of firms with poor environmental records. Furthermore, enhanced environmental performance can reduce operational costs and enhance product competitiveness (Iwata and Okada 2011).

Reducing emissions brings benefits to firms by enhancing their reputation and profitability. This can be achieved through increased earnings from higher sales turnover and easier access to financing at lower costs. As consumers increasingly prioritize sustainable consumption, firms with lower emissions can attract more customers and investors who value environmental sustainability. Consumers concerned about climate change tend to remain loyal to low-emission companies, providing them with a competitive advantage against industry shocks compared to their competitors (Ambec and Lanoie 2008), (Besley and Ghatak 2007).

Firms with lower emissions can attract a wider range of investors, particularly those focused on social responsibility, which can lead to lower capital costs (Bolton and Kacperczyk 2021), (Krueger, Sautner et al. 2020). As a result, these companies typically face lower equity financing costs and have less need to maintain large cash reserves for precautionary reasons (El Ghoul, Guedhami et al. 2011), (Cheng, Ioannou et al. 2014), (Almeida, Campello et al. 2004). This enables them to more readily obtain funding for expanding their productive capacity and investing in innovative projects, positively impacting their long-term profitability.

The operational efficiency perspective, as outlined by (Downar, Ernstberger et al. 2021), suggests that investing heavily in green technologies can lead to cost savings over time. For instance, production technologies that emit less often incorporate advanced equipment and processes, which enhance resource efficiency. This can lead to lower material and waste disposal costs. Moreover, these technologies tend to be more energy-efficient, which reduces energy expenses (Gillingham and Stock 2018).

Consequently, companies with lower GHG emissions are likely to experience reduced operational and energy costs (Eichholtz, Kok et al. 2010), (Iwata and Okada 2011).

Although using GHG emissions as an indicator provides a useful means to assess a firm's environmental impact, it's important to note that this metric doesn't encompass the entire scope of environmental effects. Nevertheless, GHG emissions are relatively straightforward to quantify, and there are well-established methods for measuring them. Investors, who are increasingly focusing on the importance of emission disclosures and the broader climate impact of businesses, are likely to perceive improved environmental performance (indicated by lower GHG emissions) favorably (Bolton and Kacperczyk 2021).

Therefore, I hypothesize that low-emission firms will have higher corporate financial performance than high-emission firms.

Hypothesis 1: Firms with lower GHG emissions have higher corporate financial performance than firms with higher GHG emissions.

2.2. Optimum level of GHG emissions and corporate financial performance

The growing concern over global environmental degradation has highlighted the environmental impacts of business activities (Chen, Tang et al. 2015), (Delmas, Etzion et al. 2013), (Malen and Marcus 2019), (Pérez-Valls, Céspedes-Lorente et al. 2019), (Qi, Zeng et al. 2014). As a result, facing pressures from a variety of stakeholders, many companies are embracing eco-friendly business strategies. These strategies range from setting goals to reduce carbon emissions to conducting environmental audits, publicly reporting on environmental performance, fostering green innovation, training staff for eco-friendly practices, and tying compensation to environmental achievements (Lin, Zeng et al. 2015), (Wang 2019), (Zeng, Xu et al. 2012), (Lin, Zeng et al. 2014), (Darnall, Henriques et al. 2010), (Zou, Zeng et al. 2015).

This shift prompts crucial questions about whether efforts toward societal improvement always equate to financial gains, and the real significance of adopting environmentally conscious practices (Aragón-Correa, Marcus et al. 2016), (Barnett and Salomon 2012), (Leonidou, Katsikeas et al. 2013).

The profitability of adopting green practices hinges on how effectively a company implements these initiatives. Recent research has delved into the costs involved in embracing green strategies, revealing a U-shaped link between green strategy and company performance. This relationship, referred to as the "too-little-of-a-good-thing" (TLGT) effect (Dixon-Fowler, Slater et al. 2013), (Trumpp and Guenther 2017), indicates that positive outcomes like firm performance can suffer when green strategies are not implemented to a sufficient extent. Conversely, the "too-much-of-good-thing" (TMGT) effect (Pierce and Aguinis 2013) shows an inverted U-shaped relationship, suggesting that when businesses exceed an optimal level of green

strategy, there can be a detrimental effect on firm performance. This leads to the hypothesis that there is a specific threshold or balance that must be achieved in green strategy implementation for optimal firm performance.

Hypothesis 2: Lower GHG emissions increase corporate financial performance, but up to a certain point, the benefits start to diminish.

2.3. Stringent environmental regulation and firm financial performance.

Government environmental policies play a critical role in shaping the initial green investments of firms. The type of environmental policy tools used can significantly affect how these investments impact a firm's financial performance. The Porter Hypothesis, proposed by (Porter and Linde 1995), suggests that well-crafted environmental regulations can promote innovation, counterbalance environmental costs, and improve resource efficiency in companies. As a result, firms are more likely to pursue environmental innovation under increased regulatory and normative pressures (Berrone, Fosfuri et al. 2013). The severity or leniency of environmental regulations also influences corporate decisions on green investments. Under lenient regulations, firms have less incentive to invest in green technologies, especially those heavily reliant on fossil fuels (Kim 2013). (Popp 2006) found that environmental regulations tend to boost patents related to emission reduction, thereby decreasing pollution and enhancing environmental performance. Similarly, (Lee 2010) observed that environmental regulations facilitate the development and spread of eco-friendly technologies, allowing firms with advanced environmental technologies to thrive under strict regulations and gain a competitive edge. Consequently, environmental regulations encourage firms to increase their green investments, develop technologies for energy conservation and environmental protection, and ultimately achieve benefits for both the economy and the environment.

Japan has recently raised its carbon emission reduction target to 46% below 2013 levels by 2030, up from an earlier goal of 26%. This ambitious target is part of Japan's strategy to achieve carbon neutrality by 2050. To meet this goal, companies will need to increasingly rely on renewable energy sources and advance technologies that utilize hydrogen, ammonia, and other carbon-free resources. The Japanese government plans to maximize the use of renewables and other non-carbon energy sources, support local decarbonization initiatives, and stimulate investment in these areas. Consequently, these stringent environmental policies present an opportunity for firms to reap benefits. Based on this context, we present our third hypothesis:

Hypothesis 3: Stringent environment regulation enhances the effect of GHG emissions on corporate financial performance.

CHAPTER 3: DATA AND VARIABLES

3.1 Data

In this study, we selected Japanese companies based on specific criteria to form our sample. We focused on firms that were part of the TOPIX index, listed on the Tokyo Stock Exchange, from 2013 to 2022. To be included in our final sample, a company had to remain in the TOPIX index for at least two consecutive years. Furthermore, we required the availability of both financial and environmental performance data for these years. Our analysis covers the period from 2013 to 2022 and includes data from 2,156 companies. This timeframe is significant because 2013 marks a year when Japan saw an increase in emissions, attributed to the shutdown of nuclear plants following the 2011 Fukushima disaster, leading to a reliance on coal and gas for power generation. We obtained carbon emissions and financial data for our analysis from Bloomberg. I present the variable descriptions in Appendix 1 and summary statistics as below:

Summary statistics This table summarizes the sample of Tokyo Stock Exchange (TSE) companies for 2013-2022. The variables are defined in Appendix 1.

Variable	Obs	Mean	Std. Dev.	Min	Max
year	21,560	2017.5	2.872	2013	2022
roa	20,747	4.216	6.475	-376.594	72.793
tobinq	20,469	.974	1.739	.004	50.728
ghg emission	21,095	509.92	4,139.253	0	141,400
ghgperevic	20,449	155.24	593.903	0	43,687.922
CompanyID	21,560	1,078.5	622.398	1	2,156
SectorID	21,560	4.87	2.212	1	9
GroupID	21,560	32.269	19.333	1	67
DStr	21,565	.2	.4	0	1
ln GHG (-1)	18,946	3.572	1.689	-6.908	11.859
GHGperEVIC (-1)	18,306	153.255	460.125	0	36,148.785
DE (-1)	18,815	66.185	214.771	0	21,559.514
CASH (-1)	18,842	185,621.84	2,421,359.3	0	1.030e+08
RD (-1)	17,653	7,212.042	41,905.489	0	1,110,369
CAPITAL INTENSITY (-1)	18,713	4.831	11.222	-7.853	361.319
FIRM SIZE (-1)	18,324	254,010.97	858,226.68	1,223.592	26,379,742
FIRM AGE (-1)	19,404	59.622	30.464	0	188
ln GHG sq (-1)	18,946	15.614	16.176	0	140.644
GHGperEVIC sq (-1)	18,306	235,190.33	10,217,464	0	1.307e+09

3.2 Independent variable

In our study, we quantified total greenhouse gas (GHG) emissions in terms of tons, with a particular emphasis on Scope 1 and Scope 2 emissions as outlined by (Bhatia and Ranganathan 2004). Scope 1 emissions include all emissions from sources that the company directly owns or controls, such as emissions from company vehicles and the combustion of fuels. Scope 2 emissions, meanwhile, are indirect emissions that arise from the consumption of purchased energy, such as electricity, steam, and heating. Both categories are essential in assessing a company's carbon footprint and its efforts in carbon management. For our analysis, we used the natural logarithm of the total tons of Scope 1 and Scope 2 emissions as our measure of GHG emissions.

3.3 Dependent variable

Table 1
Performance proxies.

Authors	Corporate performance
Cohen et al. (1995)	ROA, ROE
Hart and Ahuja (1996)	ROS, ROA, and ROE
Russo and Fouts (1997)	ROA, ROE, and ROS
Edward (1998)	ROE
King and Lenox (2002)	ROA and Tobin's q
Wagner et al. (2002)	ROS, ROE, and ROCE
Telle (2006)	ROS
Nakao et al. (2007)	ROA and ROE
Zhang et al. (2008)	ROE
Horváthová (2010)	Tobin's q
Wang et al. (forthcoming)	Tobin's q
Gallego-Álvarez et al. (2011)	ROA
Lannelongue, (forthcoming)	ROA, ROE, and Profits

ROA: Return on Assets; *ROE*: Return on Equity; *ROS*: Return on Sales; *ROCE*: Return on Capital Employed.

In this research, the dependent variable is the impact of GHG emissions variation on corporate performance. Previous international studies have used different measures as proxies for this variable, as shown in Table 1.

Table 1 demonstrates that many studies have utilized accounting measures like Return on Assets (ROA). In our analysis, we adopted Tobin's Q as a measure of firm value, following the approach used by Wang et al. (forthcoming) who emphasized its ability to capture market expectations and financial risk. (Horváthová 2010) also advocated for Tobin's Q as a suitable metric for assessing corporate financial performance based on market value. Alongside Tobin's Q, we used Return on Assets (ROA) to evaluate firm profitability. Tobin's Q is determined as the market-to-book value ratio, calculated by adding the book value of debt to the market value of equity and then dividing this sum by the book value of assets. ROA is calculated as the ratio of operating income to total assets.

3.4 Control variable

We incorporate industry fixed-effect and several firm-level characteristics as covariates in the analysis. Please see below table.

Control Variables	Relationship with corporate performance	Reference
Firm size	Coefficient is positive on ROA but negative on Tobin's Q	(Trinks, Mulder et al. 2020) (King and Lenox 2001) (Wang, Li et al. 2021) (Homroy 2023)
Firm age	Coefficient is positive on ROA	(Homroy 2023)
Leverage	Coefficient is negative on ROA and positive on Tobin's Q	(Trinks, Mulder et al. 2020) (Wang, Li et al. 2021)
Capital intensity and R&D	Coefficient is positive on ROA	(Wang, Li et al. 2021) (Homroy 2023)
Cash	Coefficient is positive on ROA and Tobin's Q	(Wang, Li et al. 2021)

Also, we have year dummies. $\mathbf{D_{Str}}$ variable is a binary variable equal to one for the period from 2021 to 2022, the stringent regulation period and equal to zero for the period from 2013 to 2020, the non-stringent regulation period. In addition, this paper controls Industry-fixed effect.

CHAPTER 4: METHODOLOGY AND RESULTS

Based on hypothesis 1, we estimate the effect of GHG emissions on financial performance using the following panel regression model:

$$\mathbf{CFP_{it}} = \beta_0 + \beta_1 \ln(\mathbf{GHG_{it-1}}) + \Phi\, \mathbf{X_{it-1}} + \mathbf{FE_{ind}} + \varepsilon_{it} \quad (1)$$

Where β_1 should be negative meaning a decrease in GHG emissions increase the corporate financial performance. $\mathbf{CFP_{it}}$ (Corporate Financial performance) is the measure of firm *i*'s financial performance at time *t*. $\mathbf{GHG_{it-1}}$ is the measure of GHG emission (natural logarithm of GHG emission), $\mathbf{X_{it-1}}$ is the vector of all control variables, and $\mathbf{FE_{ind}}$ is the industry-fixed effects. ε_{it} is the error term.

Note that we lag the independent variables to ensure they are available when financial performance is measured and to be in line with the related literature (Albuquerque, Koskinen et al. 2019), (Chava 2014).

The results on the effects of GHG emissions on corporate financial performance are presented in Table 2. ROA and Tobin's Q are the dependent variables. GHG emissions is independent variables. The result shows that firms with lower GHG emissions are associated with higher corporate financial performance. A 1% increase in the GHG emissions is associated with a decrease in the ROA and Tobin's Q by approximately 24.15% and 10.89% respectively.

As GHG emissions of a firm decrease, its corporate financial performance both ROA and Tobin's Q increases.

By actively reducing emissions, firms can experience an improvement in their financial performance such as ROA through cost reductions in energy use, compliance, and input materials. These savings can be significant, as more efficient operations often result from such initiatives. Additionally, companies that are proactive in their environmental strategies can tap into new revenue streams by meeting the growing consumer demand for sustainable practices, thereby gaining a competitive edge in the marketplace. Moreover, in an investment climate where environmental, social, and governance (ESG) criteria are becoming crucial, low-GHG companies attract more investment and can benefit from government incentives. These actions not only bolster short-term financials but also enhance long-term corporate value by building a reputation for responsibility and forward-thinking, which is invaluable in today's economy.

In assessing the relationship between reduced greenhouse gas (GHG) emissions and enhanced corporate financial performance, as indicated by both Return on Assets (ROA) and Tobin's Q, several supporting reasons emerge. First and foremost, decreasing GHG emissions is often synonymous with increased operational efficiency. Companies that actively work to reduce their emissions frequently implement energy-efficient practices, optimize resource usage, and innovate in processes and products. These changes not only reduce environmental impact but also

lower operational costs. Energy efficiency, for instance, directly cuts down on energy expenses, one of the significant operational costs for many firms. Similarly, optimizing resource use can reduce waste and associated costs, contributing positively to the company's ROA. These efficiency gains are not just beneficial in terms of cost savings; they also signal to investors and the market that the company is forward-thinking and capable of adapting to future challenges, thereby potentially enhancing its market valuation as reflected in Tobin's Q.

Moreover, a firm's commitment to reducing GHG emissions aligns with the growing global emphasis on sustainability, which can enhance its brand reputation and stakeholder relations. Consumers, investors, and regulatory bodies are increasingly favoring environmentally responsible companies. By demonstrating a commitment to reducing emissions, a company can strengthen its brand image, attract environmentally conscious customers, and build investor trust. This enhanced reputation can lead to increased sales, customer loyalty, and a broader investor base, all of which contribute positively to both the firm's profitability (ROA) and its perceived market value (Tobin's Q). Additionally, by proactively addressing environmental concerns, companies can avoid regulatory fines and penalties, further protecting and enhancing their financial performance.

Lastly, the strategic focus on reducing GHG emissions often leads to innovation, opening new business opportunities and markets. Investing in green technologies and sustainable practices can lead to the development of new products and services, catering to a market increasingly inclined towards environmentally friendly options. This innovation can lead to a competitive advantage, as the firm is able to offer unique products or services that align with the market's evolving preferences. Such innovations can drive revenue growth, improve asset utilization (enhancing ROA), and create a perception of long-term viability and growth potential in the eyes of investors, positively influencing the company's Tobin's Q. In summary, the deliberate effort to reduce GHG emissions is not only a step towards environmental responsibility but also a strategic business move that can lead to improved operational efficiency, enhanced brand reputation, and innovative growth opportunities, all contributing to better financial performance in terms of ROA and Tobin's Q.

Several researchers have proposed that the link between carbon emissions and financial development might not be straightforwardly linear, but could instead exhibit a U-shaped or inverted U-shaped pattern (Sinha and Shahbaz 2018), (Acheampong 2019), (Acheampong, Amponsah et al. 2020). To investigate whether this pattern applies to Japanese firms, our study adds a quadratic term representing carbon efficiency to the original equation, allowing for a non-linear analysis. This results in an augmented function, which we denote as Equation (2) in our research.

$$\mathbf{CFP}_{it} = \beta_0 + \beta_1 \ln(\mathbf{GHG}_{it-1}) + \beta_2 (\ln \mathbf{GHG}_{it-1})^2 + \Phi_1 \mathbf{X}_{it-1} + \mathbf{FE}_{ind} + \varepsilon_{it} \quad (2)$$

The variables in Equation (2) are identical to those in Equation (1)

With reference to hypothesis 2, we expect β_1 to be negative and β_2 to be positive. This implies that decrease in GHG emissions increase corporate financial performance but at a diminishing rate such that there is an optimal level of GHG emissions.

Table 2 describes the results of hypothesis 2 that there is evidence supporting the idea that lower GHG emissions are associated with higher corporate financial performance.

For ROA, the findings suggest that companies with lower GHG emissions tend to have better operational performance. However, the data does not provide strong evidence for an optimal level of GHG emissions in relation to ROA. While the analyzed data does not pinpoint an optimal level of GHG emissions that correlates with maximum ROA, it does suggest that there isn't a clear threshold where further reduction in GHG emissions would negatively impact a firm's profitability. This provides an opportunity for firms to explore and implement efficient emission reduction technologies. However, as they do so, firms should be mindful of the associated costs of these technologies and weigh them against both the financial and non-financial benefits, such as potential tax incentives, improved brand reputation, and the broader goal of environmental responsibility.

For Tobin's Q, the results indicate that the market values companies with lower GHG emissions more highly. Moreover, there seems to be an optimal level of GHG emissions, after which the benefits of reducing emissions on corporate financial performance start to diminish. This suggests that while sustainability is valued, there's a balance to be struck to optimize both environmental and financial outcomes.

Together, these findings provide evidence supporting the idea that lower GHG emissions can have a positive impact on corporate financial performance, but there might be an optimal level of emissions after which the benefits start to decrease, especially when considering market valuation (Tobin's Q).

In exploring the connection between reduced greenhouse gas (GHG) emissions and corporate financial performance, it becomes evident that a positive impact is indeed possible, but only up to a certain extent. This observation, particularly in terms of market valuation as measured by Tobin's Q, can be attributed to various factors. One significant aspect is investor perception and market sentiment. In the current environmental climate, investors are increasingly drawn to companies that demonstrate responsibility towards the environment. Such companies are often seen as safer, long-term investments due to their lower exposure to regulatory and reputational risks. However, there appears to be a threshold at which the market begins to perceive additional efforts in reducing emissions as less beneficial. This is primarily due to the diminishing returns on risk mitigation, innovation potential, and projected future profitability.

Additionally, the cost-benefit balance plays a crucial role in this relationship. Initially, efforts to reduce emissions often focus on easily achievable targets, which

not only lead to cost savings, such as through enhanced energy efficiency, but also contribute to operational improvements. These early wins are financially beneficial and positively received in the market. However, as companies progress beyond these initial stages, the subsequent reductions in emissions often demand more significant investments, either in new technologies or in reengineering business processes. These advanced stages of emission reduction can impose financial burdens where the costs may surpass the benefits, thereby impacting the firm's market valuation negatively. This progression suggests that while initial reductions are financially beneficial, there is a point beyond which further reductions are not economically viable.

Moreover, the role of innovation in this dynamic is critical. The early phases of emission reduction are usually marked by a surge in innovative practices and the adoption of new technologies, which can lead to increased operational efficiency and even the opening of new markets. However, beyond a certain point, these innovations may reach a plateau. Additional investments in green technology or practices at this stage may not yield substantial improvements in performance. This diminishing return on innovations may lead firms to reach a saturation point, where the additional environmental initiatives no longer contribute significantly to their market valuation or financial performance. Furthermore, as firms become more environmentally conscious, the expectations of stakeholders, including consumers and investors, rise. This increase in expectations can make it challenging for companies to continue impressing these stakeholders with their environmental efforts, potentially affecting the perceived value of the company.

In conclusion, while the pursuit of lower GHG emissions aligns with improved financial performance and market valuation, there is a complex interplay of factors such as cost, innovation, stakeholder expectations, and market dynamics. These elements collectively contribute to a scenario where the benefits of further reducing emissions start to diminish after reaching an optimal level. Therefore, it is crucial for firms to strategically balance their environmental initiatives with these various considerations to maximize their financial and market performance.To investigate the potential relationship between environmental regulation and corporate green investment, and since Japan announced in April 2021 to raise emissions reduction target from 26% to 46% relative to 2013 levels by 2030. We introduce the square term of regulation into Equation 3

$$CFP_{it} = \beta_0 + \beta_1 \ln(GHG_{it-1}) + \beta_2 (\ln GHG_{it-1})^2 + \beta_3 D_{Str} + \beta_4 D_{Str} * \ln(GHG_{it-1}) + \Phi_1 X_{it-1} + FE_{ind} + \varepsilon_{it} \quad (3)$$

Within the context of hypothesis 3, β_1 should be negative and β_2 should be positive. β_3 should be positive representing the relationship between stringent environment regulation and corporate financial performance. Further, during periods of stringent environment regulation, the impact of GHG emissions on corporate financial performance becomes more evident. Thus, we expect β_4 to be negative as increment to β_1.

The variables in Equation (3) are identical to those in Equation (2) except for $\mathbf{D_{Str}}$ which is a dummy variable that represents the Stringent regulation period.

$\mathbf{D_{Str}}$ = 0 (For period from 2013 to 2020 with the 26% GHG emissions cut: non-Stringent regulation period)

$\mathbf{D_{Str}}$ = 1 (For period from 2021 to 2022 with the 46% GHG emissions cut: Stringent regulation period)

This positive impact of the GHG emission on firm performance through a stringent environmental regulation is expected to be captured by this binary variable.

The results of hypothesis 3 are presented in Table 2. The results with respect to ROA are contrary to this hypothesis. The positive and significant β_4 coefficient implies that during the stringent regulation period, the negative effect of GHG emissions on ROA becomes weaker. This can be attributed to several underlying dynamics.

Firstly, the implementation of strict environmental regulations typically necessitates substantial initial investments by companies in green technologies and practices. These investments are often capital-intensive, involving costs related to acquiring new equipment, research and development, and retraining employees. Although these investments are intended for long-term environmental and operational efficiency, they can have an immediate impact on the company's financials. The capital diverted to these initiatives can lead to a temporary decrease in operational efficiency, as resources are being reallocated from other potentially profitable activities. This shift in resource allocation, while essential for long-term sustainability and compliance, can result in a short-term dip in ROA as the company adjusts to the new technologies and processes.

Secondly, the period of transitioning to environmentally friendly practices can lead to operational disruptions. As companies overhaul their processes to meet stringent regulations, they might face temporary reductions in productivity and efficiency. This could be due to the learning curve associated with new technologies or the time taken to optimize new processes. During this transition phase, companies might not be able to fully leverage their assets, leading to a lower ROA.

Thirdly, the stringent regulation period could coincide with increased competition and market pressure. As all firms within an industry move to comply with new regulations, there could be a scramble for resources and technologies, leading to increased prices for green technologies and services. This heightened competition can inflate the costs of compliance, impacting the firm's profitability. Additionally, if the market is not willing to pay a premium for greener products or services, firms might not be able to pass these increased costs onto customers, further squeezing their profit margins and affecting ROA.

Finally, the focus on GHG reduction might also lead to strategic myopia, where companies overly concentrate on meeting emission targets to the detriment of other aspects of their operations. This could manifest in neglecting areas such as product

innovation, customer service, or market expansion. The overemphasis on one aspect of sustainability – GHG reduction – could therefore lead to missed opportunities or weakened performance in other key areas, ultimately impacting the company's overall asset utilization and profitability.

While the shift towards lower GHG emissions is vital for long-term sustainability and compliance with regulations, the transition period can pose challenges that affect operational and financial performance. These challenges include substantial initial investments, operational disruptions during the transition, increased competition and cost pressures, and the potential for strategic myopia, all contributing to a temporary decline in ROA during periods of stringent environmental regulation.

To be short, this could be because stricter regulations often involve short-term costs for businesses as they invest in new technologies or practices to reduce emissions. While these investments might lead to long-term gains, the immediate effect could be a reduced ROA.

Also, during the stringent regulation period, firms might face higher costs associated with complying with tougher environmental standards. While firms with lower GHG emissions are ostensibly complying, the costs associated with achieving these lower emissions could be higher than expected, impacting profitability and hence ROA.

Some firms might overly focus on reducing GHG emissions at the expense of other operational efficiencies. For instance, they might opt for greener alternatives that are more expensive without a corresponding increase in product pricing, thus affecting profitability.

For Tobin's Q, the β_4 coefficient is 0.0112 and is not statistically significant. The results indicate that while GHG emissions negatively impact corporate financial performance (measured by Tobin's Q), the regulatory environment (stringent vs. non-stringent) does not enhance or alter this relationship significantly. The findings provide valuable insights for policymakers, suggesting that while regulatory measures might have short-term profitability implications, they don't necessarily negatively impact long-term firm valuations. This could be because investors anticipate that the initial costs associated with compliance will be offset by long-term benefits. These benefits could include reduced risk of regulatory penalties, enhanced corporate reputation, and potential operational efficiencies gained from adopting greener technologies. Although environmental regulations are essential to hold companies accountable for reducing emissions, they don't seem to hinder a company's long-term value in the eyes of investors. Rather, these regulations are likely viewed as an important part of how companies operate in a world that is paying more and more attention to sustainability.

However, considering that the period of strict regulation in this study is limited to two years, future research should consider extending the observation timeframe to better understand the lasting impacts of GHG regulations on business outcomes.

Table 2

All hypotheses test results of the relationship between GHG emissions and corporate financial performance. In the following table, I present the results of the tests assessing the relationship between GHG emissions and both profitability and firm valuation. Robust standard errors are in brackets. ∗∗∗, ∗∗, and ∗denote statistical significance at 1%, 5% and 10%, levels, respectively.

	GHG Emission					
	HP 1		HP 2		HP 3	
	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	ROA	Tobin's Q	ROA	Tobin's Q	ROA	Tobin's Q
ln_GHG (-1)	-0.241***	-0.109***	-0.299***	-0.230***	-0.404***	-0.237***
	(0.0367)	(0.0108)	(0.109)	(0.0242)	(0.115)	(0.0448)
ln_GHG_sq (-1)			0.00662	0.0139***	0.0131	0.0144***
			(0.0112)	(0.00255)	(0.0114)	(0.00425)
DStr					-1.041***	-0.0745
					(0.298)	(0.0890)
0b.DStr#co.ln_GHG (-1)					0	0
					(0)	(0)
1.DStr#c.ln_GHG (-1)					0.160**	0.0112
					(0.0672)	(0.0184)
FIRM_SIZE (-1)	1.16e-06***	3.04e-07***	1.16e-06***	2.96e-07***	1.17e-06***	2.97e-07***
	(9.58e-08)	(2.99e-08)	(9.61e-08)	(2.07e-08)	(9.67e-08)	(2.93e-08)
FIRM_AGE (-1)	-0.0197***	-0.00863***	-0.0196***	-0.00853***	-0.0197***	-0.00854***
	(0.00161)	(0.000387)	(0.00162)	(0.000494)	(0.00162)	(0.000384)
DE (-1)	-0.00281**	-0.000380	-0.00281**	-0.000388***	-0.00279**	-0.000386
	(0.00131)	(0.000285)	(0.00132)	(6.14e-05)	(0.00130)	(0.000290)
CAPITAL_INTENSITY (-1)	-0.0367***	0.00910***	-0.0367***	0.00908***	-0.0364***	0.00910***
	(0.00680)	(0.00343)	(0.00680)	(0.00183)	(0.00682)	(0.00343)
RD (-1)	-1.21e-05***	-2.70e-06***	-1.22e-05***	-2.96e-06***	-1.23e-05***	-2.97e-06***
	(1.29e-06)	(3.56e-07)	(1.29e-06)	(4.15e-07)	(1.30e-06)	(3.57e-07)
CASH (-1)	-2.25e-07***	-6.43e-08***	-2.25e-07***	-6.49e-08***	-2.26e-07***	-6.50e-08***
	(3.19e-08)	(8.26e-09)	(3.19e-08)	(1.32e-08)	(3.16e-08)	(8.21e-09)
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	17,042	17,059	17,042	17,059	17,042	17,059
Adjusted R-squared	0.123	0.225	0.123	0.226	0.124	0.226

CHAPTER 5: ROBUSTNESS CHECKS

I conduct an additional test to ensure the robustness of the results. These tests attempt to check the baseline results for different GHG emission measures.

5.1 Alternative measures

Ratio of total GHG per EVIC. Measuring carbon performance by GHG emissions per company's enterprise value including cash allows for a normalized assessment of a company's carbon emissions relative to its overall value. By incorporating enterprise value, which takes into account a company's market capitalization and debt, along with cash holdings, this metric provides a perspective on how efficiently a company manages its carbon emissions in relation to its overall financial worth. It allows for comparisons between companies of different sizes and financial structures and provides insight into the level of carbon emissions generated per unit of company value, highlighting the company's carbon efficiency and its ability to manage environmental impact while considering its financial performance.

A lower GHG emissions per enterprise value including cash indicates that the company is achieving a balance between financial profitability and environmental sustainability. It suggests that the company is able to generate less carbon emissions relative to its overall value and financial resources.

For this analysis, I use the Ratio of total GHG per EVIC from Bloomberg. Table 3 presents the result from all hypotheses.

For hypothesis 1, the regression results provide evidence to support the hypothesis that higher GHG emissions per EVIC are associated with a decrease in a firm's profitability and market valuation (as measured by ROA and Tobin's Q respectively). The negative relationship is statistically significant. This can be attributed to various underlying reasons.

Firstly, high GHG emissions relative to a firm's enterprise value, including cash, indicate an environmentally inefficient use of resources. Investors and stakeholders increasingly factor in environmental performance when assessing a company's long-term sustainability and growth potential. High emissions suggest that a company may be overly reliant on outdated, carbon-intensive technologies and processes, which can be more costly and less efficient in the long run. This inefficiency can lead to higher operating costs and lower profitability, as reflected in ROA. Furthermore, the market valuation, as gauged by Tobin's Q, may be adversely affected as investors seek to invest in companies better positioned for a low-carbon future.

Secondly, firms with higher GHG emissions per EVIC may face heightened regulatory risks. As global efforts to combat climate change intensify, governments are implementing stricter environmental regulations and policies. Companies with higher emissions levels may incur additional costs associated with regulatory compliance, including potential fines, carbon taxes, or the need to purchase carbon

credits. These additional costs can erode profit margins, adversely impacting ROA. Additionally, the risk of future regulatory changes and the associated financial implications can make these firms less attractive to investors, negatively influencing their market valuation.

Thirdly, public perception and consumer behavior are increasingly aligned with environmental consciousness. High GHG emissions can tarnish a company's reputation and brand image, leading to potential loss of customer loyalty and market share. This shift in consumer preference can directly impact a firm's profitability. Moreover, companies perceived as environmental laggards may find it challenging to attract and retain talent, particularly among a workforce increasingly concerned about environmental issues. This reputational risk can lead to a lower Tobin's Q, as it may impact the firm's ability to sustain and grow its business over time.

Lastly, the negative impact of high GHG emissions on market valuation and profitability can also be attributed to investment risks. Investors are progressively integrating environmental, social, and governance (ESG) factors into their decision-making process. High emissions can be a red flag for ESG-focused investors, leading to a potential decrease in investment attractiveness. This can limit a company's access to capital and increase its cost of capital, further affecting its financial performance and market valuation.

In summary, the observed negative relationship between higher GHG emissions per EVIC and a firm's financial performance is influenced by a range of factors including environmental inefficiency, regulatory risks, public perception and consumer behavior, and investment attractiveness. These factors collectively explain why higher emissions are associated with lower profitability and market valuation.

For hypothesis 2, the results suggest a non-linear, U-shaped relationship between GHG emissions per EVIC and both indicators. As emissions initially rise, firm performance drops, but after a certain level, performance starts improving with further emissions. This suggests that while increasing emissions might initially harm a firm's profitability and market valuation, there's a turning point where this trend reverses. Such findings provide valuable insights for understanding the complex implications of emissions on firm health.

The initial decline in firm performance with increasing emissions could be due to the rising costs and risks associated with high carbon footprints. In the early stages of emissions increase, firms may face higher operational costs due to inefficient processes and increased regulatory scrutiny. These costs can negatively impact profitability, as reflected in ROA, and market valuation, as indicated by Tobin's Q. Investors and consumers, who are increasingly environmentally conscious, may penalize companies with high emissions, leading to a loss in market share and investor confidence. This stage reflects the initial negative impact of emissions on firm health due to cost, regulatory, and reputational factors.

However, the trend reversal at a certain point suggests that after reaching a threshold, firms with higher emissions may start to experience different dynamics. One possible explanation is economies of scale in industries where emissions are inherently high. In such sectors, firms that grow larger may be able to invest more in efficient technologies, spread their fixed costs over a larger output, and gain a competitive edge. This efficiency can lead to improved profitability and an enhanced market valuation. Thus, beyond a certain level, increased emissions may be indicative of larger, more dominant firms in certain sectors, translating into better financial performance.

Another factor could be the strategic positioning of certain firms within high-emission industries. Firms that have grown to a certain size might be better positioned to leverage their market dominance to invest in cleaner and more efficient technologies. These investments can lead to long-term savings and open new markets, such as green technology or sustainable products, improving both ROA and Tobin's Q. Furthermore, these larger firms might be more adept at navigating regulatory landscapes, turning compliance into a competitive advantage.

Lastly, the improvement in firm performance with further emissions could also be attributed to a lag effect in the implementation and impact of green initiatives. Firms initially increasing their emissions might be simultaneously investing in green technologies and practices, whose benefits are realized only after a certain scale is achieved. This lag phase might explain why performance initially drops but improves as these investments start to pay off. As these firms reach a critical mass in terms of size and investment in sustainability, they might begin to reap the benefits of these initiatives, reflected in improved profitability and market valuation.

In summary, the U-shaped relationship between GHG emissions per EVIC and firm performance is influenced by a mix of factors, including initial costs and risks associated with high emissions, economies of scale, strategic investments in efficiency and sustainability, and the lagged impact of green initiatives. These factors collectively explain the complex implications of emissions on firm health.

For hypothesis 3, for ROA, the coefficient 0.0000493 but it's not statistically significant. This means that the impact of GHG emissions on corporate financial performance (ROA) during the stringent regulation period wasn't significantly different from that in the non-stringent regulation period.

For Tobin's Q, the coefficient is negative and significant which is in line to our expectation for Hypothesis 3. This suggests that during the stringent regulation period, the negative relationship between GHG per EVIC and Tobin's Q is stronger meaning that the market or investors may be valuing companies with lower emissions more favorably during these times because investors maybe more conscious of environmental issues during periods of stringent regulation. They may reward companies that have lower emissions because they are viewed as being better prepared

for the future and less likely to incur costs from new regulations, fines, or the need to invest in new technologies to reduce emissions.

Firms with lower emissions may also have better access to certain markets, especially if customers prefer environmentally friendly products. They might also gain a competitive advantage if their competitors are slower to adapt to the new regulations. Efforts to reduce GHG emissions often drive innovation, leading to more efficient processes and products. These innovations can result in long-term competitive advantages and open up new business opportunities.

Moreover, companies with lower emissions may incur fewer costs over the long term. This includes savings from reduced energy consumption, lower costs for emissions trading or carbon taxes, and less need for expensive retrofitting or technology upgrades to meet regulatory standards.

In essence, from all the results, reducing greenhouse gas (GHG) emissions is financially beneficial for companies in several ways. Firstly, it leads to lower costs through improved energy efficiency which saves money. Furthermore, companies that reduce emissions can avoid rising compliance costs linked to new environmental regulations.

On the revenue side, there's a growing consumer demand for eco-friendly products, opening up new markets and creating opportunities for businesses that invest in green technologies. Governments are also offering financial incentives to companies that make eco-friendly choices. From an investment perspective, lowering emissions makes a company more attractive to investors who are increasingly focused on environmental, social, and governance (ESG) criteria, which can lower the cost of capital and improve financial terms.

Market forces, like consumer preference for sustainability and investor demands for ESG compliance, are pushing companies towards reducing emissions. As consumers become more aware of the environmental impact of their consumption, they are increasingly demanding products and services from companies that are committed to reducing their GHG emissions. This is creating a strong market incentive for companies to lower their GHG emissions in order to meet the demands of their customers. Likewise, many investors, including socially responsible funds, are now using ESG (environmental, social, and governance) criteria to guide their investment decisions. This means that they are increasingly looking to invest in companies with strong ESG track records, including companies that are committed to reducing their GHG emissions. This pressure from investors is having a significant impact on the behavior of companies, as they are increasingly looking to reduce their GHG emissions in order to attract and retain investors.

Additionally, government policies such as carbon pricing, emissions trading schemes, or other types of mandates create a clear economic incentive for companies to reduce their GHG emissions. Technological advancements are also making it cheaper and more compelling for companies to become more eco-friendly.

The impact of GHG emissions on financial metrics varies over different time horizons. In the short term, ROA may be adversely affected by the initial costs of emission-reducing initiatives. However, long-term benefits such as cost savings, enhanced reputation, and customer loyalty can lead to increased market valuation, captured by the Tobin's Q ratio.

Tobin's Q reflects the market's perception of a company's future growth potential and its ability to manage long-term risks, including those associated with environmental impact. In this regard, companies that demonstrate foresight and responsibility in managing their GHG emissions are often rewarded with a higher Tobin's Q ratio, despite short-term costs potentially dampening ROA. This illustrates the market's preference for firms that not only perform well financially but also show a commitment to sustainability and risk management.

In summary, while immediate costs associated with reducing GHG emissions can affect ROA, the strategic benefits including regulatory compliance, market positioning, and investor appeal tend to enhance long-term corporate value, as reflected by an improved Tobin's Q ratio.

CHAPTER 6: CONCLUSION

In this study, we examined how Japanese companies' pollution levels (GHG emissions) connect to their financial health. We found that when companies reduce their pollution, they generally see better financial results. But there's a limit: after reducing pollution to a certain level, the financial gains slow down.

Our findings change depending on how we look at emissions. When using GHG emissions directly, stricter environmental rules make the negative impact of emissions on a company's short-term profits (ROA) more severe. However, when we look at GHG in relation to a company's financial size (GHG per EVIC), stricter rules make the negative effect of emissions on a company's long-term value (Tobin's Q) weaker. This means that during times of strict rules, the market penalizes companies with higher relative pollution more.

These results highlight the need for companies to think about their pollution levels, especially when rules are strict. While reducing pollution has clear long-term benefits, the immediate costs of adapting to new rules can be a short-term challenge.

Policymakers should emphasize and communicate about the long-term benefits of reducing GHG emissions to firms, investors, and other stakeholders to gain more collaboration. Doing so can foster a more collaborative environment where businesses view regulations as opportunities for growth and differentiation rather than mere compliance requirements. In addition, policymakers should consider supportive measures like incentives or technical assistance to help companies that might face short-term costs or challenges in adapting to stricter regulations.

Lastly, this study only looked at two years (2021-2022) of strict rules. This short time might not show all the effects, especially for long-term values like Tobin's Q. Future studies over longer periods could provide more insights.

Table 3

All hypotheses test results of the relationship between GHG emissions measured by GHG per EVIC and corporate financial performance. In the following table, I present the results of the tests assessing the relationship between GHG per EVIC and both profitability and firm valuation. Robust standard errors are in brackets. ∗∗∗, ∗∗, and ∗denote statistical significance at 1%, 5% and 10%, levels, respectively.

	GHG per EVIC					
	HP 1		HP 2		HP 3	
VARIABLES	(1) ROA	(2) Tobin's Q	(3) ROA	(4) Tobin's Q	(5) ROA	(6) Tobin's Q
GHGperEVIC (-1)	-0.000385*	-0.000127***	-0.00115***	-0.000314***	-0.00118***	-0.000305***
	(0.000213)	(4.93e-05)	(0.000173)	(3.48e-05)	(0.000175)	(3.22e-05)
GHGperEVIC_sq (-1)			4.10e-08***	9.97e-09***	4.07e-08***	1.31e-08***
			(7.81e-09)	(1.89e-09)	(1.07e-08)	(2.32e-09)
DStr					-0.462***	-0.00291
					(0.116)	(0.0321)
0b.DStr#co.GHGperEVIC (-1)					0	0
					(0)	(0)
1.DStr#c.GHGperEVIC (-1)					4.93e-05	-0.000134**
					(0.000290)	(6.30e-05)
FIRM_SIZE (-1)	1.02e-06***	2.39e-07***	9.98e-07***	2.35e-07***	1.01e-06***	2.34e-07***
	(8.23e-08)	(2.55e-08)	(8.17e-08)	(2.54e-08)	(8.20e-08)	(2.53e-08)
FIRM_AGE (-1)	-0.0217***	-0.00957***	-0.0213***	-0.00949***	-0.0215***	-0.00949***
	(0.00164)	(0.000424)	(0.00163)	(0.000421)	(0.00163)	(0.000421)
DE (-1)	-0.00292**	-0.000431	-0.00290**	-0.000425	-0.00288**	-0.000425
	(0.00137)	(0.000311)	(0.00135)	(0.000308)	(0.00134)	(0.000308)
CAPITAL_INTENSITY (-1)	-0.0403***	0.00752**	-0.0401***	0.00756**	-0.0396***	0.00762**
	(0.00679)	(0.00337)	(0.00678)	(0.00337)	(0.00680)	(0.00338)
RD (-1)	-1.28e-05***	-3.05e-06***	-1.26e-05***	-3.00e-06***	-1.27e-05***	-2.99e-06***
	(1.24e-06)	(3.36e-07)	(1.23e-06)	(3.35e-07)	(1.24e-06)	(3.35e-07)
CASH (-1)	-2.37e-07***	-6.98e-08***	-2.37e-07***	-6.97e-08***	-2.35e-07***	-6.96e-08***
	(3.23e-08)	(8.55e-09)	(3.22e-08)	(8.54e-09)	(3.29e-08)	(8.53e-09)
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	17,044	17,061	17,044	17,061	17,044	17,061
Adjusted R-squared	0.121	0.220	0.123	0.222	0.124	0.222

Appendix 1 Description of variables (Source: Bloomberg)

Variables	Definition
Ln_GHG Emission	Natural logs of GHG emissions
GHGperEVIC	GHG emission per Enterprise value including cash
ROA	Net Income/Total Assets
Tobin's Q	Annualized standard deviation of return
Debt to equity ratio (DE)	Total Debt/Shareholders Equity
cash	Cash and cash equivalent
R&D	R& D expenses
Capital intensity	Sales and operating revenue divided by stockholders' equity.
Firm size	Annual sales turnover
Firm age	The gap between the founding year and the current calendar year
DStr	Dummy for stringent environmental regulation period (2021 – 2022)

Appendix 2 Industry distribution of the sample and GHG emissions

In this table, I present the industry distribution of the sample based on Tokyo Stock Exchange. I also present the average GHG emissions of companies in each industry group.

Industry Group	**Number of Companies**	**Average GHG Emissions**
Advertising	14	103.2320099
Aerospace/Defense	3	45.89913239
Agriculture	8	136.2390405
Airlines	2	704.8500187
Apparel	18	167.817889
Auto Manufacturers	12	49.98415013
Auto Parts&Equipment	70	139.898425
Banks	81	9.539234535
Beverages	13	77.84261809
Biotechnology	5	25.69744819
Building Materials	51	340.6143887
Chemicals	96	316.5087793
Coal	2	486.4977324
Commercial Services	127	89.89432403
Computers	81	82.97260608
Cosmetics/Personal Care	20	67.41117019
Distribution/Wholesale	96	137.9304262
Diversified Finan Serv	48	19.95463946
Electric	13	1445.180846
Electrical Compo&Equip	23	154.9514021
Electronics	103	106.8810742
Energy-Alternate Sources	2	85.93600734
Engineering&Construction	97	97.84045957
Entertainment	14	43.94468794

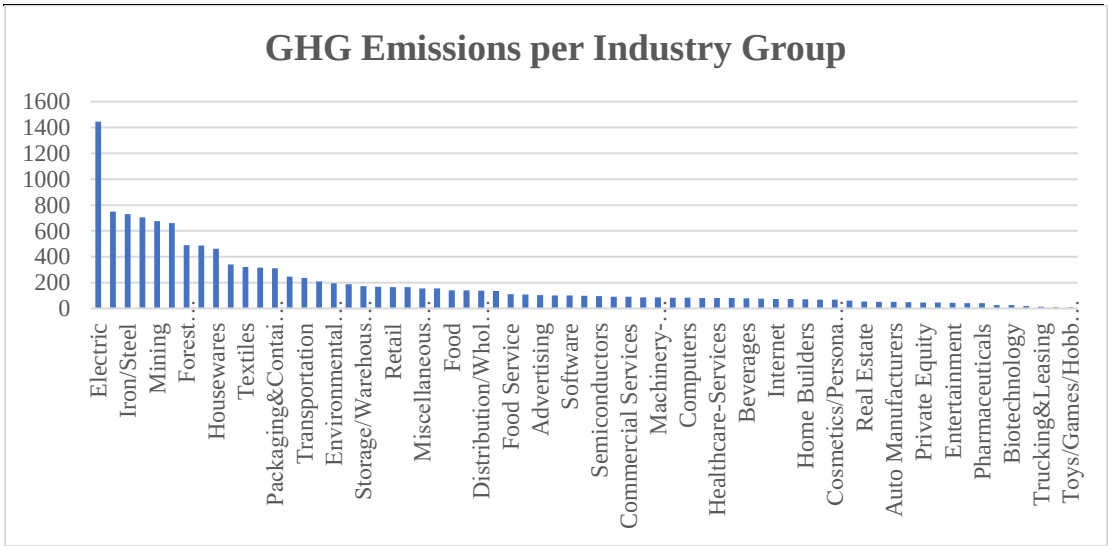
Environmental Control	19	193.6113762
Food	111	140.5898801
Food Service	2	110.2985494
Forest Products&Paper	13	488.446518
Gas	9	210.6379508
Hand/Machine Tools	19	83.70139375
Healthcare-Products	23	52.02467659
Healthcare-Services	16	80.96338853
Home Builders	18	71.4581671
Home Furnishings	18	750.2487948
Household Products/Wares	9	68.20330329
Housewares	3	461.6807642
Insurance	10	26.17282425
Internet	77	74.05219003
Investment Companies	2	41.48763029
Iron/Steel	25	729.9580263
Leisure Time	21	81.55393095
Lodging	6	90.88314604
Machinery-Constr&Mining	14	60.89037784
Machinery-Diversified	79	85.88104967
Media	14	79.982007
Metal Fabricate/Hardware	32	186.0191488
Mining	15	675.3037774
Miscellaneous Manufactur	36	155.6460208
Office Furnishings	6	75.88277584
Office/Business Equip	7	47.56968499
Oil&Gas	6	661.2551644
Oil&Gas Services	1	163.5907067
Packaging&Containers	10	310.9922192
Pharmaceuticals	49	40.18289867
Pipelines	1	246.4691527
Private Equity	3	46.22566111
Real Estate	63	52.36144511
Retail	174	164.3519473
Semiconductors	33	96.63098418
Shipbuilding	4	100.5682592
Software	95	100.2715386
Storage/Warehousing	6	171.3817967
Telecommunications	24	73.57274115
Textiles	15	321.8913879
Toys/Games/Hobbies	4	9.154899497
Transportation	64	235.4428955
Trucking&Leasing	1	14.23226388

Top 10 highest GHG emissions industry

Industry Group	Number of Companies	Average GHG missions
Electric	13	1445.180846
Home Furnishings	18	750.2487948
Iron/Steel	25	729.9580263
Airlines	2	704.8500187
Mining	15	675.3037774
Oil&Gas	6	661.2551644
Forest Products&Paper	13	488.446518
Coal	2	486.4977324
Housewares	3	461.6807642
Building Materials	51	340.6143887

Top 10 lowest GHG emissions industry

Industry Group	Number of Companies	Average GHG missions
Toys/Games/Hobbies	4	9.154899497
Banks	81	9.539234535
Trucking&Leasing	1	14.23226388
Diversified Finan Serv	48	19.95463946
Biotechnology	5	25.69744819
Insurance	10	26.17282425
Pharmaceuticals	49	40.18289867
Investment Companies	2	41.48763029
Entertainment	14	43.94468794
Aerospace/Defense	3	45.89913239



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> Having been recognised as a “resource-intensive” economy, the People’s Republic of China has been experiencing major implications in terms of ecological environment degradation, which continuously harms the health of the Chinese people and the productivity of China’s economy. Among the political efforts set forth by the Chinese central authorities, the claim of promoting a “National Ecological Accounting and Auditing Scheme” (NEAAS) has been drawing nationwide attention. Through a series of critical discourse analysis on relevant written texts produced by the central authorities, mainstream media and the Chinese academics, this paper sets out to analyse the historical evolution of the institutional context in relation to the establishment of such a scheme, and further, to decipher the ideological underpinnings that have shaped this context. The findings indicate that the signification of NEAAS goes far beyond the environment protection, in that, this scheme constitutes a fundamental institutional reform that the Communist Party of China seeks to conduct.

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