QATAR UNIVERSITY

COLLEGE OF BUSINESS AND ECONOMICS

THE ROLE OF CORPORATE GOVERNANCE IN REDUCING CARBON EMISSION DURING COVID-19: A GLOBAL PERSPECTIVE

BY

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A Thesis Submitted to the College of

Business and Economics

in Partial Fulfillment of the Requirements for the Degree of

Master of Accounting

January 2023

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ABSTRACT

ABDILLAHI, AMAL, Masters: January: 2023, Master of Accounting

Title: The role of corporate governance in reducing carbon emission during COVID-19: A global perspective

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Greenhouse gas emission is primarily responsible for global warming and climate change, which are significantly impacting air quality, human health, business activity, and the overall economy. Corporate governance plays a critical role in determining how well companies manage the risks associated with climate change (Ko & Tai, 2019; Luo & Tang, 2021; Peters & Romi, 2014; Sullivan & Gouldson, 2017). The COVID-19 pandemic provided a natural experiment, when all aspects of human life were disrupted, to examine how corporate governance can influence a company's response to carbon emission.

This study examines the relationship between corporate governance and carbon emission reduction at the micro and macro levels. It also examines this relationship before and during the COVID-19 pandemic. The sample consists of 2,226 public firms from 41 different countries during the period 2018–2021. The data are obtained from the Refinitiv Workspace database and IQAir. To test the hypotheses, the study employs ordinary least squares (OLS) multiple regression analysis to identify the relationship between corporate governance and carbon emission reduction before and during the COVID-19 period. The empirical findings reveal a positive and significant association between the effectiveness of corporate governance and carbon emission reduction. The results also indicate that the strength of the relationship between corporate governance and carbon emission reduction varies for the period prior to the pandemic relative to the period during the pandemic. Furthermore, the results suggest that the East Asia & Pacific, Eastern Europe & Central Asia, Latin America & the Caribbean, and South Asia regions are associated with a greater reduction in carbon emission during COVID19 relative to other regions. This study contributes to the growing accounting literature on corporate governance and carbon emission and provides evidence regarding how corporate governance has affected carbon reduction during a significant global crisis.

DEDICATION

I dedicate this thesis to my parents for their unending love, support, and encouragement.

ACKNOWLEDGMENTS

First and foremost, I would like to express my gratitude to Allah for providing me with the strength, patience, and guidance I needed throughout my life, especially during the preparation of my thesis.

Second, I would also like to express my sincere gratitude for the invaluable guidance, supervision, encouragement, and insightful advice I received from my supervisors, Dr. Husam Aldamen and Dr. Osama Mahd, while the writing the thesis. I could not have asked for a more supportive advisers and mentors. Without their support, this work would not have been possible. I would also like to thank the rest of the committee members for their informative comments and support.

I would like to extend my gratitude and thanks to my family, particularly my beloved mother, Khadija, and my father, Houssein (May Allah rest his soul in peace). It is impossible for me to express how grateful I am to my loving parents. It is my pleasure to express my gratitude to you for providing me with the most excellent childhood and educational opportunities. Throughout my life, I have been blessed with loving brothers Sultan and Mohamed, as well as sisters Neima and Khadra. Also, I would like to express my appreciation and gratitude to my friend and soul sister (Baina Al-marri). Also, I would like to thank to my colleagues and friends. Dur to their support, I have been able to achieve success in my studies. Finally, I would like to express my gratitude to all those who assisted me along the way.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1: INTRODUCTION AND OVERVIEW OF THE RESEARCH

1.1 Background

Greenhouse gas (GHG) emission is among the most serious of concerns that are being confronted by humanity in the twenty-first century. Climate change, encompassing wildfires, heat waves, droughts, and severe water shortages, poses various challenges to almost every country in the world (Ruffo, 2022). As the planet continues to warm, climate change is expected to create more challenges in the future. Environmentalists, policymakers, legislators, and other stakeholders are increasingly concerned about the environmental effect of GHG emission on the planet (Haque, 2017; Sarwar & Alsaggaf, 2021). Due to the emissions caused by the vast volume of material processing, which results in GHG emission, firms are responding by lowering their GHG emission and implementing different energy consumption and usage techniques (Gallego-Álvarez et al., 2015).

There is a growing amount of literature on how organizations and businesses are responding to, and combatting, changes to the environment (Cadez et al., 2019; Griffiths et al., 2007). According to Luo et al. (2012), social, economic, and regulatory factors are driving climate change efforts that have led numerous stakeholders to put pressure on firms to declare their GHG emission. This encourages policymakers to adopt a variety of solutions through which to address the issues linked to GHG emission, such as the Kyoto Protocol and the Paris Agreement (Freedman & Jaggi, 2005; Gallego-Álvarez et al., 2015). Possible actions by companies to reduce carbon emission include compliance with regulatory requirements, green strategies and policies, collaboration with supply chain partners to reduce emission, and the application of technological solutions (Galbreath, 2010; Rume & Islam, 2020).

Studies have suggested that there is an increase in carbon disclosure and overall climate change strategy throughout the world (Alsaifi et al., 2020; Bennett, 2021). This is mainly because climate change problems have become increasingly important to many business stakeholders focusing on GHG emission, particularly the impact of carbon emission on a firm's operations (Luo & Tang, 2021). However, from the start of 2020, business activities were significantly reduced as a result of COVID-19 restrictions. According to Hale and Leduc (2020) and Le Quéré et al. (2020), global carbon emission may have decreased by 7% – 8% in 2020. The COVID-19 pandemic impacted every socioeconomic and environmental level, including worldwide GHG emission (Le Quéré et al., 2020). To counteract the impact of the virus, several rigorous measures were established across the world (The State Council Information Office (SCIO), 2020), including temporarily shutting down public transportation, enforcing remote work and online learning, and ordering individuals to remain in their homes. Significant economic sacrifices were made in order for these measures to be implemented. Economic activity and industrial output in several nations slowed down drastically in 2020, resulting in a significant reduction in carbon emission. Along with reducing economic activity, fossil fuel consumption and carbon emission from industrial processes were reduced (Asumadu Sarkodie & Owusu, 2017; Wang et al., 2020). The International Energy Agency (IEA) estimated that in 2020, the pace of decrease in carbon dioxide emission was the fastest in any year during the last decade, thus raising questions regarding the real impact of the pandemic (IEA, 2020).

With the rise of environmental hazards, corporate governance has taken on an important role in focusing on firm sustainability and environmental concerns (Peters & Romi, 2014). Matsumura et al. (2014) stated that shareholders are increasingly pressuring corporate executives to evaluate the risks and opportunities that are presented by climate change, and to disclose the financial impact of company choices that are related to the environment. The literature indicates that climate-related actions are complicated as they involve conflicts of interest among stakeholders, as well as the need to maintain an appropriate balance between financial and non-financial goals (Agyabeng-Mensah et al., 2020; Liao et al., 2015; Singh et al., 2001). This is where corporate governance makes an impact as it provides effective oversight of management's activities, including environmental matters and concerns. Moreover, organizational structures are expected to be built with a view to managing emission, assessing emission-based risks, and evaluating carbon reduction techniques that are designed to solve environmental issues. However, Prado-Lorenzo and Garcia-Sanchez (2010) noted that corporate boards are largely inactive with regards to monitoring the disclosures of firms' environmental and carbon impact. The current study expects corporate governance to ensure the representation of a wider range of stakeholders. With respect to carbon emission, corporate governance is expected to influence decisions that can ultimately lead to carbon emission reduction.

The objective of this thesis is to investigate the link between corporate governance and carbon emission reduction before and during the COVID-19 pandemic. Several theories are utilized to frame this research, such as agency, stakeholder, and legitimacy theories. According to agency theory, corporate governance is considered an important internal control that monitors management's opportunistic behavior.

Based on legitimacy and stakeholder theories, firms with well-designed corporate governance policies tend to have a stronger sense of stakeholder orientation, as well as an understanding of legitimation issues, such as climate change, which encourages them to enhance their carbon efficiency in order to meet societal expectations (Liao et al., 2015; Luo, 2019). The study also examines how COVID-19 has impacted the global relationship between carbon emission reduction and corporate governance.

1.2 Motivation

There are several factors that motivated this study. First, the majority of prior studies related to this topic have concentrated on a narrow aspect of the relationship between corporate governance mechanisms and social and environmental performance (e.g. De Villiers et al., 2011; Hafsi & Turgut, 2013; Muhammad & Raza, 2018; Rubino & Napoli, 2020; Salo, 2008; Walls et al., 2012). Other studies have focused on emission disclosure and sustainability (Hussain et al., 2018; Kılıç & Kuzey, 2019; Lewis et al., 2014; Liao et al., 2015; Masud et al., 2018; Patnaik, 2019; Peng et al., 2015; Rankin et al., 2011; Tauringana & Chithambo, 2015; Towah, 2019; Zheng et al., 2021). This leaves room for a more thorough investigation of the relationship between corporate governance and carbon emission.

Second, there are mixed results regarding the relationship between corporate governance and environmental performance (e.g., Cordeiro et al., 2020; Elsayih, 2015; Haque, 2017; Lu & Herremans, 2019). In contrast, this study provides insight into the relationship between corporate governance and carbon emission reduction. Third, prior studies examining the impact of corporate governance on carbon reduction and environmental quality have traditionally focused on one country, such as Saudi Arabia (Sarwar & Alsaggaf, 2021), or on one region, such as South-West Asia (Dadgar &

Nazari, 2016), Sub-Saharan Africa (Sarpong & Bein, 2020), Middle East and North Africa (MENA) (Omri & Ben Mabrouk, 2020), and developing economies generally (Gani, 2012; Pour, 2012), or on sectors such as the tourism sector (Andlib & Salcedo-Castro, 2021). The current study uses an international sample that includes companies from various countries, regions, and sectors in order to examine the association between corporate governance and carbon emission reduction.

The COVID-19 pandemic has provided a brief, but visible, relief for the environment, as was noticed during the lockdown periods (Cheval et al., 2020). There were significant reductions in economic output and transportation operations as a result of restrictions on people's movement outside their homes. These unprecedented changes resulted in considerable decreases in GHG emission, mainly carbon emission. Both global and regional economies were impacted by lockdown-related constraints (ICIMOD, 2020; World Bank, 2020). As a result of these lockdowns, there have been reports of lower levels of air pollution, as well as lower waste creation and enhanced atmospheric visibility (McNeill, 2020). Furthermore, several researchers have investigated the impact of COVID19-related activities on carbon emission and air quality (Andreoni, 2021; Han et al., 2021; Khan et al., 2021; Liu et al., 2020); however, there has been no previous study that has examined the impact of the COVID-19 pandemic on the relationship between corporate governance and carbon emission reduction.

1.3 Research Objectives and Questions

The objective of this study is to examine the relationship between corporate governance and carbon emission reduction. Moreover, this study aims to examine the impact of the COVID-19 crisis on the relationship between corporate governance and carbon emission reduction, using an international sample over a four-year period (2018–2021). The following research questions (RQs) are addressed in this study:

RQ1: Does effective corporate governance reduce carbon emission?

RQ2: To what extent has the association between effective corporate governance and carbon emission varied during COVID-19 relative to prior periods?

RQ3: To what extent has the association between effective corporate governance and carbon emission varied based on the levels of COVID-19 control measures?

1.4 Research Hypotheses

For the purposes of answering the research questions, the following hypotheses have been developed:

H1: There is a positive and significant relationship between corporate governance and carbon emission reduction practices.

H2: The impact of corporate governance on carbon emission varies for the periods prior to the pandemic and during the pandemic.

H3: The relationship between corporate governance and carbon emission varies based on the levels of COVID-19 control measures.

1.5 Research Methodology

This study uses a quantitative approach to examine the relationship between corporate governance and carbon emission reduction prior to and during the COVID-19 crisis. Moreover, the data for the study are obtained from Refinitiv Workspace database and IQAir. This study examines the period 2018–2021 using a balanced sample of 2,226 public firms (8,904 firm-year observations) from 41 countries. The corporate governance pillar score is used as a measure of corporate governance.

Furthermore, the emission scores are used as a measure of carbon emission reduction, while IQAir's World Air Quality Index (AQI) is used to measure air pollution, which is used as a proxy for carbon emission. This study controls for various factors, including firm size, performance, leverage, industry, and region fixed effects.

1.6 Research Results

The empirical results of this study reveal a positive and significant association between carbon emission reduction and corporate governance effectiveness prior to COVID-19. This is in line with the study's argument, which asserts that the effective monitoring of management's behavior by the director with respect to the environment enhances the role of corporate governance. The results also indicate that carbon emission reduction was positively related to corporate governance during COVID-19. Furthermore, the study highlights the role of corporate governance in reducing carbon emission and air pollution at the regional level. These findings suggest that there is a negative and significant association between corporate governance and air pollution. Corporate governance has thus had a significant impact on reducing carbon emission, both before and during the COVID-19 crisis.

1.7 Research Contribution

This study contributes to the body of accounting and environmental literature in several ways. First, this study investigates whether effective corporate governance might be used to monitor managers' behavior in relation to carbon emission reduction efforts. Second, it provides empirical evidence, which extends current understanding of the association between carbon emission reduction and corporate governance during and before the pandemic. It thus fills an existing empirical gap that relates to the role of corporate governance in the reduction of carbon emission during the global COVID-19 pandemic. Third, to the best of the researcher's knowledge, this is the first research effort to explore the role of corporate governance in reducing carbon emission from a wider viewpoint, taking into consideration the relationship between corporate governance and carbon emission reduction prior to and during the COVID-19 pandemic. Accordingly, the study's findings provide useful insights both for policymakers and governments regarding the sustainability strategies, polices, and regulations that can be used to reduce carbon emission and to improve air quality.

Finally, the study contributes to the agency, stakeholder, and legitimacy theory literature by extending the body of carbon emission reduction literature. The thesis provides new evidence relating to how carbon performance was impacted globally by the strength and structure of corporate governance during the COVID-19 crisis. The current study also provides evidence of corporate governance and of a variety of company-specific characteristics as control variables that can reduce carbon emission.

1.8 Contents of the Thesis

The thesis comprises six chapters. Chapter 1 provides an overview of this thesis, which begins with the motivation of the study, followed by the objectives and research questions. It then identifies the research hypotheses and offers a summary of the research methodology and results. Finally, it describes the expected contribution of the research.

Chapter 2 provides a review of the literature that is relevant to this study. The first section of the chapter presents the research theoretical framework, discussing the theoretical perspectives adopted in this thesis. Three main theories employed in this research are agency, stakeholder, and legitimacy theories. The second section focuses on the background to carbon emission and explores related previous studies and their relationship to the control variables. Following this, the chapter provides a comprehensive definition of corporate governance and a detailed analysis of the previous literature investigating the association between corporate governance and carbon emission reduction. The chapter also discusses the development of the main hypotheses that are tested in this study. Finally, this chapter presents an overview of COVID-19's economic and environmental impact.

Chapter 3 discusses the research methods that were employed in the current study in order to test the hypotheses. The first section describes the research design, and this is followed by an explanation of the procedures utilized for the sample selection and data sources. After describing the data, Chapter 3 also describes the measurements of the dependent, independent, and control variables. The chapter concludes with an explanation of the statistical techniques that have been used in this study, as well as the regression models that have been employed in order to test the hypotheses and the outcomes of this research.

Chapter 4 presents the first phase of the current study, which uses quantitative methods to investigate the role of corporate governance in reducing carbon emission. It starts by explaining five statistical assumptions that determine the validity of the regression model, namely linearity, independence of errors, normality, homoscedasticity, and multicollinearity. The chapter then provides a comprehensive descriptive analysis of the variables. The analysis of variance test (ANOVA) then follows. An analysis of the correlation coefficients and variance inflation factor (VIF) values was used to identify any collinearity and multicollinearity problems among the variables. OLS regression analysis was employed in this study to examine the research hypotheses. The regression analysis was employed at two levels, in relation to: 1) the association between carbon emission reduction and corporate governance, at the company level; and 2) the association between the reduction of carbon emission and corporate governance, at the regional level.

Chapter 5 provides a detailed discussion of the results and the testing of the hypotheses that were developed in Chapter 2. The first hypothesis posits that there is a positive and significant relationship between corporate governance and carbon emission reduction practices. The second hypothesis asserts that the impact of corporate governance on carbon emission varies for the periods prior to the pandemic and during the pandemic. The third hypothesis posits that the relationship between corporate governance and carbon emission varies based on the levels of COVID-19 control measures. Additionally, this chapter reflects on the previous research and the theoretical framework that has been used in this thesis.

Chapter 6 presents the conclusions of the thesis. This chapter also summarizes the major limitations of the study. The chapter concludes by highlighting several potential research avenues that may be explored in the future, based both on the empirical results and the limitations that have been identified in this study.

CHAPTER 2: LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

This chapter discusses the theoretical framework, addressing prior research on carbon emission reduction, corporate governance, firm characteristics, and the impact of the COVID-19 pandemic. The first section of this chapter introduces the theoretical framework, which focuses specifically on agency, stakeholder, and legitimacy theories. The second section reviews prior research on factors that affect carbon emission reduction. Specifically, it reviews prior studies relating to corporate governance and its relation to carbon emission reduction, as well as studies that are related to COVID-19 and its social, economic, and environmental impact. The final section provides a comprehensive summary of the chapter.

2.1 Theoretical Framework

This section aims to introduce the related theories, which are used to explain the research phenomena. These theories are agency, stakeholder, and legitimacy theories, which are among the most relevant theories that have been addressed by prior research with respect to carbon reduction and the disclosure of environmental information (Datt et al., 2019; Liao et al., 2015; Luo, 2019).

2.1.1 Agency Theory

Agency theory describes the relationship between owners (principals) and managers (agents). It suggests that shareholders delegate authority to managers so that they can make decisions on their behalf; while managers are accountable for these shareholders' interests (Eisenhardt, 1989; Jensen & Meckling, 1976). According to agency theory, managers are responsible for establishing a strategy and then implementing it, while directors are responsible for monitoring the implementation of that strategy (Jensen & Meckling, 1976; Kock et al., 2012). Typically, managers have power over the company's resources, and they are privy to information that is not available to others, including the company's shareholders (Brammer & Millington, 2008). This information asymmetry prompts managers to make decisions that serve their interests, rather than those of the shareholders (Brammer et al., 2007), which could ultimately lead to the misappropriation of company resources. As a result of the separation of ownership and control, the principal bears a certain cost, which is to direct and monitor the agent. This cost is known as the agency costs (Jensen and Meckling, 1976). A variety of monitoring activities are performed by the principal to limit the actions of the agent, and to mitigate agency costs. Several factors play an important role in the principal–agent contract, including incentives, labor market dynamics, and information asymmetry. According to Rodríguez et al. (2012), one of the primary ways to reduce agency costs is to align the interests between the principal and the agent through the use of incentives.

The assumption that managers tend to engage in activities at the expense of shareholders lays the foundation for a conflict between the principal and the agent, which is known as the agency problem (Mitnick, 1975). Prior research has found that corporate governance mechanisms may mitigate this conflict by monitoring management, as well as by requesting the disclosure of information, with the aim of reducing information asymmetry (Baysinger & Hoskisson, 1990).

Companies are defined by Jensen and Meckling (1976) as "sets of contractual arrangements between production factors." According to Jensen and Meckling (1976), a firm is a black box that aims to maximize value and profitability. Similarly, Fama (1980) suggested that firms might be disciplined through competition with other firms, which leads to monitoring the performance of the entire team and its members individually. Furthermore, firms can be considered as legal fictions, with certain contractual obligations between their members. An agency relationship is a form of contract in which the principal and agent seek their own interests, resulting in conflicts between them.

Eisenhardt (1989) suggested that agency theory can be categorized into two models: positivist agency model; and a principal–agent model. In the two models, there is a contractual relationship between the principal and the agent. The principals make decisions that are aimed at risk neutrality and profit maximization, while agents are risk-averse and seek to generate revenue (Harris & Raviv, 1978). Positivist agency theory explains how agency problems are created and resolved.

A conflict between shareholders and managers regarding the company's goals is highly likely. In general, shareholders who closely monitor management will work harder to be more critical, request more information, and often object forcefully when management does not offer information that makes sense to them (Baysinger & Hoskisson, 1990). According to Hoskisson et al. (1994) and Minichilli et al. (2009), the monitoring of corporate strategic decisions by a board of directors appears to have a positive correlation with the business's bottom line. According to agency theory, a self-interested manager may respond opportunistically to climate change threats by taking advantage of the information asymmetry between corporate insiders and outsiders. Cespa and Cestone (2007) asserted that to recruit effective CEOs, it is critical to establish relationships with social activists, as they will be motivated to adopt socially responsible behaviors that will be supported by the public. As a means of improving their reputation at the expense of shareholders, managers tend to overinvest in corporate social responsibility (CSR) (Malmendier & Tate, 2005). Therefore, effective corporate governance is essential for a company to prevent opportunistic investments in CSR.

The board of directors often initiates and implements strategies (Hillman & Dalziel, 2003). By appointing an environmental professional to the firm's board, the firm's environmental performance tends to improve (Hillman & Dalziel, 2003). Furthermore, managers often convey to the shareholders that they are acting in their interests. Consequently, shareholders receive more information, which is one of the most effective ways to support an improvement in corporate culture (Ness & Mirza, 1991). In accordance with this theory, managers' report only voluntary information that benefits them. Baysinger and Butler (1985) concluded that larger boards, with a greater number of independent directors and commissioners, may exert greater control over managers' decisions.

According to the agency theory framework, the disclosure of analysts' reports can be an effective method for reducing information asymmetry that may arise between firms and investors (Easley & O'Hara, 2005). Management may therefore need to provide investors with financial, as well as non-financial, information in order to reduce the risks of a hostile takeover and to decrease investor monitoring costs (Healy & Palepu, 2001). However, stock exchanges can be useful as a means of monitoring companies' environmental disclosures, as well as those disclosures that are related to emerging economies (Gupta & Goldar, 2005). The disclosure of carbon information, however, can reduce financial risk and increase the transparency of firms (Gonzalez-Gonzalez & Ramírez, 2016), as well as preventing information imbalances within firms (Li et al., 2019) and enabling companies to analyze their financial risk (Matsumura et al., 2014). Research has indicated that the voluntarily disclosure of GHG emission will negatively impact stock prices (Griffin et al., 2017). On the other hand, Borghei et al. (2018) reported that the disclosure of GHG emission is positively associated with the return on assets. According to these authors, companies accept the additional costs associated with voluntary disclosure in order to achieve the perceived benefits. Moreover, Goodstein et al. (1994) found that a firm can avoid engaging in strategic actions by increasing the proportion of independent board members (Verrecchia, 1983). In the context of agency theory, it is assumed that independent board members will monitor and control the opportunism of insider executives in order to protect shareholders' interests. Daily et al. (2003) and Finegold et al. (2007) argued that, in order to maintain a board's independence, it would be desirable to have sufficient outside members, such as members who are not executives working in the company or significant shareholders. They also suggested, for better independency, to have diverse board members with no material contractual relationship with the company.

Finally, it is important to note that agency theory is limited in that, in many cases, opportunistic misinformation takes place in the organizational context rather than in the context of an individual, which means that the manager is not the only partly to blame. Some companies have majority shareholders who prefer that the firm keeps operating as usual rather than "going green," as agency theory describes possible conflicts of interest between managers and outside shareholders, particularly in large organizations (Eisenhardt, 1989). As far as climate change is concerned, the real conflict is between shareholders who are motivated by financial gains and stakeholders who are motivated by environmental concerns. A firm is more likely to engage in socially responsible activities in order to maximize shareholder wealth (Friedman, 1970).

2.1.2 Stakeholder Theory

Stakeholder theory was formulated by Ansoff (1965), and it was later developed by Freeman (1984). It is considered one of the most utilized theories in environmental disclosure research (Baalouch et al., 2019). Freeman (1984) defined stakeholders as a group that has a strong influence on the company and its activities. Stakeholders, which consist of the shareholders, customers, governments, the media, employees, banks, creditors, and suppliers, can exert significant influence on management's decisions and policies (Deegan, 2000). This influence also includes the environmental disclosure of their activities, which ultimately outlines how those activities have an impact both on the environment and society.

Stakeholder theory suggests that companies must perform their work to satisfy and create value for stakeholders, who provide the necessary economic resources for the company (Gray et al., 1995). Hence, organizations need to have a concrete flow of resources, as well as the management structures that are required in order to meet the stakeholders' demands and provide the maximum value to them (Foster & Juncker, 2005; Roberts, 1992). Management is required to consider the various demands that are made by stakeholders (Huang & Kung 2010; Wernerfelt, 1984). Furthermore, stakeholders are usually concerned with the company's strategies, as well as with the profits that result from its economic performance. It has been argued that stakeholders are also interested in the company's position on environmental issues (Huang & Kung 2010), which results in increased pressure on management to disclose environmental information (Suttipun & Stanton, 2012). Additionally, stakeholders view environmental disclosures as indicators of corporate accountability (Utz, 2019). Such disclosures often assist companies in making ecologically responsible decisions, as well as improving overall business success. Research has shown that environmental disclosure influences the stakeholders' view of the business and helps to boost the business's reputation (Dewi, 2019). According to Wood (1991), managers should consider themselves moral actors whose actions must be socially responsible. Accordingly, management's commitment to CSR practices can be seen when it adheres to accountability and transparency principles and holds stakeholders accountable (Medawar, 1976). Companies are pressured by stakeholders to be more transparent (Cho & Patten, 2007), due to the impact that their actions may have on the environment. Furthermore, unecological practices may have serious consequences for the company's operations (Donaldson & Preston, 1995). Prior research has suggested that companies with good economic performance tend to disclose more environmental information, such as carbon emission, than companies with poor performance (Akhiroh & Kiswanto, 2016; Pirsch et al., 2007). Similarly, well-governed companies encourage their management to disclose environmental information and to respond to stakeholders' environmental concerns (Luo & Tang, 2020).

An effective corporate governance process focuses on stakeholders, promotes participatory decision-making, and maintains transparency throughout the organization. Social and environmental responsibility is generally more common among companies that have board of directors that acts ethically and listens to stakeholders' concerns while pursuing conventional financial objectives (Jo & Harjoto, 2012). A company's operating and reporting behaviors may be modified based on stakeholder expectations and power (Deegan & Blomquist, 2006). Depending on the stakeholders' power, company directors may feel that there is a need to inform the public of any implementation of social or environmental initiatives or plans to implement these initiatives. In this way, any concerns they may have regarding the company's performance will be alleviated. Disclosures may be used by firms to manage stakeholder demands. Several aspects of environmental disclosure, including GHG emission, are explained by stakeholder theory. The disclosure of environmental information occurs in response to stakeholder requests for social and environmental information (Freedman & Jaggi, 2005; Liao et al., 2015). Liao et al. (2015) posited that the intensity of competing stakeholder interests may have an impact on GHG emission disclosures. These include a firm's response to climate change and its social responsibility strategy.

The level of environmental disclosure depends on stakeholder pressures (Deegan & Rankin, 1996; Huang & Kung 2010; Walden & Schwartz, 1997). External stakeholders, such as governments, creditors, and the media, can exert significant pressure on management to respond to external demands relating to environmental disclosures (Huang & Kung, 2010; Shen et al., 2020). In contrast, internal stakeholders, such as employers, managers, or investors, are often able to put direct pressure on management to report on the company's environmental practices (Huang & Kung, 2010). Support both from external and internal stakeholders plays a crucial role in the success of a company. However, the presence of information asymmetry between management and stakeholders could yield negative consequences for the company in general and for environmental disclosures specifically (Öberseder et al., 2014; Palsson & Kovacs, 2014).

2.1.3 Legitimacy Theory

Legitimacy theory is commonly used in the field of CSR and environmental disclosure. Legitimacy theory suggests that there is a contract between the company and the community (Mousa & Hassan, 2015). This implies that companies disclose environmental information and contribute to the environment through a set of activities that are used to gain legitimacy from the community in which the company operates (Michelon & Parbonetti, 2012). Companies are viewed as an integral part of society, and they contribute by bearing essential responsibilities (Deegan, 2002). The theory assumes that companies must have an awareness of, and adherence to, social values, in order to ensure their continuity. Clearly demonstrating their legitimacy enables companies to demonstrate to society that the activities they are undertaking are desirable, legitimate, and appropriate (Suchman, 1995). Moreover, society's view of that company will change if it fails to abide by the contract that binds it to that society (Milne & Patten, 2002). One of the major issues that could potentially breach the social contract is environmental damage that results from business activities. According to Deegan (2002), companies that adversely affect the environment may experience decreased demand for their products and disruptions to their relationships with their suppliers.

Prior studies have suggested that the main reason for disclosing environmental information is to obtain legitimacy (Mitchell, 2005; Tilling & Tilt, 2010) and support from society and stakeholders (Prasetya & Yulianto, 2018). According to Chelli et al. (2014), companies disclose environmental information due to social and political pressures. Furthermore, companies must often integrate their operational activities with social activities in order to ensure the flow of necessary resources and to support the community (Dıéz-Martín et al., 2013). Research has shown that society and stakeholders require greater disclosure of relevant environmental information (Darnall et al., 2009; Deegan, 2002; Ingley, 2008). Accordingly, companies seek to disclose information if their legitimacy and survival are threatened (Welbeck et al., 2017). However, prior studies have also suggested that some companies could minimize their environmental disclosures if they perceive that society's and stakeholders' reaction will not be hostile towards them (Brown & Deegan, 1998; Frost & Wilmshurst, 2000). According to Luo (2019), in light of legitimacy theory, there is a negative correlation between social and environmental disclosure and carbon emission performance. Stakeholders' pressure on companies with poor environmental performance is likely to be greater, and they may experience legitimacy issues. Such companies often make voluntary disclosures in order to maintain a positive reputation rather than to enhance environmental protection (Luo, 2019).

Legitimacy and stakeholder theories tend to emphasize external pressures from society in general or from various stakeholders in particular, while agency theory focusses on the idea that corporate governance is responsible for curbing managers' opportunistic behavior in the relationship between a company's managers and its shareholders. Moreover, stakeholder theory is related to legitimacy theory. As with legitimacy theory, stakeholder theory places the organization within the society in which it operates. Stakeholder theory is concerned with stakeholders that are involved in an organization's activities. Legitimacy theory, on the other hand, focuses on society itself. According to legitimacy theory, organizations should always adhere to societal norms; their actions should also be considered legitimate by society as a whole (Elsayih, 2015). Despite this, stakeholders are only provided with information regarding the organization's accountability.

2.2 Literature Review

The literature review of this study begins with a review of prior studies of carbon emission. A major objective of this section is to summarize the key findings from previous studies, as well as their methodologies, in order to identify research gaps. Therefore, prior studies are divided into the following two sections. The first section provides an overview of carbon emission, air pollution. The second section reviews the literature that has investigated corporate governance's effect on carbon emission and air pollution. This section also discusses the impact of COVID-19 on the economy and the environment according to recent research. Furthermore, this section discusses the relationship between corporate governance environmental disclosures and the COVID-19 crisis.

2.2.1 Carbon Emission

2.2.1.1 Background

Global warming, which is caused primarily by carbon emission, is one of the most important issues on the international stage (Gleick et al., 2010; Ruffo, 2022; Sarwar & Alsaggaf, 2021). According to the Intergovernmental Panel on Climate Change (IPCC) (2015) and Barrett et al. (2014), the emission of harmful gases between the years 2000 and 2010 increased by nearly 2.2% annually, with an increase of 0.8% compared to 1.3% per year between the years 1990 and 2000. According to IEA (2020), in 2019, coal-related CO_2 emission decreased by approximately 1.3%, although there was an increase in oil and natural gas emission. Among advanced economies, 85% of the reduction in emission came from the power sector. In comparison with 2018, the weather was milder in most large economies, which in turn had a significant impact on trends by reducing emission. In major emerging economies such as India, slower economic growth also moderated the increase in emission. In 2020, however, the demand for fossil fuels decreased, as did worldwide emission, particularly oil, which decreased by 8.6%, and coal, which declined by 4% (IEA, 2021). The oil Industry accounted for more than half of the reduction in global emission in 2020, which was the largest reduction ever recorded. According to recent statistics, primary energy demand decreased by 4% (representing almost 2,000 million tons) in 2020, resulting in the largest reduction in energy-related CO_2 emission since 1945. Further, across major regions, there has been a reduction in daily CO2 emissions (Liu et al., 2020). During the first half of 2020, the United States had the largest decline, declining by 13.3%, which led to a reduction of 338.3 million tonnes (Mt). EU-27 and the United Kingdom followed this, reducing by 12.7%, contributing to a decrease of 205.7 Mt, India by 15.4%, contributing to a decrease of 205.2 Mt, and China by 3.7%. In addition, Japan and Russia saw progressive decreases (7.5%, or 43.1 Mt) and (5.3%, or 40.5 Mt) (Liu et al., 2020). Additionally, electricity and heat production represented the biggest increase in CO_2 emission by sector in 2021 (IEA, 2021). Due to the fact that all fossil fuels were used to meet the growth in electricity demand, 46% of the global increase in emission can be attributed to this factor. Meanwhile, worldwide energy-related carbon dioxide emission increased by 6% to 36.3 billion tons in 2021, their highest level ever. Moreover, gas emission, which includes carbon dioxide, methane, dinitrogen oxide, hydrofluorocarbon, perfluorocarbon, and sulfur hexafluoride, are among the most harmful GHG emissions that are impacting the environment (Hermawan et al., 2018). There has been a yearly increase in the levels of gas emission in several countries. In 2018, carbon emission in the United States and India reached a rate of 5.41 and 2.65 billion tons respectively, which resulted primarily from the transportation sector, as it is the primary industry in these countries (IEA, 2020). Other industries that contribute to carbon emission, include utilities and agriculture. This emission is expected to increase in the future, since many countries are maintaining their dependence on coal to generate energy.

Researchers have extensively studied the effects of carbon emission, air pollution, and GHG emission on the environment (Belal, 2008; Hong et al., 2015; Pan et al., 2007; Solazzo et al., 2016; Straf et al., 2013; Yan et al., 2010; Goud, 2022). Previous studies have shown that the increase in carbon emission will be as much as 50% by 2050, and this will raise the earth's temperature dramatically (Kitamori, 2012; BBC, 2019). Furthermore, other practices, such as forestry clearing and excessive agriculture, will most likely have detrimental effects on the environment if proper actions are not taken (Kolk et al., 2008). This has prompted stakeholders to demand the disclosure of information about GHG emission, especially in those countries that do not have strong disclosure policies and regulations (Rankin et al., 2011). Furthermore, governments around the world have taken steps to reduce emission. The Paris Agreement and the Kyoto Protocol are among the most important of these steps (Freedman & Jaggi, 2005). In 1997, the United Nations' Kyoto Protocol Agreement was signed, and it was later approved formally in 2005. It stipulated that, by the year 2012, industrialized countries should reduce their carbon emission (Revkin, 2001). Regarding the Paris Agreement, it was adopted in 2005 to limit the negative effects of such emission, and to encourage the publication of voluntary and mandatory environmental disclosures in annual reports (Stanny & Ely, 2008).

Some companies have adopted the voluntary disclosure of environmental information (Healy & Palepu, 2001; Lan et al., 2013). However, the collection and reporting of this information requires additional costs and effort (Prasetya & Yulianto, 2018). There are benefits to voluntary disclosures, such as gaining legitimacy and the trust of society, which may ultimately assist companies in securing financial support in the future (Kansal et al., 2014). Considerable attention has been directed towards examining the link between a variety of firm characteristics and their general disclosures in relation to environmental concerns (Elsayih et al., 2021; Goud, 2022; Kiliç et al., 2015; Naser et al., 2006). Prado-Lorenzo et al. (2009) used a cross-national sample [the United States, the European Union (EU), Canada, and Australia] to examine the factors that influence company disclosures relating to GHG emission. In addition to the required Global Reporting Initiative indicators relating to GHG emission, they concluded that firm size and market capitalization influence information disclosures. Furthermore, Gonzalez-Gonzalez and Ramírez (2016) used a sample of Spanish companies to examine the factors associated with the disclosure of carbon information. According to their results, large firm size, high financial risk, and low ownership concentration are significantly associated with disclosures. This could indicate that stakeholders place pressure on companies, which then prompts them to disclose more information. Luo et al. (2012) investigated the corporate factors that contribute to companies' disclosure of carbon information and found that bigger companies voluntarily disclose carbon information about their operations as a result of their environmental responsibilities.

Previous research has suggested that companies in developing countries tend to focus on economic performance rather than on environmental performance (Belal, 2008; Liu & Anbumozhi, 2009). These studies argued that developing countries suffer from high levels of pollution, intensive use of fertilizers and pesticides, random disposal of toxic wastes, and other activities that harm the environment (Belal, 2008; Liu & Anbumozhi, 2009). Studies have concluded that environmental reports for companies in developing countries are of poor quality, and that stakeholders do not influence environmental disclosures in these companies (Belal, 2000; Liu & Anbumozhi, 2009; Yusoff et al., 2007).

Industrialization and urbanization are contributing to a decline in the quality of life (Straf et al., 2013). There is varying public awareness about pollution and environmental protection (Zeng et al., 2019). According to Seinfeld (1986, p. 14), air pollution is an “atmospheric condition in which substances are present at concentrations higher than their normal ambient levels to produce significant effects on humans, animals, vegetation or materials.” In addition to various sources, e.g., industries, electricity plants, vehicles, and natural disasters, there are also other sources of air pollution (Afroz et al., 2003), for instance nitrous and sulfur dioxide, carbon monoxide, hydrocarbons, and particulate matter (PM), including dust, fumes, and smoke.

Several trends are driving population growth and causing air quality to worsen, such as traffic, industrialization, and energy use. A severe air pollution crisis has been plaguing developing countries in the past few years, especially those in Asia, Africa, Latin America, and the Caribbean (UNEP, 2012). Afroz et al. (2003) conducted a study in Malaysia, which indicated that mobile sources are responsible for about two-thirds of the total air pollution, stationary sources are responsible for more than 25%, and open burning is responsible for about 3%. Mobile energy sources include cars, trucks, and motorcycles, while stationary fuel sources include power plants, the combustion processes of industrial fuel, and domestic fuel use (Afroz et al., 2003). Automobiles, as well as other oil- and gasrelated equipment, are creating huge amounts of unburned hydrocarbons that are released into the environment. This is evident in places that rely heavily on sulfur fuels for industrial production and the generation of electricity

(Awang et al., 2000). China is the second biggest consumer and producer of energy, after the United States (Wang, 2010). In addition to air pollution, energy sector pollution has negative effects on water, soil, agriculture, and human health (Pan et al., 2007). Managers working as agents on behalf of shareholders could potentially play an important role in their societies by making decisions that protect the environment (Tan et al., 2020). As is the case with agent–owner dynamics, proper governance often increases the disclosure of information (Aldamen & Duncan, 2016), reduces information asymmetry (Lang & Lundholm 2000), and mitigates agency conflicts (Gompers et al., 2003).

An important aspect of environmental economics that has been discussed recently is the role of governance in affecting environmental pollution (Elsayih et al., 2021; Goud, 2022; Baloch et al., 2019). Consequently, both the quality of government institutions (political system) that is in place and the quality of institutions contribute, directly and indirectly, to the quality of the environment. Prior studies have found that corporate governance can contribute to the reduction of pollution levels (Jorgenson, 2009; Shandra et al., 2008), which in turn contributes to improving the environment (Martinez et al., 2022; Hassan et al., 2020). According to Dash et al. (2020), the transparency of governance mechanisms and the improvement in a country's political system influence CO_2 emission, thereby reducing pollution. Studies have been conducted on samples of countries, such as the five major emerging economies [Brazil, Russia, India, China, and South Africa (BRICS)] (Baloch et al., 2019) and 19 states in the South-East Asian region (Gill et al., 2019), to examine the effects of different governance factors on the environment. These studies found that improved governance in these countries is associated with a reduction in CO_2 emission, which therefore improves air quality. Furthermore, Gani (2012) studied CO_2 emission and various dimensions of governance in 99 developing countries and found that a higher quality of governance results in lower emission levels. Halkos and Tzeremes (2013) used a non-parametric estimator to show a significant association between CO_2 emission and governance. Reflecting on the findings of prior studies, the current study asserts that governance practices are key to protecting natural resources and reducing environmental pollution.

Construction activities have a significant impact on the environment. These activities include building residential and non-residential property, workplace structures, roads, bridges, and tunnels. According to Hong et al. (2015), there are several factors that contribute substantially to GHG emission globally, but the most prominent factor is the construction industry, which is responsible for a significant amount of global warming emission. In addition to the most important GHGs, namely carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), GHG emission can also be the result of a variety of other sources. Hong et al. (2015) conducted a study to assess GHG emission that results from the construction industry in China. After analyzing the data, they concluded that not only did the manufacturing of building materials contribute to most of the indirect emission but transporting materials in China accounted for nearly three-quarters of the indirect emission. Similar findings were reported by Yan et al. (2010), who showed that, in the context of GHG emission, 87% came from construction, 6%–8% from transport, and 6%–9% from construction equipment.

Aside from these industries, there are also many others that contribute to GHG emission, such as agriculture. According to European Environment Agency (2015), global agricultural emission contributes significantly to GHG emission in the EU-28, accounting for 11.7% of the total CO_2 emission between 2013 and 2015. Across the EU, the countries that emit the greatest amount of agricultural CO_2 are France (17.7%), Germany (13%), the UK (10.4%), Spain (9.8%), Poland (8%), and Italy (7.5%) (Solazzo et al., 2016). From a governance perspective, Deloitte has published a report emphasizing the importance of corporate governance in terms of corporate sustainability (Wagner et al., 2009), recommending that corporate boards should place climate change high on their agendas. As Ewing (2008) pointed out, addressing climate risk requires the definition of the roles and responsibilities of boards and management. Additionally, Battisti et al. (2015) and Chattopadhyay et al. (2017) examined the impact of a variety of variables on the release of GHGs. Even though many sectors emit GHGs, it can be extremely difficult to reduce this. However, the most crucial factor that may help to control this emission is effective governance (Larch & Wanner, 2017). Moreover, the presence of an environmental committee on the board of directors has been found to correlate significantly with an improvement in the environmental performance of high polluting firms (Lam & Li, 2008). In order to reduce pollution, governance practices must be implemented in concert with regulatory quality in terms of the implementation of environmental laws and environmental standards (Ferrero et al., 2016). Zhou (2016) suggested that corporate governance practices encourage companies to adopt sustainable policies and to protect the environment more effectively.

2.2.2 Corporate Governance

Corporate governance enables businesses to attract a variety of investors, whether local or foreign (Osemene & Fagbemi, 2019), and oversees the relationships between the related parties in the company, including management and stakeholders.

Furthermore, corporate governance provides a framework that helps companies to achieve their goals (Ioana & Gherghina, 2007; Elsayih et al., 2021; Goud, 2022; Osemene & Fagbemi, 2019). According to Cadbury (1992, p. 14), corporate governance is defined as “the system by which companies are directed and controlled.” Munir et al. (2019) also added that corporate governance clarifies the procedures that are followed when management makes decisions, and that this greatly affects all stakeholders. This also includes the preservation of the rights of small shareholders and the resolution of conflicts of interest between management and stakeholders (Carney et al., 2011). This is carried out via a set of mechanisms through which responsibilities are distributed among the various parties in the company.

The relevance of corporate governance has increased with the emergence of financial crises that have occurred in recent decades (El Mahdy, 2019), most notably the Asian financial crisis (AFC) in 1997 and the global financial crisis (GFC) in 2008 (Aldamen & Duncan, 2016; Johnson et al., 2000; Kumar & Singh, 2013). Prior studies have indicated that poor corporate governance led to the exacerbation of the GFC (AlGamrh et al., 2018; Essen et al., 2013). According to Bebchuk et al. (2010), the financial crisis was caused by the banks’ inability to control risk as a result of ineffective corporate governance.

One of the most vital governance mechanisms is the board of directors, which is responsible for the strategic decisions that are made by organizations (Minton et al., 2010). The board often analyzes the quality of information in the market, monitors risk practices, and ensures that management practices are in line with the shareholders’ interests (Maher & Andersson, 2002; Torea et al., 2016; Nuber & Velte, 2021). Minton et al. (2010) discussed how board independence and financial expertise are related to risk-taking. Kirkpatrick (2009) showed that board independence reduces the conflicts of interest between the principal and the agent. The latest global crisis, which resulted from the COVID-19 global health pandemic, was unlike prior crises, in that it was non-financial in nature. However, corporate governance remains an important factor in times of uncertainty, as it serves to control management actions and to safeguard the interests of stakeholders (Alpaslan et al., 2009).

Previous studies have indicated that an effective internal system and an independent board of directors play a positive role in a firm's performance (Barney, 1991). Minton et al. (2010) added that corporate governance mechanisms are negatively associated with a company's financial performance during a financial crisis. However, in normal times, there is a positive association between corporate governance and financial efficiency (Kowalewski, 2016). Orazalin and Mahmood (2019) examined the effect of corporate governance on the performance of banks in Kazakhstan prior to, during, and after the GFC. They concluded that banks with high levels of corporate governance were able to withstand risks and achieve higher profits in the post-crisis period. Other studies have suggested that the banking sector requires strong control over management behavior and the implementation of effective corporate governance to protect the interests both of depositors and shareholders (Macey & O'Hara, 2003; Turner, 2004). Moreover, Wang et al. (2012) argued that having risk management practices, transparency, accountability, and an efficient corporate governance system will improve the monitoring of a bank's behavior.

Countries that extract natural resources, such as oil, gas, and coal, often suffer from harmful emission, which ultimately adversely affects public health (Al-Rawashdeh et al., 2014). As a result, companies in regions such as the Middle East have put in place procedures and policies to reduce harmful emissions, but the results may not be as successful as they had originally anticipated (Shahbaz et al., 2015). For instance, Egypt issued a set of regulations to protect the environment from the effects of emission in 2008– 2009, but many parts of these regulations were not followed (Shahbaz et al., 2015). However, the presence of strong corporate governance can assist in adherence to these policies, thus curtailing those negative corporate practices that harm the environment. According to Kilincarslan et al. (2020), the governance structure at the board level, with its various sub-committees, could play a vital role in addressing these environmental challenges. Haque and Ntim (2017) argued that companies typically seek to comply with corporate governance practices due to stakeholders' accountability, with a desire to improve their reputation in the marketplace. It thus seems that companies with effective corporate governance are better positioned to reduce their carbon emission. Despite a growing awareness of environmental performance, Luo and Tang (2020) investigated whether corporate governance is the main reason for improving CSR with regard to carbon performance in the UK. The study also found that corporate governance quality affects carbon performance, and that management's awareness of carbon risk moderates the relationship between corporate governance and the company's carbon performance. Furthermore, Luo and Tang (2014) found that many companies in Europe comply with regulations and laws that aim to address climate change issues, thereby gaining legitimacy.

Budiharta and Kacaribu (2020) conducted a study to examine whether the board of directors, the audit committee, and managerial ownership influence carbon emission disclosure. They used an index that was developed by Choi et al. (2013) to measure the carbon emission disclosure. The results of their study showed that there is a relationship between managerial ownership and carbon disclosure. These authors suggested that, if managers are also shareholders, they will consider information on carbon emission to be essential in taking the appropriate decisions. Additionally, they found that the audit committee and the board do not influence carbon emission disclosure. However, Akhiroh and Kiswanto (2016) found a significant relationship between the audit committee and carbon emission disclosure in the same market and industry in 2012–2014. Elsayih et al., (2021) and Goud, (2022) demonstrated that board size, board meetings, gender diversity, CEO duality, and concentration of ownership negatively affect carbon emission performance (i.e. higher emissions). Moreover, the environmental committee and board independence have positive associations with carbon emission performance, indicating that these factors are associated with improved carbon emission performance (i.e. lower emissions). Additionally, companies that have gender-diversified boards and separate boards from CEOs are more likely to disclose CSR information and improve their environmental performance (Lu & Wang, 2021).

Companies with a higher quality of corporate governance, according to the present study, are more likely to reduce their carbon emission. Accordingly, companies with effective governance will demand effective policies and strategies to reduce carbon emission as well as to provide information about the environment to their stakeholders. The current study posits that corporate governance may play an important role in directing management towards a more environmentally friendly position. In this regard, this study presents the following hypothesis with regards to the relationship between corporate governance and carbon emission:

***H1*: There is a positive and significant relationship between corporate governance and carbon emission reduction practices.**

2.2.3 COVID-19

2.2.3.1 Overview

COVID-19, which is said to have originated in Wuhan, China, resulted in a global pandemic and had a profound impact on all aspects of life (Horton, 2021). The spread of COVID-19 resulted in the loss of lives; by the end of September 2022, the total number of deaths reached over than 6.5 million, or a rate of 0.08% worldwide (Worldometer, 2022). Additionally, it resulted in social, economic, technological, and health effects. Governments worldwide put strict measures in place, which changed the lifestyle of people across the globe. These changes included social distancing, wearing protective masks, quarantine, shutting down all unnecessary activities, and imposing a complete closure in some cities (Abu-Rayash & Dincer, 2020). Over the past two years, the COVID-19 outbreak has alternated between periods of outbreak and periods of reduced infection throughout all countries affected. Across countries, regions, states, and cities, each infectious disease outbreak is distinct in some way. Several countries had reached their fourth and fifth waves of the COVID-19 pandemic during 2020 and 2021, while others were still recovering from a second wave (Mensah, 2021).

The spread of COVID-19 varied between the different countries. In Asia, the number of cases increased rapidly in some places, while steadily decreased in others. In the UK and other European countries, including Germany, France, and Switzerland, cases of COVID-19 increased after previously declining (Topol, 2022). According to Topol. (2022), at least 12 countries, extending from Finland to Greece, have reported increased cases, some quite dramatically. Countries such as Austria exceeded its previous peak while Finland recorded an 85% increase in cases. Several of these countries also reported an increase in hospital admissions. As infections reached their peak level in the second wave in the UK, hospital admission rates almost doubled, and death rates from COVID-19 nearly tripled (Topol, 2022). Furthermore, hospital admission rates and death rates associated with COVID-19 were consistently lower during the third wave compared to the second wave, when infection rates were at similar levels. The infection rate in several European countries increased sharply following the fourth and fifth waves. Furthermore, South Africa was the first country to discover the new Omicron variant, which resulted in an increased number of infections, which led to the fourth wave of infections in the country. Middle Eastern countries have suffered severe outbreaks of the virus since the pandemic began (BBC, 2022).

Mexico experienced late and partial lockdowns. The lack of testing, contact tracing, quarantine, and isolation programs made it impossible for outbreaks to be contained without resorting to painful and costly national closures (Valle & Knaul, 2021). Mexico had a relatively low level of testing compared to other Latin American countries. Further, due to the lack of a coordinated, timely, and rigorous national pandemic response, these measures differed from city to city. There were considerable differences in the responses of states, which were not determined by testing or the level of disease burden in the area, but rather by economic and political factors. Moreover, since early 2020, there have been several waves of COVID-19 in the United States, resulting in 985,164 deaths (Reuters Graphics, 2020). In the United States, during its peak, more than 3,300 people died every day on average in January 2021 (Reuters Graphics, 2022). Later in the same year, the Delta variant caused a spike in cases and hospitalizations across the country. In December 2021, COVID-19 cases reached record levels in the United States due to the fast-spreading Omicron variant. Given the low testing rates, it is not yet clear how serious the pandemic is on the continent. Ironically, there was a positive and unexpected impact on the environment. Due to reductions in industrial activities during the pandemic, less harmful carbon emission was released into the atmosphere.

2.2.3.2 Economic Effects

COVID-19 posed a real challenge for decision-makers as they attempted to respond to its impact on the economy. It was evident in early 2020 that the pandemic had resulted in the temporary closure of businesses, which affected productivity and global trade and had profound impacts on the world's economy (Pak et al., 2020). With the environmental changes that have resulted from global warming, the spread of diseases has become a threat that requires the cooperation of world leaders to mitigate its impact on the global economy (Yamey et al., 2017). It also requires financial support and the necessary resources to support various emergency response initiatives (Katz et al., 2018).

Pak et al. (2020) showed how the lockdowns in various countries, during the pandemic, resulted in the sharp decline of important measures, such as gross domestic product (GDP), income, and productivity, as well as creating logistical and supply chain problems. Governments across the globe suspended business activities, especially in the hospitality, education, tourism, and aviation sectors, thus causing major disruptions to the global economy. Many people lost their jobs and were unable to maintain a lifestyle that was similar to the one they had in the pre-pandemic period. The lockdowns had a bigger impact on the economies of developing countries, leading to income falling below the poverty line. The lockdown also disrupted educational systems, due to school closures, which may have major long-term effects on children's learning (United Nations, 2020).

Many sectors have been affected by the spread of the COVID-19 pandemic. The transportation and hospitality sectors were among the most heavily affected (Aref, 2020). According to International Civil Aviation Organization (ICAO). (2020), considerable losses are expected in the air transport sector, as 80% of the passengers were unable to travel, due to the overall health conditions. Economists agree that there will be adverse effects on the global economy (Statista Research Department, 2020) because of the outbreak of the COVID-19 pandemic; it was estimated that there would be a drop in GDP of 0.4%. Maliszewska et al. (2020) studied the impact of COVID-19 on GDP, with the results indicating that around a 2.1% decrease in GDP is expected, due to the decrease in employment, which leads to weak production and lower per capita income. Similarly, Maliszewska et al. (2020) predicted that GDP in developed and developing countries would decline by 1.9% and 2.5%, respectively, by the end of 2020. Given the pandemic's direct impact on most industries, it has been predicted that China's and Thailand's GDP will decrease by 2.3% and 3%, respectively, while Malaysia's GDP is predicted to decrease by 2.1% (Maliszewska et al., 2020). The continuation of the pandemic and the uncertainty as to when it will end may lead to unprecedentedly harsh economic conditions.

According to Blancard and Desroziers (2020), during the first four months of 2020, the financial markets were impacted heavily due to the outbreak of the virus. Their study examined the stock markets in various countries prior to and during the crisis. The study also considered the containment efforts and economic policies that were adopted during the crisis. The sample was composed of 74 countries for the period from January to April 2020. The data used in the study included information about stock index prices, total number of COVID-19 cases and deaths, global market volatility, and government reaction to the outbreak. Blancard and Desroziers (2020) concluded that the financial markets initially ignored the pandemic and then responded strongly to the rise in the number of infected cases. They also noted that volatility increased as the pandemic's threat rose.

The central banks in many countries intervened to contain the economic ramifications of the pandemic. The main action that was taken was the reduction of interest rates. The markets' responses varied from one country to another. However, there was a general decline in share prices worldwide (Hatmanu & Cautisanu, 2021). Moreover, the policies and measures that were taken to limit the spread of the virus, as well as the support provided to companies, impacted the financial markets' reaction. Cesa-Bianchi et al. (2020) concluded that COVID-19 might affect economic growth due to lower demand, increased uncertainty, and higher capital costs, which were caused by the unstable environment.

2.2.3.3 Environmental Effects

Although a significant number of medical studies have focused on COVID-19, there remains little empirical evidence that shows how the pandemic affected the environmental situation. One of the environmental consequences of the pandemic was the surge in medical waste. According to Zuo (2020), this waste reached 240 tons in Wuhan, the city in which the pandemic is said to have originated. Simultaneously, the most used medical products during the pandemic were made from non-biodegradable material, such as gloves and masks (Master & Chow, 2020). These items also added to the increase in medical waste during the outbreak (Torkashvand et al., 2020).

Myllyvirta (2020) found that carbon emission in China decreased by 25%, and that global carbon emission decreased approximately 6%, due to the strict measures that were taken following the outbreak of the virus. Additionally, a decrease in air pollution was observed in Wuhan after only one month of lockdown measures (Lian et al., 2020). Similar results were revealed by Broomandi et al. (2020), who demonstrated that there was a sharp decrease in the level of air pollution in Iran. India's capital city, New Delhi, also witnessed a decrease in air pollution levels by about 50% in the first week of the lockdown (Mahato et al., 2020). Le Quéré et al. (2020) stated that the GHG emission reduction measures relating to forced isolation during the phases of the COVID-19 lockdowns were calculated using the government's policy and operation information. Worldwide, carbon dioxide emission decreased by 17% when compared to April 2019.

In some countries, including China and Italy, carbon emission decreased as a result of government-imposed restrictions on daily activities in response to the COVID-19 outbreak (Le Quéré et al., 2020). Although there is no daily measure of emission, the world has witnessed an overall decrease in carbon emission since the start of the pandemic (Hale & Leduc, 2020). There was an increase in the use of videoconferencing tools, such as Microsoft Teams and Zoom, in order to facilitate online education for students and virtual work for employees (Karl et al., 2022). Consequently, carbon dioxide emission decreased as the daily commute was limited considerably (Eroğlu, 2020). During the early phases of the outbreak, people were not able to travel internationally, resulting in a decline in transportation related GHG emission in most countries.

In many cities throughout the world, the COVID-19 pandemic caused unexpected changes in air quality (Saadat et al., 2020), where many industries were put on hold. For example, the use of cars decreased, thus reducing the amount of GHGs emitted into the atmosphere. There was also a reduction in emission related to economic activities, including production and transportation activity. According to Barboza (2020), carbon emission reached its lowest level during the first half of 2020, which was the start of the COVID-19 crisis. Barboza (2020) added that such emission might return to pre-pandemic rates, and possibly even higher after medical solution become available to combat the virus.

Prior crises may shed light on economic activities and their impact on the environment. During the 2008 financial crisis, carbon emission decreased temporarily (Peters et al., 2012). However, as economic recovery started to take place, these rates increased almost to their pre-crisis levels (Sadorsky, 2020). The COVID-19 pandemic may not be similar to the financial crisis, in terms of GHG emission, if countries and governments continue to reduce emission and set detailed and appropriate waste-disposal plans for all sectors. According to Barboza (2020), Joel Jaeger, a climate program research associate at the World Resources Institute stated that "it does not matter that global emission will decrease by 7% in 2020, unless we maintain and accelerate those cuts after the world opens again and the economy recovers." Governments must take advantage of the impact of COVID-19 on the environment and of the positive outcomes that are associated with it, through raising awareness about the importance of adopting positive behavior in order to preserve the environment and to develop strict strategies and policies to reduce emission. For example, governments should continue to apply the precautionary measures that were taken during the crisis by allowing people to work remotely to reduce traffic, and they should promote a carbon reduction strategy by developing long-term visions in this regard.

2.2.3.4 Corporate Governance, Environmental Disclosures, and COVID-19

The COVID-19 crisis is unique when compared to previous crises, such as the AFC of 1997 or the GFC of 2008. It was not caused by organizational misconduct, such as accounting fraud, unnecessary risk-taking, or corruption (Conyon et al., 2011; Mishra & Bhattacharya, 2011). Nevertheless, effective corporate governance could assist management in making optimal decisions with respect to operations and the disclosure of pertinent information. It could even be argued that the intrinsic value of corporate governance is realized during times of distress (Aldamen & Duncan, 2016). It is specifically during such periods that stakeholders will require disclosures that are precise and transparent. Given that COVID-19 has posed new and significant complications for businesses, corporate governance could facilitate the timely flow of relevant information to track COVID-19-related problems and address these complications in a systemic fashion (Kucera et al., 2020). Moreover, the COVID-19 virus also infected employees, which led to internal disruptions in operations (Al-Kuwari et al., 2021). This crisis prompted companies' boards of directors to establish comprehensive backup plans for management succession in the case of key employees contracting the virus (Kucera et al., 2020). According to Kucera et al. (2020), the board should consider forming a COVID-19 transition committee to serve as a coordinating body to make the necessary leadership changes. The transition committee will assist in defining the duties and obligations required to handle representation, organizing manager supervision, and assisting individuals in acting in management roles (Kucera et al., 2020). In addition, the company's long-term approach should be re-evaluated by forming new partnerships, developing innovation and technologies, and expanding through acquisitions. In addition, some businesses have considered wage cuts as a result of the pandemic, either on a case-by-case basis or across the executive ranks. In such a unique and constantly evolving market, good coordination is critical in ensuring efficient business decisions. It should be noted that it is during such unstable periods that corporate governance stands to provide the most value-added for the firm.

COVID-19's influence on emerging environmental challenges in the corporate and financial worlds remains unknown. According to Gelter and Puaschunder (2021), the pandemic is likely to force people to change their food habits and live a more sustainable lifestyle. Moreover, it may shift people's minds to living a healthier lifestyle, which is less dependent on fossil fuels. As a result of stakeholder demand, corporations will be incentivized to move away from production that relies heavily on carbon (Severo et al., 2021). Risk management boards may be helpful to companies when they face disasters, especially in circumstances in which businesses are confronted by a new crisis. As the COVID-19 pandemic has entailed new types of challenges, an effective board could offer valuable support to the firm's decision makers. In addition, sub-committees within the board stand to play an important role as the pandemic stretches on. The lockdowns and the limits placed on travel have had environmental consequences for all countries. However, the environmental consequences of COVID-19 infection have been seen most in those countries that were most affected (Zambrano et al., 2020).

The current study assumes that the COVID-19 pandemic has influenced the relationship between corporate governance and carbon emission, as reflected in the following hypothesis.

***H2:* The impact of corporate governance on carbon emission varies for the periods prior to the pandemic and during the pandemic.**

There have been mass social disruptions due to the pandemic, including cancellations of flights worldwide and disruptions to transportation systems (Mousazadeh et al., 2021; Saadat et al., 2020). It has also become increasingly difficult to access basic and essential facilities due to the pandemic (Mousazadeh et al., 2021). Research has shown that energy consumption is positively correlated with economic growth (Abdoli et al., 2015; Acaravci & Ozturk, 2010; Shahbaz et al., 2013). In response to government restrictions, industrial activities were temporarily halted, which ultimately resulted in a reduction in energy consumption. Furthermore, temporary closures in the transportation industry and in offices reduced mobility significantly (IEA, 2020). Most countries implemented pandemic control measures during the pandemic, including lockdowns, isolation of symptomatic individuals, prohibitions on mass gatherings, school closures, and even mandatory quarantines. These measures have had a significant impact on the global economy, which has resulted in significant emission reduction throughout the world. According to Gillingham et al. (2020), a decrease in fuel and electricity consumption resulted in a reduction in GHG emission. It is essential to examine the impact of COVID19 on the environment, and to assess the role played by corporate governance during these challenging times (see Figure 2.1). The current study assumes that the level of COVID-19 controls measures influences the relationship between corporate governance and carbon emission, which is reflected in the following hypothesis.

***H3:* The relationship between corporate governance and carbon emission varies based on the levels of COVID-19 control measures.**

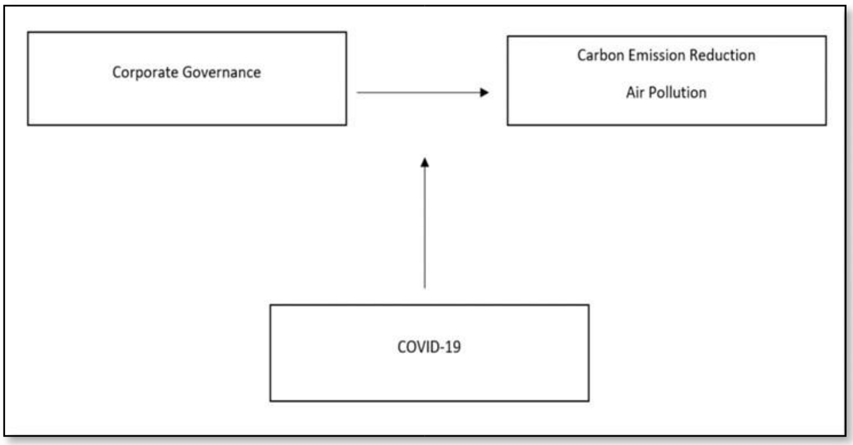

Figure 2.1. Conceptual Framework

2.3 Chapter Summary

This chapter discusses the conceptual framework and reviews the literature to explain the research phenomena. It offers an overview of agency, stakeholder, and legitimacy theories. Additionally, the chapter discuss prior research related to carbon emission, corporate governance, and firm characteristics to examine the relationship between carbon emission reduction and corporate governance during the COVID-19 period. Moreover, the nature of this relationship is often unclear during a period of exogenous shock, such as the COVID-19 crisis. This collection of factors has prompted the current research to explore the relationship between corporate governance and carbon emission reduction, and to examine the role of corporate governance in the reduction in carbon emission in 2020 while strict measures were being implemented by governments. The next chapter describes the methodology that has been used in this study, the analysis used to test the hypotheses, and an explanation of the dependent, independent, and control variables.

CHAPTER 3: METHODOLOGY

This chapter discusses the methodology used in this study. It comprises the research design, study sample, variables, and regression models, which are used to test the hypotheses. The chapter is divided into several sections. Section 3.1 presents the research design. Section 3.2 discusses the sample and provides information about the procedures used to obtain the data. Section 3.3 describes the variables used in the analysis and provides details related to their measurement. Section 3.4 presents the empirical models used to test the various relationships and the hypotheses. Finally, section 3.5 summaries the pertinent components of the chapter.

3.1 Research Design

There are various research strategies that could be used, such as positivism (scientific) and interpretivism (Galliers, 1991). As defined by Neuman (2003), positivism describes a method of organizing probabilistic causal laws for predicting patterns of human behavior by combining deductive logic with empirical observations of individual behavior. In the positivism view, social reality is characterized by factual evidence that exists independently of personal ideas and thoughts, governed by laws of cause and effect, and structured in stable patterns that are determined by cause and effect (Marczyk et al., 2005; Neuman, 2003). According to positivism, science seeks to approximate reality as closely as possible by developing methods that are objective. According to Ulin et al. (2004), this is essential to the objectives of science. On the other hand, the interpretivism research philosophy emphasizes social construction of reality and meaning, assuming that people create their own understanding of social reality.

A researcher conducting research in any area must be able to understand both the general tone of the research and the logic that underlies deductive and inductive approaches. An inductive process moves from the specific to the general, whereas a deduction process goes from the general to the specific (Decoo, 1996). According to Burney and Mahmood (2006), a deductive process is a "top-down" approach, where the conclusions follow from the premises, while an inductive process is a "bottom-up" approach in which the conclusions are based on the premises. Furthermore, Sekaran and Bougie (2010) stated that quantitative research involves a deductive approach and a variety of quantitative methods, from providing descriptions of variables to providing statistical relationships among variables through complex statistical modeling (Saunders et al., 2009). Methodologies and techniques used in quantitative research are intended to measure relationships between variables. In contrast, qualitative research uses an inductive approach to arrive at a deeper understanding of human behavior and its causes (Sekaran & Bougie, 2010). Sometimes, it is necessary to combine qualitative and quantitative research methods, also known as a mixed methods approach (Saunders et al., 2009). Schwandt (2007) and Tashakkori and Creswell (2007) argued that the nature of the methodologies contributes to answering the following questions: what constitutes a problem for investigation; what constitutes a testable hypothesis; how to frame a problem so that it can be examined using particular methods and designs; and how to choose appropriate data collection methods. According to this definition, a research problem or an area of interest should be identified. Furthermore, the researcher needs to determine appropriate methods to approach the problem, such as the researcher's philosophical orientation, the research strategy adopted, the timeframe under consideration, and the data collection technique employed.

According to Swanson and Holton (2005), quantitative research consists of five steps, including formulating the research question and selecting the study participants (both population and sample). Next comes developing a methodology to achieve objectives and answer questions, such as variable measurement and overall design. This is followed by choosing the appropriate analysis tools and interpreting the results of the analysis. Given the objectives and aims of the current study, a quantitative method within a deductive approached is used to explore the research question.

As explained in previous chapters, this study aims to examine the relationship between corporate governance and carbon emission reduction. Furthermore, it examines the effect of COVID-19 on the aforementioned relationship. The study relies exclusively on secondary data, comprising a sample of companies from 41 countries from 2018 to 2021. Several statistical analyses are used to test the impact of corporate governance on carbon emission reduction, such as univariate, bivariate, and multivariate analysis. The study uses two alternate dependent variables, which are carbon emission reduction and air pollution. The independent variable includes corporate governance and a selection of control variables. The analysis is expected to yield results that facilitate the acceptance or rejection of the research hypotheses.

3.2 Sample

The sample used in this thesis includes publicly listed companies from 41 countries for a four-year period from 2018 to 2021 (Refer to the Appendix). The reason for selecting the 2018–2021 period is to examine two years prior to COVID-19 (2018–2019) and two years during the outbreak of COVID-19 (2020–2021). The sample excluded firms with missing data in order to ensure that a balanced sample is maintained throughout the four-year period. Additionally, the continuous variables are winsorized at the 1st and 99th percentiles to reduce extreme values. The final sample is divided into two levels, which are the micro and macro levels. The micro level examines the relationship between corporate governance and carbon emission at the company level, while the macro level examines the aforementioned relationship at the regional level.

As shown in Table 3.1, the final sample included 2,226 firms (8,904 firm-years) from 41 countries. Moreover, in this study, the data are categorized into eight regions to examine the relationship at a macro level. The eight regions are as follows: East Asia and Pacific (EAP); East Europe and Central Asia (ECA); Western Europe (WE); Latin America and the Caribbean (LAC); North America (NA); Middle East and North Africa (MENA); South Asia (SA); and Sub-Saharan Africa (SSA). The main sources used to obtain the data are Refinitiv Workspace database and IQAir.

Table 3.1. Summary of the Sample Size

Sample size	2018	2019	2020	2021
Initial sample	4,208	5,209	4,804	5,018
First balancing	(895)	(1,896)	(1,491)	(1,705)
Outliers	(312)	(357)	(234)	(326)
Missing data	(478)	(462)	(456)	(460)
Second balancing	(297)	(268)	(397)	(301)
Final sample	2,226	2,226	2,226	2,226

3.3 Variable Measurement

This section defines the variables and explains the methods used to measure them. It also provides the reason for selecting the dependent, independent, and control variables.

3.3.1 Dependent Variables

The dependent variable in this study is carbon emission reduction (*CER*). Two alternate measurements are used to represent this variable: carbon emission score; and air pollution (Griffin et al., 2017; Hong et al., 2015; Peng et al., 2019; Perera, 2017; Solazzo et al., 2016; Straf et al., 2013). The following sections provide detailed information about how the two alternate dependent variables are measured.

3.3.1.1 Carbon Emission Reduction (CER)

The study uses *CER* as the main dependent variable. It is measured as the firm's emission score, which ranges from zero to 100, where a higher score indicates a great effort to reduce carbon emission (Tanthanongsakkun et al., 2022). Information related to *CER* was obtained from Refinitiv Workspace, which defines the emission score as the percentile rank of a company's commitment to, and effectiveness in, lowering environmental emission in its production and operational practices.

Carbon emission results from industrial processes and human activities, such as the burning of fossil fuels (Cui et al., 2019; Xi, et al., 2016). There is a substantial risk that climate change and global warming may significantly disrupt firm operations and reduce shareholder value (Jung et al., 2016). Moreover, climate change should not be limited to the impact of carbon emission. Other gases should be considered and investigated, e.g., methane, nitrous oxide (N_2O), and fluorinated gases (Darkwah et al., 2018). It has been reported that carbon emission will increase by more than 50% by

2050 (BBC, 2019; Kitamori, 2012), which will have a dramatic impact on the earth's temperature. Additionally, other practices, such as forestry clearing and excessive agriculture, can have detrimental effects on the environment if appropriate measures are not taken in order to reduce them (Kolk et al., 2008). The increase in emission can be attributed to a variety of factors, such as an increase in energy consumption and economic growth. Thus, damage to the world's resources will have negative consequences for people, society, and the environment. It is imperative to use natural resources in an environmentally friendly manner in order to maintain a balance between the various elements of development (Charumathi & Mangaiyarkarasi, 2022). As a result, companies must follow guidelines and regulations that provide for full disclosure of all emission, so that stakeholders can clearly and transparently evaluate the company's climate change performance and ways to reduce such emission (Liesen et al., 2015).

3.3.1.2 Air Pollution (AP)

The alternate measure of carbon emission is air pollution (AP), which represents the air quality at the country level. IQAir's World AQI is used as a proxy for AP. The index has a range between 0 and 500, but it is divided into six brackets. The first bracket is 0 to 50, which suggests that air quality conditions are generally good. The second bracket is from 51 to 100, which indicates that air quality conditions are moderate. The third bracket is from 101 to 150, which means that air quality is unhealthy for sensitive groups. The fourth bracket is from 151 to 200, which indicates unhealthy air quality. The fifth bracket is 201 to 300, which suggests extremely unhealthy air quality. Finally, the last bracket is from 301 to 500, which indicates hazardous air quality (Lanzafame et al., 2015; Mirabelli et al., 2020).

It is widely recognized that air pollution is a major concern, particularly in developing countries. Researchers have been explaining the adverse effects of air pollution on health for several years (Atkinson et al., 2010; Chuang et al., 2011). In addition to affecting human health, air pollution also contributes to global climate change, ozone depletion, acid rain, and poor visibility (Sonwani & Maurya, 2019). Pollutants are generally classified according to their sources of production, categorized as: major sources (including power stations, petrochemicals, metallurgical industries, and chemical plants); natural sources; mobile sources; and area sources (Manisalidis et al., 2020). PM is one of the most damaging air pollutants and causes a great deal of harm to human health (Wang et al., 2018). There are several countries that are experiencing dramatic environmental degradation and rapid economic growth at the same time. In recent years, there has been a significant increase in international and domestic attention to the severe pollution around the world, with levels of PM concentration that have never been seen before (Chen & Chen., 2018).

3.3.2 Independent Variable

Corporate governance (*CG*) is the independent variable used in this study. It is measured as the corporate governance pillar score, which ranges from 0 to 100 (Jitmaneeroj, 2016). It is obtained from Refinitiv Workspace and ASSET-4, which provides environmental, social, and corporate governance (ESG) information. This study, however, uses the corporate governance pillar score instead of the ESG score as a measure of corporate governance. The ESG score measures or evaluates the environmental, social, and governance (ESG) performance of a company, fund, or security objectively. While the CG pillar score measures the company's internal governance process, including its board of directors and executives, and commitment to shareholders (more information regarding the variables is presented in Table 3.2). Moreover, ASSET-4 analysts use 278 KPIs and 750 individual data points, based on the industries, to calculate the final ESG score. Scores that are greater than 50 indicate effective corporate governance, while scores that are less than 50 suggest ineffective corporate governance (Heuvel, 2012; Jitmaneeroj, 2016). In addition, ASSET4 provides a collection of data about global companies that are obtained from several sources, e.g., annual reports, company websites, and CSR reports, among others.

3.3.3 Control Variables

This study controls for several pertinent firm characteristics when examining the relationship between corporate governance and carbon emission reduction. In accordance with prior studies, the current study controls for size, profitability, leverage, and industry type (Hermawan et al., 2018; Kılıç & Kuzey, 2019; Liao et al., 2015). The following sections explain the measurements for these variables.

3.3.3.1 Company Size (SIZE)

Previous research has indicated that carbon emission is impacted by firm-specific characteristics, such as firm size (Wahyuningrum et al., 2020), profitability (Berthelot & Robert, 2011), industry type (Zeng et al., 2012), and leverage (Clarkson et al., 2008). Several studies have examined the relationship between firm size and environmental disclosure and found that there is a positive relationship between them (Akbas, 2014; Mohamed, 2015; Wahyuningrum et al., 2020; Wahyuningrum & Budihardjo, 2018; Welbeck et al., 2017). Effectively, they have all concluded that large firms are prepared to disclose their environmental information in order to satisfy stockholders and to avoid any penalties from regulators. Moreover, Liao et al. (2015)

and Rankin et al. (2011) found that firm size is positively related to carbon emission disclosure. However, these results are not in line with those of Winarsih and Supandi (2020), who investigated whether Performance Rating Program (PROPER) ranking, company size, profitability, leverage, and media exposure influence Indonesian mining firms' carbon emission disclosure. Their results showed that there was no relationship between firm size and carbon disclosure. This might be attributed to weaknesses in the laws and regulations in Indonesia that relate to environmental problems and disclosures (Solikhah et al., 2020).

Large companies are expected to disclose more information regarding carbon emission reduction (Jannah & Muid, 2014; Stanny & Ely, 2008). Additionally, they have many shareholders, who may be interested in the company's social and environmental activities, which increases the level of information disclosure (Jannah & Muid, 2014). The importance of company size has been documented in several studies that have focused on GHG emission disclosures (Choi et al., 2013; Clarkson et al., 2008; Liao et al., 2015; Prado-Lorenzo et al., 2009). This study uses the variable *SIZE* to represent company size. The variable is measured as the natural logarithm of the total assets of the sampled companies (Al-Tuwaijr et al., 2004; Clarkson et al., 2008; Cormier et al., 2005; De Villiers et al., 2011; Luo et al., 2013; Shan & Taylor, 2014).

3.3.3.2 Profitability (ROA)

Prior studies have suggested that companies with high performance are expected to disclose environmental information, due to their ability to bear the cost of additional reporting (Berthelot & Robert, 2011; Zhang et al., 2012). Disclosure is used by some companies to gain a competitive advantage and to increase financial performance (Mishra & Suar, 2010), which in turn leads to better decisions regarding non-financial information. According to Berthelot and Robert (2011) and Hermawan et al. (2018), profitability has a positive influence on the disclosure of carbon emission. However, Freedman and Jaggi (2005), Winarsih and Supandi (2020), and Choi et al. (2013) argued that there is no significant relationship between carbon emission disclosure and profitability. They argued that companies with higher performance do not disclose information that may affect their success. However, Prado-Lorenzo et al. (2009) found a negative relationship between GHG emission and profitability. More specifically, they showed that companies with high profitability are more likely to comply with laws and regulations and, for that reason, they have fewer environmental issues to report.

According to De Villiers et al., (2011); Prado-Lorenzo et al., (2009); and Sureeyatanapas et al., (2018) highly profitable companies tend to care more about the environment and the damage that results from their activities Moreover, companies that have good financial performance tend to disclose non-financial information voluntarily, and to implement more effective practices in order to reduce their emission (Jannah & Muid, 2014). Furthermore, profitable firms often possess sufficient resources to reduce and cover the costs of reporting on carbon emission reduction (De Villiers et al., 2011; Luo & Tang, 2021). In contrast, low-profit companies pay more attention to economic performance than to environmental issues, and, as a result, fewer resources can be used to disclose carbon emission (Elsayih, 2015). This study uses return on asset (*ROA*) as a proxy for profitability. The variable is measured as the net income divided by total assets (Choi et al., 2013; De Villiers et al., 2011; Luo et al., 2012, 2013; Peters & Romi, 2011).

3.3.3.3 Leverage (LEV)

Previous studies have shown contradictory results regarding the relationship between leverage and carbon emission. Some have argued that, because of the pressure exerted by creditors, companies with high leverage are more likely to disclose environmental reports in order to demonstrate their responsibility towards the environment (Clarkson et al., 2008). Others have found that the greater the leverage of companies, the more investors request additional information so that they can gain insights into the company's operational and environmental performance (Huang & Kung, 2010).

Prior studies have shown that high-leverage companies disclose less information about their impact on the environment (Choi et al., 2013; Liao et al., 2015). The rationale is that such disclosures are costly, which would require companies to use resources that are already scarce. The existing literature argues that prominent levels of debt may also lead to financial distress, which prevents companies from voluntarily disclosing or reducing GHG emission (Liao et al., 2015). Moreover, companies must take creditors into account when disclosing environmental information, because the higher the debt, the greater the creditors' expectations that the company will voluntarily disclose its environmental information and improve environmental performance (De Villiers et al., 2011; Roberts, 1992). This study uses the variable *LEV* to represent leverage. The variable is measured as total debts to total assets (Huafang & Jianguo, 2007; Luo et al., 2013; Peters & Romi, 2011; Wegener et al., 2013).

3.3.3.4 Industry Type (IND)

Several studies have examined the relationship between environmental disclosure and industry type (Brammer & Pavlin, 2008; Campbell et al., 2003; Liu &

Anbumozhi, 2009; Zeng et al., 2012). They concluded that companies whose activities have a significant impact on the environment, such as transportation, mining, oil and gas, energy, and manufacturing, should disclose sufficient environmental information (Brammer & Pavlin, 2008; Campbell et al., 2003). Furthermore, environmentally sensitive industries, such as chemicals, construction materials, minerals, oil and gas, and forestry, are gaining wide attention from stakeholders due to their activities, which have a significant impact on the environment and lead to environmental concerns (Kuo et al., 2012). Moreover, businesses in sensitive sectors must comply with strict environmental laws and provide reporting of their environmental activities (Cormier & Magnan, 2003). Furthermore, they are more likely to pollute with harmful substances, thus putting them under significant public pressure (Monteiro & Guzmán, 2010). Brammer and Pavelin (2008) found that there was a positive relationship between environmentally sensitive industries and environmental disclosure. They concluded that companies operating in environmentally sensitive industries, as well as companies with strong financial resources, are more likely to make high quality disclosures.

Firms operating in industries that produce high GHG emission levels are governed more by stakeholders and society. These are, for instance, companies in the energy, agriculture, transportation, and coal industries, which are concerned with fossil fuels (Kolk et al., 2008). As a result, industries with a high GHG emission level may face environmental risks. According to Robert (1992) and Richardson and Welker (2001), firms are classified as being in environmentally sensitive or less-sensitive industries. According to Robert's (1992) classification, environmentally sensitive industries may face commercial or political risks, high emission levels, and intense competition. Other sensitive industries include gas, oil, chemicals, and raw materials

(Robert, 1992). In comparison, other sectors, such as finance, healthcare, and services, produce less carbon than other industries, and as a result are classified as being insensitive (Robert, 1992). The current study uses the variable industry type (*IND*). The variable is measured as a dummy variable that takes a value of 1 if the company belongs to an environmentally sensitive industry, and 0 otherwise.

3.3.3.5 Region Fixed Effects (RFE)

The consumption of energy is crucial to economic growth (Gorus & Aydin, 2019). The significant reliance on fossil fuels for energy consumption makes energy consumption a significant source of GHG emission (Iwata et al., 2012; Shafiei & Salim, 2014). Major economies of the world are under pressure to improve energy efficiency in order to ensure sustainable development (Akram et al., 2021). Moreover, there is a high correlation between the growth rates of overall consumption and emission. Environmental concerns have been raised as a result of the economic development of the world. As a result of the growth of the BRICS economies, which account for nearly half of the world’s population, global energy demand is continuing to increase. BRICS economies are responsible for approximately 38% of global carbon emission (Khobai et al., 2021). The EU’s economic growth is one of the main factors contributing to the emission of GHGs. Due to this, carbon emission accounts for 81% of all GHG emission in the EU (Eurostat, 2019). A significant empirical relationship has been found between economic growth and carbon dioxide emission (Halkos & Tzeremes, 2011). Jaunky (2011) argued that economic growth adversely impacts environmental quality. It is therefore imperative that environmental regulations are in place to ensure that economies can achieve economic growth while reducing emission.

The current study uses the variable *RFE*, which is a dummy variable. During the study, eight variables were created, each representing a different region: East Asia and Pacific (EAP); East Europe & Central Asia (ECA); Western Europe (WE); Latin America & the Caribbean (LAC); North America (NA); Middle East and North Africa (MENA); South Asia (SA); and Sub-Saharan Africa (SSA). For instance, in the East Asia & Pacific region, there is a value of 1 for all companies, while in other regions, companies have a value of 0. In this way, any potential effects of the region can be assessed.

Table 3.2. Summary of Variable Measurement

Variable	Measurement	Source of information
Dependent variable:		
Carbon emission reduction (*CER*)	Emission score	Refinitiv Workspace
Air pollution (*AP*)	US Air Quality Index	IQAir's World Air Quality Index (AQI)
Independent variable:		
Corporate governance (*CG*)	Corporate governance pillar score	Refinitiv Workspace
Control variables:		
Firm size (*SIZE*)	Natural logarithm of total assets	Refinitiv Workspace
Profitability (*ROA*)	Return on assets	Refinitiv Workspace
Leverage (*LEV*)	Total debts to total assets	Refinitiv Workspace
Industry type (*IND*)	Dummy variable that takes a value of 1 if the company belongs to an environmentally sensitive industry, and 0 otherwise	Refinitiv Workspace
Region fixed effect (*RFE*)	Dummy variable that takes a value of 1 if the company belongs to a specific region, and 0 otherwise	Kenourgios and Dimitriou (2015)

3.4 Analysis and Empirical Models

This study uses various analyses to assess the relationships between corporate governance and carbon emission reduction during the COVID-19 pandemic. There are primarily two phases in the analysis process. The first phase focuses on univariate statistical analysis, which includes descriptive statistics and bivariate analysis (ANOVA and Pearson's correlation). The second phase involves multivariate analysis via regression analysis.

Univariate analysis is used to describe the variables' essential characteristics and offer preliminary insights into the nature of each variable. This includes examining the variables' central tendency and dispersion, e.g., standard deviation, mean, and median. Moreover, ANOVA is used to compare two means, thus testing whether there are statistically significant differences between the means of the variables, based on a distinct factor (Sawyer, 2009). Furthermore, Pearson's correlation is used to identify the strength and direction of the correlation between *CG* and the control variables.

Ordinary least squares (OLS) regression is used to analyze the causal relationships between the dependent variable (using the two alternate variables), and the independent variable (Cohen et al., 2013). A multicollinearity test is also used in this study to assess whether the independent variables are highly correlated (Mardini, 2015; Naser et al., 2006). Moreover, the study incorporates VIF values (Mangena & Tauringana, 2007; Naser et al., 2006) as an additional test to ensure that the models do not suffer from multicollinearity. The regression analysis can therefore be performed with confidence (Mangena & Tauringana, 2007; Naser et al., 2006). Prior studies have suggested that a correlation of 65% or higher indicates the existence of a multicollinearity issue (Alsaeed, 2006; Mangena & Tauringana, 2007). According to Salmerón et al. (2018), the multicollinearity issue arises when the VIF value exceeds 10.

Several versions of the original OLS regression model are developed to examine the relationships between corporate governance, carbon emission reduction, and air pollution. The models examine the relationship between carbon emission reduction and corporate governance prior to and during the COVID-19 period.

Listed below are the various OLS regression models used in this study. Model 1, represents the company level:

$$CERit = \beta 0 + \beta 1CGit + \beta 2SIZEit + \beta 3ROAit + \beta 4LEVit + \beta 5INDit + \varepsilon i$$

(Model 1)

where *CERit* is carbon emission for firm *i* in year *t*, *CGit* is the corporate governance pillar score for firm *i* in year *t*, *SIZEit* is firm size for firm *i* in year *t*, *ROAit* is profitability for firm *i* in year *t*, *LEVit* is leverage for firm *i* in year *t*, *INDit* is industry type for firm *i* in year *t*, and *ε* represents the error term for firm *i* in year *t*.

In addition to the first model, a RFE is included to examine the relationship between carbon emission reduction and corporate governance at the regional level:

$$CERit = \beta 0 + \beta 1CGit + \beta 2SIZEit + \beta 3ROAit + \beta 4LEVit + \beta 5INDit + \beta 6RFEit + \varepsilon i$$

(Model 2)

where *CERit* is carbon emission for firm *i* in year *t*, *CGit* is the corporate governance pillar score for firm *i* in year *t*, *SIZEit* is firm size for firm *i* in year *t*, *ROAit* is profitability for firm *i* in year *t*, *LEVit* is leverage for firm *i* in year *t*, *INDit* is industry type for firm *i* in year *t*, *RFEit* is the region fixed effect for firm *i* in year *t*, and *ε* represents the error term for firm *i* in year *t*.

The third model examines the relationship between air pollution and corporate governance, prior to and during the COVID-19 period:

$$APit = \beta 0 + \beta 1CGit + \beta 2SIZEit + \beta 3ROAit + \beta 4LEVit + \beta 5INDit + \beta 6RFEit + \varepsilon i$$

(Model 3)

where *APit* is carbon emission for firm *i* in year *t*, *CGit* is the corporate governance pillar score for firm *i* in year *t*, *SIZEit* is firm size for firm *i* in year *t*, *ROAit* is profitability for firm *i* in year *t*, *LEVit* is leverage for firm *i* in year *t*, *INDit* is industry type for firm *i* in year *t*, *RFEit* is the region fixed effect for firm *i* in year *t*, and ε represents the error term for firm *i* in year *t*.

3.5 Chapter Summary

This chapter discusses the research methods and the analysis used in collecting data to test the relationship between corporate governance and carbon emission reduction. Furthermore, the study controls for firm-specific characteristics, such as firm size, profitability, leverage, industry type, and region fixed effect.

An overview of the sampling procedures and the major data sources are presented in this chapter. The data related to corporate governance and carbon reduction were obtained from the Refinitiv Workspace database. Air pollution data were primarily collected from IQAir. The final sample includes 2,226 public companies (8,904 firm-years) from 2018 to 2021. Additionally, the chapter has discussed the process that was used to select the final samples for this study. Furthermore, the chapter provides details on how carbon emission reduction and air pollution are measured. A discussion has also been provided in this chapter regarding the measurement of corporate governance and the control variables. Finally, this chapter concludes with a discussion of the regression models used to examine the impact of corporate governance on the reduction of carbon emission and air pollution.

CHAPTER 4: EMPIRICAL RESULTS

This chapter provides an overview of the data analysis and the statistical techniques utilized in this study. It appears from the main results of the analysis that corporate governance had a positive influence on carbon emission reduction both prior to and during COVID-19. This suggests that even during the ongoing crisis, corporate governance has had a positive effect on carbon emission reduction. The content of this chapter is organized as follows. The results for the descriptive statistics are presented in Section 4.1. Section 4.2 shows the results related to ANOVA. Section 4.3 shows the Pearson's correlation results, and Section 4.4 presents the multicollinearity test. Section 4.5 addresses the main findings of the multiple regression analysis to test the hypotheses introduced in Chapter 2. Finally, the chapter summary is presented in Section 4.6.

4.1 Descriptive Statistics

Descriptive statistics provide information about the sample and its distribution, which is useful for determining subsequent analysis. The results of the descriptive statistics are provided for the dependent, independent, and control variables. This includes information about the mean, standard deviation, maximum, and minimum values for the various variables. In Table 4.1, Panel A and Panel B present the results for the years prior to COVID-19 (2018 and 2019, respectively), while Panel C and Panel D present the results for the years during COVID-19 (2020 and 2021, respectively).

Table 4.1. Descriptive Statistics for the Study's Variables

	N	Min.	Max.	Mean	SD	*N*	Min.	Max.	Mean	SD
			Panel A: 2018					Panel B: 2019		
Main variables										
CER	2,226	0.00	99.71	42.87	33.66	2,226	0.00	98.96	49.27	32.84
AP	2,226	6.60	72.5	13.9	10.06	2,226	5.60	58.1	12.86	7.97
CG	2,226	2.97	97.84	53.8	21.04	2,226	5.67	92.28	55.92	20.57
Control variables										
SIZE	2,226	7.34	12.54	9.91	0.73	2,226	7.53	12.56	9.96	0.72
ROA	2,226	0.00	2.44	0.07	0.08	2,226	0.00	2.21	0.06	0.07
LEV	2,226	0.00	3.89	0.26	0.21	2,226	0.00	2.98	0.26	0.2
IND	2,226	0.00	1.00	0.48	0.5	2,226	0.00	1.00	0.48	0.5
			Panel C: 2020					Panel D: 2021		
Main variables										
CER	2,226	0.00	99.77	53.24	31.89	2,226	0.00	99.81	56.04	31.11
AP	2,226	5.00	51.9	12.82	8.56	2,226	5.50	58.10	12.59	7.60
CG	2,226	3.99	96.95	56.92	20.5	2,226	2.98	97.00	58.92	20.22
Control variables										
SIZE	2,226	7.62	12.62	9.86	0.72	2,226	7.91	12.68	10.04	0.71
ROA	2,226	0.00	0.87	0.06	0.06	2,226	0.00	1.39	0.07	0.07
LEV	2,226	0.00	2.63	0.26	0.20	2,226	0.00	3.03	0.25	0.20
IND	2,226	0.00	1.00	0.48	0.50	2,226	0.00	1.00	0.48	0.50

Notes: *CER* = carbon emission reduction; *AP* = air pollution; *CG* = corporate governance pillar score; *SIZE* = natural logarithm of total assets; *ROA* = return on assets; *LEV* = leverage (total debt to total assets); *IND* = 1 if the company belongs to an environmentally sensitive industry, and 0 otherwise.

In Panel A, which represents the year 2018, the mean for *CER* is 42.87, while the standard deviation is 33.66. The variable has values that range from 0.00 to 99.71. Regarding *AP*, it has a mean is 13.90, which indicates that the majority of the firms in the study are located in areas where the air quality is acceptable. The variable *AP* has a range between 6.60 and 72.50, with a standard deviation of 10.06. Moreover, the mean for *CG* is 53.80, which indicates that, on average, the governance quality for the sampled companies is approximately 54 out of 100. The variable *CG* has a range between 2.97 and 97.84, with a standard deviation of 21.04. Table 4.1 also shows the descriptive statistics for the study's control variables. The mean for *SIZE* in Panel A is 9.91, with a standard deviation of 0.73. Regarding *ROA*, it has a mean of 0.07 and a standard deviation of 0.08. Moreover, the mean for *LEV* is 0.26, which suggests that the sampled companies are not highly leveraged. Regarding IND, it has a mean of 0.48, which indicates that, on average, 48% of the companies are environmentally sensitive and operate in industries such as agriculture, transportation, energy, chemicals, cement, oil and gas, etc. (Cunanan, 2018; Ge & Friedrich, 2020).

Panel B in Table 4.1 presents the information for the year 2019. The mean for CER is 49.27, with a standard deviation of 32.84. Th minimum value for CER is 0.00, while its maximum value is 98.96. The mean for AP is 12.86, with a standard deviation of 7.97. The variable *AP* ranges between 5.60 and 58.10. Regarding the mean for *CG*, it is 55.92, with a standard deviation of 20.57. This indicates that, on average, the governance quality for the sampled companies is approximately 56 out of 100, which shows an improvement of 2% from the previous year. The minimum and maximum values for *CG* are 5.67 to 92.28, respectively. The variable *SIZE* has a mean of 9.96, with a standard deviation of 0.72. The mean for *ROA* is 0.06. Moreover, *LEV* and *IND* have means of 0.26 and 0.48, respectively, with a standard deviation of 0.20 and 0.50, respectively.

Panel C in Table 4.1 presents the descriptive statistics for the year 2020. The means for *CER* and *AP* are 53.24 and 12.82, respectively, with a standard deviation of 31.89 and 8.56, respectively. The minimum value for *CER* is 0.00, while its maximum value is 99.77. Regarding *AP*, the minimum value is 5.00, while the maximum value is 51.90. Furthermore, the mean for *CG* is 56.92, with a standard deviation of 20.50. The minimum and maximum values for *CG* are 3.99 to 96.95, respectively. The variable *SIZE* has a mean of 9.86, with a standard deviation of 0.72. The mean for *ROA* is 0.06. Moreover, *LEV* and *IND* have means of 0.26 and 0.48, respectively, with a standard deviation of 0.20 and 0.50, respectively.

Panel D shows that the means for *CER* and *AP* in 2021 are 56.04 and 12.59, respectively. The standard deviation for *CER* is 31.11, while for *AP* it is 7.60. *CER* ranges from 0.00 to 99.81, while *AP* ranges from 5.50 to 58.10. Regarding *CG,* the mean is 58.92, which indicates that, on average, the governance quality for the sampled companies is approximately 59 out of 100, which also shows an improvement of 2% from the previous year. *CG* has a range between 2.98 and 97.00, with a standard deviation of 20.22. For the control variables, the mean for *SIZE* in Panel D is 10.04, with a standard deviation of 0.71. Regarding *ROA*, it has a mean of 0.07 and a standard deviation of 0.07. Moreover, the means for LEV and IND are 0.25 and 0.48, respectively, with a standard deviation of 0.20 and 0.50, respectively.

It is clear from Table 4.1 that the CER mean for the sampled companies across all four years has increased, indicating that, on average, the emission score increased from 23 in 2018 to 56 in 2021. This indicates that most of the sampled companies are more committed to reducing their carbon emission through setting effective polices and strategies. Meanwhile, the maximum values for *CER* dropped from 2018 to 2019 by

0.75 and continued to increase in 2020 and 2021, reaching 99.8. Regarding *AP*, the results show that its mean during the COVID-19 period did not change significantly. This indicates that most of the sampled companies operate within an acceptable air pollution spectrum. Table 4.1 also shows that the mean for *CG* increased across all four years, reaching 59 in 2021, compared to 54 in 2018. This suggests that most of sampled companies have an effective governance process that ensures that the company's board of directors and executive officers act in the best interests of long-term shareholders. In order to ensure that the difference between CG and CER prior and during the pandemic was statistically significant, an ANOVA test was run.

4.2 Analysis of Variance (ANOVA)

ANOVA is used to compare the means of two different variables (Saunders et al., 2009). Furthermore, it tests whether there are statistically significant differences among those means, based on a distinct factor (Sawyer, 2009). ANOVA is used in the current study to test whether significant differences exist between the means of *CER*, *CG*, and AP, while using the COVID-19 period as the factor to determine the differences in means prior to and during the pandemic.

Table 4.2 presents the ANOVA results for CER, AP, and CG, in relation to the COVID-19 period. The results show that there is a significant difference between the means for *CER*, *CG*, and *AP* at the 1% significance level. The results indicate that the *CER* mean for companies prior to the COVID-19 period was 46.10, while it was 54.64 during COVID-19. This suggests that carbon emission reduction was higher during the COVID-19 period compared to the period prior to COVID-19. Regarding *CG*, the mean prior to the COVID-19 period was 54.86, while it was 57.92 during COVID-19. These results suggest that governance effectiveness improved during the pandemic.

Furthermore, the mean for *AP* prior to COVID-19 was 13.38, while it was 12.70 during the COVID-19 period. Table 4.2 shows that air pollution decreased during COVID-19. However, the differences are not large between the two periods. Overall, the means for CG and CER increased during the pandemic, indicating that government-imposed measures led to a reduction in emissions. Additionally, the time of crisis and uncertainty enhanced the quality of governance.

Table 3.2. ANOVA for Carbon Emission and Corporate Governance in Relation to COVID-19

	Factor	Mean	SD	*F*	Sig.
CER	Prior to COVID-19	46.10	33.40	154.93	<0.001***
	During COVID-19	54.64	31.53		
	Total	50.35	32.76		
CG	Prior to COVID-19	54.86	20.83	49.05	<0.001***
	During COVID-19	57.92	20.38		
	Total	56.39	20.66		
AP	Prior to COVID-19	13.38	9.09	13.811	<0.001***
	During COVID-19	12.70	8.03		
	Total	13.04	8.61		

Notes: *CER* = carbon emission reduction; *CG* = corporate governance pillar score; *AP* = air pollution. *** Significance level of 1%.

Overall, the firms performed better during the pandemic in terms of *CER* and *CG*. These results may relate to the strict measures implemented by governments to control the spread of COVID-19. Furthermore, the air quality improved during the pandemic. Moreover, the findings indicate that environmental performance, governance effectiveness, and air quality were better during the pandemic period compared to prior to the pandemic.

4.3 Pearson's Correlation

This study uses Pearson's correlation to determine both the direction and strength of the correlation between the independent and control variables to check for the existence of multicollinearity issue (Field, 2017). Table 4.3 provides the correlation results between the independent and control variables for periods 2018, 2019, 2020, and 2021. Panels A and B show the results prior to COVID-19 (2018 and 2019) and Panels

C and D show the results during COVID-19 (2020 and 2021). Panel A in Table 4.3 represents the year 2018, showing that the independent variable, *CG*, is positively correlated to *SIZE* and *IND*, at the 1% and 5% significance levels, respectively. However, the strength of these correlations is low. Furthermore, the results show that *CG* is not correlated to *ROA* and *LEV*. Table 4.3 also shows that the correlation coefficients for all firm characteristic variables are low. *SIZE* is negatively related to *ROA*, at the 1% significance level; however, *SIZE* is not correlated with *LEV* and *IND*. Moreover, the table shows that *LEV* is positively correlated with *IND* at the 1% significance level. However, these correlations are low, meaning that there is no multicollinearity among these variables. Panel B in Table 4.3 shows the results for the year 2019, revealing that *CG* is positively correlated with *SIZE*, *IND*, and *LEV* at the 1% and 5% significance levels, respectively; however, *CG* is not correlated with *ROA*. Moreover, *SIZE* is negatively correlated to *ROA* and *IND* at the 1% significance level. According to Panel B, *LEV* is positively correlated with *IND* at the 1% significance level. However, the strength of these correlations is quite low in panel B, indicating that there is no multicollinearity among the independent variables.

The results for the year 2020 are presented in Panel C in Table 4.3. The results show that CG is positively correlated with LEV and IND at the 5% significance level; however, *CG* is not correlated with *SIZE* or *ROA*. Furthermore, the results indicate that *LEV* is positively correlated with *IND* at the 1% significance level. These correlations show the absence of any multicollinearity issues. Panel D in Table 4.3 shows the results for the year 2021. Panel D shows that *CG* is positively correlated with *SIZE* and *IND* at the 1% significance level; however, *CG* is not related to *ROA* and *LEV*. Moreover, *SIZE* is negatively related to *ROA* at the 1% significance level. However, *SIZE* is not correlated with *LEV* and *IND*. Table 4.3 also shows that *LEV* is positively correlated with *IND* at the 1% significance level. Overall, Table 4.3 shows the correlation among the independent and control variables is exceptionally low.

To conclude, prior to COVID-19, *CG* is positively correlated to *SIZE*, *LEV*, and *IND*. This indicate that, when *CG* increases, the values for *SIZE*, *LEV*, and *IND* also tend to increase, meaning they are going in the same direction; however, the strength of this correlation is weak. On the other hand, during COVID-19, *CG* is positively correlated with *SIZE*, *LEV*, and *IND*. This indicates that when *CG* increases, the values for *SIZE*, *LEV*, and *IND* also tend to increase, meaning they are going in the same direction; however, the strength of this correlation is still weak. It can be concluded from the results that all variables have weak correlations; therefore, there is no evidence of multicollinearity.

Table 4.3. Pearson's Correlation Matrix for the Study's Variables

Variable	*CG*	*SIZE*	*ROA*	*LEV*	*IND*
Panel A: 2018					
CG	1				
SIZE	0.243***	1			
ROA	–0.012	–0.334***	1		
LEV	0.021	0.008	0.032	1	
IND	0.050**	–0.011	–0.006	0.118***	1
Panel B: 2019					
CG	1				
SIZE	0.211***	1			
ROA	–0.012	–0.314***	1		
LEV	0.046**	–0.011	0.028	1	
IND	0.057***	–0.081***	–0.029	0.0178***	1
Panel C: 2020					
CG	1				
SIZE	0.018	1			
ROA	–0.037	0.005	1		
LEV	0.052**	–0.019	0.026	1	
IND	0.054**	–0.016	–0.021	0.164***	1
Panel D: 2021					
CG	1				
SIZE	0.187***	1			
ROA	0.008	–0.279***	1		
LEV	0.040	–0.018	0.037	1	
IND	0.063***	–0.037	–0.001	0.142***	1

Notes: *** Correlation is significant at the 0.01 level (2-tailed). ** Correlation is significant at the 0.05 level (2-tailed).

4.4 Multicollinearity Test

It is necessary to conduct a multicollinearity test to check whether the independent variables are correlated (Mardini, 2015; Naser et al., 2006). The presence of multicollinearity could distort the statistical significance of the independent variables

(Field, 2017). It would make it difficult to assess the influence of the independent variables on the dependent variable, thus leading to inaccurate results. Prior studies have indicated the absence of multicollinearity when the correlation among the independent variables does not exceed 0.65 (Alsaeed, 2006; Mangena & Tauringana, 2007). Table 4.3 shows that there is no multicollinearity between the independent and control variables. Furthermore, the study incorporates the VIF values (Mangena & Tauringana, 2007; Naser et al., 2006) as an additional test through which to ensure that the models do not suffer from multicollinearity. According to Salmerón et al. (2018), the multicollinearity issue arises when the VIF value exceeds 10. Table 4.4 presents the VIF results for the years prior to COVID-19 (2018 and 2019) and the years during COVID-19 (2020 and 2021). The results show that the VIF values for the independent and all control variables are between 1.204 and 1.001, which indicates that there is no multicollinearity between the predictor variables. This finding supports the lack of correlation between the independent variables presented in the Pearson's correlation (Table 4.3).

Table 4.4 Variable Inflation Factor Results

	Panel A: Prior to COVID-19		Panel B: During COVID-19	
	2018	2019	2020	2021
Variable	CER	CER	CER	CER
CG	1.072	1.058	1.007	1.047
SIZE	1.204	1.180	1.001	1.132
ROA	1.134	1.119	1.003	1.091
LEV	1.016	1.035	1.031	1.023
IND	1.018	1.049	1.031	1.027

4.5 Multiple Regression

4.5.1 Carbon Emission and Corporate Governance at the Micro Level

As discussed in Chapter 3, this study estimates an OLS regression to examine the relationship between corporate governance and carbon emission reduction. Modeling the dependent variable with OLS regression can be accomplished using linear modeling. Due to its potential for checking assumptions, such as linearity, constant variance, and outlier effects, the OLS technique has traditionally been viewed as a powerful tool. The regression analysis results for the relationship between *CER* and *CG* at the micro level (company level) is presented in Table 4.5. Panel A shows the relationship between *CER*, *CG*, and the control variables prior to COVID-19 (2018 and 2019), while Panel B shows the results during COVID-19 (2020 and 2021).

Table 4.5. The Relationship Between Carbon Emission and Corporate Governance at the Micro Level

Variable	Panel A: Prior to COVID-19		Panel B: During COVID-19	
	2018	2019	2020	2021
CG	0.244*** (13.075)	0.246*** (13.359)	0.320*** (16.011)	0.268*** (14.180)
SIZE	0.413*** (20.890)	0.421*** (21.702)	–0.001 (–0.037)	0.354*** (18.066)
ROA	0.128*** (6.654)	0.168*** (8.880)	0.033 (1.665)	0.152*** (7.902)
LEV	–0.023 (–1.240)	0.003 (0.141)	0.037 (1.817)	0.050*** (2.658)
IND	0.140*** (7.693)	0.186*** (10.180)	0.098*** (4.832)	0.115*** (6.136)
Adjusted R^2	0.278	0.289	0.117	0.244
F	172.573	181.537	60.129	144.304
Sig.	<0.001***	<0.001***	<0.001***	<0.001***

Notes: *** Correlation is significant at the 0.01 level.

The results presented in the first column (2018) in Table 4.5 shows that *CER* is positively related to *CG* at the 1% significance level. This finding suggests that effective corporate governance reduces carbon emission. A possible explanation for this is that companies with strong corporate governance are more committed to reducing their carbon emission. Furthermore, *CER* is positively related to *SIZE*, *ROA*, and *IND* at the 1% significance level, which indicates that large firms that generate higher profits and operate in sensitive industries have the resources to lower their carbon emission. The adjusted R^2 value for the first column in Panel A indicates that 28% of the variance in carbon emission reduction can be explained by the model. The *F*-value for the first model is 172.57, statistically significant at the 1% level. This shows that the model has relatively good explanatory power. Moreover, the second column (2019) shows that *CER* is positively related to *CG* at the 1% significance level. Moreover, *CER* is also positively related to *SIZE*, *ROA*, and *IND* at the 1% significance level. These results are similar to the results shown in the first column. The adjusted R^2 value square for the second column in Panel A suggests that 29% of the variance in carbon emission reduction can be explained by the model. The *F*-value for the first model is 181.53, statistically significant at the 1% level. This shows that the model has relatively good explanatory power. Based on these results, it can be concluded that prior to the COVID-19 pandemic, the quality of governance had a significant impact on the reduction of carbon emission.

The second model is tested in Panel B, where the first column shows the results for the year 2020 and the second column shows the results for the year 2021. The results presented under the first column show that *CER* is positively related to *CG* at the 1% significance level. Additionally, *CER* is positively related to *IND* at the 1% significance level. These results indicate that firms with effective *CG* and that operate in sensitive industries are more committed to reducing their carbon emission. As a result of the increase in COVID-19 cases, governments implemented strict measures in order to prevent the spread of the disease. Following the implementation of these measures, transportation, agricultural, industrial, and manufacturing activities declined, negatively affecting socioeconomic activities. This resulted in a reduction in global

GHG emission, which had a positive impact on the environment (Le Quéré et al., 2020). The adjusted R^2 value for the first column in Panel B indicates that 12% of the variance in carbon emission reduction can be explained by the model. The *F*-value for the first model is 60.12, statistically significant at the 1% level. This shows that the model has less explanatory power relative to prior years. Furthermore, the second column in Panel B shows that *CER* is positively related to *CG* at the 1% significance level. Moreover, *CER* is also positively related to *SIZE*, *ROA*, *LEV*, and *IND* at the 1% significance level. The adjusted R^2 value square in the second column in Panel B is 24%, indicating that 24% of variance in carbon emission reduction can be explained by the model. The *F*-value for the first model is 144.30, statistically significant at the 1% level. This suggests that the model has satisfactory explanatory power.

To conclude, Table 4.5 shows that *CER* is positively related to *CG* at the 1% significance level across all years. This indicates that, across the four years, firms with effective *CG* are committed to implementing effective policies and strategies to reduce carbon emission resulting from their daily activities. Regarding the control variables, the table shows that *SIZE*, *ROA*, and *IND* are also positively related to *CER* in Panels A, B, and C. Regarding COVID-19's impact, the table shows that there was no significant change between 2020 and 2021.

4.5.2 Carbon Emission and Corporate Governance at the Macro Level

The regression analysis results for the relationship between *CER* and *CG* at the macro level (regional level) are presented in Table 4.6. The table also how this relationship has been impacted as a result of COVID-19. Panel A shows the relationship between CER, AP, CG, as well as the control variables, prior to COVID-19 (2018 and 2019), while Panel B shows the results during COVID-19 (2020 and 2021).

Panel A shows the relationships between CER, AP, CG, and control variables and regions, prior to the COVID-19 pandemic. The first and second columns in Panel A show the results for the years 2018 and 2019, while the third and fourth columns show the results for 2020 and 2021. The results of the first column demonstrate that *CER* is positively related to *CG* at the 1% significance level. This is similar to the results reported at the micro level for the year 2018. Furthermore, the variable *CER* is positively related to *SIZE*, *ROA*, and *IND* at the 1% significance level. Moreover, the first column in Panel A also shows that *EAP*, *ECA*, *LAC*, *WE*, and *SA* are positively related with *CER* at the 1% significance level. This indicates that firms in these regions have effective strategies and policies to reduce their carbon emission. However, no significant relationship was reported for MENA and SSA. The adjusted R^2 value shows that 38% of the variance in carbon emission reduction can be explained by the model. The *F*-value for the model is 115.484, statistically significant at the 1% level. This shows that the model has strong explanatory power.

The second column in Panel A demonstrates that *AP* is negatively correlated with *CG* at the 1% significant level. This indicates that the high quality of governance reduces air pollution levels. Moreover, *SIZE* is positively correlated with *AP* at the 1% significant level. This result implies that the production of output and pollution by large firms is undeniable; however, large firms are under considerable pressure from the government to reduce pollution. In this regard, large companies have a greater ability to control pollution than smaller ones. Moreover, the second column also shows that *AP* is positively related to *EAP*, *ECA*, *LAC*, *MENA*, *WE*, *SA*, and *SSA* at the 1% significance level. This indicates that the regions where the sample firms operate have high levels of pollution. This pollution is caused by several factors, such as increasing energy consumption, extraction, economic growth, dust from desert soil, industrial pollution, and firewood (Choi, et al., 2019; Omri, 2013; Zhu et al., 2019). The adjusted R^2 value suggests that 38% of the variance in air pollution can be explained by the model. The F-value for the model is 114.352, statistically significant at the 1% level. This shows that the model has strong explanatory power.

Table 4.6. The Relationship Between Carbon Emission and Corporate Governance at the Macro Level

	Panel A: Prior to COVID-19				Panel B: During COVID-19			
Variable	*CER* (2018)	*AP* (2018)	*CER* (2019)	*AP* (2019)	*CER* (2020)	*AP* (2020)	*CER* (2021)	*AP* (2021)
CG	0.236***	–0.085***	0.224***	–0.068***	0.291***	–0.028	0.225***	–0.061***
	(13.595)	(–4.867)	(12.842)	(–3.923)	(15.171)	(–1.423)	(12.173)	(–3.221)
SIZE	0.400***	0.175***	0.413***	0.151***	0.015	–0.001	0.364***	0.200***
	(21.830)	(9.543)	(22.749)	(8.331)	(0.792)	(–0.035)	(19.637)	(10.549)
ROA	0.112***	0.031	0.155***	0.044**	0.041**	–0.011	0.164***	0.059***
	(6.274)	(1.751)	(8.741)	(2.492)	(2.175)	(–0.584)	(8.923)	(3.178)
LEV	0.027	0.028	0.036**	–0.012	0.066***	–0.003	0.082***	0.004
	(1.570)	(1.618)	(2.091)	(–0.714)	(3.390)	(–0.158)	(4.575)	(0.221)
IND	0.096***	0.001	0.143***	0.018	0.060***	–0.003	0.074***	0.006
	(5.597)	(0.061)	(8.244)	(1.046)	(3.083)	(–0.173)	(4.150)	(0.347)
EAP	0.179***	0.532***	0.190***	0.526***	0.202***	0.373***	0.215***	0.380***
	(9.523)	(28.191)	(10.160)	(28.209)	(9.594)	(17.495)	(10.990)	(19.032)
ECA	0.069***	0.094***	0.065***	0.102***	0.061***	0.064***	0.066***	0.097***
	(4.127)	(5.561)	(3.866)	(6.085)	(3.235)	(3.332)	(3.735)	(5.423)
NA	–	–	–	–	–	–	–	–
LAC	0.128***	0.181***	0.109***	0.216***	0.110***	0.123***	0.104***	0.164***
	(7.430)	(10.517)	(6.354)	(12.600)	(5.690)	(6.289)	(5.814)	(8.993)
MENA	0.005	0.099***	0.015	0.115***	0.026	0.023	0.018	0.094***
	(0.296)	(5.919)	(0.871)	(6.869)	(1.376)	(1.220)	(1.006)	(5.282)
WE	0.340***	0.102***	0.318***	0.092***	0.320***	0.011	0.290***	–0.003
	(18.438)	(5.541)	(17.217)	(5.035)	(15.381)	(0.524)	(14.829)	(–0.149)
SA	0.072***	0.327***	0.053***	0.319***	0.055***	0.252***	0.067***	0.329***
	(4.292)	(19.537)	(3.161)	(19.130)	(2.897)	(13.178)	(3.828)	(18.442)
SSA	0.030	0.051***	0.033**	0.079***	0.005	0.024	0.018	0.084***
	(1.798)	(3.031)	(1.977)	(4.764)	(0.277)	(1.243)	(1.026)	(4.701)
Adjusted d R^2	0.382	0.379	0.379	0.385	0.210	0.193	0.325	0.298
F	115.484	114.352	114.182	116.907	50.170	45.465	90.205	79.540
Sig.	<0.001***	<0.001***	<0.001***	<0.001***	<0.001***	<0.001***	<0.001***	<0.001***

Notes: *** 1% significance level; ** 5% significance level.

The third column in Panel A shows that *CER* is positively related to *CG* at the 1% significance level. Further, the variable *CER* is positively related to *SIZE*, *RO*A, and *IND* at the 1% significance level, and to *LEV* at the 5% significance level. Moreover, the third column in Panel A shows that *CER* is positively related to *EAP*, *ECA*, *LAC*, *WE*, and *SA* at the 1% significance level, and to *SSA* at the 5% significance level. However, no significant relationship was reported with *MENA*. The adjusted R^2 value shows that 38% of the variance in carbon emission reduction can be explained by the model. The *F*-value for the second model is 114.182, statistically significant at 1% level. This shows that the model has strong explanatory power. Moreover, the fourth column in Panel A demonstrates that *AP* is negatively related to *CG* at the 1% significance level. Furthermore, the variable *AP* is positively related to *SIZE* at the 1% significance level, and to *ROA* at the 5% significance level. The fourth column in Panel A also shows that *AP* is positively related to *EAP*, *ECA*, *LAC*, *MENA*, *WE*, *SA*, and *SSA* at the 1% significance level. This indicates that these regions have high air pollution. The adjusted R^2 value indicates that 39% of the variance in air pollution can be explained by the model. The F-value is 116.907, statistically significant at the 1% level. This shows that the model has strong explanatory power.

Panel B shows the relationships between CER, AP, CG, and control variables and regions during the COVID-19 pandemic. The first and second columns in Panel B show the results for the year 2020, while the third and fourth columns show the results for 2021. In Table 4.6, the first column in Panel B shows that CER is positively related to CG at the 1% significance level. Furthermore, the variable CER is positively related to *ROA* at the 5% significance level, and to *LEV* and *IND* at the 1% significance level. Moreover, the column shows that *EAP*, *ECA*, *LAC*, *WE*, and *SA* are positively related with *CER* at the 1% significance level. However, no significant relationship was reported for *MENA* and *SSA*. The adjusted R^2 value for the first column is 21%, indicating that 21% of the variance in carbon emission reduction can be explained by the model. The *F*-value for the third model is 50.170, statistically significant at the 1% level. Regarding *AP*, the second column in Panel B shows that *AP* is negatively and insignificantly related to *CG*. Further, the variable *AP* is positively related to *SIZE* and *ROA* at the 1% and 5% significance levels, respectively. Moreover, the column shows that *EAP*, *ECA*, *LAC*, and *SA* are positively related with *AP* at the 1% significance level. However, the coefficients for *EAP*, *ECA*, *LAC*, and *SA* were lower during pandemic period compared to the period prior to the pandemic. This indicates that these regions had lower air pollution during COVID-19 relative to the level before COVID-19. A possible explanation is that the shutdown of certain industries resulted in a significant reduction in industrial GHG emission (Niveditha et al., 2021). According to Quah et al. (2020), lockdown measures led to a decrease in the concentrations of pollutants such as NO_2, CO, PM 2.5, and PM 10. However, no significant relationship was reported for *WE*, *MENA*, and *SSA*. The adjusted R^2 value shows that 19% of the variance in air pollution can be explained by the model. The *F*-value for the fourth model is 45.465, statistically significant at the 1% level.

The third column in Panel B shows that *CER* is positively related to *CG* at the 1% significance level. The column also shows that the variable *CER* is positively related to *SIZE*, *ROA*, *LEV*, and *IND* at the 1% significance level. Furthermore, the column shows that *CER* is positively related to *EAP*, *ECA*, *LAC*, *WE*, and *SA* at the 1% significance level. However, no significant relationship was reported for *MENA* and *SSA*. This indicates that the *EAP*, *ECA*, *LAC*, *WE*, and *SA* regions have adopted policies to reduce their carbon emission. According to Ray et al. (2022), many countries in Europe and Asia implemented strict lockdown measures as a result of the COVID-19 pandemic, which led to a significant reduction in carbon emission in 2020. Despite this, the results show that Africa and Australia were only slightly affected by the COVID-19 pandemic, as less strict lockdown measures were implemented in those continents. The adjusted R^2 value is 33%, while the F-value for the model is 90.205. This shows that the model has good explanatory power. Moreover, the fourth column in Panel B demonstrates that *AP* is negatively related to *CG* at the 1% significance level. This indicates that effective *CG* can reduce *AP*. Furthermore, *AP* is positively related to *SIZE* and *ROA* at the 1% significance level. Moreover, *AP* is also positively related to *EAP*, *ECA*, *LAC*, *MENA*, *SA*, and *SSA* at the 1% significance level. However, no significant relationship was reported for *WE*. The adjusted R^2 value is approximately 30%, and the F-value for the fourth model is 79.540. This shows that the model has good explanatory power.

4.6 Chapter Summary

This chapter provides the results of the data analysis, including descriptive statistics, ANOVA, Pearson's correlation, collinearity analysis, and regression analyses. The findings reported in this chapter document the relationship between corporate governance and carbon emission for an international sample over the period 2018 to 2021. The sample is divided into two phases. The first phase is the micro level, which examines the relationship between corporate governance and carbon emission reduction based on the level of the companies. The second phase is the macro level, which explores the relationship between corporate governance and carbon emission reduction and the relationship between corporate governance and air pollution at the regional level. At the micro level, the results show that, for the period before and during COVID-19, corporate governance had a positive effect on carbon emission reduction. However, the relationship was stronger during the pandemic. Regarding the macro level, the results indicate that corporate governance had a positive impact on carbon emission reduction prior to and during COVID-19. Furthermore, corporate governance had a negative relationship with air pollution. Moreover, the Eastern Asia & Pacific, Eastern Europe & Central Asia, Latin America & the Caribbean, Western Europe, and South Asia regions showed a positive and significant relationship with carbon emission reduction prior to and during COVID-19. Moreover, the relationship was higher during the pandemic. Regarding air pollution, the Eastern Asia & Pacific, Eastern Europe & Central Asia, Latin America & the Caribbean, and South Asia regions were positively and significantly related to air pollution. However, the effect was different. The next chapter provides a discussion based on the study's findings.

CHAPTER 5: DISCUSSION

This chapter discusses the findings presented in Chapter 4. It also considers the results related to the hypotheses, which are mainly concerned with the relationship between the corporate governance and carbon emission reduction during COVID-19. The chapter is structured as follows. First, Section 5.1 presents a discussion related to the relationship between carbon emission reduction and corporate governance. It also discusses the change in the relationship between carbon emission reduction and corporate governance prior to and during COVID-19. Section 5.2 discusses the regional effect on carbon emission reduction and air pollution prior to and during COVID-19.

5.1 Carbon Emission Reduction and Corporate Governance

This study examines the relationship between corporate governance and carbon emission reduction before and during the COVID-19 pandemic. The empirical results presented in Chapter 4 demonstrate that there is a significant positive association between corporate governance and carbon emission reduction. This finding offers support for *H1* (*There is a positive and significant relationship between corporate governance and carbon emission reduction practices*). The findings imply that firms with strong corporate governance tend to reduce carbon emission more effectively. This finding is consistent with results provided by previous studies (Cong & Freedman, 2011; Cordeiro et al., 2020; De Villiers et al., 2011; Kassinis et al., 2016; Kilincarslan et al., 2020; Lu & Herremans, 2019; Luo and Tang, 2020; Post et al., 2011; Walls et al., 2012). The argument is that companies with high-quality governance are more likely to reduce their carbon emission relative to those with low-quality governance. This is consistent with Sarpong and Bein (2020), who confirmed that there is a negative relationship between corporate governance and carbon emission in countries that produce oil. Moreover, the negative relationship supports the notion that effective governance plays a role in reducing the amount of carbon emission produced by firms. Based on the argument of the current study, if administrative functions are sufficient to control unethical practices and ensure the transparency of organizational operations, then there is a greater possibility of reducing emission through the implementation of the required measures.

The positive relationship between corporate governance and environmentally conscious practices is in accordance with agency theory. Further, governance can align the interests of directors and shareholders, which makes it more likely for managers to disclose carbon information to outside investors. As a general rule, the more effective the firm's governance, the greater its responsibility for monitoring managers' activities towards the environment (Lu et al., 2015). In addition, the findings of this study align with stakeholder theory, which suggests that companies with high quality of corporate governance behave in a more socially responsible manner and are more responsive to stakeholders' requests. Furthermore, these companies tend to establish ambitious carbon reduction targets and improve their carbon performance (Chan et al., 2014). From the perspective of legitimacy theory, an effective board is more socially responsible and is less likely to engage in activities that negatively affect the environment (Luo & Tang, 2021). According to stakeholder and legitimacy theories, firms with high-quality corporate governance are more likely to respond to stakeholder needs and are more aware of legitimacy issues arising from climate change. Consequently, these firms are motivated to reduce their carbon emission to meet society's expectations (Luo, 2019).

Several studies have found that board characteristics are positively related to carbon emission reduction (e.g., Biswas et al., 2018; Burkhardt et al., 2020; De Villiers et al., 2011; Dixon-Fowler et al., 2017; Galia et al., 2015; Liao et al., 2015; Lu &

Herremans, 2019; Luo and Tang, 2020; Martín & Herrero, 2020; Martinez et al., 2022; Nuber & Velte, 2021; Prado-Lorenzo & Garcia-Sanchez, 2010; Walls et al., 2012; Zhang et al., 2013). However, there are studies that show contrary results. For example, Haque (2017) concluded that there is no link between corporate governance and GHG emission. Additionally, Elsayih (2015) showed that corporate governance strength is unrelated to carbon emission reduction. For instance, some firms are struggling to control their carbon emission, especially those in Africa, due to corruption, which results in ineffective environmental regulations and poor governance at all levels (Fredriksson et al., 2005). In general, companies must adopt corporate governance practices that directly monitor GHG emission and climate change risks. As stated by Peters and Romi (2014), governance practices that emphasize corporate sustainability and environmental concerns enhance a company's transparency regarding GHG emission. Furthermore, all managers must be required to evaluate carbon control practices as well as assess the risks associated with GHGs (Kumarasiri, 2017).

In summary, the implementation of effective corporate governance in a company should encourage management to fulfill the company's social responsibilities and raise awareness about the environment. Additionally, companies that have high-quality corporate governance are more concerned about the challenges that are presented by climate change, which leads them to enhance their carbon reduction performance to meet their stakeholders' expectations (Liao et al., 2015). Furthermore, strong corporate governance limits the negative effects of carbon emission on firms' value. As demonstrated in this thesis, firms with high-quality corporate governance will be able to reduce their carbon emission more effectively when they implement effective policies. Practitioners and policymakers may be able to learn more about how corporate governance can help manage climate concerns as a result of these findings. A carbon reduction plan may be used to encourage heavily polluting firms to establish better corporate governance.

5.1.1 Carbon Emission and Corporate Governance Prior to and During COVID-19

The results presented in Chapter 4 demonstrate that corporate governance was positively related to practices that reduce carbon emission prior to COVID-19. Moreover, the results show that the relationship remained positive during the COVID-19 pandemic, but its strength was different. The coefficient for corporate governance during the COVID19 period was higher than that of the period prior to COVID-19. This indicates that during crises, corporate governance has a stronger impact on the reduction of emission. It is expected that stronger governance practices motivate companies to develop effective policies and strategies to reduce carbon emission. This result supports *H2* (*The impact of corporate governance on carbon emission varies for the periods prior to the pandemic and during the pandemic*). Moreover, Karamahmutoğlu and Kuzey (2019) concluded that, through corporate governance, companies can minimize the climate change challenges and maximize the opportunities to manage and implement effective strategy and emission reduction goals. This finding seems to be consistent with other research, which has found that well governed firms reduce their carbon emission (e.g., Finegold et al., 2007; Paek et al., 2013; Rupley et al., 2012).

Other research has demonstrated a positive influence that is related to board structure and carbon reduction performance (Rose, 2007). In order to monitor the effects of climate change and GHG emission, corporate sustainability and environmental concerns can be addressed through the creation of an effective board structure. Additionally, the composition, characteristics, expertise, and background of the directors can provide valuable information that helps in improving the efficiency of decision-making related to carbon emission reduction. However, prior research has frequently provided inconsistent findings on the relationship between corporate governance and carbon emission reduction. Prado-Lorenzo and Garcia-Sanchez (2010) concluded that the board performs limited monitoring with respect to the reduction in carbon emission. Walls et al. (2012) suggested that corporations with bigger, less diversified boards have poor environmental performance. Further, Cong and Freedman (2011) revealed that there is no association between effective corporate governance and pollution performance.

The current study argues that high quality governance enables a company's business strategy to include carbon reduction. Hussain et al. (2018) argued that effective corporate governance can ensure that a company's environmental strategy is carried out effectively. Moreover, Michelon and Parbonetti (2012) and Peters and Romi (2014) found that adopting effective governance can provide more transparency on the decisions made regarding environmental issues. Furthermore, the presence of corporate governance will enable the monitoring of environmental policies and practices, as well as taking effective measures to reduce carbon emission. It is more likely that companies with effective governance will gain legitimacy and maintain credibility by demonstrating their good performance, over time, in relation to carbon emission.

The study shows that there was a strong positive relationship between corporate governance and carbon emission reduction during the COVID-19 period. The coefficient for the corporate governance variable was 0.32 in 2020, while it was only 0.24 in 2018 and 2019. This suggests that the emergence of the COVID-19 pandemic resulted in new challenges, as well as an increase in the level of uncertainty, which led to enhanced governance in order to deal with this condition. This result is in line with Kucera et al. (2020), who asserted that it might be necessary for firms to create a COVID-19 transition committee in order to lead the necessary management changes that are required to face this new situation. Moreover, Barboza (2020) reported that carbon emission reached its lowest levels during the first half of 2020, which was at the start of the COVID-19 pandemic.

During the massive lockdown that occurred around the world, production and consumption both decreased significantly. Moreover, the consequences of the ongoing pandemic led countries around the world to implement preventive measures. These measures were effective in decreasing air pollution and carbon emission in several nations, including, for example, India (Kumari & Toshniwal, 2020; Singh et al., 2020), Egypt (Mostafa et al., 2021), China (Myllyvirta, 2020), Brazil (Dantas et al., 2020), Spain (Baldasano, 2020), Tunisia (Chekir & Ben Salem, 2021), and Italy (Filippini et al., 2020). Since the majority of prior studies have focused on the impact of lockdowns on the environment, there is a gap in the literature with respect to the impact of corporate governance on carbon emission reduction during lockdowns.

The corporate governance coefficient was less prior to the COVID-19 crisis than during it, especially in 2021 (when the vaccine was developed). This supports *H3* (*The relationship between corporate governance and carbon emission varies based on the levels of COVID-19 control measures*). This indicates that, when the lockdown restrictions were lifted and life returned to normal, carbon emission returned to the pre-COVID level. A similar conclusion was reached by Barboza (2020), who concluded that emission might return to pre-pandemic levels, and might even be higher once the vaccine became available and economic activities returned to normal. Moreover, the decrease in emission observed by some countries was only temporary, and it was possible that there would be a significant increase in emission once the pandemic ended or the lockdown measures were lifted (Filonchyk et al., 2020; Le Quéré et al., 2020). It can be argued that significantly lowering carbon emission in the long term may be difficult without significant and continuous changes in human activities that cause carbon emission to grow. The COVID-19 pandemic, on the other hand, can help policymakers and communities implement action plans to minimize carbon emission in the long term. Furthermore, there are opportunities to implement strategies to minimize carbon emission using the information gained during the COVID-19 outbreak.

In summary, the study contributes to the literature by providing evidence of the relationship between corporate governance and carbon reduction prior to COVID-19. Corporate governance has a positive impact on carbon emission reduction, and this is due to the increasing concern for the environment and the effects of climate change, which has empowered decision-makers to take actions towards carbon performance. Furthermore, the study's findings have highlighted the role of governance in carbon emission reduction during the COVID-19 crisis. However, it is important to note that the disruptive impact of the crisis in prior literature findings was mainly focused on the carbon emission reduction associated with the strict measures implemented by governments globally. The current study, however, is based on the premise that corporate governance plays a significant role in establishing a positive trend towards the reduction of emission. The goal here was to provide evidence that strong governance enhanced carbon reduction both prior to and during the COVID-19 pandemic.

Among the control variables, the findings show a positive and significant association between carbon emission reduction and firm size prior to COVID-19. The findings suggest that larger companies reduce their emission by following effective policies and strategies. Furthermore, large firms may face growing stakeholder pressure to manage carbon reduction activities to be seen as proactive regarding climate change problems (Luo & Tang, 2021). Although larger firms create more pollutants, which harm the environment, they are more likely to be targeted by carbon regulations

(McGuire et al., 2003). The present study's findings are similar to those in prior research that has shown that large firms are active participants in carbon emission reduction (e.g. Busch & Hoffmann, 2011; Waddock & Graves, 1997; Wahyuningrum et al., 2020; Wahyuningrum & Budihardjo, 2018; Welbeck et al., 2017). Similarly, profitability has a positive and significant relationship with carbon emission reduction. This finding indicates that profitable firms reduce their emission and have good environmental performance. It has been argued that companies with high performance are expected to implement carbon reduction strategies due to their ability to bear the cost (Zhang et al., 2012). Moreover, profitable firms are more likely to be able to pay for environmental compliance (De Villiers et al., 2011). This finding is consistent with those from prior studies that revealed a positive relationship between profitability and environmental performance (De Villiers et al., 2011; Jaggi & Freedman, 1992; Kock & Santaló, 2005).

It was also observed that industry type is positively associated with carbon emission reduction. This finding indicates that firms in environmentally sensitive industries, such as manufacturers, transportation, food processors, miners, and contractors, are more likely to reduce their carbon emission. This is consistent with Garcia et al. (2018), Kilian and Hennigs (2014), and Kuo et al. (2012), who stated that environmentally sensitive industries, such as chemicals, construction materials, minerals, oil and gas, as well as forestry, have a significant impact on the environment. These industries receive wide attention and pressure from stakeholders and regulators to reduce their emission. However, during COVID-19, the findings showed a positive and significant relationship between carbon emission reduction and firm size, profitability, leverage, and the type of industry. Except for leverage, these findings are in line with the findings prior to COVID-19. Considering these results, it appears that higher leveraged firms were more likely to reduce their emission during the COVID-

19 pandemic. This indicates that an increase in carbon emission will negatively influence the company's image, which may lead to financial consequences affecting the financial position of the company.

This thesis recommends that policymakers should develop policies that focus on reducing carbon emission in order to reduce global warming. In addition, policymakers should implement technical standards and regulations that are effective in reducing carbon emission from direct and indirect corporate operations. Furthermore, policymakers should establish long-term incentives that will encourage industries to invest in green technologies and adopt environmentally friendly products and processes that are designed to minimize the effects of climate change.

5.2 The Regional Effect on Carbon Emission

The results shown in Chapter 4 indicate that, prior to COVID-19, carbon emission reduction was positively related to the following regions: East Asia & Pacific; Eastern Europe & Central Asia; Latin America & the Caribbean; Western Europe; South Asia; and Sub-Saharan Africa. The findings for the period during the COVID-19 pandemic were similar those prior to COVID-19 except for Sub-Saharan Africa, where the results showed no significant association between Sub-Saharan Africa and carbon emission reduction. The indication is that firms that operate in these regions are more likely to be committed to reducing their carbon emission. In addition, they are more likely to create effective strategies and policies in order to achieve their goals.

The results of the current study are in line with Nepal et al. (2017), who argued that carbon emission continues to be high in many countries in the Eastern Europe & Central Asia region, such as Russia, Uzbekistan, Kazakhstan, and Ukraine. However, Ganebnykh et al. (2019) found that Russia is likely to be able to mitigate climate change more effectively through adopting a new integrated strategy for handling waste. On the other hand, the Turkish government has also made great strides in creating mechanisms for dealing with its environmental problems in recent years by setting a plan for environmental management.

The finding of the current study also seems to contradict those in some prior studies (Robalino-López et al., 2014); According to Ganda and Milondzo (2018), the Eastern Europe & Central Asian region emits a significant amount of GHGs. Moreover, in the EastAsia & Pacific region, the results showed a positive relationship with carbon reduction. Hanif (2018) and Sharvini et al. (2018), however, produced differing results; they concluded that various countries in the East Asia & Pacific region, including Malaysia and China, use differing amounts of energy to meet rising energy demands, the growth of their populations, and the growth of their economies. All these factors have a negative impact on reducing carbon emission.

According to the findings in Chapter 4, the Latin America & the Caribbean region has a positive and significant relationship with carbon emission reduction. However, Anser et al. (2020) suggested that Latin American economies lack sophisticated technologies, along with the development of medium-level technology industries, which causes countries in this region to emit more carbon (Anser et al., 2020). Pao and Tsai (2011) concluded that Latin American and Caribbean countries are struggling to stabilize their economies, leading to increased energy consumption and environmental degradation. Furthermore, Hanif et al. (2019) and Pablo-Romero and De Jesús (2016) suggested that this struggle has led to an increase in the demand for goods in the manufacturing, public utility, and transportation industries, which leads to increased carbon emission. Khurshid and Khan. (2021) found that the Western Europe region has the largest economies, which are damaging the regional environment through economic expansion, energy consumption, and urbanization. The current study finds that there is a positive association between carbon emission reduction and South Asia. However, Ahmed et al. (2017) found that population growth and energy consumption are major contributors to environmental degradation in South Asia. Additionally, India's population growth and associated rise in energy consumption are resulting in an increase in carbon emission.

The results from the period prior to COVID-19 are similar to those from during the COVID-19 pandemic. However, in the East Asia & Pacific region, the coefficient during the COVID-19 period was higher than prior to COVID-19. This indicates that the restrictions and lockdown measures implemented by governments resulted in reducing carbon emission. This finding is in line with Ray et al. (2022), who found that the carbon emission in Asia was lower in 2020. Moreover, the carbon emission reduction in the Eastern Europe & Central Asia region was almost the same during the two periods. Furthermore, the coefficient for the South Asia region shows that the carbon reduction in 2020 was lower than that for the period prior to COVID-19. As a consequence of the global lockdown and the interruption in human lives and industries, there has been a large reduction in air pollution in China and several European and American countries (Muhammad et al., 2020; Tobías et al., 2020; Wang & Su, 2020). Moreover, according to Kanniah et al. (2020) and Pani et al. (2020), during the shutdown phase, large cities in South Asia witnessed decreases in PM from vehicle and industrial activity. Moreover, in several African countries, agriculture accounts for approximately 60% of total anthropogenic GHG emissions (Thornton & Herrero, 2015). According to Kganyago & Shikwambana. (2021) during the lockdown, emissions increased due to the burning of woods, grasslands, and agricultural lands in Sub-Saharan Africa.

The results show that, in 2021, most of the regions had a higher coefficient compared to 2020. This is because they had fewer restrictions and lockdown measures, or they were for a shorter period of time. This means that, once the lockdown restrictions were lifted and life resumed as normal, carbon emission began to rise to the pre-COVID levels. Barboza (2020) came to a similar conclusion, predicting that emission would revert to prepandemic levels, if not greater once the vaccine became available and economic activity resumed normally.

Air pollution was used in this study as an alternate proxy for carbon emission reduction. The results show that, prior to COVID-19, air pollution was positively related to the following regions: East Asia & Pacific; Eastern Europe & Central Asia; Latin America & the Caribbean; Middle East and North Africa; Western Europe; South Asia; and Sub-Saharan Africa. However, during the COVID-19 pandemic, the results were similar to those from the period prior to COVID-19, except for Western Europe and SubSaharan Africa (and Middle East and North Africa in 2020 only). These findings indicate that these regions have high levels of air pollution. The coefficients for the East Asia & Pacific, Eastern Europe & Central Asia, Latin America & the Caribbean, and South Asia regions during the COVID-19 period were lower than those prior to COVID-19. This indicates that there was a significant reduction in emission and pollution in several countries around the world due to the implementation of stringent lockdown measures. According to Barbuzano (2020), a decrease in pollution levels was evidenced throughout Western Europe. Furthermore, Metya et al. (2020) suggested that the stringent lockdown measures imposed by the governments of India and China, two big Asian nations, resulted in a huge reduction in air pollution. They showed that extensive restrictions on automotive mobility resulted in a considerable improvement in air quality.

South America and Africa were not heavily impacted by the COVID-19 pandemic due to the lack of strict measures taken to prevent the spread of the virus. As a result, pollution levels in South America and Africa were higher in 2020. Additionally, in the first half of 2020, air quality improved significantly in heavily impacted areas, such as China, Italy, and some areas of the United States, due to people staying home. Otmani et al. (2020) argued that lockdown measures resulted in the closure of manufacturing facilities and restrictions on transportation. This resulted in decreased pollution levels in cities around the world. Furthermore, in the year following the spread of the COVID-19 pandemic, many countries relaxed their strict lockdown measures, and economic activities resumed as usual, resulting in increased air pollution similar to pre-pandemic levels. To summarize, air pollution is caused by a variety of activities, including traffic, industries, refineries, and agriculture. However, global air pollution levels changed as a result of COVID-19 due to strict lockdowns and social distancing.

CHAPTER 6: CONCLUSIONS, IMPLICATIONS, AND FURTHER RESEARCH AVENUES

6.1 Introduction

The study's conclusions are detailed in this chapter by reflecting on the general research objectives in the context of the main findings in the literature and the empirical findings of this study. The chapter also discusses the implications of the study's research findings and offers recommendations for authorities and policymakers. Finally, the chapter discusses the current study's limitations, as well as potential areas for future research.

6.2 Summary of the Study

This thesis has sought to accomplish three main objectives. The first objective was to investigate the relationship between corporate governance and carbon emission reduction. The second objective was to determine whether the relationship between corporate governance and carbon emission reduction differed for the periods prior to and during the pandemic. The third objective was to investigate how the relationship between corporate governance and carbon emission reduction varied depending on the level of COVID-19 control measures. Moreover, this study used different economic and social theories as the foundation for the relationship between corporate governance and carbon emission reduction. Legitimacy and stakeholder theories emphasize the external pressures from stakeholders and society as a whole, while agency theory is concerned with the relationship between corporate management and shareholders, with a particular emphasis on how corporate governance monitors and controls management's behavior. The premise is that firms with high-quality corporate governance are better able to respond to stakeholder needs and are more aware of legitimacy issues related to climate change compared to other firms.

Reviewing the prior literature reveals that there is a significant gap with regards to the role of corporate governance in reducing carbon emission during crises (Debata et al., 2020; Gharehgozli et al., 2020; Khan et al., 2021; Mofijur et al., 2021; Varona & Gonzales, 2021; Xiong, et al., 2020; Zheng et al., 2021). In response to this literature gap, the present study investigated the effect of corporate governance on the reduction of carbon emission by comparing the periods prior to and during the COVID-19 pandemic. The study's sample comprises 2,226 firms from 41 countries. Data regarding carbon emission reduction, corporate governance, and company-specific information were obtained from the Refinitiv Workspace database. Air pollution data were gathered from IQAir. The dependent variable was the reduction in carbon emission, which reflects the emission score. Regarding the independent variable, this study used corporate governance. The control variables included company-specific characteristics, such as firm size, leverage, performance, industry, type, and region fixed effects. The sample was divided into two categories: micro; and macro. The micro level sample was used to explore the relationship between corporate governance and carbon emission reduction at the firm level. The macro level sample was utilized to examine the aforementioned relationship at the regional level. Moreover, to characterize the data, the study employed univariate, bivariate, and multivariate statistical analysis. OLS regression models were utilized to test the three hypotheses. Furthermore, the analysis focused on the relationship between corporate governance carbon emission reduction in the following regions: East Asia & Pacific; East Europe & Central Asia; Western Europe; Latin America & the Caribbean; North America; Middle East and North Africa; South Asia; and Sub-Saharan Africa.

The results revealed a positive and significant association between carbon emission reduction and corporate governance, suggesting that firms with effective corporate governance implement policies and practices to reduce their emission. Moreover, the results showed a positive and significant association between corporate governance and carbon emission reduction prior to and during the COVID-19 pandemic. However, the relationship between carbon emission reduction and corporate governance was stronger during the COVID-19 period. Furthermore, these results suggested that the relationship between corporate governance and carbon emission reduction was stronger due to the strict measures implemented by governments. However, when these strict measures were lifted or reduced, the relationship between carbon emission and corporate governance was reduced. Regarding air pollution, the results revealed a negative and significant relationship between corporate governance and air pollution. At the regional level, the results showed that the carbon emission reduction in the East Asia & Pacific, Eastern Europe & Central Asia, Latin America & the Caribbean, Western Europe, and South Asia regions was stronger during the pandemic period. Furthermore, air pollution decreased during the pandemic in the East Asia & Pacific, Eastern Europe & Central Asia, Latin America & the Caribbean, and South Asia regions.

This work contributes significantly to the body of literature by examining the relationship between corporate governance and carbon emission reduction before and during the COVID-19 pandemic. Previous research has investigated the relationship between one or several corporate governance mechanisms and carbon performance. Previous research has also studied the influence of the COVID-19 pandemic (and the strict measures implemented to stop the spread of the virus) on carbon emission. However, to the best of the researcher's knowledge, this is the first study to examine the role of corporate governance in reducing carbon emission from a broader perspective, considering the relationship between corporate governance and carbon emission reduction prior to and during the global COVID-19 pandemic.

6.3 Conclusion

This study's findings supported *H1* (*There is a positive and significant relationship between corporate governance and carbon emission reduction practices*). Furthermore, *H2* was also supported (*The impact of corporate governance on carbon emission varies for the periods prior to the pandemic and during the pandemic*). This suggests that the association between corporate governance and carbon emission reduction differed prior to and during the pandemic. Furthermore, *H3* (*The relationship between corporate governance and carbon emission varies based on the levels of COVID-19 control measures*) was also supported, showing that, during the pandemic, governments imposed strict lockdown measures to restrict the spread of the virus, which influenced the relationship between governance and carbon reduction positively. The findings also showed that effective governance lowered air pollution levels.

6.4 Implications and Recommendations

The findings of this study are useful for various stakeholders, such as corporate executives and directors, regulators, investors, and academics who are interested in global climate change and carbon emission reduction. The study can help executives and directors identify factors related to corporate governance that may have an impact on firms' carbon emission reduction. More precisely, they should be able to recognize the critical role that strong corporate governance plays in promoting carbon emission reduction in businesses, as well as in limiting negative environmental repercussions. Furthermore, policymakers can benefit from the results of the current study to develop strong climate change strategies and increase their ability to reduce carbon emission.

Another group of stakeholders that will benefit from the results of the study is regulators, who can utilize the findings to identify corporate governance best practices that may require further regulatory attention to meet carbon policy objectives. The study findings benefit regulators in terms of assessing the efficacy of governance in mitigating carbon risks and promoting suitable corporate governance reform. Furthermore, regulators can use the results to provide advice on corporate governance improvements to assist corporations in balancing their financial and environmental objectives.

Investors are also stakeholders that stand to gain from the results of this study. According to Elsayih (2015), investors are increasingly worried about GHG emission and how companies should react to such threats. As a result, it is projected that investors will put increasing pressure on corporations to analyze and disclose more information about their GHG emission. The study's findings are important for investors because they provide a solid framework to understand the impact of corporate governance on carbon reduction. Academics are also stakeholders who are concerned about the environment and how business activities contribute to its degradation. The findings of this study can be applied in further academic research aimed at improving knowledge of the impact of corporate governance on carbon emission reduction. The findings can also be used to help policymakers develop solutions and recommendations regarding how to reduce emission and increase governance effectiveness.

6.5 Limitations and Future Research Avenues

Similar to other studies, this research has some limitations that must be acknowledged, which highlight future research opportunities. First, future research may consider the effect of corporate governance on alternative carbon emission measurements. This may include carbon management systems, limiting carbon emissions in the supply chain, and changes in total carbon emissions. Second, the study examined how corporate governance affects carbon emission reduction at the regional level. Nevertheless, there is inconsistency in the number of countries included in each region. Future studies may re-evaluate the study in light of the equality of regions. Third, this study conducted a comparative analysis of the role of corporate governance in relation to carbon emission reduction, both prior to and during COVID-19. However, it did not cover the post-COVID-19 period. Thus, future research should extend the research period and examine the post-COVID-19 period to determine if enhanced corporate governance led to reduced carbon emissions prior, during, and after the pandemic. Finally, this study used public firms to assess the association between governance and carbon reduction; therefore, future research may increase the sample size by including private or family-owned firms.

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Appendix**: Distribution of Firms across the Different countries**

Country	N	%	Country	N	%	Country	N	%
Argentina	1	0.03%	Hungary	1	0.03%	Switzerland	40	1.8%
Australia	138	2.6%	India	6	0.3%	Turkey	18	0.8%
Austria	11	0.5%	Indonesia	24	1.1 %	Ukraine	1	0.03%
Belgium	17	0.8%	Ireland	18	0.8%	United Kingdom	134	6%
Brazil	42	2.8 %	Italy	11	0.5%	United States of America	835	37.5%
Canada	62	2.38%	Japan	229	10.3%	Total	2226	100%
Chile	12	0.5%	South Korea	18	0.8%			
China	216	9.7%	Luxembourg	7	0.3%			
Colombia	8	0.4%	Mexico	24	1.1%			
Cyprus	1	0.03%	Netherlands	26	1.2%			
Czech Republic	4	0.2%	New Zealand	30	1.3%			
Denmark	22	1.0%	Norway	9	0.4%			
Finland	19	0.9%	Palestine	6	0.3%			
France	44	2.0%	Poland	15	0.7%			
Georgia	1	0.03%	Portugal	1	0.03%			
Germany	56	2.5%	Russia	7	0.3%			
Greece	4	0.2%	South Africa	5	0.2%			
Hong Kong	62	2.8%	Sweden	41	1.8%			